Technical Report No. 236

AN ABSTRACT BIBLIOGRAPHY ON SHORTGRASS AND MIXED-GRASS PRAIRIE ECOSYSTEMS

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GRASSLAND BIOME

U.S. International Biological Program

November 1973

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ABSTRACT

Perhaps because of its size, or perhaps because of the traumatic experiences of the dust bowl days, the shortgrass and mixed-grass prairie ecosystems have been the subject of many studies. In order to gather this information together, the attached bibliography has been prepared. Although the emphasis has been on shortgrass and mixed-grass prairies, other references have been included where they have shed particular understanding on basic processes.

The original beginning of this bibliography was derived from the literature files of the listed consultant. Additional listings were included from the literature citations of the original lists, and recent journals were searched for later literature.

Abstracts were taken from the article themselves or from abstract journals such as *Biological Abstracts* wherever possible. Where published abstracts were not available, abstracts were prepared from summaries and consultant's abstract files.

A

Abstract No. 1.

Aase, J. K., and J. R. Wight. 1970. Energy balance relative to percent plant cover in a native community. J. Range Manage. 23(4):252-256.

Net radiation (R_n) and evapotranspiration (ET) were poorly correlated during both a "wet" and a "dry" period on native range near Sidney, Montana within each of five levels of vegetational cover. The ratio ET:R_n fluctuated greatly in all cases and was generally higher during the period of higher rainfall. During dry periods, substantial amounts of energy were dissipated as heat flux to the atmosphere. Maximum evaporation and/or transpiration from 0%, 25%, 50%, 75%, and 100% cover occurred for 12 days after rainfall and was, respectively, 0.7, 0.8, 1.1, 0.3, and 1.9 times the evaporation from a Class A evaporation pan. Total evapotranspiration for the season was 21% lower and dry matter production was 14% higher with 50% cover than with complete cover. Water use from 75% and 25% cover was similar to that from 50% cover, but forage yields were 5% and 14% less, respectively, than from complete cover.

Abstract No. 2.

Ahring, R. M. 1962. Storageability under laboratory conditions of seed of blue grama, side-oats grama and smooth bromegrass. Oklahoma State Univ. Exp. Sta., Agr. Res. Service, USDA, Tech. Bull. T-97. 11 p.

This study was initiated to measure the normal pattern of seed longevity of one introduced and two native grasses. The objective was to measure both the length of seed longevity in the laboratory and the effect of container and insecticide treatment on the pattern of deterioration.

Abstract No. 3.

Albee, L. R., E. W. Kosterman, W. H. Burkitt, and H. R. Olson. 1948. South Dakota grasslands: Their condition and management. South Dakota Agr. Exp. Sta. Circ. No. 70. 39 p.

Statewide surveys of South Dakota grasslands have been made in 1940, 1942, and 1946.

The stocking rates presented on the map were determined from the 1946 survey, based upon the past ten years' actual use-grazing records from representative farms and ranches. The range and pasture condition method of study was introduced into the 1946 resurvey of South Dakota grassland. The condition approach is much more usable by stockmen and agricultural workers alike than former methods of making grassland inventories.

The 1946 inventory of range and pasture condition shows South Dakota grasslands are near the peak of productivity. Above-average rainfall is largely responsible for this condition. When the precipitation cycle becomes less favorable and dry years come--and they surely will--then only good management of our grasslands can maintain their productivity and prevent the unfavorable conditions of the mid-thirties.

Further studies and follow-up surveys will be made periodically to keep abreast of changes in condition and stocking rates for South Dakota grasslands.

Abstract No. 4.

Albertson, F. W. 1937. Ecology of the mixed prairie in west-central Kansas. Ecol. Monogr. 74:481-547.

The structure and distribution of three types of mixed prairie in west-central Kansas have been determined and the factors controlling the distribution ascertained.

Abstract No. 5.

Albertson, F. W. 1938. Prairie studies in west-central Kansas. Kansas Acad. Sci., Trans. 41: 77-83.

The prairies of west-central Kansas are usually composed of three general types of vegetation. The shortgrass (*Buchloe-Bouteloua*) type constitutes about 30% of the area and is found capping the nearly level uplands. The little bluestem (*Andropogon scoparius*) type is well distributed over the hillsides and makes up 60% of the prairie. The remaining 10% is composed primarily of big bluestem (*A. furcatus*) and is found in the lowlands. The average annual rainfall at Hays, Kansas (1868-1937) was 22.67 inches. For the 5-year dry period (1933-1937) it was only 16.2 inches. During the drought, soil water was seldom available to plant use below 2 feet in the shortgrass type and only occasionally in the upper 24 inches, resulting in enormous losses of vegetation. Meter quadrats staked out and charted in the shortgrass before the drought and every year since indicate no great difference in ground cover existed before the drought on ungrazed and grazed prairies, but in the fall of 1937 they ranked 23% and 4%, respectively. Weedy forbs were also greatly increased as a consequence of overgrazing. Little bluestem and wire grass (*Aristida purpurea*) are found widely scattered throughout the shortgrasses during wet cycles, but upon the advent of drought they retreat to the hillsides. Even in the ungrazed little bluestem type along the hillsides, tall grama (*Bouteloua curtipendula*) and big bluestem have gained at the expense of the little bluestem. Grazing only makes the situation worse. Here there is a great increase in the number of species of unpalatable forbs. Dust blown from cultivated fields probably causes greater damage than overgrazing.

Abstract No. 6.

Albertson, F. W. 1938. Studies of a 189-year-old American elm tree in west-central Kansas. Kans. Acad. Sci., Trans. 41:85.

One of the largest American elm (*Ulmus americana*) trees observed in this section of the state was removed from the edge of Big Creek, near the college buildings on the campus of the Fort Hays Kansas State College, during the fall of 1933. The removal of this tree, along with many other trees and shrubs, was a part of a program in attempting to relieve the flood hazard for the Fort Hays Kansas State College and the city of Hays.

A section of the trunk, taken about 5 ft above the water in the creek, was polished and preserved for study. Pins were set at intervals of 10 annual rings radiating in various directions from the center of the section. As nearly as could be determined, the tree was 189 years old when removed.

The section measured approximately 4 ft in diameter in an east-to-west direction and about 6 inches less from north to south.

Three rifle bullets of the type used during the days of the Fort Hays Military Reservation (1865-1889) were found imbedded in the trunk, and also a shallow scar 7 inches in diameter filled with shot from a shotgun. It was difficult to determine, due to scar tissue, just when the bullets and shot entered the tree, but all were found near the same annual ring, although in different positions on the circumference of the section. The outside edge of the scars indicated that the bullets and shot entered the tree sometime between 1870 and 1880 and penetrated to a depth somewhat deeper than the ring formed in 1865. A large scar, which appears to have been caused by fire, is located in one side of the section. The inner edge of this scar extends into the rings laid down early in the 19th century.

There are two periods in the life of this tree when increased ring width was evident. The first period began about 1754 and the second period began about 1844. This conforms fairly well with the observations made by Dr. E. L. Moseley in Ohio. Whether or not the climatic cycles observed in Ohio extended to this section of Kansas; and further, if they did, just how much effect they might have had on the growth of a tree living on the edge of a stream, would seem somewhat problematical.

Abstract No. 7.

Albertson, F. W. 1939. Prairie studies in west-central Kansas. Kansas Acad. Sci., Trans. 42: 97-107.

The results of quadrat data taken before and during the recent great drouth from eight stations along a radius from the periphery of the dustbowl near Hays, Kansas, to Holcomb and Tribune, Kansas, concerned with basal ground cover of buffalograss (*Buchloe dactyloides*) and blue grama grass (*Bouteloua gracilis*), the important shortgrasses, and little bluestem (*Andropogon scoparius*), big bluestem (*A. furcatus*) and sideoats grama (*B. curtipendula*), and the important tallgrasses, under various conditions of grazing, make it safe to assume that the dustbowl is gradually becoming smaller. This is due to the gradual improvement of climatic conditions along the periphery as evidenced by the increased basal ground cover of the native grasses. Little or no improvement, however, was found nearer the center, as yet.

Abstract No. 8.

Albertson, F. W. 1939. The tragedy of the Great Plains. Aerend 10.

General paper on the impact of drought on shortgrass prairies in the 1930's. When the drought began in 1933, some 80 to 100% of the native prairie land was covered with grass and their associates; while today (1939), this cover has been reduced to 0 to 25%.

Abstract No. 9.

Albertson, F. W. 1940. Science, plants, and mankind. Aerend 11.

A short treatise on the importance of plants in the development of civilization.

Abstract No. 10.

Albertson, F. W. 1940. Studies of native red cedars in west-central Kansas. Kansas Acad. Sci., Trans. 43:85-95.

Tree counts made in red cedar (*Juniperus virginiana*) groves in Trego, Ellis, and Russell counties in western Kansas in 1935-1939 (after the great drouth) disclosed losses from 80% in the most western county to 10% in the most eastern of these counties.

Abstract No. 11.

Albertson, F. W. 1941. Prairie studies in west-central Kansas: 1940. Kansas Acad. Sci., Trans. 44:49-57.

Numerous questions have arisen concerning the effect of the drought, particularly that one of 1939, upon the native vegetation. It is a fairly common belief that there was considerable improvement in the native vegetation during the growing season of 1940 over that of 1939. The principal purpose of this paper is to present some evidence which might be used in determining the accuracy of this assumption.

Abstract No. 12.

Albertson, F. W. 1942. Prairie studies in west-central Kansas: 1941. Kansas Acad. Sci., Trans. 45:47-54.

The prolonged drought extending from 1933 to 1939 left the native vegetation of the Great Plains region at low ebb. Details of the response of vegetation to this drought period have been reported and reference to these details in this paper will be only incidental to presenting data relative to recovery that occurred during the growing season of 1941. Notes were carefully taken on observations made on plant response throughout the season; and the work of charting many meter quadrats, as was done during previous years, was continued in the fall of 1941.

Plants weakened by years of adversity seemed to spring forth with renewed vigor when environmental conditions became more conducive to growth. The purpose of this paper, then, is to present data relative to the improved climatic and soil conditions that prevailed during 1941 and the response of the vegetation to this improvement.

Abstract No. 13.

Albertson, F. W. 1943. Prairie studies in west-central Kansas: 1942. Kansas Acad. Sci., Trans. 46:81-84.

For many years the pasture land of west-central Kansas has been observed to fluctuate greatly in the amount and kind of vegetation covering the soil. With this great variation in basal cover and composition it was obvious that great differences in yield must also have occurred. Specifically, what do pastures actually yield under different types of plant cover? It is the purpose of this paper to report on the yield of prairie grasses on the various grazing types common to this section of the state of Kansas.

Three types of native vegetation occur widely in the loam soils of west-central Kansas. These are the disclimax shortgrass community of the more level and gently rolling lands; the little bluestem (*Andropogon scoparius*) type of steep hillsides where rock outcrops occur or where rock is covered only by a shallow soil; and the big bluestem (*Andropogon furcatus*) type of deep ravines and lowlands which are supplied with run-in water and thus receive more moisture than is afforded by the local precipitation.

Stockmen and others are much interested as to the productivity of each type in terms of increase in weight of grazing animals per unit area grazed. Since the amount of forage produced is an important factor in determining the answer to this question, the following study was made at Hays in 1940, 1941, and 1942.

Barbed wire exclosures were placed on representative areas of each type and 20-meter quadrats were staked out in each exclosure. These were all in the same 750-acre pasture and consequently had been subjected to the same moderate degree of grazing in past years. The vegetation was charted and clippings were made at a height of one-half inch. The forage was divided into shortgrass, midgrass, forbs, and weeds. It was air-dried and the yields expressed in pounds per acre.

Abstract No. 14.

Albertson, F. W. 1945. Prairie studies in west-central Kansas: 1943. Kansas Acad. Sci., Trans. 47:405-413.

Great changes in environment produce striking reactions throughout the plant and animal world. During the past decade or more, the native vegetation of west-central Kansas has undergone significant changes in response to wide variations in its environment. In order to measure these vegetative changes in considerable detail at Hays, Kansas, numerous meter-quadrat areas were staked out and charted for annual readings in 1932. The quadrats whose vegetative changes are included in this report were located in an exclosure so as to include vegetation representative of the area where the shortgrasses of the table land met and in places intermixed with the midgrasses of the slopes and ravines.

Abstract No. 15.

Albertson, F. W. 1949. Man's disorder of nature's design in the Great Plains. Kansas Acad. Sci., Trans. 52:117-131.

An ecological survey of what man has done on the High Plains and some suggestions as to what can be done about it.

Abstract No. 16.

Albertson, F. W. 1950. Wild flowers in the Great Plains. Kansas Gardner 2.

General discussion of the prairie as a seasonal flower garden.

Abstract No. 17.

Albertson, F. W., and J. E. Weaver. 1942. History of the native vegetation of western Kansas during seven years of continuous drought. Ecol. Monogr. 12(1):23-51.

The prairie vegetation of western Kansas was studied through seven years of continuous drought, 1933 to 1939, inclusive. Water content of soil was determined weekly during the growing season, and a record of aerial environmental factors was obtained. Reactions of the mixed prairie and short grass vegetation were recorded year by year in scores of permanent, widely-distributed quadrats, and by extensive field notes. Moderately-grazed and ungrazed prairies were in excellent condition in 1933 because of a very favorable six-year period just preceding when the average annual precipitation (27.8 inches) was approximately five inches above normal. Annual precipitation during each of the drought years was below normal and during four of the seven years, nearly seven inches below. Most of this deficit occurred during the growing season. Periods of 5 to 7 weeks in summer with practically no rainfall occurred. An accumulated deficit of 6.7 inches in 1933 increased to 21.6 in 1936 and to 34.5 inches in 1939. Temperatures were abnormally high during the drought and duration of periods with high temperatures unusually long. Wind movement was also unusually high. That of 1934 was greatest, being 41,782 miles from April to September, inclusive. The lowest (1936) was 33,838 miles. High wind velocity resulted in dust storms which reached a climax in March and April 1935. Vast areas of vegetation were smothered by thin blankets of silt or by great drifts of loose earth. After the vegetation died, the dust was again moved by the wind and thus supplied the silt for later black blizzards. Water content of soil was determined at weekly intervals throughout the growing season to a depth of 5 ft. Available water was the limiting factor to plant production. Water was nonavailable throughout most of the drought period except for short intervals in the upper 6 inches. Three types of vegetation, with varying degrees of intermixtures are common in the mixed prairie of west-central Kansas. They are the little bluestem (*Andropogon scoparius*) type, common on hillsides and in shallow ravines; the shortgrass (*Buchloe-Bouteloua*) type, widely distributed over nearly level uplands; and the big bluestem (*Andropogon furcatus*) type of larger ravines and lower moist slopes. During the 7 years of drought, vegetation remained wilted or dried over periods of several weeks' duration. Periods of dormancy alternated with those of growth several times during a single summer. Many mesic plants disappeared completely, and even the most xeric species were reduced greatly in numbers. Animal life was also greatly depleted. The original basal cover of about 60% in the little bluestem type was composed of approximately one-sixth big bluestem and nearly all of the remainder was little bluestem. Little bluestem decreased so rapidly that only 1 to 4% remained in 1939. Big bluestem was reduced to 2% or less. Invasion of more xeric species, especially side-oats grama (*Bouteloua curtipendula*) and blue grama (*B. gracilis*), resulted in the minimum basal cover of 16% (1936) being increased from 22 to 30% in 1939. Studies in the *Buchloe-Bouteloua* type were begun in 1932 and extended in 1935 to include several grazing treatments. In 1937, quadrats were established in pastures in 10 counties of western Kansas; some pastures had undergone various degrees of covering by dust. Moderately-grazed pastures with an equal mixture of buffalo grass (*Buchloe dactyloides*) and blue grama grass in almost pure stands had a basal cover of 80 to 90% when protected from grazing. This decreased slowly until 1936 when it was only 58%, and in 1939 only 22%. Overgrazed shortgrass ranges were reduced to a cover of 2.6% in 1936, but gradually increased to 19% in 1939. Intensive studies of ranges were made in 10 additional counties in western Kansas beginning in 1937. All were in the shortgrass type. On lightly dusted and moderately-grazed ranges, basal cover varied from 10 to 33%. Percentage of buffalo grass usually averaged higher than that of blue grama. Variations in cover were usually closely correlated with the amount of rainfall. No permanent gains occurred by 1939. Drought, overgrazing, and hordes of grasshoppers have caused great reduction in carrying capacity of the range. Yield of palatable forage in overgrazed pastures is <10% of that produced in well-managed ones. Where 10 to 12 acres were formerly required to sustain one animal unit, 30 to 50 acres are now needed.

Abstract No. 18.

Albertson, F. W., and J. E. Weaver. 1944. Effects of drought, dust, and intensity of grazing on cover and yield of shortgrass pastures. Ecol. Monogr. 14(1):1-29.

At Hays, Ness City, Dighton, and Quinter in western Kansas, pastures in rangelands were selected for study of the recent severe drought. Investigations were made on four classes of pastures at each station: lightly-grazed and lightly-dusted, heavily-grazed and lightly-dusted, lightly-grazed and heavily-dusted, and heavily-grazed and heavily-dusted. Records of annual and monthly precipitation were obtained for each station, available soil water measured to a depth of 5 ft each month during the growing season, and additional ecological factors were studied in the years 1939, 1940, and 1941. To measure the recovery, studies were made on the increase in basal area of perennial grasses, the amount of various species concerned, and the dry weight of forage produced. Certain exclosures were made against stock. Precipitation was low in 1939, moderate (normal) in 1940, and above normal in 1941. Blue grama (*Buchloe gracilis*), buffalo grass (*Buchloe dactyloides*), and shortgrasses, constituted the bulky perennial vegetation. Sand dropseed (*Sporobolus cryptandrus*) was practically the only midgrass. Annual weeds were abundant, but native forbs were few.

Abstract No. 19.

Albertson, F. W., and J. E. Weaver. 1944. Nature and degree of recovery of grassland from the great drought of 1933 to 1940. Ecol. Monogr. 14(4): 393-479.

Recovery of midwestern grasslands from the great drought (1933-1940) has been studied during three years of sufficiently increased precipitation (1941-1943) to promote the development of a good cover. The true prairie was studied in southwest Iowa, southern Nebraska, and northern Kansas; and mixed prairie in southwest Nebraska, western Kansas, and eastern Colorado. Precipitation increased, evaporation decreased, wind movement decreased, dust storms were less frequent, and summer temperatures were lower after the drought. The following perennial grasses decreased during the drought. All native grasses suffered loss, but death was greatest among those with shorter roots: *Andropogon scoparius*, *Koeleria cristata*, *Stipa spartea*, *Sporobolus heterolepis*, and *Sorghastrum nutans*. *Andropogon furcatus*, with deeper roots, was injured less. Among the understory grasses and forbs, destruction was rather complete for *Poa pratensis*, *Panicum scribnerianum*, *Eragrostis spectabilis*, *Agrostis hiemalis*, *Antennaria campestris*, *Viola papilionacea*, *V. pedatifida*, *Gentiana puberula*, *Senecio plattensis*, and *Hieracium longipilum*. While the above were thinning the prairie cover, certain forbs spread rapidly and widely: *Aster multiflorus*, *Solidago glaberrima*, *Artemisia gnaphalodes*, and *Erigeron ramosus*. Ruderals invaded, profiting by the situation: *Lepidium densiflorum*, *Leptilon canadense*, *Bromus secalinus*, *Salsola pestifer*, *Chenopodium album*, and *Amaranthus retroflexus*. Among the native grasses making progress at this time were: *Festuca octoflora*, *Buchloe dactyloides*, *Bouteloua gracilis*, and *Agropyron smithii*. In 1935 six-weeks fescue (*Festuca octoflora*), blue grama (*Bouteloua gracilis*), and especially western wheatgrass (*Agropyron smithii*) increased greatly. Severe drought in 1936-1937 resulted in great advantage to these grasses and buffalo grass (*Buchloe dactyloides*), since they thrived while their competitors waned. Approximately normal precipitation in 1938 resulted in an excellent development of vegetation and the production of much seed. Wheatgrass, blue grama, and buffalo grass continued their spread. Big bluestem (*Andropogon furcatus*), needle grass (*Stipa spartea*), and prairie dropseed (*Sporobolus heterolepis*) thickened their relict stands and increased greatly. Blue grama often survived where all other grasses died. It spread almost without interruption from 1935 to 1942 and promptly thickened its stands. Buffalo grass, less abundant and more greatly harmed by drought than blue grama, increased greatly. The present mosaic of grassland patterns is merely one phase of a long developmental process. In order of size of area occupied, the types of 1943 were mixed prairie, western wheatgrass, big bluestem, needlegrass, blue grama, prairie dropseed, relict big bluestem-little bluestem, and mixed grasses. Recovery was repeatedly delayed by losses on driest years offsetting gains made by the less dry ones. Methods of recovery of grasses were increase in size of relicts by tillering, production of rhizomes and stolons, breaking of dormancy in old rootcrowns and underground parts, and production of abundant seedlings. Recovery was expressed by increase in numbers, vigor, and stature of plants; and by the resultant thickening of the stand, and the exclusion of ruderals. It was also shown by reappearance of societies of forbs, reconstruction of a layered vegetation, accumulation of debris, and increased yield. Recovery in mixed prairie, where most of the area is rangeland, was delayed by overgrazing in some places and by understocking in others, but usually it was prompt. Buffalo grass entirely disappeared from some ranges, and in many remained alive only in the best-watered places. Rate of recovery varied widely depending upon kind of pre-drought cover, degree of depletion, and kind of grass relicts at the end of the drought. Other factors were amount of damage from burial by dust, intensity of grazing and trampling during recovery, and amount and distribution of local precipitation.

Abstract No. 20.

Albertson, F. W., and J. E. Weaver. 1945. Injury and death or recovery of trees in prairie climate. Ecol. Monogr. 15(4):393-433.

This study describes the effects of the greatest drought since the beginning of recorded weather history on forests and trees growing in a prairie climate. The area considered extends from central Iowa westward into Colorado and includes the territory from southern Oklahoma to Canada.

Data are from a wide range of sources; they include pre-drought surveys of trees and conditions for their growth in grassland which give a necessary background for an understanding of their injury and death or recovery in different sites. The most intensive studies were made in the western half of Kansas.

Abstract No. 21.

Albertson, F. W., and J. E. Weaver. 1946. Reduction of ungrazed mixed prairie to shortgrass as a result of drought and dust. Ecol. Monogr. 16(4): 449-463.

This is the history of a typical area of mixed prairie near Phillipsburg in north-central Kansas from 1920 to the time it was plowed in 1945. The midgrasses, little bluestem (*Andropogon scoparius*), side-oats grama (*Bouteloua curtipendula*), and western wheatgrass (*Agropyron smithii*); together with taller ones--big bluestem (*Andropogon furcatus*), Indian grass (*Sorghastrum nutans*), and nodding wild rye (*Elymus canadensis*)--alternated with blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) or formed an open layer above them. About 50 species of forbs, many of which formed extensive societies, were found. Great damage was done by a single year (1933) of intense drought and burial by dust. Although blue grama and buffalo grass lost heavily, they alone recovered rapidly with spring rains. Only about 15 species of the perennial forbs remained, but annual weeds became plentiful. Five years of continuous or intermittent drought was followed by a period of extreme drought. Despite the deep loess soil, in the spring of 1940 only a little vegetation was left alive. Chief perennials were buffalo grass and blue grama. Nearly all other perennial grasses had died; native forbs were reduced to remnants of 11 species. Heavy rainfall, beginning in 1941, permitted the rapid spread of buffalo grass and blue grama and, by 1942, the consolidation of the formerly open cover. The average basal area in 11-m quadrats containing these grasses was (1940 to 1944, inclusive) 13, 36, 48, 61, and 72%. Similar gains were recorded in other quadrats. After 1942, buffalo grass greatly exceeded blue grama in amount. Usually these grasses became so tall (6 to 8 inches) and dense that the soil was completely concealed.

Abstract No. 22.

Albertson, F. W., A. Riegel, and J. L. Launchbaugh, Jr. 1953. Effects of different intensities of clipping on shortgrasses in west-central Kansas. Ecology 34(1):1-20.

This study was conducted from 1942 to 1947 to determine the effect of various intensities of clipping on growth of blue grama and buffalo grass.

The experimental plot consisted of two square areas, each of which contained 36 1-m quadrats. The quadrats in each area were arranged in six series, each of which consisted of six quadrats.

Each series was clipped at different intensities and different frequencies through the growing seasons. Amount of grasses not removed by clipping was determined by a utilization gauge or by clipping similar locations outside the areas of study.

Percent basal cover of vegetation was determined each spring and fall by a pantograph and planimeter.

Soil water to a depth of 5 ft was determined each week from soil samples taken with a geotome. Amount of moisture above hygroscopic coefficient was considered available for plant growth.

Abstract No. 23.

Albertson, F. W., G. W. Tomanek, and A. Riegel. 1957. Ecology of drought cycles and grazing intensity on grasslands of Central Great Plains. Ecol. Monogr. 27(1):27-44.

Effects of two periods of drought (1933-1939 and 1952-1955) on the native vegetation of the Central Great Plains were compared. Effects of the former were more severe in the panhandle of Oklahoma and southwestern Kansas than the most recent dry spell. The reverse was true in east central Colorado and northwestern Kansas. For example, in eastern Colorado density of grass cover was reduced to as low as 1.4% in 1955, but was only 6% in 1939. Recovery of grasses between drought periods was very rapid. Cover was restored after only two or three years of good rainfall, but original composition was not completely restored when the second drought came. Intensity of grazing on native grasslands greatly affected the amount of loss due to drought. Prairies overused in the past suffered much more heavily from drought than those areas which had been properly utilized. The most recent dry period is still in progress.

Abstract No. 24.

Albertson, F. W., and G. W. Tomanek. 1965. Vegetation changes during a 30-year period in grassland communities near Hays, Kansas. Ecology 46(5):714-720.

Three plant communities near Hays, Kansas, showed considerable change in the composition of their dominant vegetation over the 30-year period from 1932 to 1961. The shortgrass community was dominated by *Euchloe dactyloides* and *Bouteloua gracilis* in 1932 and dominated only by *Bouteloua gracilis* in 1961. The little bluestem community was dominated by *Andropogon scoparius* during favorable years, but by *Bouteloua curtipendula* and *Bouteloua gracilis* during drought years. The dominants of the little bluestem-big bluestem community were *Andropogon scoparius* and *Andropogon gerardi* in 1932, but by 1961 *Andropogon gerardi* was the only dominant. Two drought periods, 1933-39 and 1952-56, were important in affecting these vegetation changes.

Abstract No. 25.

Albertson, F. W., D. A. Riegel, and G. W. Tomanek. 1966. Ecological studies of blue grama grass (*Bouteloua gracilis*). Fort Hays Stud. Sci. Ser. No. 5. 37 p.

Blue grama grass (*Bouteloua gracilis*) was selected for detailed description here because of its wide distribution and importance throughout the Great Plains Region in the United States.

The wide distribution of this grass, its value in restoring and preserving productivity of soil, its ability to endure drought and other climatic adversity, and its excellence as herbage for livestock; all attest to its importance to profitable living in the Great Plains. The value of this grass is further indicated by the fact that "grama grass" is a household term to almost everyone who resides in this vast grassland area, or writes or reads of life on the Great Plains during pioneers days, even to this day.

Abstract No. 26.

Alcorn, J. R. 1941. Counts of embryos in Nevadan kangaroo rats (*Dipodomys*). J. Mammal. 22:88-89.

During the first part of each of the two years 1938 and 1939 in the Soda Lake district, Churchill County, Nevada, I examined 183 *Dipodomys ordii columbianus* and 311 *D. merriami merriami* as to sex and condition of the reproductive tracts of females. Of *D. ordii columbianus*, 90 females (49.2%) and 93 males were taken. Of *D. merriami merriami*, 141 females (45.3%) and 170 males were taken. All animals obtained in February (8 *D. merriami*, 61 *D. ordii*), August (59 *D. merriami*), and September (11 *D. meriami*) were trapped. Those taken in the other months were poisoned.

In 50 pregnant females of *D. ordii columbianus* the largest number of embryos in any one female was 5; the smallest number was 2; and the average was 3.6. In 32 pregnant females of *D. merriami merriami* the largest number of embryos found was 4; the smallest number was 2; and the average was 3.1.

Some females have more than one litter of young a year. This indication results from the fact that in *D. merriami merriami* more than one-third of all the females taken in each of the months of March, April, and May were pregnant. The indication that there is more than one annual litter is stronger in *D. ordii columbianus* because three-fourths of all females taken in February were pregnant, as were nearly half of those taken in March and April.

Abstract No. 27.

Aldon, E. F. 1964. Ground-cover changes in relation to runoff and erosion in west-central New Mexico. U.S. Forest Service Res. Note RM-34. 4 p.

In 1952 a cooperative study on three San Luis Experimental watersheds in New Mexico was begun to determine the feasibility of restoring the more deteriorated portions of this region. Grazing management was started, but full control of the livestock through overwinter use only was not achieved until 1958. The periods 1952-58 and 1959-62 have been examined to determine the effect this different grazing use had on sediment yield, surface runoff, and ground cover.

Before the uniform grazing treatment, average ground cover, measured by three key grass species, ranged from 3 to 5% on the watersheds. Three years later the percentages had doubled: they ranged between 6 and 12%; bare ground decreased. Runoff during periods was similar, although the precision of the measurements was such that small changes could not be detected. Sediment production decreased between 0.2 and 0.7 acre-ft/year on the watersheds. The changes may be attributable to the change in grazing use between periods. Ground cover improved under summer-deferred grazing and fencing. Precipitation averages during the two periods was similar.

Abstract No. 28.

Aldous, A. E. 1930. Effect of different clipping treatments on the yield and the vigor of prairie grass vegetation. Ecology 11:752-759.

The experiments were conducted on two prairie grass pastures in the vicinity of Manhattan, Kansas.

The yield of vegetation varied inversely with the frequency of the cutting, being least on the plats clipped at 2-week intervals throughout the season, and highest where clipped once at the maturity of the vegetation.

The density of the vegetation decreased about 60% on plats clipped at 2-week intervals for 3 seasons, while the plats clipped at 3-week intervals decreased in density by about 13%.

The composition of the vegetation on the plats clipped at 2-week intervals deteriorated in the period of the experiments to the point where these plats contained about 50% annuals practically worthless for feed. Where the plats were clipped at less frequent intervals there was very little change in their original composition.

The protein content of the vegetation was highest on the plats clipped most frequently. This amount would not be sufficient to compensate for the decreased yield and the injury to the vegetation.

Abstract No. 29.

Aldous, A. E. 1934. Effects of burning on Kansas bluestem pastures. Kansas Agr. Exp. Sta. Bull. 38. 65 p.

The experiments were conducted on two areas of bluestem pastures near Manhattan, Kansas, where the mean annual precipitation is 31.49 inches. Big bluestem (*Andropogon furcatus*) and little bluestem (*Andropogon scoparius*) are the dominant grasses on both areas. These two grasses are about equally divided in the Casement pasture area, and little bluestem comprises about 50% of the vegetative cover in the College pasture. Other important grasses in the two areas include Indian grass (*Sorghastrum nutans*), side-oats grama (*Bouteloua curtipendula*), prairie June grass (*Koeleria cristata*), prairie dropseed (*Sporobolus heterolepis*), Kentucky bluegrass (*Poa pratensis*), and switch grass (*Panicum virgatum*).

The major portion of the experiments were started in 1927 to obtain information on the effect of burning on (i) yield of vegetation, (ii) control of weeds and brush, (iii) quality of the vegetation, (iv) soil water and soil temperature, (v) composition and succession of the vegetation, (vi) starting growth in the spring, and (vii) effect on the fertility of the soil.

Abstract No. 30.

Aldous, A. E. 1935. Management of Kansas permanent pastures. Kansas Agr. Exp. Sta. Bull. 272. 44 p.

More than one-third of the total acreage of Kansas is in permanent pasture. At least 90% of this land is nontillable because of steep slopes, excessive amounts of sand, or the thin or rocky nature of the soil. This makes it valuable only for its natural vegetative growth which provides pasturage for livestock. The present productivity of these lands varies greatly, depending upon the precipitation, type of soil, the natural vegetative covering, and the grazing management.

It has generally been considered that if a pasture was depleted of its original vegetative covering, no practical method could be used to restore its productivity. Recent investigations have shown that many run-down pastures can be improved at little expense by using methods of management that will give the desirable forage species an opportunity to make more top growth. It is the purpose of this publication to outline methods that can be used to increase the productivity of these areas, representing one-third of the land area of Kansas, and to suggest systems of grazing management that can be used effectively to maintain a high grazing capacity.

Abstract No. 31.

Aldous, A. E. 1938. Management of Kansas bluestem pastures. J. Amer. Soc. Agron. 30:244-253.

Brief description of native vegetation and effect of grazing on density and succession in Riley county.

Abstract No. 32.

Aldous, A. E., and H. L. Shantz. 1924. Types of vegetation in the semiarid portion of the United States and their economic significance. J. Agr. Res. 28:99-127.

In the following paper the principal types of vegetation occurring on the unreserved public lands and the patented homestead lands west of the one-hundredth meridian are briefly discussed with special reference to their economic significance to crop production and grazing, and some of the more important ones are illustrated. These types have been recognized and used in connection with data on topography, soil, climatic conditions, accessibility, and past agricultural history to determine the value of the lands for the production of cultivated crops and for grazing. At the time the land classification work was started there were numerous areas that had not been settled or where settlement had been so recent that no agricultural history was available. In most of these areas definite climatic data were also lacking. The vegetation therefore served as the principal means of determining the relative value of these lands for farming.

To aid in the use of the vegetation types, especially to show their range, a map was prepared dividing the western part of the United States into 15 regions, each having in a general way a similarity in vegetation. A copy of this map, together with a list of the types giving their distribution in the various regions, follows the text.

Abstract No. 33.

Alexander, M. 1969. Soil decomposers, p. 403-409. *In* R. L. Dix and R. G. Beidleman [ed.]. The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Despite the extensive literature on soil decomposers, there exists a dearth of significant findings relative to the participation of these organisms in grassland function. Consideration is given to the necessity and importance of research dealing with further description of decomposer species in grassland soils, studies of interactions within the decomposer community, and investigations of the interplay between the decomposers and their surroundings. Some problems in investigations of decomposer ecology and function are raised and possible avenues of approach are suggested. The characterization of the dominant species, the nature of the microbiological climax, biogeographic problems, dispersal of microbial propagules, the course and causes of succession, the phyllosphere, and root-decomposer associations are briefly reviewed. The interspecific interactions and causes of these relationships are examined, and attention is given to the biochemical influence of the decomposer community on its subterranean ecosystem.
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Abstract No. 34.

Alizai, H., and L. C. Hulbert. 1970. Effects of soil texture on evaporative loss and available water in semi-arid climates. Soil Sci. 110:328-332.

Greenhouse experiments were conducted on three soils to test effect of soil texture on evaporation. Evaporation was often three times as great from the loams as from the gravelly sand after adding equal amounts of water. When water added per unit time was constant, evaporation increased in all soils with a decrease in interval between waterings. Sorghum plants remained turgid in gravelly sand but wilted and died in loam supplied with equal amounts of water.

These experiments confirm that more water evaporates from fine-textured than from coarse-textured soils and support the hypothesis that differences in evaporation help explain the more mesophytic vegetation on coarse than on fine-textured soils in semiarid and arid areas.

Abstract No. 35.

Allan, P. F. 1946. Notes on *Dipodomys ordii richardsoni*. J. Mammal. 27(3):271-273.

Late in the summer of 1938, I captured and kept as pets several individuals of *Dipodomys ordii richardsoni*. All of the animals were taken about seven miles north of Amarillo, Potter County, Texas, in a sandy drainageway with a raw sand wash down the channel. The burrows at which the rats were trapped were located in the edges of the wash. The dominant vegetation here was *Sporobolus aeroides*, and there was an abundance of forbs--notably, *Amaranthus blitoides*, *Helianthus annuus*, *Euphorbia albomarginata*, *Ambrosia* sp., and *Desmanthus illinoensis*. *Cenchrus* sp. was common. The habitat was also occupied by a *Peromyscus*, a *Sigmodon*, a *Reithrodontomys*, none of which I have yet identified, and the black-tailed prairie dog, *Cynomys ludovicianus*. Some of the other important animals occurring in the drainageway or nearby were prairie rattler, *Crotalus confluentus* (seen); coyote, *Canis latrans* ssp. (tracks); house cat, *Felis catus* (seen); and Swainson's Hawk, *Buteo swainsoni* (seen).

Abstract No. 36.

Allan, P. F., and P. R. Sime. 1940. Breeding bird census, shortgrass plains. Bird-lore (Suppl.) 41:18, 42:477.

Shortgrass Plains. Typical blue grama-buffalo grass range, having a light scattering of mesquite, yucca, and cactus; 13 additional species of grass occur as well as numerous forbs. Size: About 25 acres. Location: 14 miles north of Amarillo, Potter County, Texas. Topography: Rather even with a gentle northward slope; bisected by a shallow drainageway and containing a .66-acre stock tank. Edge: No appreciable "edge effect" adjacent to the area. Weather: Excellent rains early in the year gave the grass a good start, the average depth of which was 4 to 5 inches, or about an inch or two taller than in 1938. Around the mesquites, the grass ran close to 12 inches in depth. However, extremely dry weather during the late spring "burned" the grass, and it was not until late June that there was an appreciable recovery. Mean average temperatures for March to June inclusive were 51.4, 58.2, 67.6, and 76.6°F; against 52.0, 58.3, 65.2, and 74.2 for last year: total precipitation for these months in 1939 was .25, 2.30, 1.71, and 7.59 inches; against 1.20, .80, 3.90, and 2.50 inches in 1938. Heavy rains following the last census cruise accounted for most of the 7.59 inches this June. Surveys: Studied in 1938. Coverage: May 14, 21; June 11, 18, 25. Hours varied from 6:30 AM to 6 PM, totaled 24. Census: W. Mourning Dove, 6P (6N, 3Y); Killdeer, 1P; Howell's Nighthawk, 2P; Desert Horned Lark, 3P (3Y); W. Mockingbird, 1Y; W. Meadowlark, 2P (1N, 4Y); W. Lark Sparrow, 7P (3N, 1Y); Cassin's Sparrow, 6P (6N). Total: 26 pairs. Density: 104 pairs/100 acres. Regular Visitors: Swainson's Hawk, 1; Arizona Scaled Quail, 1P; W. Mourning Dove, 1P; Killdeer, 1P; Arkansas Kingbird, 1P; W. Mockingbird, 2P; W. Meadowlark, 2P; Cliff Swallow, 1; Cassin's Sparrow, 2P; Lark Bunting, 1P. Total: 23 birds. Density of regular visitors: 92 birds/100 acres. Because of nest destruction in 1938, presumably by pack rats, nests found this year were not revisited.

Abstract No. 37.

Allden, W. G., and I. A. McD. Whittaker. 1970. The determinants of herbage intake by grazing sheep: The interrelationship of factors influencing herbage intake and availability. Australian J. Agr. Res. 21(5):755-766.

The interrelationship of characters of the pasture (herbage yield, height of sward) and of the animal (size of animal, rate of intake, rate of biting, size of bite, and time spent grazing) which influence the consumption of herbage by the grazing sheep was examined in three short-term experiments.

In one study the high correlation usually observed between herbage yield per unit of land area and plant height was disturbed by manipulating the spatial relations of the sward; it was observed that the rate of intake of pasture by grazing animals was closely associated with plant height (estimated from tiller length) there being little relation between herbage yield and intake.

Size of bite increased almost linearly with changing tiller length, whereas after a small initial increase the rate of biting decreased. These differences produced a seven-fold change in the rate of herbage consumption between sheep grazing pastures of 3.7 cm tiller length (1.0 g dry matter/min) and 7.7 cm (7.1 g/min). At greater tiller lengths the size of bite and rate of biting varied inversely to maintain a constant rate of intake.

When accessibility of herbage imposed limitations on the rate at which the animal was able to prehend its feed, it was shown that the sheep was able partially to compensate for the reduced amount of herbage present by an increase in grazing time (from 6 to 13 hr/day). However, as the animal extended its period of grazing the compensation became progressively more incomplete.

Under sparse pasture conditions lambs were able to consume feed at a significantly greater rate than yearlings, but as pasture availability increased the situation was reversed.

The role of short-term grazing studies in relation to problems of grazing management is discussed.

Abstract No. 38.

Alldredge, A. W., and F. W. Whicker. 1971. A method for measuring soil erosion and deposition with beta particle attenuation. U.S. IBP Grassland Biome Preprint No. 21. Colorado State Univ., Fort Collins. 23 p. [Submitted to J. Range Manage].

A method utilizing beta particle attenuation was developed for measuring soil erosion and deposition in a shortgrass plains ecosystem. Initial results indicate that quantitative measurement of soil depth fluctuations in amounts considerably less than one millimeter and over a period of a few weeks are possible. Preliminary data are presented from application of this method in six soil series under heavy, moderate, and light summer grazing treatments.

Abstract No. 39.

Alldredge, A. W., and F. W. Whicker. 1971. Soil movement in a grassland ecosystem as measured by beta particle attenuation. U.S. IBP Grassland Biome Tech. Rep. No. 65. Colorado State Univ., Fort Collins. 21 p.

This report covers progress made on a soil movement study being conducted at the Pawnee Site. A method involving beta attenuation was developed and employed. From initial investigation, this method gives sensitive measurements of both erosion and deposition of soil and litter over a period of a few weeks. Data recorded on 265 field plots are summarized in tables. Future plans include continuing observation on field plots and laboratory studies to solve minor problems with the beta attenuation method as well as those associated with a proposed cesium tag concept.

Abstract No. 40.

Allred, B. W. 1940. Range conservation practices for the Great Plains. U.S. Dep. Agr. Misc. Pub. No. 410. 19 p.

The improvement and maintenance of the grazing resources of the Great Plains are dependent on the employment of sound range conservation practices that will foster the growth of desirable forage plants and maintain the productivity of the soil. It is the purpose of this bulletin to present the more important of these essential range conservation practices. For the Great Plains these differ but little from those needed in other range areas; the main difference lies in the degree and the timing of the practices that are used rather than in the kind.

Abstract No. 41.

Allred, B. W. 1945. Some conditions and influences pertaining to the native forage crops of the northern mixed prairie. J. Amer. Soc. Agron. 37:876-887.

1. Individual native grazing plants, whether grasses, shrubs, or nongrassy herbs, have distinctive growth habits and feeding values. The native forage crop is composed of many species, thus making its management more difficult than a single farm crop like corn or alfalfa.

2. The mixed prairie is composed of climax midgrasses, shortgrasses, and dryland sedges, plus a variety of subdominant nongrassy herbs.

3. Grasses and other vegetation have been modified throughout the ages as environment has been changed by shifting climates.

4. The mixed prairie supports nearly one-fourth of the livestock in the United States west of the 98th meridian.

5. The cool season midgrasses, and palatable nongrassy herbs, are the first plants to go out under heavy grazing and drought.

6. The drought-resistant summer-growing shortgrasses, dryland sedges, Sandberg bluegrass, and unpalatable nongrassy herbs increase during the first stages in the depletion of excellent mixed prairie grasslands.

7. The following annual grasses and weeds increase on depleted mixed prairie ranges: Lambs quarter, Russian thistle, Woolly Indian wheat, sunflower, peppergrass, six weeks' fescue, witches' broom, Japanese chess, cheatgrass brome, little barley, and false buffalo.

Abstract No. 42.

Allred, B. W. 1948. How to inventory grazing resources and develop a ranch conservation plan. Sheep Goat Raiser 29(3):28-32.

The probability of securing effective conservation of range resources depends entirely upon how well the fundamental principles and benefits of conservation are understood. Keeping livestock and forage resources in balance requires continuous close observance yearlong. Sound conservation only comes about when forage is correctly grazed. It has been said that "the eye of the master fattens the steer" in the feedlot. Likewise, the observing eye of the ranchman fattens his livestock on the range and keeps his grasslands in maximum production. Forage productivity fluctuates with rainfall. Therefore, grazing plans must be flexible so that vegetation can thrive continually.

Abstract No. 43.

Allred, B. W. 1956. Mixed prairie in Texas, p. 267-283. *In* Grasslands of the Great Plains. Johnsen Publ. Co., Lincoln, Nebr. 395 p.

This great grassland is still (1955) in a serious drought that has been prolonged in places 4 to 7 years. The drought has added further damage to a weakened plant cover. Recent examination revealed that all range land, whether grazed or not, suffered some losses. Droughty ranges provided too little moisture to permit all of the plants to live and reproduce. Ranges that had many climax grasses before the drought are recovering with enough living grass to restock them with desirable species. Considerable grass and forbs of good forage value survived in localities covered with brush where animals have been unable to graze. Areas without brush lost proportionately more grass than brush-covered ranges, except where light grazing was practiced. An exception occurred on sandy, shinnery-oak ranges near Cheyenne (Roger Mills County), Oklahoma. Ranges that have had moderate grazing are recovering more rapidly than those on which heavy grazing had been practiced. Moderately grazed ranges are recovering almost as rapidly as those in similar condition which had not been grazed for several years.

Vegetation on rocky ranges survived better than that on hard land. The better and more deeply rooted grasses endured drought longer on rocky ranges because moisture conditions were more favorable.

All plants survived better on well-managed ranges than on fair or poor ones. Generally the taller and more deeply rooted grasses, the first to go out under heavy use, survived the best.

Grasses in the group of increasers suffered more from drought than the decreasers. Drought losses in this group ranged from 25 to 90%.

Examination of seedlings in areas where drought was broken indicated that those of taller grasses were still scarce. Generally there were fewer of the taller grasses left to produce seed.

Drought experiences of southwestern ranchers show clearly that ranches on which sound conservation had been practiced suffered less hardship than those without conservation. On the former, loss of grass was comparatively much less, livestock lived better, and the income was considerably greater.

Before the drought it was estimated that 10 to 12 million acres of range land needed seeding in order to restore their productivity. The present drought probably has added another 3 to 4 million acres to that unfortunate condition.

Abstract No. 44.

Allred, B. W., and W. M. Nixon. 1955. Grass for conservation in the southern Great Plains. U.S. Dep. Agr. Farmers' Bull. No. 2093. 30 p.

Grass is the most economical feed for livestock in the southern Great Plains. It also is the best means of protecting soil from wind and rain.

You can use grass in rotation on cropland to produce feed and to protect and improve your soil. You can seed land which is not suited to cultivation to permanent grasses. This bulletin tells what kinds of grass to use and how to seed them successfully.

Rangeland yields most when the grass is in top condition. You can improve most ranges by proper stocking, good grazing management, and special conservation practices to fit each range site and condition. Or you can restore native pastures ruined by drought and overuse by reseeding or by natural revegetation. Ranges brought to high condition will return you greater profits. They will also help prevent erosion and reduce floods.

The suggestions in this bulletin apply to the subhumid and semiarid plains of the western parts of Texas and Oklahoma, southwestern Kansas, southeastern Colorado, and eastern New Mexico.

Abstract No. 45.

Anderson, K. L. 1940. Deferred grazing of bluestem pastures. Kansas Agr. Exp. Sta. Bull. 291. 27 p.

1. Experiments were started in 1916 to compare deferred and rotation grazing of the bluestem grasses with season-long grazing.

2. When grazing was deferred until September 1 the carrying capacity was not increased because it was not possible to obtain maximum or uniform utilization. However, when the beginning of the deferred grazing period was changed to June 15, there was a decided increase in carrying capacity.

3. The original set of experiments was discontinued in 1922; but, since 1927, grazing deferred until July 1 has been compared to season-long grazing.

4. The deferred pasture has had a higher carrying capacity than those grazed season-long either in terms of time actually grazed or when converted to a six-months grazing season.

5. Gains of livestock have been greater on the deferred pasture than on the pastures grazed season-long. The deferred pasture has yielded an average of 65.1 pounds of beef per acre per grazing season compared to 37.4 pounds and 42.5 pounds for the two season-long pastures.

6. Gains per animal unit per grazing day have also been higher on the deferred pasture. Cattle on this pasture have gained an average of 1.32 pounds per animal unit per grazing day as compared to 1.17 pounds and 1.09 for the pastures grazed season-long.

7. Seasonal gains per animal unit have been somewhat smaller on the deferred pasture. However, it has required about twice the acreage on pastures grazed season-long to produce about one-third more gain per animal unit per grazing season. Furthermore, it has taken from 40 to 50 days longer each year to do this.

8. As a result of spring protection, stands of grass on the deferred pasture have been maintained in better condition in spite of the fact that it has been subjected to much harder use. At the end of each grazing season it has had a better cover of grass to afford protection against runoff and erosion during winter and spring.

9. Severe climatic conditions during the last several years of this experiment caused severe depletion of the grass population. Later when the depleted grasses were replaced, a great deal of sand dropseed and buffalo grass appeared on the pastures grazed season-long, whereas in the deferred pasture, side oats grama was largely responsible for this replacement.

10. To permit deferred grazing, it is thought advisable to provide other forms of pasture during May and early June. For pastures where the stand and vigor of the vegetation are good, a plan of a deferred system of grazing is suggested in which supplemental pastures are not needed.

Abstract No. 46.

Anderson, K. L. 1951. The effects of grazing management and site conditions on Flint Hills bluestem pastures in Kansas. Ph.D. Thesis. Univ. Nebraska, Lincoln. 87 p.

Bluestem pasture vegetation of the Flint Hills has been maintained in relatively good condition through light stocking and early removal of livestock. Early grazing and annual spring burning have caused a certain degree of depletion as expressed in departure of vegetative population from climax.

Trials have been initiated in six pastures to compare relatively heavy-grazing use in a deferred-rotation system with different intensities of season-long grazing. Results are given in terms of livestock gains and vegetational responses.

Abstract No. 47.

Anderson, K. L., and C. L. Fly. 1955. Vegetation-soil relationships in Flint Hills bluestem pastures. J. Range Manage. 8:163-169.

To facilitate studies of vegetation in experimental bluestem pastures and to aid in the evaluation of species populations and trends that result from management treatments, soils of the experimental bluestem pastures of the Kansas Agricultural Experiment Station were mapped, delineating 13 upland soil mapping units on the basis of slope, degree of erosion and soil conditions. This number was reduced to 10 by combining certain similar ones.

Sampling of the plant populations by means of randomized line-transect samples revealed that the number of distinctive vegetational units was smaller than the number of soil units mapped. Statistical analyses of the populations of major forage species, together with major site differences, have been the basis for recognizing six range sites, one of which was not sampled in these studies.

Future sampling and population trend studies will be based on deviations from the populations originally found on these range sites. Thus, the groundwork has been laid for accurate and reliable evaluation of population responses to management treatments.

Comparison of the study area with the Flint Hills grasslands as a whole reveals that it is representative of the region and conclusions drawn from the study should have widespread application. A groundwork has been laid for classification of Flint Hills rangelands for purposes of conservation and land use and for research.

Abstract No. 48.

Anderson, K. W., and E. D. Fleharty. 1964. Additional fox records for Kansas. Kansas Acad. Sci., Trans. 67(1):193-194.

The paucity of fox records for western Kansas indicates that their geographical distribution in the state is poorly known. Three records have recently been added to the vertebrate collection of the Museum of the High Plains, Division of Biological Sciences, Fort Hays Kansas State College. These are a Red Fox, *Vulpes fulva fulva* (Desmarest), skull, No. 827; a male Swift Fox, *Vulpes velox velox* (Say), skin and skull, No. 1262; and a male Gray Fox, *Urocyon cinereoargenteus ocythous* (Bangs), skin and skull, No. 1817.

Abstract No. 49.

Anderson, K. W., and E. D. Fleharty. 1968. Mammalian distribution within biotic communities of northeastern Jewell County, Kansas. Fort Hays Stud. Sci. Ser. No. 6. 46 p.

The purpose of this investigation was threefold. First, to obtain as complete a list as possible of mammals occurring in the area through collecting and observational procedures. Second, to determine their specific distribution within the study area; and third, to correlate and elucidate the relationships between their distribution and the major vegetational regions within the study area.

Abstract No. 50.

Anderson, N. L. 1961. Seasonal losses in rangeland vegetation due to grasshoppers. J. Econ. Entomol. 54:369-378.

Livestock-free grazing areas were used for studies of grasshopper damage on Montana rangelands. Half of each study area was sprayed with an insecticide at the beginning of the season to eliminate nearly all grasshoppers. The grasshopper population remaining on the unsprayed portion of the area was assessed by the use of cages that were placed over representative areas at night. Within both the sprayed and unsprayed portions of an area, sites were selected which appeared comparable from the standpoint of both the composition and abundance of the vegetation. Quadrats were established at these sites in which production was measured by clipping the vegetation at ground level, then air-drying and weighing. A comparison of the yield from an area without grasshoppers was thus made with that from an area on which grasshoppers fed.

Little correlation was found between numbers of grasshoppers per unit area and the loss of vegetation. This may be accounted for by the differences in feeding habits of the various species comprising any particular grasshopper population.

Further evaluation of the data from the various studies has proved more difficult. Problems have arisen primarily because of the nonrandom distribution of both grasshoppers and vegetation even where so-called uniform types of vegetation were considered. Difficulties in interpretation have also been encountered by the lack of knowledge concerning the phenomena of plant growth as shown by a study of two comparable areas during 1950-1959. These areas were subjected to grazing by livestock during the winter months only, and the numbers of grasshoppers remained much below one per square yard during the period. Differences in yield of vegetation from the two areas were measured, and it was found that considerable loss in forage may take place during a season without grasshoppers being present.

Abstract No. 51.

Anderson, N. L. 1964. Some relationships between grasshoppers and vegetation. Ann. Entomol. Soc. Amer. 57:736-742.

A report is made of detailed studies carried out on 105 native grassland and abandoned field sites. Measurements of vegetational changes over a 10-year period on one area and field experiments on grasshopper movement involving marked individuals are also reported. The results of the investigations are discussed and evaluated in terms of field observations on grasshopper behavior. Both the taxonomic composition and physical structure ofthe vegetation are found to play an important role in the selection of areas of occupancy by grasshoppers. There is no evidence to suggest that changes in vegetation are directly responsible for initial fluctuations in population density.

Abstract No. 52.

Anderson, N. L., and J. C. Wright. 1952. Grasshopper investigations on Montana rangelands. Montana Exp. Sta. Bull. No. 486. 46 p.

The results of grasshopper investigations on Montana rangelands in 1949, 1950, and 1951 are given.

Daily field observations of 36 grasshopper species show that each species must be considered separately and that in Montana:

1. Grasshopper species distribution on rangeland is not random, but is dependent on vegetation.

2. Most rangeland grasshoppers are not omnivorous, but are selective and have food-plant preferences.

3. Rangeland grasshopper species may differ widely in feeding habits.

4. Feeding habits may change as the grasshoppers develop or may vary with changes in environmental conditions.

A list of the types of food and the instar of each of 44 species observed eating the food is found in the appendix.

A description and an analysis of the cage method of determining grasshopper abundance are given.

Data show that the amount of damage to vegetation by grasshoppers cannot be predicted solely by grasshopper abundance, but evaluation must be on the basis of the grasshopper species present and the composition and condition of the vegetation upon which they are feeding.

Abstract No. 53.

Arnold, J. F. 1942. Forage consumption and preferences of experimentally fed Arizona and antelope jackrabbits. Arizona Agr. Exp. Sta. Bull. 98: 50-86.

Arizona and antelope jackrabbits, common to southern Arizona, were fed in captivity over a period of 3 years to determine consumption of and preferences for a large number of range plants in the vicinity.

To facilitate handling and feeding, rabbits were hand-reared from Caesarian births.

Forage consumption and preferences were determined by means of hand-feeding trials in specially designed enclosures and by measurements of grazing on artificially established forage plots.

Palatability tests were made with 32 species of grasses, 47 weed species, and 21 kinds of browse. When each kind of forage is offered in excess, jackrabbits appear to prefer plants in the order of weeds, grasses, and browse with the first two making up the major and about equal parts of the diet.

The equal proportion of weeds and grass in the diet offers an explanation as to why rabbits are more abundant on overgrazed than on normal rnages. It is also suggested that once deterioration is well under way, rabbits may be a partial cause of overgrazing, and in the final stages of deterioration they may be the primary cause of depletion.

On the basis of available data, jackrabbit grazing pressure can be visualized in terms of cows as follows: When competition is considered to be direct, 62 ± 7 Arizona rabbits consume the equivalent of a 1,000-lb range cow, while 48 ± 2 antelope rabbits consume the same equivalent. When the two classes of animals are considered to compete only for perennial grasses, the equivalents become 260 ± 20 for the Arizona rabbits and 164 ± 7 for the antelope jacks.

Abstract No. 54.

Arnold, J. F. 1955. Plant life-form classification and its use in evaluating range conditions and trend. J. Range Manage. 8:176-181.

Plant life form provides a convenient basis for visually evaluating (i) ecological dominance and subordination in natural communities, (ii) the susceptibilities of different plants to grazing injury and to injury from other land-use disturbances, and (iii) stages of secondary succession and recovery that result when disturbances are reduced or removed.

Plant life form provides a visual means of evaluating ecological range condition because the life forms that prevail on a given range unit indicate conditions with respect to herbage yields, organic mulch, range vigor, and soil erosion.

Trends in leaf development and in annual yields fluctuate erratically in the short run with seasonal and annual variations in climate. Trends in plant life forms and range productivity change slowly in the long run in response to changes in management practices.

The recognition of plant life forms helps: (i) to evaluate range productivity, (ii) to establish the goals for proper stocking, (iii) to distinguish differences in grazing preferences, (iv) to establish the needs for seasonal use and other systems of grazing, and (v) to estimate the economic justification for restoring depleted ranges by artificial reseeding.

Abstract No. 55.

Arnold, J. F., and H. G. Reynolds. 1943. Droppings of Arizona and antelope jackrabbits and the pellet census. J. Wildlife Manage. 7:322-327.

1. Arizona and antelope jack rabbits fed in captivity on different types of food show certain characteristic depositions of fecal material.

2. The age and weight of mature animals do not affect the number or weight of pellets voided by either species of jackrabbit.

3. Pellet count remains constant, on the average, irrespective of age, sex, size, or species of rabbit. A jackrabbit of either species voids an average of 531 ± 27 pellets per day when eating green, native forage material.

4. Pellet weight and weight of food consumed show a direct linear relationship. When eating green native forage the animals of either species void about 55% of the weight of ration ingested.

5. Character of forage consumed has a greater effect upon pellet weights than upon pellet counts.

6. Some uses of pellet weights and counts are outlined. The use of pellet weights to determine forage removal is suggested.

Abstract No. 56.

Arrington, O. N., and A. E. Edwards. 1951. Predator control as a factor in antelope management. North Amer. Wildlife Conf., Trans. 16:179-191.

Annually, since 1940, antelope surveys have been conducted over northern Arizona antelope range with special attention given to Management Units 1, 4, 5, 6, and 7. Since 1944, standardized midsummer surveys have been made by airplane, directed toward fawn percentages, buck-doe ratio, and population trend information.

For the past six years, predator-antelope relationships have been studied, comparing areas where predator control work of various types has been done with those unaffected in comparable antelope range.

In six years of correlation, covering five antelope management units, thus providing 30 separate checks, antelope fawn crops have corresponded closely with the amount and type of predator-control work done in each.

Antelope populations have shown a steady upward trend in carefully correlated surveys, with the exception of last year when dispersal from the survey areas to adjacent range may have been the reason for the slightly lower survey figures.

To be effective, predator-control operations must cover large blocks of range, preferably 100 townships or more. Otherwise an infiltration of predators from adjacent untreated range soon repopulates the treated area.

Increased fawn crops result after predator-control operations using steel traps, strychnine drop baits, cyanide guns, thallium sulphate, or compound 1080, but the response is greater following the use of the latter two chemical control methods, and the cost of treating is much less. The cost of effectively using traps or cyanide guns over large areas is prohibitive, and strychnine drop baits are not selective because of their wide dispersal. Compound 1080 provides the cheapest effective control.

An open season on antelope, the first in Arizona in six years and fourth in 33 years, was declared in 1949 and again in 1950. Without the effective predator-control operations, resulting primarily from the use of compound 1080 beginning in 1947, there is little reason to believe these hunts would have been possible.

Abstract No. 57.

Atwood, W. W. 1940. The physiographic provinces of North America. Ginn & Co., Boston. 536 p.

During the last fifty years a widespread interest in the study of regional physiography has been developing. That study has involved the application of the principles of geomorphology, evolved during the preceding century, to the study of well-defined units of the land surface in each of which the relief features do not differ greatly.

Regional physiography has become an important branch of learning for all those who are interested in geology or geography. Those who try to work out the physical history of any portion of the land surface must rely on a knowledge of physiography in the interpretation of many events recorded in the history of the earth, and especially in working out the last chapter of that history. A physiographic province is usually a logical and convenient unit area for geologic investigation, and certainly no geologic study should be reported without placing the area under study in its appropriate physiographic setting.

Abstract No. 58.

Austin, O. L. 1968. Life histories of North American cardinals, grosbecks, buntings, towhees, finches, sparrows, and allies. U.S. Nat. Mus. Bull. 237. 3 parts. 1890 p.

This is the twenty-first and last in a series of bulletins on the life histories of North American birds. This work is in three parts and is a continuation of Arthur Cleveland Bent's work started on this series in 1910. The coverage and format developed for the first volume (1919) have remained essentially unchanged. At the time of his death, Mr. Bent completed a respectable number of fringillid histories, 14 main species accounts plus 34 lesser ones of accompanying subspecies included in this contribution. Twenty-two genera are covered. Part 1: Order Passeriformes; Family Fringillidae; 1. Genera Richmondena through Pipilo. Part 2: Order Passeriformes; Family Fringillidae; 2. Genera Pipilo through Spizella. Part 3: Order Passeriformes; Family Fringillidae; 3. Genera Zonotrichia through Emberiza.

Abstract No. 59.

Ayyad, M. A. G., and R. L. Dit. 1964. An analysis of a vegetation-microenvironmental complex on prairie slopes in Saskatchewan. Ecol. Monogr. 34(4):421-442.

Four sites, all within 6 miles of each other, were divided into 72 stands which displayed various aspects and positions. All slopes were between 13 and 18°. The vegetation was quantitatively sampled and various measurements were made of the microenvironment. Collective information from the correlations between phytosociological gradients and environmental factors suggested that the distribution of species on these prairie slopes is controlled by moisture and heat regimes of the soil layers in contact with the vegetation. Further, each species had its own characteristic behavioral pattern in relation to both environmental and phytosociological gradients, suggesting that any vegetational units established would be highly arbitrary.

Abstract No. 60.

Bach, R. N. 1952. Those precious three inches! North Dakota Outdoors 14(9):18-19, 21.

Everything that lives in North Dakota is dependent, to some degree, upon the state's annual supply of moisture. The statewide, long-term average shows that this supply averages over 17 inches of water per year. Fourteen inches comes as rain, but the other 3 inches results from snowfall. Those 3 inches of water are precious to our state.

Snow serves many important functions in the plant life of our state. In the winter time it serves as an important insulator against the cold. Because of this insulating property, many plants, and especially grasses, that would die because of severe freezing are kept at a high enough temperature to survive and grow again the next summer.

Because they instinctively know of the insulating properties of snow, our native upland game birds, the grouse, burrow down into the snow during severe storms. All our previous strategems of snow management were concerned with keeping the snow off a certain place. We are beginning to realize that our concept must be changed to one of putting snow on the spots where it will do the most good. We do know that the movement of the snow is directly influenced by the movement of the wind. When some obstacle sets up a turbulence in the river of wind, the smooth flow is interrupted; and momentarily the wind loses some of its velocity. With the resultant loss of speed comes a resultant loss in snow-carrying capacity of the wind. Some of the snow load is dropped, and a snow drift begins to build up. Since the days of the settlers in North Dakota, man has worked to plant trees in such a manner that the barrier of the trees would stop the wind, or at least slow it down. His efforts, after 80 years of shelter belt planting, appear as if his main aim was to dump as much snow as possible in the immediate vicinity of the house. We are now learning to plant a snow-trap of shrubs and low trees at some distance upwind from the belt. It may be that we need an entirely new concept of shelterbelt layout. It may be that circular forms of planting offer better chances of bringing a large portion of the planting area through the winter without undue snow deposits.

Abstract No. 61.

Bailey, V. 1905. Biological survey of Texas. North Amer. Fauna 25:1-222.

For a number of years the Biological Survey has been collecting information and specimens bearing on the natural history of Texas. Some of the results are here brought together in a discussion of the life zones and their subdivisions and a report on the mammals and reptiles of the state.

Much of the fieldwork has been carried on in connection with that in adjacent regions, and on several occasions it has been possible to continue parties in the field until late in the season or throughout the winter by moving them southward into Texas in the fall, or to begin work there early in the spring before the season had opened sufficiently for operations farther north. Part of the fieldwork has been carried on in connection with special studies of urgent economic problems, as the prairie dog, coyote, and boll weevil pests, and throughout all of it the economic status of birds and mammals has received special attention. The distribution of mammals, birds, reptiles, and plants, so far as they have an important bearing on the extent and boundaries of faunal areas, has been studied in detail in the field; and in the case of most species a sufficient number of specimens has been collected to show the variation due to climatic differences. Of many of the larger game mammals, and especially of the deer, bear, and panther, it has not been possible to secure enough material to satisfactorily establish the present geographic limits of the species and subspecies.

Abstract No. 62.

Bailey, V., and C. C. Sperry. 1929. Life history and habits of the grasshopper mice, Genus *Onychomys*. U.S. Dep. Agr. Tech. Bull. 145. 19 p.

So many of our native rodents have habits conflicting with human interest, making it necessary to control their abundance and distribution, or to wage a ceaseless warfare of destruction against them, that a species or a group of species of rodents that is mainly useful to man and beneficial to agriculture becomes of special interest and importance. The grasshopper mice are of this class. These sturdy little rodents are so largely insectivorous and carnivorous in food habits as to be of considerable value over their wide range in the western United States and adjoining parts of Canada and Mexico in helping to hold in check the natural increase of numerous injurious insects and to keep a wholesome balance among many groups of small animal life. Their possible injury to crops or other property is so slight as to be negligible.

Generally the grasshopper mice are regarded as rather scarce or rare, partly because they are hunters and wanderers, are not colonial, and do not follow definite runways. They thus leave little trace of their presence and are not easily located except as they accidentally get into traps set for other animals. The collector rarely sets a trap with any assurance that he will capture one of these mice, whereas with most other rodents he gets what he is trapping for. In favorable localities, however, considerable numbers are taken in traps, and the individuals are generally found to be more numerous than they appear to be. In many places they are present in sufficient numbers to have a decided influence on the abundance of the animal life that furnishes their food.

Abstract No. 63.

Baldwin, P. H. 1970. Feeding dynamics of the Lark Bunting. Joint Annu. Meeting Cooper Ornithol. Soc. and Wilson Ornithol. Soc., June 19, Fort Collins, Colorado.

The foods ingested by Lark Buntings (*Calamospiza melanocorys*) have been determined by stomach analysis methods. In addition, preliminary calculations have been made to show requirements for the daily intake of biomass and calories. This work is part of a study of feeding dynamics of small ground-feeding birds of the shortgrass prairie.

Abstract No. 64.

Baldwin, P. H. 1970. The feeding regime of granivorous birds in shortgrass prairie of Colorado. General Meeting Working Group Granivorous Birds, IBP, Section on the Productivity of Terrestrial Communities, September 6-8, Arnhem/The Hague.

Baldwin, P. H. 1970. The feeding regime of granivorous birds in shortgrass prairie of Colorado. International Biological Program, Working Group on Granivorous Birds--PT Section (Warszawa). 4(1):26-30. (Abstr.)

The feeding dynamics of ground-dwelling passerine birds inhabiting the shortgrass prairie of the high plains in Colorado were investigated. The Lark Bunting (*Calamospiza melanocorys* Stej.) and McCown's Longspur (*Rhynchophanes mccownii* Lawr.) are two prominent members of this group. The kinds and amounts of foods eaten during the nesting season are interpreted in terms of trophic levels and energy flow. Food in the stomachs was partly of animal origin (62% arthropods for Lark Bunting and 78% for McCown's Longspur) and partly of plant nature (38% seeds for lark bunting and 22% for the longspur). The same arthropods (Acrididae, Curculionidae, Formicidae, Scarabaeidae) were eaten as major food items by both species; however, the mean length of insect was greater for buntings than for longspurs (grasshoppers 17.5 vs. 13.0 mm, and weevils 7.1 vs. 6.5 mm). The use of seeds was similar for the two birds. Both birds took most of their food from the primary consumer level, although their diet included organisms from other levels, especially producer and secondary consumer. Comparison of amounts of foods eaten with amounts available where the birds fed at ground level indicated that some foods were selected positively.

Abstract No. 65.

Baldwin, P. H. 1971. Diet of the Killdeer at the Pawnee National Grassland and a comparison with the Mountain Plover, 1970-1971. U.S. IBP Tech. Rep. No. 135. Colorado State Univ., Fort Collins. 22 p.

The diet of the Killdeer (*Charadrius vociferus*) in shortgrass prairie of Weld County, Colorado, was studied for the summer period, June 16 to July 28. A similar bird, the Mountain Plover (*Eupoda montana*), also feeds in the same shortgrass prairie during this period, so the two diets were compared to determine the amount of overlap. The food of the Killdeer was 99.7% animal in nature and 0.3% plant on the basis of biomass consumed. Types of food eaten in greatest quantities were ground-dwelling beetles (77.0%), aquatic arthropods (13.6%), and crickets (5.0%). The most important family was the Carabidae (33.0%), and the second was the Tenebrionidae (26.3%). The mean length of food items eaten by the Killdeer was 8.0 mm, and the mean dry weight was 0.01 g.

The diets of Killdeer and Mountain Plover showed much overlap. Each bird obtained 77.3% of its food biomass from taxa eaten also by the other bird. Most of the overlap was from consumption of ground-dwelling beetles by both birds. The use of aquatic beetles by the Killdeer accounted for much much of the non-overlapping foods. The similarities in diet resulted mainly from both birds feeding in the dry, upland shortgrass vegetation; the differences resulted from the Killdeer feeding frequently at water and on damp ground.

Abstract No. 66.

Baldwin, P. H. 1971. Diet of the Mountain Plover at the Pawnee National Grassland, 1970-1971. U.S. IBP Grassland Biome Tech. Rep. No. 134. Colorado State Univ., Fort Collins. 34 p.

The diet of the Mountain Plover (*Eupoda montana*) in Weld County, Colorado, was studied for the spring and summer period between the dates May 4 and August 11. Thirteen birds, eight adult and five juveniles, were available for analysis of stomach contents. Identifications of 90 food taxa and estimates of dry weight parameters for each type of food showed the diet to consist of 99.7% arthropods and 0.3% seeds. The most important food types were ground-dwelling beetles (60.0%), grasshoppers and crickets (24.5%), and ants (6.6%). The most important genus eaten was *Eleodes* (a darkling beetle) comprising 22% of the diet. Comparisons of diets of juvenile and adult Mountain Plover revealed that juveniles ate smaller insects such as ants, bees, wasps, and parasites, leaf and flower beetles, and leafhoppers in slightly greater proportions than did adults. Adults, however, ate larger insects such as caterpillars, billbugs, and darkling beetles in somewhat greater proportions than did juveniles. The mean length of food items eaten by all adults was 10.0 mm and by juveniles 8.5 mm. Overlap in size, i.e., length of food items eaten by the two age groups, was 60.3%.

Abstract No. 67.

Baldwin, P. H., J. D. Butterfield, and P. D. Creighton. 1969. Summer ecology of the Lark Bunting, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 29. Colorado State Univ., Fort Collins. 37 p.

Nest site selection of the Lark Bunting (*Calamospiza melanocorys* Stejneger) is examined in this paper. The problem is to determine what factors the bird is responding to when it selects a site for its nest. The procedure is to examine each situation where a nest is found. Vegetation has been sampled to determine if a correlation exists between site selection and height of associated plant species or a type of plant. Location of the nest in relation to its immediate cover is scrutinized in an attempt to find any effect of weather (wind) on nest placement. Nest success in the different stand classes will be examined to determine trends that may exist between nest success and type of stand.

The Lark Bunting is one of the principal avian consumers during the summer on the plains of north-central Colorado. Because this species feeds on both seeds and insects, it has a major role as both a primary and secondary consumer in the food chain of the grassland community. The Lark Bunting was chosen for study because of this influence in the food chain of the grasslands, and adequate data could be obtained on its principal foods. Therefore, a second purpose of this study is to gather data concerning the feeding ecology of the Lark Bunting and the role it plays as a consumer in the grassland ecosystem.

Abstract No. 68.

Baldwin, P. H., P. D. Creighton, and D. S. Kisiel. 1971. Diet of the Mourning Dove at the Pawnee National Grassland, 1970-1971. U.S. IBP Grassland Biome Tech. Rep. No. 136. Colorado State Univ., Fort Collins. 25 p.

The diet of the Mourning Dove (*Zenaidura macroura*) was studied for the spring and summer months of 1970 and 1971. Thirty-one birds, 28 adults and 3 juveniles, were collected for analysis of the stomach contents. Identification of 45 food taxa and estimates of dry weight parameters showed the diet to consist of over 99.9% seeds and less than one-tenth of one percent arthropods and molluscs. The most important food types were bee plant (*Cleome serrulata*) (28.1%), grasses (24.3%), and composites (19.6%). Almost 76% of the Mourning Dove diet was composed of seeds from plants characteristic of disturbed habitats, i.e., roadsides, cultivated and abandoned fields. Comparisons of adult and juvenile diets during midsummer revealed that juveniles ate mainly composites and grasses (96%), while adults consumed seeds of bee plant and spiderwort (*Tradescantia occidentalis*) (68%). Selection of seed size (length) by the two age classes also varied, with juveniles taking about 80% of their seeds in the 4.1 to 3.5 mm size class. Of the adult diet, 84% was composed of seeds less than 3.5 mm in length. This difference in seed size for juveniles and adults apparently resulted from the heavy use by juveniles and light use by adults of a single seed type, sunflower (*Helianthus annuus*), which was approximately 4.2 mm in length. Although sunflower seeds were equally available to both age classes, they were not the preferred food of adults.

Abstract No. 69.

Barger, G. L., and H. C. S. Thom. 1949. Evaluation of drought hazard. Agron. J. 41:519-526.

The incomplete Γ-curve has been fitted to frequency distributions of n-week rainfall totals. The parameters in this equation were estimated by the method of maximum likelihood. This curve, when checked against the frequency histograms by the chi-square test, showed a good fit in most cases. Only when the frequencies exhibited a definite bimodal tendency were the chi-square values greater than would be expected from random fluctuation. More years of record would probably erase much of this tendency.

From the probability integrals of the fitted curves, the likelihood of occurrence of a certain class interval of n-week rainfall totals can be estimated for each station. The probabilities of like amounts, X_a, or less for given durations at each station have been computed; and, likewise, the probabilities of the proper base amounts, X_d, or less (different for each station) have been estimated. These probabilities afford a basis for comparison of different areas with regard to rainfall distribution alone and also with regard to the likelihood of receiving the minimum amount of precipitation needed to produce a normal corn crop. Similarly, the probability of occurrence of any class of rainfall totals could be determined; e.g., the probability of receiving between 8.0 and 10.0 inches of precipitation at Ames during the 3-week period beginning July 5 could be estimated. The use of the ditribution function is by no means limited to the drought problem.

The probabilities determined point to distinct differences in the drought hazards experienced at various stations. Southern Iowa, while enjoying a rainfall contingency comparing favorably with other areas in the state, has rainfall requirements so high that drought is much more likely in the southern counties than in the central and northern sections. While less pronounced, western Iowa presents more of a drought problem than does the eastern part of the state. It is supposed that soil characteristics and evaporation conditions are responsible for the greater needs of the southern and western counties.

Abstract No. 70.

Barger, G. L., and H. C. S. Thom. 1949. A method for characterizing drought intensity in Iowa. Agron. J. 41:13-19.

Rainfall records and corn yield figures for six Iowa counties, each representative of a specific association of soil areas, have been analyzed to determine a method for characterizing drought in each county.

The criterion of drought intensity developed is based on the association of certain minimum required total rainfall amounts with time intervals of varying duration, i.e., the amount of rainfall which will just permit normal corn development during a period of n consecutive weeks is the minimum required total rainfall for that duration. These minimum amounts increase parabolically with duration and differ considerably among stations.

The maximum rainfall deficiency with respect to these base amounts recorded for any period of weeks during a corn-growing season constitutes a measure of drought effect on the final yield of the crop.

Correlations between maximum rainfall deficits and deviations of county corn yields from normal show that, for years in which drought conditions occurred, from 25 to 60% of the total variation in yield was explained by this criterion.

Abstract No. 71.

Barmington, R. D. 1957. Problems involved in the reseeding of grasses on abandoned cropland. Colorado Agr. Exp. Sta. Gen. Ser. No. 658. 15 p.

Nearly any expert can tell us what should not have been done in connection with much of our windblown Great Plains land. Some of it should never have been plowed. The fact remains that it has been plowed, and it is up to us to try to correct the mistake and return this land to a stable condition with useful plants.

To begin a systematic procedure of reestablishing grasses in this area it is necessary to recognize certain forces of nature: namely, very high wind velocities and long periods of drought. A survey of these conditions and consultation with authorities in this field of work seemed to indicate that perhaps a machine could be built that would aid young grass seedlings in getting started.

Abstract No. 72.

Barnes, O. K., D. Anderson, and A. Heerwagen. 1958. Pitting for range improvement in the Great Plains and the southwest desert regions. U.S. Dep. Agr. Production Res. Rep. 23. 17 p.

Pitting for range improvement and water conservation is effective over a wide range of soil and climatic conditions. Some variations in type of pitting are required in different areas of the west to meet different cover, soil, and climatic conditions. Research and field experience have been summarized for northern and southern Great Plains conditions and for the southwest desert area.

Range pitting with disks that gouge out small, closely spaced basins has increased grazing capacities and per-acre animal gains considerably and at the same time provided a greater carryover of grass from one grazing season to the next.

Range pitting has significantly increased water absorption rates into the soil during rainstorms that exceed the water-intake capacity of the normal soil condition. The pits provide a holding capacity of 1/3 to 1/2 inch of water, as well as creating a condition that favors higher water-intake rates.

Seeding grass with the pitting operation has generally been unsuccessful in the northern Plains. In some parts of the southern Plains and under southwest desert conditions, seeding and reestablishment of perennial grass cover have been successful and are the major objectives of the mechanical treatment program. Treatments are not recommended for very light soils or for steep slopes. In the northern Plains, wheatgrass bottomland has shown little benefit from pitting. Pitting will have other local limitations, and range users are urged to consult local advisers who have had experience with this type of range improvement practice.

Abstract No. 73.

Barret, G. W. 1968. The effects of an acute insecticide stress on a semi-enclosed grassland ecosystem. Ecology 49(6):1019-1035.

The effects of a carbamate insecticide, Sevin, on plant, arthropod, and mammal components within a grain crop grassland ecosystem were investigated. A single application of 2 lb. of the insecticide was applied in July to one of two comparable and adjacent one-acre fenced enclosures, each planted in a crop of millet (*Panicum ramosum*) and stocked with three species of small mammals, the cotton rat (*Sigmodon hispidus*), the house mouse (*Mus musculus*) and the old-field mouse (*Peromyscus polionotus*). Intensive and frequent sampling of plants, arthropods, and mammals on both control and treated enclosures provided the data for evaluating the effects of the insecticide stress on productivity, density, diversity, and equitability of the three components.

Sevin residues on plants decreased rapidly from 35 ppm on the first day following spraying to 0.37 ppm on the 16th day. No effect of the insecticide could be detected on producer standing crop or net community primary production which averaged for the two areas 567 g dry wt/m^2 for the season or 3.9 g/day.

A highly significant decrease in litter decomposition in the treated area was measured 3 weeks after spraying, presumed to be the result of a reduction in microarthropods and other decomposers.

The total biomass and numbers of arthropods were reduced more than 95% in the treated area and remained well below the control area for 5 weeks; after 7 weeks total biomass, but not total numbers, returned to the control level. Phytophagous insects (Homoptera and phytophagous Hemiptera were dominant at the time of spraying) were more severely affected than predaceous insects and spiders; density of the latter returned to control levels in 3 weeks.

Species-numbers diversity in terms of $\frac{S-1}{\ln N}$ also was markedly reduced in all orders of insects immediately after treatment, but with the exception of the Hemiptera and Hymenoptera, returned to control levels within 1 to 2 weeks. Diversity in spiders was not affected by the treatment, even though numbers were reduced. In terms of trophic groupings, species diversity of phytophagous insects, although more severely reduced, "recovered" more quickly than did diversity in predaceous insects.

The equitability index of Lloyd and Ghelardi (1964), in contrast to species-numbers diversity, tended to rise 1 to 3 weeks after treatment, especially in the phytophagous insect group. In terms of the seasonal succession, equitability index values for the predator populations increased to about 1.0 while that of herbivores remained at lower levels of 0.5 to 0.6 throughout the study on the control area, suggesting that predators tended to be food limited and to occupy non-overlapping niches.

Cotton rat reproduction was delayed with ultimate density reduced in the treated grid; laboratory tests indicated this was a probable direct effect of the insecticide. However, the total mammal population, which grew in sigmoid fashion to an asymptotic level of about 180/acre in both grids, was not affected by the treatment because there was a compensatory increase in the house mouse population in the treated grid.

In summary, although the insecticide remained toxic in the environment for only a few days, long-term side effects on litter decomposition, arthropod density and diversity, and mammalian reproduction were demonstrated. It is hoped that this study will provide a model for an ecosystem approach to the testing of pesticides.

Abstract No. 74.

Barrs, H. D. 1962. Plant water stresses as summations of plant-environment water relations and their importance in evaluating plant production. CSIRO Paper No. 48. Presented at 3rd Australian Conf. in Soil Science, Canberra, February. 12 p.

The present contribution has been written with the object of emphasizing the need for making physiological observations together with measurements of the potential gradient for water movement that exists between the soil and the air, in order to enlarge our understanding of the role of water in plant growth.

Abstract No. 75.

Bartos, D. L. 1968. Root-rhizome production in a mixed prairie grassland in western Kansas. M.S. Thesis. Fort Hays Kansas State College, Hays. 25 p.

Root system production in a mixed prairie grassland in western Kansas was found to vary from 3,129 g/m^2 prior to resumption of growth to a low of 2,231 g/m^2 during the winter. Root-rhizomes were most abundant (58%) in the top 3 inches of the profile. In the A_1 horizon (top 6 inches), 77% of the root systems occurred. Annual increment for the A_1 horizon was 686 g/m^2 and the AC horizon was 304 g/m^2. These annual increments were approximately 25% of the total dry matter, thus, suggesting a turnover rate of approximately 4 years. Total aerial biomass ranged from a high of 1,714 g/m^2 in December to a low of 1,351 g/m^2 in March with the fresh mulch contributing a significant amount more than green herbage standing cured, and humic mulch. Decay constants increased with depth from a low of 2.7% in the top 3 inches and 155.9% in the 9 to 12 inch layer. The time required to reach 99% equilibrium was found to be 191 years for the A_1 horizon and 21 years for the AC horizon.

Abstract No. 76.

Bartos, D., and J. Hughes. 1969. Preliminary methodology and results for root biomass sampling on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 2. Colorado State Univ., Fort Collins. 20 p.

Biweekly sampling of root biomass, organic matter, and crown material was conducted at the Pawnee Site during the summer of 1969. The biomass data collected are presented here with means and standard deviations. These data will be utilized to determine future methods of sampling.

Abstract No. 77.

Bartos, D. L., and D. A. Jameson. 1972. A dynamic root model. U.S. IBP Grassland Biome Preprint No. 38. Colorado State Univ., Fort Collins. 13 p. [Submitted to Ecology].

Most authors who have worked with root mass fluctuations have explained changes on the basis of carbohydrate storage and utilization. Changes reported here, however, were far too great to be accounted for by such carbohydrate fluctuations. An hypothesis of root decomposition and growth was developed as an alternative which overcomes some of the disadvantages of the storage-utilization view. In an analysis of the decomposition-growth hypothesis, two logistic equations were added together and fitted to the data. The resultant curve was separated into an increasing curve representing growth and a decreasing curve representing decomposition and respiration losses.

Abstract No. 78.

Bauerle, B. 1971. Snakes and lizards of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 120. Colorado State Univ., Fort Collins. 47 p.

Some 167 snakes were marked and released on the Intensive Site during the study period of 1970. The four most numerous species present were: (i) the prairie garter snake (*Thamnophis radix*), 140 specimens; (ii) the gopher (bull) snake (*Pituophis catenifer*), 13 specimens; (iii) the prairie rattlesnake (*Crotalus viridis*), 8 specimens; and (iv) the western hog-nosed snake (*Heterodon nasicus*), 6 specimens. In addition to these, 27 prairie rattlesnakes (*C. viridis*) were collected near the Intensive Site for egg counts, fat body weights, dry weights, and ash weights. Continuous trapping by using drift fence-funnel traps was the most effective collecting method for snakes. However, most garter snakes were caught by hand. Snake populations on the Intensive Site, except immediately around Cottonwood Pond, were low according to the methods used. Initial data indicate a standing crop of between 100 and 300 g of snake per hectare over most of the site. The standing crop around the only permanent water at the site (Cottonwood Pond) was calculated to be nearly 8 kg/ha. Sex ratios of trapped and captured snakes were nearly equal for all four species. In the spring of 1970 the prairie rattle snakes (*C. viridis*) and the plains garter snakes (*T. radix*) emerged from dens between May 1 and May 4. No snakes were collected after October 20, 1970. The plains garter snake (*T. radix*) began breeding between May 18 and May 24. The prairie rattlesnake (*C. viridis*) was shown to have mature appearing eggs present in the body in both May and October 1970. Two recaptures of plains garter snakes (*T. radix*) occurred over a long enough period to show weight increases. Egg counts varied from 9 to 37 eggs per female. Growth curves of all four species have been presented in the data section. Length was plotted against weight for snakes collected during the summer of 1970. Coefficient of correlation of length to weight was +.82 on the plains garter snakes (*T. radix*), and coefficient of correlation of length to weight on prairie rattlesnakes (*C. viridis*) was +.85. Numbers of individuals of the other two species were so low as to not warrant correlation coefficients. There was great variation in the amount of stored fat in both emerging and denning snakes. No significant difference was found in the amount of fat per body weight in the spring-collected snakes, when compared to fall-collected snakes. This study is the initial phase of a two-year investigation concerning the role of snakes on the Grassland Biome.

Abstract No. 79.

Bauerle, B., and D. L. Spencer. 1971. Environmental pollutants in two species of snakes from the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 137. Colorado State Univ., Fort Collins. 15 p.

Food chain magnification of environmental pollutants would suggest that a nonmigratory, locally occurring, and higher order consumer such as the snake may prove to be a valuable pollution indicator on the shortgrass prairie. Fat bodies were removed from two male gopher snakes (*Pituophis catenifer*) and two male prairie rattlesnakes (*Crotalus viridis*) collected near the Pawnee Site during July 1971. Adipose tissue was analyzed by the Colorado State Department of Health Pesticide Laboratory, Greeley, Colorado, for the presence of 36 different herbicides, pesticides, and organophosphate fertilizers by using electron capture gas chromatographic methods. Samples were also analyzed for PCB's (poly-chlorinated bipherals) and sulfur compounds. Results show that the snakes sampled, which are secondary consumers feeding on small mammals, have low levels of environmental pollutants in their adipose tissues. Gopher snakes were found to contain .20 ppm of p,p'-DDE, .04 ppm of dieldrin, .013 ppm beta benzene hexachloride, and .01 ppm heptachlor epoxide. Prairie rattlesnakes contained .62 ppm p,p'-DDE and .03 ppm dieldrin. Data indicated that further analysis by flame photometric methods was unnecessary. Low levels found in snakes sampled would seem to correlate with agricultural practices on the Pawnee National Grasslands. Artificial fertilization and pesticide spraying are seldom used in this area.

Abstract No. 80.

Bear, G. D., and R. M. Hansen. 1966. Food habits, growth and reproduction of white-tailed jackrabbits in southern Colorado. Colorado State Univ. Agr. Exp. Sta. Tech. Bull. No. 90. 59 p.

White-tailed jackrabbits (*Lepus townsendii*) were studied in southern Colorado from June 1959 through September 1962. The seasonal diet was determined by examination of the contents of stomachs from 131 jackrabbits. Tests to determine food preferences of adults and young were conducted in the summer in portable bottomless cages placed within four distinct habitat types. The vegetative composition and rabbit-days-use were measured on 200-meter square plots in each of the four habitats. The relation of weight to age for young up to 24 weeks was recorded for three young born in captivity and five additional young captured in the field for more than 800 recorded days of growth. Size and reproductive characteristics were taken from about 163 adults and 188 young. The rates of consumption and defecation were measured in pens with captive animals.

Abstract No. 81.

Becker, C. F., R. L. Lang, and F. Rauzi. 1957. New methods to improve shortgrass range. Univ. Wyoming Agr. Exp. Sta. Bull. 353. 12 p.

The treatment of certain types of rangeland with the Wyoming range seeder, which tills two strips of land about 18 inches wide, leaving 22 inches of undisturbed range between strips, and plants, and fertilizes in one operation, appears to be a promising method of increasing grazing capacity and pounds of meat. This treatment may be particularly applicable to the shortgrass range of the Great Plains, where the introduction of legumes and cool-season grass species would contribute to the summer grazing and possibly extend the grazing season in both spring and fall.

Abstract No. 82.

Beetle, A. A. 1952. A relict area on the Wyoming shortgrass plains. J. Range Manage. 5:141-143.

It has been proposed that the stages of vegetation be named from best to worst, as (i) natural stage, (ii) increaser stage, (iii) invader stage, and (iv) weed stage. The usage will be followed here. The reduction in total ground cover observed to occur on different sites is due: (a) to poorness of site; (b) to accumulation of moisture, and therefore soil, and mulch. Highest estimates of cover are correlated directly with the proportion of shortgrasses present --whether buffalo grass or blue grama. Cover estimates were made by averaging at least 10 (often 100) square foot samples, using "basal density" only. Although blue grama is an increaser under most conditions, its presence as 70% of the cover on ordinary dry upland in the relict area indicates that under those conditions the grass is, practically speaking, a decreaser. Western wheatgrass is reduced along with other mid-grasses during the early stages of grazing but, under heavier grazing, returns in greater abundance and therefore exhibits a rare case of a plant which is alternately decreaser (natural class to increaser class), increaser (increaser class to invader class) and then decreaser (invader class to weed class). Natural stage is dominated by mid-grasses under ordinary circumstances with shortgrasses occupying the extremes. Increaser and invader stages are characterized by the reduction of mid-grasses and the increase of both shortgrasses. Weed stage is characterized by introduced annual invaders. The reading of species "to the nearest 5 percent" probably would not be seriously questioned in the case of swale where this type of reading would include 90% of the vegetation and more than half the species. However, in describing ordinary upland climax, although 85% of the cover is included, only three of 22 species enter the list. The five percent method has the tendency to perpetuate the "key species" type of survey which ignores and neglects many of the finer points in systematic botany and plant ecology. In four situations out of six, 15% of the vegetation is misrepresented under the present system.

Abstract No. 83.

Beetle, A. A. 1957. Grassland climax, evolution, and Wyoming. Univ. Wyoming Pub. 21(2):64-70.

In a paper entitled "Grassland Climax, Fire, and Man," Sauer (1949) developed a thesis that concerned "a drift of vegetation toward more grassland." He said, "This deformation has probably derived its driving force from fires," and concluded that, "Fire, or its elimination, is still a main problem."

As apparently the first challenge to these conclusions, it will be contended here that (i) fire has been only incidental in the development of grassland, (ii) grassland is as normal where it occurs as forests are where they occur, (iii) the forces which resulted in grasslands began to operate early (rather than late) in the Cenozoic.

Abstract No. 84.

Behle, W. H. 1942. Distribution and variation of the Horned Larks (*Otocoris alpestris*) of western North America. Univ. California Pub. Zool. 46(3): 205-316.

In addition to the circumstance that Horned Larks in general constitute especially favorable material for the study of variation and consequently for inquiry into species and race formation, there are certain other considerations that favored the choice of this bird for study. Horned Larks are most strikingly differentiated into races in western North America, and in this region there were several problems in the systematics of Horned Larks that needed attention. There has been no comprehensive study of the distribution and variation of this bird.

In undertaking such a revision, however, my main objective was to describe the observed facts of variation as shown by the materials assembled and to correlate these facts, if possible, with physiographic features in the ranges of the individual races. It was felt that pertinent information might thus be gained which would further our knowledge of the factors operative in the process of species formation in this particular bird. As prerequisite to the study of the geographic variation, the variation caused by age, sex, and individuality was given consideration. Molts, plumages, and feather wear were also necessary points of initial attention.

Because of the many factors involved in the great variability of these birds and also because of the practical difficulties in attempting to study them throughout the whole of their range, even on this continent, I limited my investigation to the far-western American races, west of the Rocky Mountains and north of Mexico. More explicitly stated, the area of the investigation includes Alaska, Yukon Territory, British Columbia, Washington, Oregon, California, Lower California, Arizona, New Mexico, Utah, Idaho, and Nevada.

Abstract No. 85.

Beidleman, R. G. 1953. The island of pines. Living Wilderness 18(46):7-10.

Here in northern Colorado, 17 miles south of the Wyoming state line, lies an isolated woodland of piñon pine, like a transplanted vignette of the Southwest. On an east-sloping hogback, thrown up out of the ancient ocean basin by the awakening Rocky Mountains 60 million years ago, the woodland extends its trees. For two miles the grove stretches, an open forest at the southern end, interspersed with competing ponderosa pine, juniper, and mountain mahogany. Northward, the piñons branch their scraggly trunks, forming a dense canopy of dusty green above the gray limestone outcrops. Then, suddenly, the grove comes to an end, as its mesa drops sharply off into the deep cut of the North Poudre River.

This woodland of piñon pine, isolated though it may be, represents no last struggling outpost of the species at the northeastern edge of its range. Despite eternal battering by the adverse and often arctic winds that howl down out of the Wyoming plains, this forest contains some of the oldest and largest piñons in the world. Like giants, the patriarch trees, frequently measuring 25 feet in height and with trunks four feet through at the gnarled base, raise squared crowns above their fellows, their thin-lined growth rings recording a history that spans the centuries.

Abstract No. 86.

Bell, R. T. 1970. Identifying Tenebrionidae (Darkling beetles). U.S. IBP Grassland Biome Tech. Rep. No. 58. Colorado State Univ., Fort Collins. 12 p.

This report contains keys and descriptions of Tenebrionidae (darkling beetles) known to occur on the Pawnee Site. It is designed to be used in conjunction with a synoptic set in the reference collection at the site headquarters and is intended for the use of workers who are not trained taxonomists. Technical terminology is kept to a minimum. The arrangement of species in the keys is not phylogenetic, but is based on the most easily observed reliable characteristics. The descriptions are arranged in alphabetic order and emphasize comparisons with the species which are most likely to be confused with the one under consideration. Twenty-three species are recorded from the site. Complete identification has had to be deferred in *Blapstinus* and three less important genera.

Abstract No. 87.

Bell, R. T. 1971. Carabidae (Ground beetles). U.S. IBP Grassland Biome Tech. Rep. No. 66. Colorado State Univ., Fort Collins. 58 p.

This report contains keys and descriptions of the Carabidae (ground beetles) known to occur on the Pawnee Site. The tiger beetles are included as subfamily Cicindelinae. The paper is designed to be used in conjunction with a synoptic set in the site reference collection and is intended for the use of workers who are not trained taxonomists. Technical terminology is kept at a minimum. The family is divided into tribes. The dominant tribe, Harpalini, is discussed first, and the remaining ones follow in alphabetical order. Within the tribes, the arrangement in the key is not phylogenetic, but is based on the most easily observed reliable characteristics. The descriptions are arranged in alphabetic order and emphasize comparisons with the species most likely to be confused with the one under consideration. There are 81 species in the family recorded from the Pawnee Site.

Abstract No. 88.

Bement, R. E. 1969. Dynamics of standing dead vegetation on the shortgrass plains, p. 221-224. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The aboveground plant biomass on the shortgrass plains fluctuates widely, both intra-seasonally and inter-seasonally. Intra-seasonal fluctuation is characterized by the on and off growth pattern of grama grass. The transfer rate from live plant tissue to standing dead vegetation accelerates after each spurt of growth. Two methods for measuring the rate of transfer from live plant tissue to standing dead vegetation are considered.

Abstract No. 89.

Bement, R. E. 1969. A stocking-rate guide for beef production on blue-grama range. J. Range Manage. 22:83-86.

A stocking-rate guide for cattle on blue-grama range was developed at Central Plains Experimantal Range. The guide is based on the amount of herbage left ungrazed at the end of the summer season as it relates to gain per animal and gain per acre. Maximum dollar returns per acre from yearlings were obtained when 300 lb of air-dry herbage were left at the end of the season. The average optimum stocking rate was 2.6 acres/yearling month.

Abstract No. 90.

Bement, R. E. 1970. Leaf-weight management on blue grama range. Annu. Meeting Amer. Soc. Range Manage., February 9-12, Denver, Colorado.

The rancher who stocks his range during the period when he expects it to make its growth must be equally concerned about forage production and forage harvest.

Blue grama ranges usually make their herbage growth in brief spurts when moisture becomes available. The amount of leaf tissue working during these spurts of growth affects the quantity of herbage produced. For optimum forage production blue grama ranges should be managed to provide sufficient leaf tissue to insure fast herbage growth when a growth opportunity occurs. The amount of standing vegetation gives a good estimate of the amount of leaf tissue present during a given growth period. At Central Plains Experimental Range, maximum herbage growth occurred with adequate moisture and at least 300 lb/acre of standing vegetation on the range.

The quantity of forage available to livestock, and the use they make of it, affect grazing efficiency. At Central Plains Experimental Range maximum daily beef gain was reached when pastures were stocked at rates which left at least 350 lb of ungrazed herbage standing on the pasture at the end of the 6-month summer grazing season. Maximum gain per acre was obtained at stocking rates, leaving 250 lb of ungrazed herbage. Maximum cattle return ($/acre) occurred when 300 lb of ungrazed herbage remained at the end of the growing season.

Both optimum plant and optimum livestock production were made when 300 lb of herbage per acre were left ungrazed. The key to stocking rates and grazing systems on this kind of blue grama range is leaf weight management, to maintain 300 lb of herbage per acre during the growing season.

Abstract No. 91.

Bement, R. E., and G. E. Klipple. 1959. A pasture-comparison method of estimating utilization of range herbage on the Central Great Plains. J. Range Manage. 12:262-297.

Several factors should be recognized if the use of this pasture-comparison method of estimating herbage utilization is being considered. An estimate of the percentage of herbage remaining on a range grazed season-long is made in terms of grazing on a small pasture allowed protection during the growing season. Utilization is estimated on the assumption that several factors are negligible or balance one another. Some of these factors are regrowth of grazed plants and the differential effects of insects, rodents, disease, trampling, and moisture supply on plants grazed season-long versus those protected during the growing season. In the use of this pasture-comparison method at Central Plains Experimental Range we have assumed that the factors mentioned tend to balance one another and that their net effect upon the estimate of herbage utilization is negligible. This assumption has been made because with this method of estimating utilization, the air-dry weight of herbage eaten has consistently been very close to the dry matter feed requirements of the cattle. The actual net effect remains to be determined.

Abstract No. 92.

Bement, R. E., D. F. Hervey, A. C. Everson, and L. O. Hylton, Jr. 1961. Use of asphalt-emulsion mulches to hasten grass seedling establishment. J. Range Manage. 14:102-109.

The effect of two asphalt-emulsion mulches on the establishment of blue grama, sideoats grama, and Sudangrass was studied at Central Plains Experimental Range. Results were interpreted in terms of soil water, soil temperature, plant emergence, plant growth, and plant survival.

Abstract No. 93.

Bement, R. E., R. D. Barmington, A. C. Everson, L. O. Hylton, Jr., and E. E. Remmenga. 1965. Seeding of abandoned croplands in the Central Great Plains. J. Range Manage. 18:53-58.

Crested wheatgrass and Russian wildrye were successfully established by late-summer planting in summer-fallowed strips using a double-disc depth-band drill. Crested wheatgrass was also established by spring planting. Blue grama and sideoats grama were not established.

Abstract No. 94.

Bement, R. E., W. R. Houston, and D. N. Hyder. 1970. Annual report--Central Plains Experimental Range, crop year 1969. USDA Agr. Res. Service, Fort Collins, Colorado. 144 p.

Grass Seedling Morphology. Grass seedlings are divided into two types depending upon the depth in the soil at which adventitious roots are initiated. Panicoid-type grass seedlings, i.e., blue grama, have elongated sub-coleoptile internodes and initiate adventitious roots near the soil surface. Festucoid-type grass seedlings, i.e., crested wheatgrass, do not have elongated sub-coleoptile internodes, and the lower-most adventitious roots may be initiated near planting depth. Seedling characteristics of 16 species or varieties are shown.

Controlling Geyer Larkspur. Defoliation of larkspur by paraquat two days after spraying with 2,4-D did not increase the effect of 2,4-D. Paraquat alone was more effective than 2,4-D, and the combination of paraquat and 2,4-D was equal to or less effective than paraquat alone. Paraquat at ¼ lb/A applied April 28 killed 57% of the larkspur and at ½ lb/A on May 12 killed 90%.

Atrazine and Nitrogen. Atrazine has no effect on dry matter herbage production of blue grama range. It has increased percent protein by about 50% for two successive years. Foliar applied urea and ammonium nitrate fertilizers have increased percent protein of the herbage and also increased dry matter production. The fertilizers resulted in increases in crude protein per acre of 40 to 50%. The combined effects of atrazine and nitrogen fertilizers have the potential of doubling the production of crude protein on blue grama ranges.

Herbage Growth Rate. Herbage growth rates on lightly- and heavily-grazed upland-blue-grama pastures were compared in 1970. When the first growth opportunity occurred, the lightly-grazed pasture grew at the rate of .99 g/m^2/day for a 2-week period before exhausting the soil water. The adjacent heavily-grazed pasture grew at the rate of .20 g/m^2/ day for 6 weeks before exhausting its soil water. With this first growth opportunity, the lightly-grazed pasture produced 14 g/m^2 of herbage while the heavily-grazed pasture produced 8 g/m^2.

International Biological Program. The Pawnee Site is located on the western portion of Central Plains Experimental Range. Results during 1969 were primarily in the areas of construction of facilities, scientific hardware, development, reference, and collections.

Major construction items included a kitchen-diningroom-laboratory-office building and a dormitory. Construction was started on a storage building, corral, and residence.

Hardware development included instrumentation of micro watersheds with soil water, precipitation, run-off, and temperature measuring devices. Equipment for measuring soil nitrogen, photosynthesis, and ATP development was installed.

Reference collections of mammals, birds, insects, terrestrial vascular plants, aquatic plants, and lower plants such as algae, lichens, and fungi were compiled.

Abstract No. 95.

Bement, R. E., W. R. Houston, and D. N. Hyder. 1971. Annual report--Central Plains Experimental Range, crop year 1970. USDA Agr. Res. Service, Fort Collins, Colorado. 52 p.

Seasons of Grazing. In a 7-year experiment, 180 significant plant responses were caused by weather, season of grazing, and N fertilization. Opportunities to manipulate botanical composition by heavy grazing in short seasons are revealed. Twenty pounds of N/acre applied annually increased animal gains from an average of 42 lb/acre to 66 lb/acre with grazing in June through September.

Atrazine and Nitrogen. Atrazine increased crude protein of blue grama from 57 to 104 lb/acre, but had no effect on herbage yield. N fertilization increased crude protein from 59 to 124 lb/acre primarily by increasing herbage yield. The two effects were additive.

Nitrogen-Induced Plant Mortality. On abandoned cropland, red three-awn, an undesirable perennial grass, is killed with 100 lb of N/acre. Secondary succession of annual species induced by residual N goes from slimleaf goosefoot to prairie sunflower to Russian thistle in three years with only slight increases by pioneer perennial grasses. The botanical changes result in large increases in herbage yield and offer potential for increased animal production.

Water-Soluble Tracers. The relationship between water drunk and dry matter consumed by grazing cattle offers an opportunity to develop a method of determining forage intake and forage quality. Studies are designed to determine the energy and nutrient components associated with the water components of forage, feces, urine, and vapor of cattle on pasture to estimate digestibility, digestible energy, and metabolizable energy.

In 1969 tritium-labeled water was used to develop water-tracer techniques for determining total body water of cattle. Respired water, which requires no purification, was compared with water from saliva, blood, and urine for the purpose of following the course of tritium dilution. Respired water is reliable for assay of tritiated water in animals for the study of water partitioning and kinetics.

The dye materials FD and C Violet No. 1, FD and C Red No. 3, and phloxine B were tested for suitability as water soluble tracers to be recovered in cattle feces. Recovery in feces was only 70 to 80% and would not permit the use of these dyes as gut water tracers.

Polyethylene glycol labeled with ^{14}C was also tested for suitability as a tracer. About 94% of the ^{14}C was recovered. This method might be usable.

Abstract No. 96.

Bergquist, N. O. 1964. Absorption of carbon dioxide by plant roots. Bot. Notiser 117(3):249-261.

The ability of plant roots to absorb carbon dioxide in low concentrations in water culture was studied by comparing the net dry weight growth of plants (in 2 jars) given more or less carbon dioxide at the roots. Other factors were kept constant. Eighteen experiments, with 141 test plants and 141 controls (beans, tomatoes, and mustard) are reported. The average gain obtained was 27.7%. Direct absorption of CO_2 through the roots must be considered an acceptable working hypothesis, strongly supported by the observed facts, until another satisfactory explanation is found.

Abstract No. 97.

Berthet, P. 1967. The metabolic activity of oribatid mites (Acarina) in different forest floors, p. 709-725. *In* K. Petrusewicz [ed.] Secondary productivity of terrestrial ecosystems. Vol. II. Polish Acad. Sci., Warsaw.

In the present study the oxygen-consumption measured in the laboratory was taken as an estimate of the respiratory activity of animals in natural conditions. These data, combined with measured population densities, were used to compute the energy flow rate through Oribatid communities in different biotypes. We feel that these results not only provide an estimate of the activity of Oribatid mites in the forest floor, but also provide an insight into the structure of the communities from a metabolic point of view.

Abstract No. 98.

Bertolin, G., and J. Rasmussen. 1969. Preliminary report on the study of the precipitation on the Pawnee National Grassland. U.S. IBP Grassland Biome Tech. Rep. No. 17. Colorado State Univ., Fort Collins. 34 p.

Preliminary results of a study of the precipitation of the Pawnee National Grasslands are presented. The spatial and time distributions and variations of precipitation are presented. A markov chain probability analysis is included in the discussion in addition to more classical statistical treatments. Some discussion of other meteorological parameters is included.

Abstract No. 99.

Beutner, E. L., and D. Anderson. 1943. The effect of surface mulches on water conservation and forage production in some semidesert grassland soils. Amer. Soc. Agron. J. 35:393-400.

Results of small plot studies conducted on two soil types near Tucson, Arizona are outlined. Various types of vegetal materials were used as surface mulches and incorporated into the soil. Their effects on infiltration were evaluated by means of measuring runoff secured from artificial application of rain and by collecting runoff resulting from natural rains.

It was found that protection of the soil surface either by plants themselves or by organic litter which they furnish prevents sealing of the soil and is of utmost importance in promoting infiltration of water into the soil and conserving moisture for plant growth. In areas of low rainfall, maximum conservation of water is essential if adequate forage production is to be expected. A 20% increase in conservation of moisture in well-vegetated areas may easily increase forage production by 50%. Where plant cover is sparse, conservation of moisture aids in increasing plant density and may increase total forage production many fold.

Abstract No. 100.

Bidwell, O. W. 1956. Major soils of Kansas. Kansas Agr. Exp. Sta. Circ. 336. 17 p.

Soil is one of Kansas' most important resources. Unlike most other resources, soil is inexhaustible *if properly managed*. The state is covered with soil (a mineral-organic layer) that varies widely in thickness, color, particle size, chemical fertility, productivity, and biological characteristics. These characteristics depend upon six things: (i) kind of geologic material, (ii) climate, (iii) relief, (iv) natural vegetation, (v) length of time of weathering, and (vi) the activities of man. Soils are products of these factors, so wherever they are the same, the soils will be similar. The wide variation in these factors in Kansas has produced many different kinds of soils.

It is impossible to show the many soil variations on a map of this scale. So on this map the soils are grouped into general associations of usually two or more soil series that occur together. The map shows the broad soil areas of the state, together with their general characteristics. For more detailed information see county soil maps, available for these 15 Kansas counties: Allen, Bourbon, Cherokee, Clay, Cowley, Crawford, Jewell, Johnson, Kingman, Marion, Montgomery, Neosho, Reno, Wilson, Woodson.

Because climate is important in soil formation, maps showing the average annual distribution of precipitation, mean annual temperature, and the length of the growing season are included.

Abstract No. 101.

Birch, H. F. 1960. Nitrification in soils after different periods of dryness. Plant Soil 12: 81-96.

An experiment is described in which soils with carbon contents ranging from about 1 to 7% were air dried for 3, 6, 9, 12, and 15 weeks and then remoistened. The amounts of carbon mineralized and ammonia and nitrate-nitrogen subsequently produced during 19 days were then determined and compared with the amounts mineralized from a non-dried soil. For a given drying period the amounts of carbon and nitrogen mineralized were proportional to the carbon content of the soil while, for a given soil, they were found to be a significant linear function of the log of the time the soil was in an air-dry state prior to moistening. With high-humic soils drying produced extra nitrogen on moistening sometimes equivalent to over 1 ton of sulphate of ammonia per acre. Even with low-humic soils, values of about 300 pounds were common.

The results of the drying effect are tabulated both in conventional units and as pounds of sulphate of ammonia per acre 6". In the latter units the table should more readily serve as a general guide in applying the results. The application of the results to nitrogen fertilizer trials, irrigation, rundown of soil fertility and soil carbon, the effect of shade, etc. is then discussed. The material and mechanism possibly involved is also considered. The results should be of fairly wide application since a basic principle operating on material (humus) of more or less uniform composition and common to all soils is involved.

Abstract No. 102.

Birch, T. 1960. Grazing studies at Archer, Wyoming. Wyoming Range Manage., Issue No. 140. 2 p. (Abstr.)

Three intensities of grazing of shortgrass range by ewes and lambs have been studied at the Archer Substation in southeastern Wyoming for 15 years, 1945-1959. Vegetational composition studies have been made at different times during the period, making it possible to know what vegetation changes have taken place over the 15 years of differential use. Records of pounds of grass remaining after grazing on the flat upland sites have been obtained during all these years. Production records of grass at the three levels of use on the flat uplands are available for the last 13 years. Forage production records on the slope sites were obtained during the last three years of the study. Records of weight gains made by ewes and lambs have been made during the length of the study period.

Abstract No. 103.

Birney, E. C., and E. D. Fleharty. 1966. Age and sex comparisons of wild mink. Kansas Acad. Sci., Trans. 69:139-145.

Sex and age comparisons of 126 wild trapped mink from northwestern Kansas indicate that condylepremaxillae length appears to be a valid criterion to distinguish sex by skull alone for those animals 18 months of age or older. In spite of evident sexual dimorphism, there is some size overlap between male and female mink in some skeletal characteristics. Width of the least interorbital constriction grows narrower with age for at least eight months after birth.

A significant size and weight difference exists between juveniles and adults, at least through the first trapping season after birth with males exhibiting this difference to a greater degree than do females.

Abstract No. 104.

Biswell, H. H., and J. E. Weaver. 1933. Effect of frequent clipping on the development of roots and tops of grasses in prairie sod. Ecology 14(4):368-390.

This paper deals with the effects of the removal of tops on root growth in soil and on regeneration and yield of aerial parts. Blocks of well established sod of seven important native pasture grasses were transplanted into large containers, grown in the field, and clipped fortnightly.

The harmful effects of the frequent removal of the cover of grasses and the accompanying deterioration of the parts underground are discussed.

Abstract No. 105.

Black, H. L. 1968. Populations of small rodents in relation to grazing by cattle on foothill rangelands. M.S. Thesis. Univ. Utah. 56 p.

The presence and relative abundance of small rodents on native and reseeded foothill rangelands as correlated with grazing by cattle and type of grass was investigated by sampling the mammals with snap traps arranged in one acre grids. Trapping was conducted during early summer and early fall of 1966 and 1967 at the Benmore Experimental Area, Tooele County, Utah, where there are records of over 20 years of controlled grazing and of a variety of reseeded grass stands. A total of 18,420 trap nights yielded 592 rodents (488 in 1966 and 104 in 1967). *Perognathus parvus olivaceous* Merriam, *Reithrodontomys megalotis megalotis* (Baird), and *Peromyscus maniculatus sonoriensis* (Le Conte) comprised over 99% of the mice captured. No definite correlation was found between relative abundance of mice and type of grass. The influence of grazing by cattle appears to have a differential effect on rodents depending upon the intensity and season of grazing. Great Basin pocket mice (*P. parvus*) and harvest mice (*R. megalotis*) were captured most frequently in the lightest-grazed reseeded range. Deer mice (*P. maniculatus*) were captured most frequently in native and heaviest-utilized reseeded range. Pocket mice were captured most infrequently where the intensity of grazing was heaviest. Harvest mice were rarest in the lightest-grazed native range, while deer mice were rarest in the lightest-grazed reseeded range.

Abstract No. 106.

Black, W. H., A. L. Baker, V. I. Clark, and O. R. Mathews. 1937. Effect of different methods of grazing on native vegetation and gains of steers in northern Great Plains. U.S. Dep. Agr. Tech. Bull. 547. 18 p.

The grazing investigations at the United States Dry Land Field Station, Ardmore, South Dakota, were begun in 1919 and continued through 1933, as a cooperative enterprise of the Bureaus of Animal Industry and Plant Industry. The experiments were planned to compare the effects of different methods of grazing the native pastures on the vegetation of these pastures and on the gains of steers used on them. The results should be applicable to sections of the northern Great Plains having native vegetation similar to that at Ardmore.

Abstract No. 107.

Black, W. H., and V. I. Clark. 1942. Yearlong grazing of steers in the northern Great Plains. U.S. Dep. Agr. Circ. 642. 16 p.

Experiments were carried on at the Ardmore Field Station, Ardmore, South Dakota, for 4 successive years, beginning in the fall of 1936, to determine whether about 20 acres of native range were sufficient to carry a yearling steer for 1 year and whether alternate grazing would have any advantage over continuous grazing. Two areas of 350 acres each were used, one of which was grazed continuously and the other divided into two equal areas of 175 acres each and the steers changed from one half to the other every 28 days. The rate of stocking was 19.44 acres per head, or 18 animals for each of the 350-acre tracts. The animals used were yearlings, approximately 16 months of age at the beginning of each experiment, and were grazed for one full year.

The vegetation was the native range, which includes a large number of species from widely separated families. The vegetation is dominated, however, by western wheatgrass (*Agropyron smithii*), buffalo grass (*Buchloe dactyloides*), and blue grama grass (*Bouteloua gracilis*). During the period covered by the study, precipitation was favorable for vegetative growth.

Abstract No. 108.

Blair, B. O. 1949. The ecology of a pasture in the Dakota sandstone formation in Ellsworth County, Kansas. Kansas Acad. Sci., Trans. 52:38-57.

The pasture under consideration was typical of those found in the Dakota Sandstone Formation. Irregular terrain, rocky outcrops, and spring-fed streams were features of the prairie. Three habitats representative of the three grass types, shortgrass, midgrass, and tallgrass were studied.

Abstract No. 109.

Blair, W. F. 1942. Rate of development of young spotted ground squirrels. J. Mammal. 23:342-343.

A female spotted ground-squirrel (*Citellus spilosoma major*), trapped on the White Sands, Otero County, New Mexico, was pregnant and on May 14, 1940, gave birth to six young. Since little was known about the rate of development of young of this species, the young were kept under observation at the Laboratory of Vertebrate Genetics.

Abstract No. 110.

Blair, W. F. 1943. Populations of the deer-mouse and associated small mammals in the mesquite association of southern New Mexico. Contrib. Lab. Vertebrate Biol. (Univ. Michigan, Ann Arbor) 21:1-39.

In the period from March to May 1940 the maximum population of all small mammals in an area of mesquite association near Alamorgordo was estimated from live-trap records to have averaged 3.64 individuals per acre. The 11 species observed are all rodents. The home ranges of the rodents living in this desert association averaged larger in size than those of related forms living in the prairies and deciduous forests further east in the United States. No evidence of territorial behavior was discovered in any of the species. Neither was there any evidence of severe competition between the several associated species for either food or home sites. Two closely related species in each of the genera *Dipodomys*, *Onychomys*, and *Peromyscus* were members of the mesquite association, and their home ranges often overlapped.

Abstract No. 111.

Blair, W. F., and T. H. Hubbell. 1938. The biotic districts of Oklahoma. Amer. Midland Natur. 20: 425-545.

Ten biotic districts are distinguishable in Oklahoma. The Ozark, Ouachita, Mississippi, and Cherokee Prairie districts are a part of the eastern deciduous forest. The Osage Savanna district is an area of transition from the eastern deciduous forest to the grasslands of the Great Plains. The Wichita Mountain district is an outlier of the eastern deciduous forest in the Great Plains grasslands. The Mixed-grass Plains, Mesquite Plains, and Shortgrass Plains are biotic districts of the Great Plains grasslands. The Mesa de Maya district belongs with the southern Rocky Mountains.

The various districts are distinguishable *inter se* by characteristic physiographic features and plant associations, by characteristic species of Orthoptera, by characteristic species and races of mammals, and by characteristic assemblages of species of Orthoptera and mammals.

Abstract No. 112.

Blake, A. K. 1935. Viability and germination of seeds and early history of prairie plants. Ecol. Monogr. 5(4):405-460.

Seeds of 42 species of plants of tallgrass prairie were tested for germination by plantings made in soil. The percentage of germination was ascertained and also the length of time after planting before the largest proportion of seedlings appeared.

The seeds were gathered when ripe from plants growing naturally in undisturbed prairie. A résumé is given of the environmental conditions under which they developed and to which germinating seeds and seedlings were subjected in nature.

Abstract No. 113.

Bledsoe, L. J. 1970. ODE: Numerical analysis for ordinary differential equations. U.S. IBP Grassland Biome Tech. Rep. No. 46. Colorado State Univ., Fort Collins. 42 p.

ODE (Ordinary Differential Equation) is a general purpose routine for solving sets of ordinary differential equations. The equations may be of any complexity so long as they can be reduced to a first-order form and the derivatives of the dependent variables can be calculated in a subroutine given the present vector of system variables plus time and any other independent variables. The program requires that the user write one or more subroutines to evaluate these derivatives. The subroutine to find the derivatives should be called DER. Other subroutines which must be provided by the user to perform various options include INIT, PL1, and DEBUG.

Abstract No. 114.

Bledsoe, L. J., and D. A. Jameson. 1969. Model structure for a grassland ecosystem. p. 410-437. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

This report relates the methods used by the personnel of the Grassland Biome program for the initiation of development of a whole ecosystem mathematical model. The form of that model, as it stands before computational or field testing, is set forth. A section, intended in part to be read by the non-mathematically inclined scientist, is devoted to the explanation of notation and mathematical conventions. The abiotic variables are divided into extrinsic or driving variables and intrinsic variables such as environmental temperatures and soil moisture which are mathematically related to the driving variables. A relation of photosynthesis to sunlight, temperature, and soil water and nutrients is derived on the basis of information in the literature. A series of equations summarizing inputs and losses from the primary producer compartment are presented. A general form for consumer population dynamics in terms of a continuously variable age structure is used. Individual animal weights are calculated on the basis of estimated food intake and respiration functions. Members of the detritus food chain are treated in a functional manner and only nitrogen cyclers are mentioned as an example. Finally, the close interaction of the four sections is illustrated with three examples of mathematical connections between trophic level variables.

Abstract No. 115.

Bledsoe, L. J., and G. M. Van Dyne. 1969. Evaluation of a digital computer method for analysis of compartmental models of ecological systems. Oak Ridge Nat. Lab. (Oak Ridge. Tennessee) TM-2414. 60 p.

This report presents results of development and testing of a FORTRAN program for exploration and analysis of data from experiments in which the system may be depicted by a compartmental model. Both real and artificial data were used to check for rate and type of convergence toward the minimum sum of squares of deviations of observed from predicted data values for each compartment. Data with known degree and kind of error were generated to simulate various degrees of noise encountered in real biological data. Results of these computer studies are presented in graphic and tabular form, limitations of the program are discussed, and program and subroutine listings with directions for use are given in appendices.

Abstract No. 116.

Bledsoe, L. J., and P. P. Sims. 1970. A model for intraseasonal herbage dynamics. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

A differential equation describing the rate of change and growth of aboveground biomass of a single forage species in relation to the environmental variables of air temperature and soil water is developed. The purpose is to enable a method of quantitative analysis for simple range forage production studies which is connected to other phases of the ecosystem and is capable of expansion to multispecies and multitrophic level models. The model is modular in the sense that its complexity can be easily increased or decreased depending on the detail available in a particular experimental study. The equations are solved by numerical analysis and compared with actual data through a numerical minimization technique to determine unknown coefficients of the model. The coefficients are determined so as to minimize the sums of squared deviations between theoretical and observed data. The resulting model is used to make some tentative predictions for seasonal yield and growth patterns of several sandy plains grass species on the basis of various hypothesized precipitation regimes.

Abstract No. 117.

Bledsoe, L. J., R. C. Francis, G. L. Swartzman, and J. D. Gustafson. 1971. PWNEE: A grassland ecosystem model. U.S. IBP Grassland Biome Tech. Rep. No. 64. Colorado State Univ., Fort Collins. 179 p.

The primary objective of Grassland Biome Project modelling efforts this year (1970) has been to produce a mechanistic total system model of a grassland ecosystem. The result has been a model which is mechanistic to the extent that, wherever possible, the mathematical formulations are analogous, at some level of resolution, to the functional mechanisms operating within the system.

The model is primarily designed to describe the shortgrass prairie ecosystem of the Pawnee National Grassland. It is designed as a highly modular system for two reasons: (i) So that individual processes or mechanisms may be changed as information becomes increasingly available, and (ii) So that the model can be used in situations having greater (Pawnee Site) or lesser (Comprehensive Sites) detail in data and information.

The current version of the model is in a first-pass condition, and has not been subjected to extensive scientific debugging (i.e., the mechanisms have not been closely reexamined by biologists).

The model is structured in the following way: (i) It is a time-dependent biomass model. No spatial aspects are taken into consideration at present. (ii) The primary equations to be solved make up a series of first-order differential equations. Thus, the equations for the principal system variables express the rate of change of biomass with respect to time. (iii) The total model is made of trophic level submodels. Within each trophic level various functional relations describe the processes.

A set of 46 first-order differential equations has been developed to describe the abiotic, producer, consumer, and decomposer components of the ecosystem. The abiotic section involves driving forces of solar energy, air temperature, wind speed and precipitation, and driven variables of microclimatic temperature, soil temperature, and soil water. The producer biomass is compartmentalized as animal live material, animal dead material, and animal fecal material. The animal live biomass is further subdivided into five functional groups (wild primary consumers--mammal, domestic primary consumers--mammal, secondary consumers--mammal, birds, and insects). The decomposer compartments are mediated by microbial functional groups whose activity is in turn controlled by their biotic and abiotic environment.

Abstract No. 118.

Bledsoe, L. J., and J. D. Gustafson. 1971. Multivariate normal data generator. U.S. IBP Grassland Biome Tech. Rep. No. 92. Colorado State Univ., Fort Collins. 13 p.

This FORTRAN program is designed to generate vectors of data whose components are distributed according to the multivariate normal distribution function with a given mean vector and a given covariance matrix. The data generated can be either printed on the output unit or punched on Hollerith cards under program options.

Abstract No. 119.

Bledsoe, L. J., D. M. Swift, G. M. Van Dyne, and J. H. Hughes. 1971. A statistical analysis and simulation study of the dry weight rank method as a double-sampling technique for determination of vegetation composition. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

The dry weight rank method has been used in several field investigations for determination of Vegetation composition. The method involves mathematical treatments of estimates of the ranks of Vegetation species made by a visual observer. In this study data from a wide variety of vegetation types ranging from old field grassland communities in Tennessee to salt desert shrub communities in western Colorado are used to test that technique. Hand clipping and separation provide a vegetation composition estimation used as a basis for comparing with the dry weight rank method. Cursory examination of the results indicates that the method is a reliable one. Calculation of correlation coefficients and other statistics seems to support this conclusion. The method is further analyzed by applying it to simulated data which has the advantage that the actual vegetation composition is known. The simulation studies carried out by computer reveal that the dry weight rank method can never result in a reduction in variance over the estimates made by the hand clipping and separation technique. Thus, it is of little use as a double sampling procedure for estimation of vegetation composition.

Abstract No. 120.

Bledsoe, L. J., and G. M. Van Dyne. 1971. A compartment model simulation of secondary succession, p. 479-511. *In* B. C. Patten [ed.] Systems analysis and simulation in ecology. Vol. I. Academic Press, New York.

The current trend in environmental biology toward the use of mathematics, statistics, and computer languages for description of experimental data raises the question of whether or not these methods are at variance with the traditional methods and concepts of ecology. Is it possible to place early classical ecological studies in a quantitative framework and preserve the values therein? If so, are there advantages to be gained by a fresh look at classic data through the viewpoint of a mathematical treatment?

In an attempt to answer these questions, as well as to provide a starting point for modeling studies in an important phase of ecology, two classical studies of succession in abandoned cultivated fields have been used to develop systems of equations which reflect the observations and conclusions of the original authors. The data which were gathered in the two studies are primarily semiquantitative in form and not of a type which readily lends itself to objective measures of "goodness-of-fit," such as minimum squared error. Nevertheless, much of the progress in modern ecology and the understanding of mechanisms of environmental biology is based upon observations and data of this type. If the techniques of systems ecology are to supplement previous findings of ecologists, they must build upon traditional techniques rather than seek to supplant them. The main objective of this chapter is to show that quantitative methods can be made to intermesh in a workable manner with qualitative statements of hypotheses. The important aspect of a quantitative model is translation of the verbally stated mechanism into mathematical form; use of empirical numerical data to test the model statistically is only one of several ways of gaining confidence in its efficacy. We hope to demonstrate that the techniques of modeling and simulation are equally applicable to situations involving nonnumerical or semiquantitative data.

Abstract No. 121.

Blocker, H. D. 1969. The impact of insects as herbivores in grassland ecosystems, p. 290-299. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Grasshoppers are the only insect group which is presently known well enough to evaluate in detail their impact upon grasslands. Life-system studies on major species are also desirable. Little is known concerning leafhoppers as herbivores. A population census is needed before it can be determined which species of leafhoppers as well as other insect herbivores warrant concentrated ecological study in the Grasslands Biome. The effect of parasites, predators, and diseases on herbivores should also be considered. The major literature pertaining to methodology of ecological research has been surveyed. It is evident, however, that existing methods need to be adapted to suit the grassland environment, and new supplementary methods must be found. Various methods of population sampling and damage evaluation are discussed briefly.

Abstract No. 122.

Blocker, H. D., and R. Reed. 1971. 1970 insect studies at Osage Comprehensive Site. U.S. IBP Grassland Biome Tech. Rep. No. 93. Colorado State Univ., Fort Collins. 38 p.

Results of 1970 collections of insects at the Osage Site are summarized. Samples were collected at approximately two-week intervals through the growing season, beginning in July, on the grazed and ungrazed treatment areas.

Abstract No. 123.

Blood, D. A. 1966. The *Festuca scabrella* association in Riding Mountain National Park, Manitoba. Canadian Field-Natur. 80:24-32.

Small areas of fescue prairie occur, apparently as relicts, in the southwestern portion of Riding Mountain National Park. Vegetation on 16 sample plots was clipped and weighed by species in July 1963. *Festuca scabrella* made up about 43% of the total and about 72% of the graminoid vegetation. The most important subdominant grasses were *Stipa* spp. Forbs and shrubs made up about 30 and 10%, respectively, of total vegetation.

Compared with data for two Saskatchewan sites, a greater proportion of *Festuca* in the graminoid component and a greater proportion of forbs in the total vegetation is indicated. Many areas of natural grassland in the Park appear to have degenerated from an original fescue prairie association to a bluegrass-dandelion-shrubby cinquefoil association due to heavy grazing by domestic stock.

Abstract No. 124.

Blumstock, G. 1942. Drought in the U.S. analyzed by means of the theory of probability. U.S. Dep. Agr. Tech. Bull. 819. 63 p.

This bulletin develops a statistical method for the description of occurrence of drought and shows how drought hazard can be expressed in terms of probability or chance. Drought occurrence was tabulated for a large number of stations in the United States for the interval 1898-1937. Length of each drought was expressed in days, and frequency distributions were prepared showing the number of occurrences of droughts of various length. For the purposes of this study, drought was considered terminated by 0.10 inch or more of precipitation in 48 hours or less.

Abstract No. 125.

Bocock, K. L., and J. Heath. 1967. Feeding activity of the millipede *Glomeris marginata* (Villers) in relation to its vertical distribution in the soil, p. 233-240. *In* O. Graff and J. E. Satchell [ed.] Progress in soil biology. Proc., Colloquium Dynamics Soil Communities (Amsterdam).

Detailed quantitative data on seasonal changes in the feeding activity of the millipede *Glomeris marginata* (Villers) are not available. As part of recent studies on the role of *Glomeris* in woodland soils we determined seasonal changes in the type and amount of food in the gut and the percentage of animals with gut contents. To enable us to determine indirectly the period when *Glomeris* is feeding, these data are compared with changes in (i) the vertical distribution of *Glomeris* and (ii) soil temperature. The technique which we used to estimate gut contents is described and its applications are discussed.

Two sites were used in these studies. The first was in mixed deciduous woodland on a very stony base-rich soil at Merlewood Research Station. A similar site was used in Heaning Wood, 3 km from Merlewood.

Abstract No. 126.

Bogan, M. A., and T. R. Mollhagen. 1969. Wind training in some prairie trees. Southwestern Natur. 14(1):134-136.

Prairie trees are typically found in open stands, and to our knowledge no quantitative studies have been done on their crown asymmetry. The present study on the nature of this asymmetry is an attempt to fill the void.

Abstract No. 127.

Bond, R. M. 1945. Range rodents and plant succession. North Amer. Wildlife Conf., Trans. 10:229-233.

A few recent studies, and some unpublished observations, make it appear possible that small mammals of the range may exert enough preferential pressure on range vegetation to help speed up plant succession, and therefore range improvement, since range is usually most productive at or near the climax stage. The different mammalian groups considered separately are: Prairie dogs, ground squirrels, pocket gophers, kangaroo rats, pocket mice, white-throated wood rat, and jackrabbits.

Abstract No. 128.

Bonham, C. D. 1971. A computer program for mapping ecological data. Range Sci. Dep. Sci. Ser. No. 9. Colorado State Univ., Fort Collins. 45 p.

In ecological disciplines the major objectives for using operations research include: evaluation, optimization, and control of manipulative processes. Ecological evaluation problems arise, for example, in the assessment of availability of vegetation resources while optimization problems arise in the development of a management plan to use the vegetative resource. Control problems arise when consideration is given to the efficient application and successful operation of a management scheme designed especially for the ecological system. Major disciplines which are applicable to the solution of these problems include: ecology, statistics, systems analysis, and operations research. Computer mapping techniques have proven useful in solving problems existing in several disciplines and can be used for ecological evaluation purposes, determination of optimization procedures, and to control management procedures in ecological systems. To date these computer mapping techniques have not been applied extensively to the study of ecological systems.

Computer mapping refers to presenting displays of response surfaces or contouring ecological variables of interest. These procedures are analogous to drawing in elevation contour lines for topographic maps and can be used to display ecological variables by levels over a particular geographic region. Specifically, we may be interested in studying the aboveground standing crop and its characteristics over a given area. The use of computer contouring techniques is one approach that is available for this purpose. This procedure is useful for obtaining samples from a region and interpolating between each of the sample points.

Abstract No. 129.

Booth, W. E. 1941. Algae as pioneers in plant succession and their importance in erosion control. Ecology 22(1):38-46.

1. Several species of soil algae, belonging to the Myxophyceae, constitute an initial stage in plant succession by the formation of a complete algal layer over hundreds of acres of badly eroded land in the south-central United States. The decided prominence of this plant cover may last for many years until higher perennial plants are able to form an abundant ground cover.

2. The rate of infiltration of water into the soil is not slowed down by the algal stratum, with exception of one stratum type, in which there is a slight retardation for about the first 7 mm of water.

3. Soil losses from plots with the protection afforded by an algal stratum were greatly reduced as compared with the losses from bare areas. The algal resistance to erosion is apparently the result of binding the surface particles of soil into a non-erosible layer which is also very effective in breaking the force of falling water.

4. Somewhat inadequate tests indicate a higher water content in the top inch of soil which has had the protection of an algal layer, as compared with bare soil.

Abstract No. 130.

Booth, W. E. 1941. Revegetation of abandoned fields in Kansas and Oklahoma. Amer. J. Bot. 28:415-422.

An extensive field survey accompanied by a botanical analysis has been conducted in an attempt to determine the course of natural plant succession on abandoned crop land.

The fields examined were in east-central Oklahoma and southeastern Kansas. This area includes two distinct vegetation types, savanna and prairie.

The sequence of the stages of plant succession is as follows: weed, annual grass, perennial bunch grass, fully-developed prairie. Under favorable conditions the weed stage lasts for 2 years, the annual grass from 9 to 13 years, and the bunch grass for an undetermined length of time. The oldest abandoned field examined in this stage was 30 years old, and it did not appear to be nearing the fully-developed prairie stage.

Heavy pasturing and burning are a hindrance to plant succession and may cause the fields to remain unproductive much longer than would otherwise be necessary.

Certain blue-green algae play an important role in the prevention of soil erosion and may thus compensate for the inadequacies of the seed plants.

Plant succession can be stimulated by cultural practices such as terracing and contour furrowing.

Natural revegetation of gullies should not be relied upon. The control of gullies, by methods in accordance with land values, should be practiced before the injury to future forage production is excessive.

Abstract No. 131.

Borchert, J. R. 1950. The climate of the central North American grassland. Ann. Ass. Amer. Geogr. 40(1):1-39.

The steppes of the Great Plains and the Prairies of the mid-West have long been of interest to scholars in many fields because of the significance of those regions in the white settlement of Anglo-America. The physical aspects of the Grassland alone have provided the topics for an enormous number of studies. In the natural sciences the explanation of the geographical distribution of the original grass vegetation has long been an enigma. This has been particularly true of the prairies.

One important segment of the knowledge which will lead to an understanding of the distribution of original grassland is an understanding of the distinctive climatic characteristics of the region and of their significance to wild vegetation. The present paper is added to the vast literature already published primarily as a contribution to the regional climatology of the Grassland. The ecological literature is reviewed very briefly to show how the findings of the Grassland ecologists fit the facts of the present climatic pattern of the region and to complete the background for a discussion of the prehistoric climate. It is hoped that the study will lead to a better understanding of the role of climate in determining the regional pattern of the original grassland east of the Rockies in Anglo-America.

Abstract No. 132.

Botkin, D. B., and C. R. Malone. 1968. Efficiency of net primary production based on light intercepted during the growing season. Ecology 49(3): 438-444.

Net primary production of a 1-year-old field on the New Jersey Piedmont was 1.08 kcal/cm^2 or 10% of the radiant energy (0.4-0.7 μ) intercepted by the vegetation from the last spring frost to the latest date a dominant producer reached its peak standing crop biomass; 3.8% of the energy available above the vegetation during the same period; 7.5% of the energy intercepted from the last spring frost to the first fall frost; 3.1% of the energy available above the vegetation during this period; and 1.8% of the energy available yearly. These results are among the first direct determinations of efficiency of net primary production based on interception of radiant energy under field conditions. Interception, the difference between radiant energy available above and below the vegetation, was measured with the Yellott solarimeter, whose small size made possible below-vegetation measurements with minimum disturbance to the cover. Net primary production for shoots was determined on a species basis by the short-term harvest method. Root production was estimated on a community basis by extracting roots from soil samples by a soil-dispersion and chemical flotation technique.

Abstract No. 133.

Boulette, E. P., III, R. C. Porter, and R. W. Gorden. 1971. Microbial measurements at the Pantex Site, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 95. Colorado State Univ., Fort Collins. 16 p.

A study of microbial populations and decomposition of the shortgrass prairie was started in May of 1970 supported by IBP on the Pantex Site. The study was to be conducted in two parts: first, a study of the viable bacterial population over a period of time using the standard plate count technique, and second, a study of microbial decomposition using the litter bag method.

Abstract No. 134.

Bourliére, F., and M. Hadley. 1970. The ecology of tropical savannas, p. 125-152. *In* R. F. Johnston [ed.] Ann. Rev. Ecol. Syst. 1.

At the present time there is no consensus regarding either the origin or the classification of savannas; and, given the obvious space limitations of this review, no purpose would be served by detailing the data and opinion currently at hand. Much of this information is, moreover, already available in the Proceedings of the IGU Humid Tropics Commission Symposium on the Ecology of the Forest/Savanna Boundary.

For the purpose of this review, the term *savanna* is used in its broad sense to refer to a tropical formation where the grass stratum is continuous and important, but occasionally interrupted by trees and shrubs; the stratum is burnt from time to time, and the main growth patterns are closely associated with alternating wet and dry seasons. Given this broad description and the many millions of square kilometers covered by such formations, a short review must obviously concentrate on particular geographic areas and specific directions of study. From the area viewpoint, therefore, major attention will be paid to Africa and, more particularly, to West Africa. The aim is to draw attention to some of the as yet limited quantitative data on the producers and consumers of savanna areas with a view to highlighting some aspects of the functioning of savanna communities and suggesting some likely directions for future study.

Abstract No. 135.

Bouyoucos, G. J. 1922. Relation between heat of wetting, moisture equivalent, and unfree water. Soil Sci. 14:431-434.

In this paper are presented the results of an investigation conducted to ascertain the relationships that exist between heat of wetting, unfree water, and moisture-equivalent of soils. The experimental results show that there is a close and consistent relationship between the heat of wetting and the unfree water, but there appears to be no close and regular relationship between the heat of wetting and moisture-equivalent or between unfree water and moisture-equivalent.

Evidences obtained go to indicate that the moisture-equivalent method does not give a true and absolutely equivalent moisture in all of the various soils. Some of the fine textured and colloidal soils contain considerably more moisture than their true moisture-equivalent.

Abstract No. 136.

Bouyoucos, G. J. 1929. A new, simple, and rapid method for determining the moisture equivalent of soils, and the role of soil colloids on this moisture equivalent. Soil Sci. 27:233-241.

A new method has been developed for determining the moisture equivalent or comparative moisture holding power of soils.

The principle of this method is based upon the pulling of water from the soil by vacuum pressure forces instead of by centrifugal forces.

The method is simple, rapid, accurate, reliable, and infinitely more available than the centrifugal method.

The results obtained by this method show that there is a remarkably close relationship between the moisture equivalent and the colloidal content of soils as determined by the hydrometer method. There is, however, no relationship between coarse silt and sand and the moisture equivalent.

It is shown that the moisture equivalent or comparative moisture-holding powers of the different soils can be indirectly determined by the hydrometer method.

It is also shown that the hydrometer method may be used to obtain "single value" factors for summarizing the various physical properties of soils.

The hydrometer method has inherently great possibilities for the study of soils.

Abstract No. 137.

Box, T. W. 1959. Density of plains wood rat dens on four plant communities in south Texas. Ecology 40(4):714-715.

Density of wood rat dens appeared to be closely associated with overhead cover. Greatest density occurred in prickly pear communities, lesser numbers in chaparral communities; dens were essentially lacking in running mesquite communities, and houses were absent from true prairie communities.

Abstract No. 138.

Box, T. W. 1967. Influence of drought and grazing on mortality of five west Texas grasses. Ecology 48:654-656.

Significantly more plants of silver bluestem (*Andropogon saccharoides* Swartz.), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), sand lovegrass (*Eragrostis trichodes* (Nutt.) Nash), switchgrass (*Panicum virgatum* L.), and Indiangrass (*Sorghastrum nutans* (L.) Nash) died on Brownfield fine sand, eroded phase, grazed pastures, than on adjacent ungrazed areas, during a recent 4-year drought, although grazing pressure was light. The majority of ungrazed plants had either normal or hollow growth forms. Grazed plants commonly had only a small amount of living material along one edge. Size of clone and percentage of dead material in clones were positively correlated ($P < .01$) in grazed sideoats grama and sand lovegrass plants and negatively related ($P < .01$) in ungrazed plants.

Abstract No. 139.

Brandhorst, C. T. 1943. A study of the relationship existing between certain insects and some native western Kansas forbs and weedy plants. Kansas Acad. Sci., Trans. 46:164-175.

In this study 10 native prairie plants have been examined as collected from 15 areas in western Kansas. These were found to be hosts to a large population of insects. Of these 46 were studied. The rate of infestation was found to vary from .45 to 68%. Several insects were found effective checks of their host plants, while the majority seemed to exert little effect upon them. The distribution of the insects was found to vary from a single area to eight locations as widely separated as Phillipsburg, Quinter, Hoxie, and Ness City.

Abstract No. 140.

Branson, F. A. 1942. A preliminary report on the insect orders found in various grassland habitats in the vicinity of Hays, Kansas. Kansas Acad. Sci., Trans. 45:189-194.

The purpose of this paper is to present some tentative results of entomological work done at Hays, Kansas during the year of 1941. The results obtained will be supplemented by future work. One of the newest fields in entomology is that of the ecological relationships of insects to the plants upon which they live. This field is of economic importance and reveals that insects are one of the most destructive competitors of livestock for our native range. The present study has been made to determine what insect groups attack our native vegetation and the relative abundance of each group.

Abstract No. 141.

Branson, F. A. 1953. Two new factors affecting resistance of grasses to grazing. J. Range Manage. 6:165-171.

Two factors affecting resistance of grasses to grazing were studied for eight species of grass in the dissected loess plains of central Nebraska. Heights of growing points and the ratio of fertile to vegetative stems were studied in switchgrass, western wheatgrass, little bluestem, big bluestem, Kentucky bluegrass, buffalo grass, blue grama, and side-oats grama. In general, the grasses in which the growing points reached a height that permitted their removal by grazing decreased as intensity of utilization increased, but grasses with growing points at the ground level usually increased. Also species with a high ratio of flower stalks to vegetative stems usually decreased in heavily grazed ranges.

Abstract No. 142.

Branson, F. A. 1956. Quantitative effects of clipping treatments on five range grasses. J. Range Manage. 9:86-89.

Root and shoot production was studied in five western range grasses subjected to three clipping intensities. Growth of both roots and shoots was inversely proportional to the intensity of clipping. However, root production was more detrimentally affected than top production. In all species the numbers of culms were greatest under the least severe of the clipping treatments.

In the five species the growing points (apical meristems) of only two species, western wheatgrass and bluebunch wheatgrass, reached a height that would permit their removal by grazing.

Abstract No. 143.

Branson, F. A. 1956. Range forage production changes on a water spreader in southeastern Montana. J. Range Manage. 9(4):187-191.

Yields, vegetational changes, and chemical composition of plants and soils were studied on a water spreader in southeastern Montana. Yields were 2.6 times greater on the water spreader than on the controls. Basal area increased considerably on the water spreader, on dikes, and in borrow pits. The most striking vegetational changes on the spreader were a decrease in aerial and basal cover of big sagebrush and pricklypear cactus and an increase in foxtail barley.

In general, the protein, phosphorus, and calcium contents of plants from the water spreader were higher than in plants from the controls.

Soil analyses indicated that the water spreader was a slightly more favorable site for plant growth than were the controls.

Abstract No. 144.

Branson, F. A., and J. E. Weaver. 1953. Quantitative study of degeneration of mixed prairie. Bot. Gaz. 114:397-416.

An extensive area of Mixed Prairie in the loess hills of central Nebraska was studied to ascertain the degree of degeneration that had resulted from long periods (60 to 70 years) of grazing.

Abstract No. 145.

Branson, F. A., R. F. Miller, and I. S. McQueen. 1962. Effects of contour furrowing, grazing intensities, and soils on infiltration rates, soil moisture, and vegetation near Ft. Peck, Montana. J. Range Manage. 15(3):151-158.

An area near Fort Peck, Montana was contour furrowed and seeded to crested wheatgrass. After 10 years vegetation measurements were made to determine the consequences. Three grazing intensities and two soil conditions were also available for study.

Abstract No. 146.

Branson, F. A., R. F. Miller, and I. S. McQueen. 1964. Effects of two kinds of geological materials on plant communities and soil moisture, p. 165-175. *In* M. Stelley [ed.] Forage plant physiology and soil-range relationships. Amer. Soc. Agron. Spec. Pub. 5:1-250.

Plant communities and some causal factors were studied on a stony soil and an adjacent soil derived from the Pierre Shale. The area investigated is 8 miles north of Golden, Colorado, at approximately 6,000 feet altitude. Average annual precipitation is 15.2 inches.

Vegetation contrasts on the two soil conditions are great. The three dominant perennial species on the soil derived from Pierre Shale were buffalo grass, blue grama, and western wheatgrass, all of which are characteristics of the mixed prairie association of the Great Plains. True prairie species characteristic of prairies of the Midwest (big bluestem, little bluestem, indian grass, switchgrass, and prairie dropseed) were present in significant amounts on the stony soil; however, most of the other species were montane. Some of the montane species were mountain muhly, sandwort, and beardtongue. More than twice as many species occurred on the stony soil as on the shale-derived soil.

The greater availability (lower tensions) of soil water in the stony soil appears to be the primary cause of the large number of species and generally more mesic flora. Infiltration rates were highest on the stony soil.

Chemical analyses of the stony and shale-derived soils and associated plant species exhibited some interesting anomalies. Although the stony soil contained less zinc, potassium, sodium, and sulfate, plant species from the stony soil contained larger quantities of these nutrients. The higher pH in the shale-derived soil (7.1 as compared to 6.0 to 6.3) and larger quantities of montmorillonitic clays may have reduced the availability of these nutrients to plants.

Abstract No. 147.

Branson, F. A., R. F. Miller, and I. S. McQueen. 1965. Plant communities and soil moisture relationships near Denver, Colorado. Ecology 46: 311-318.

Plant communities and some causal factors were studied on a stony soil, on pebble mounds on stony soil, and on an adjacent soil derived from the Pierre Shale in an area 14 miles northwest of Denver, Colorado, at approximately 6,000 ft altitude. Average annual precipitation is 15.2 inches. The three dominant perennial species on the soil derived from Pierre Shale were buffalo grass, blue grama, and western wheatgrass, all of which are characteristic of the mixed prairie association of the Great Plains. True prairie species characteristic of prairies of the Midwest, big bluestem, little bluestem, Indiangrass, switchgrass, and prairie dropseed, were present in significant amounts on the stony soil; however, most of the other species were montane. Some of the montane species were mountain muhly, sandwort, and beardtongue. More than twice as many species occurred on the stony than on the other two soil conditions.

The great availability (lower tensions) of soil water in the stony soil appears to be the primary cause of the larger number of species and generally more mesic flora. Infiltration rates were highest on pebble mounds and stony soil. Although the stony soil contained less zinc, potassium, sodium, and sulfate, plant species from the stony soil contained larger quantities of these nutrients. The higher pH in the shale-derived soil (7.1 as compared to 6.0-6.3) and larger quantities of montmorillonitic clays may have reduced the availability of these nutrients to plants.

The presence of vegetation on pebble mounds that indicates either disturbance or droughty conditions is attributed to the activities of the mountain pocket gopher. Species prominent on mounds were cheatgrass, sixweeks fescue, ragweed, and hairy goldaster. Similar soil water conditions in mounds and in stony soil indicate that the two soils should have the same kind of vegetation if disturbance is not a factor. Evidence suggests that pocket gophers may be the causal factor for both the mounds and the subclimax vegetation on mounds.

Abstract No. 148.

Branson, L. R. 1941. An analysis of seed production of native Kansas grasses during the drought of 1939. Kansas Acad. Sci., Trans. 44:116-125.

The purpose of the study was to determine the production of caryopses in the native grasses of Kansas during the drought of 1939. Samples of native grass seed were collected from all the grass regions of the state of Kansas. These samples were analyzed to determine the percent of perfect and pistillate florets containing caryopses.

The methods of recording the seed set of the native grasses studied was the percent of caryopses per hundred florets. Although this method of recording seed set has been used but very little in the past, its use by investigators should clarify the confusion that now exists in literature pertaining to the production of caryopses by native grasses.

This study indicated that the production of caryopses by native grasses correlated with the available soil water during the period of flowering and seed maturing and that other climatic factors were indicators of caryopses production to whatever extent they affected soil water.

Abstract No. 149.

Bray, J. R. 1960. The chlorophyll content of some native and managed plant communities in central Minnesota. Canadian J. Bot. 38:313-333.

Concentration of chlorophyll per unit area of land surface was measured for six forests and 13 native and managed herbaceous stands in central Minnesota. Chlorophyll samples were extracted in acetone and in ethyl ether, and spectrophotometric analysis made of chlorophyll *a* and *b* content. Wet and ovendry weights of the aboveground crop were determined.

A highly significant correlation was found between the dry weight of the aboveground crop of the annual herbaceous stands and the chlorophyll content of these stands. All stable natural herbaceous stands had an approximately similar ratio of chlorophyll to the dry weight of aboveground parts.

Chlorophyll content in grams per square meter of land surface along an upland gradient from field crop through native communities of increasing age or successional development or both was *Zea mays* (2.7), *Soja max* (0.9), younger to older successional stages of old field (0.3 to 0.6), native prairie (0.7), xeric (more open) savanna (0.6), mesic (less open) savanna (1.0), conifer-hardwood forest (3.1). Chlorophyll content for a pond hydrosere from the *Nymphaea odorata* margin through *Carex lasiocarpa* mat to *Chamaedaphne calyculata* shrub and *Larix laricina* forest increased from 0.3 to 1.4 g/m^2. Values for a younger and older *Populus tremuloides* lowland grove were 1.7 and 5.9 and for a *Typha* marsh were 4.6 g/m^2.

These data showed a tendency for later successional stages to exceed earlier stages, for some lowland stands to exceed upland stands, for forest to exceed herbaceous communities on a given moisture level, and for field crops to exceed prairie and old field. The upland old field to forest sequence and the lowland *Nymphaea* to *Larix* sequence had similar chlorophyll contents for a given stage of successional development. There was a highly significant positive correlation between chlorophyll content and height of the arboreal stands and a significant positive correlation between chlorophyll content and herbaceous stand height.

A significant difference in chlorophyll content was found between all stands with three or more sample plots, except those with closely correspondent mean values. The maximum difference between stands was twentyfold, which does not support previous studies which have suggested a similarity of chlorophyll content in diverse communities.

Chlorophyll concentrations and wet and dry weights per various plant parts are presented for the seven tree samples and the presence of chlorophyll in other than leaf parts emphasized.

Abstract No. 150.

Bray, J. R. 1963. Root production and the estimation of net productivity. Canadian J. Bot. 41:65-72.

Data on the net production of ovendry organic matter from 28 temperate angiosperm herbaceous species and 4 temperate arboreal species were analyzed to determine the relationship between belowground and aboveground yearly increment. Mean yearly net herbaceous production (t/ha) was 3.9 for belowground parts, 5.9 for aboveground parts, and 9.8 total. Mean yearly net arboreal production (t/ha) was 1.9 for belowground parts, 8.9 for aboveground parts, and 10.8 total.

The mean belowground/aboveground ratio and mean belowground production was significantly higher for herbaceous species. Mean aboveground production was significantly higher for arboreal species. There was no significant difference between total herbaceous and total arboreal production. Productivity comparisons based only upon aboveground parts are likely to be biased in favor of arboreal species.

In herbaceous species, root production decreased with age and increased from fruit crops to root and tuber crops, and the belowground/aboveground ratio increased from moist to mesic to xeric species. Arboreal species were uniform in belowground/aboveground ratios.

Abstract No. 151.

Bray, W. L. 1906. Distribution and adaptation of vegetation of Texas. Texas Univ. Bull. 82. 108 p.

The preparation of this bulletin was begun under the stimulus of desiring to present to the teachers in the public schools of Texas a point of view from which to study the vegetation of the state. The aim is not to supplant other phases of botanical study, but to supplement them. Nor is the bulletin addressed solely to teachers in public schools, but to teachers in all schools and to the larger public which may wish to enlarge its knowledge and appreciation of the varied and interesting vegetation of our state's vast area.

We are to consider in this bulletin the vegetation of Texas as a whole from the standpoint of its relation to environment. We are wont to speak with enthusiasm about the great diversity of climate, of soils, and of physiographic features in Texas. This diversity is measured in terms of the plant life which has adapted itself to these diverse conditions. The densely luxuriant forests of east Texas and the desert vegetation of cacti agaves, yuccas, and greasewood of the Great Bend of the Rio Grande are the extremes of this measure.

Mention of these extreme types of vegetation suggests that we have before us these three questions: first, the adaptation of the individual plant or species to its environment; second, the association of plants together thus constituting types of vegetation; third, the geographical distribution of these types of vegetation over the state.

Abstract No. 152.

Breazeale, J. F., and F. J. Crider. 1934. Plant association and survival, and build-up of moisture in semi-arid soils. Arizona Agr. Exp. Sta. Tech. Bull. 53:93-123.

This bulletin presents the results of experiments covering a period of several years upon moisture translocation by plants, plant association, and plant survival in dry-land soils. It has been shown:

1. That roots of certain plants are able to penetrate soils that are below the wilting point.

2. That plants are able to absorb moisture from one soil horizon, where it is available, and to transport this moisture and exude it into another soil horizon where it is scarce.

3. That a certain amount of dependence of one plant upon another may exist in nature in relation to their moisture supply. A deep-rooted plant may absorb moisture from the subsoil, transport this and exude it into the surface soil where a shallow-rooted plant may absorb it and thus tide over periods of stress.

4. That certain dry-land plants can endure drought as long as they are able to exude water which has been stored up in their tissues and thus maintain the soil in close contact with their roots at the wilting percentage.

Abstract No. 153.

Breckenridge, W. J. 1935. A bird census method. Wilson Bull. 47(3):195-197.

During the course of an ecological study of the Marsh Wrens in a limited area in eastern Minnesota, the writer found it desirable to ascertain something regarding the populations of other birds breeding on the same area.

The observer, traversing the section along compass lines, identified each individual bird, as far as was possible, as it was encountered and recorded the species and the approximate distance in steps from the compass line from which it was seen. These traverses were made during the morning and evening hours when the birds were most active.

The securing of the total population was the primary object in the present study. In order to obtain this, the total number of birds flushed at each of the indicated distances from the compass line was determined and plotted as an open bar. It was assumed that some error occurred in estimating these distances. Accordingly these errors were corrected by distributing the records over ranges, and the result presented a fairly accurate picture of the actual distribution of the birds flushed. A number of individuals walking close together might materially reduce the error from this source. The results arrived at in the above manner must be taken as minimum populations.

Information regarding the actual and relative abundance of the more common species was also secured from the above-mentioned data. Figures similar to the one constructed for the total population were drawn up for the more abundant species separately. A limit was set in each case beyond which the records began to definitely decrease. The number of birds was determined within this limit, and from this the species totals for the square mile were calculated. This method of determining actual bird populations, like all other methods, is open to criticism at various points.

Abstract No. 154.

Bredemeier, L. F. 1958. Measurement of time and rate of growth of range plants with application in range management. J. Range Manage. 11(3): 119-122.

Aerial length measurements of grasses were made over 2 years. *Agropyron smithii* and *Stipa comata* made some growth during the winter. The main growth of these grasses and of *Bouteloua curtipendula*, *Andropogon scoparius*, and *Calamovilfa longifolia* began at roughly the same time and was made within 3 months so that maximum elongation was reached at about the same time. Seasonal variations in amount and time of rainfall had little influence on linear growth.

Abstract No. 155.

Brehm, C. D. 1955. Which way blows the wind? U.S. Soil Conserv. Service, Soil Conserv. 20:246-248.

Wind erosion of soil may result from a single cause, or from a combination of many factors. It is equally true that the control of wind erosion may be effected by a single practice, or under other conditions require multiple practices and combinations. Thus, are posed many interesting questions.

When we have a full understanding of particle sizes, soil erodibility, surface condition, vegetative cover, and wind velocities--do we have all the answers? Generally, yes. Would a knowledge of damaging wind directions be helpful? Are data on prevailing wind directions satisfactory information for predictions as to the direction from which damaging winds will appear? For the last two answers, it appears that we need more data to go on than is now at hand. Wind directions also are important when wind strips or shelterbelts are used as a control measure.

This study of monthly maximum windstorms (wind velocities of 15 miles or more and durations of 2 hours or more) and their directions of flow indicates a need for additional detailed data. It can be seen that further consideration of high velocity windstorms should be given in both the planning and application of conservation practices. Mile-hour and directional data on all high velocity windstorms ultimately may be the best method for determining directional control of soil erosion by wind.

Abstract No. 156.

Brehm, C. D., and H. E. Malmsten. 1954. Contour furrows on pasture and range land. J. Soil and Water Conserv. 9(3):111-114.

Contour furrows were plowed on thousands of acres of western rangeland during and immediately following the great drought of the "thirties."

Overgrazing and drought combined had greatly reduced or eliminated the soil-protecting mantle of grass. These conditions and the resultant accelerated runoff and erosion created a need for conservation practices that would hold water on the land. Contour furrows were found to be one of the effective practices for this purpose on range and pasture land.

Abstract No. 157.

Brennan, L. A. 1932. Mammal extinction in Kansas: I. The prong-horned antelope. Aerend 3.

A general survey of the early history of the prong-horned antelope in Kansas.

Abstract No. 158.

Brennan, L. A. 1934. A check list of the amphibians and reptiles of Ellis County, Kansas. Kansas Acad. Sci., Trans. 37:189-191.

During the years 1931-1934 the writer has made a study of the amphibian and reptilian fauna of Ellis County, Kansas. The specimens collected have been placed in the Department of Zoology of the Fort Hays Kansas State College, Hays, Kansas.

Abstract No. 159.

Brennan, L. A. 1937. A study of the habitat of the reptiles and amphibians of Ellis County, Kansas. Kansas Acad. Sci., Trans. 40:341-347.

A description of the seven habitats present, together with the numbers and kinds of these animals present in each.

Abstract No. 160.

Brian, M. V. 1965. Social insect populations. Academy Press, New York. 135 p.

This book is an attempt to bring together a large number of disconnected observations on populations of social insects and to encourage a comparative approach in the future. Population is simply one of several possible measures of the status of a species; it is naturally influenced in many ways, and it would be easy to extend the scope of this book to cover a much larger part of the biology of social insects. This has, however, been avoided as far as possible, for such important subjects as foraging and feeding behavior or caste determination have recently been thoroughly reviewed by others.

In this review, after enumerating some actual densities, the development of populations is considered, first in an ideal environment, then in progressively more realistic ones. In the last section a tentative consideration of the population control of a few selected species is attempted.

Abstract No. 161.

Brinegar, T. E., and F. D. Keim. 1942. The relations of vegetative composition and cattle grazing on Nebraska range land. Nebraska Agr. Exp. Sta. Res. Bull. 123. 39 p.

The objectives of this study were: to obtain an analysis of the vegetation of tall and short grass rangeland, to observe the activities of cattle on the range, and to determine the effects of grazing upon the vegetation.

It was noted that in the sandhills there was a great diversity of vegetative types. In order of decreasing forage production per acre, these types were: wet meadow, dry meadow, salt grass, dry valley, and dune sand.

The hardland region dominated at present by shortgrasses was an area with very uniform vegetation. There were no distinct vegetative types such as those of the sandhills. One reason for this uniformity of the hardlands was the wide occurrence of blue grama.

The factors of temperature, wind, cloudiness, or other climatic factors seemed to have little or no direct effect upon the activities of the cattle. Neither the rate of stocking nor the type of forage produced had any great effect upon the total hours spent in grazing and resting; but the cattle grazing on the hardlands (irrespective of rate of stocking) grazed and rested for shorter periods than did herds in the sandhills. Thus the length of the grazing and resting cycles seems to be affected by the difference in the type of forage upon which the cattle graze.

The effects of grazing upon the vegetation were studied by an analysis of the grazing zones of each pasture. These zones showed that nearest the watering place there was much disturbance by trampling and overgrazing. The zone nearest the water may be likened to an overgrazed pasture, the zone at an intermediate distance to a moderately grazed area, and the zone near the pasture boundary to a lightly grazed pasture. The various pastures studied showed that after several years of this overgrazing near the windmill the vegetative composition became drastically changed, resulting in the invasion of unpalatable weeds in the abused areas. It appears that a great change in vegetative composition is usually the result of several years of abuse, while the difference in the percentage of utilization in the various zones may be an index to present use.

Probably the most serious factor in the deterioration of the sandhill ranges is the improper distribution of grazing animals over the range area, resulting in extreme overgrazing on parts of the range and undergrazing on other parts. This is also a serious problem in the hardland pastures.

The final aim in range research should be to discover means of securing the essential facts for a better range management program. Probably the three most essential elements in a management program should be: (i) proper season of grazing by the kind of livestock best suited to the area, (ii) use of proper number of animals, and (iii) satisfactory distribution of livestock over the range area.

Abstract No. 162.

Bronson, F. H., and O. W. Tiemeier. 1959. The relationship of precipitation and black-tailed jackrabbit populations in Kansas. Ecology 40(2): 194-198.

Data are presented on the changes in numbers of black-tailed jackrabbits on a study area in relation to the termination of a 5-year drought. The data were collected during the period July 1956 to November 1957 in the Arkansas River valley and the sandhills of east-central Kearny County, Kansas.

An inverse relationship between the monthly precipitation and the abundance of jackrabbits was indicated for the study area located in the edge of the sandhill region. When drought and overgrazing depleted the food supply in the hills, the jackrabbits migrated to the edge of the hills in search of food. When the drought ended and food was again available, the jackrabbits dispersed throughout their normal range. Field observations indicated that north of the Arkansas River valley jackrabbits concentrated because of a lack of suitable daytime resting habitat.

Abstract No. 163.

Brougham, R. W. 1956. Effect of intensity of defoliation of regrowth of pasture. Australian J. Agr. Res. 7:377-387.

A pasture association comprising short-rotation ryegrass, red clover, and white clover was subjected to three different intensities of defoliation by cutting down to 1, 3, and 5 inches.

At 4-day intervals over a period of 32 days, measurements were taken of herbage dry matter yield, the leaf area per unit area of ground, and the percentage of light penetrating to a level 1 inch above the ground surface.

Where pasture was defoliated to 1 inch, light interception was almost complete (95% or over) approximately 24 days after cutting, whereas pastures defoliated to 3 inches and 5 inches intercepted almost all the incident light 16 and 4 days after cutting, respectively.

At these stages of growth the leaf area was approximately 5 square feet per square foot of ground and the herbage yield approximately 1450 lb dry matter per acre, regardless of treatment.

The rate of pasture growth increased until complete light interception was approached, and thereafter an almost constant maximum rate was sustained.

Leaf efficiency (the rate of increase of herbage dry weight per unit area of leaf) was greatly influenced by intensity of defoliation. Efficiency was initially lower following severe defoliation than following less severe treatment. It increased rapidly to a maximum and thereafter declined gradually. Maximum efficiency in the 3 inch and 5 inch cutting treatments was attained when maximum growth rate was first reached. For pasture defoliated to 1 inch, it reached a maximum level during the phase of accelerating growth.

Abstract No. 164.

Brougham, R. W. 1959. The effects of season and weather on the growth rate of a ryegrass and clover pasture. New Zealand J. Agr. Res. 2(2): 283-296.

An experiment is described in which the effects of seasonal climate and of temporary (weekly) weather variations on the growth rate of a pasture of short-rotation ryegrass and white clover were determined. The technique of measurement included replication in time as well as space. Statistical analyses showed significant positive correlations between seasonal trends in growth rate and light and temperature. Positive correlations were also obtained for the weekly fluctuations in growth rate attributable to weather factors. The pasture was irrigated during the summer and early autumn so that water was at all times adequate for growth. The average daily growth rate of the pasture ranged from 10 lb of DM per acre in the winter to 120 lbs per acre in early summer. The weekly fluctuations in growth rate attributable to weather factors were as large as ±50% of the weekly growth rate. The potential annual yield of DM obtainable from this pasture type growing in this locality was estimated as 22,000 lb per acre.

Abstract No. 165.

Brouse, E. M., and D. F. Burzlaff. 1968. Fertilizers and legumes on subirrigated meadows. Univ. Nebraska Agr. Exp. Sta. SB 501. 20 p.

The Agronomy Department in 1945, through its Outstate Testing Program, conducted fertilizer tests on two Holt County meadows. A nitrogen response was obtained on one meadow; another that was extremely wet did not respond to either N, P, or K.

This publication summarizes the fertilizer-meadow research conducted by the authors and associates from 1948 to 1959, inclusive, in the Nebraska sandhills.

Abstract No. 166.

Brouwer, R. 1966. Root growth of grasses and cereals, p. 153-166. *In* F. L. Milthorpe and J. D. Ivins [ed.] The growth of cereals and grasses. Butterworths, London.

Although the root represents one of the three main organs of the plant body, much less attention has been paid to its physiology than to that of the aboveground parts. As well as to its being less accessible and conspicuous, this may be due, at least partly, to the fact that only on few occasions is the root the product to be harvested. On the other hand, the important functions of the root system for the plant as a whole are in danger of being too greatly neglected.

Earlier investigators have approached the problems involved in a descriptive way, and their work has contributed much towards a better insight into them. Recently, the need for a more quantitative approach has become obvious, and this requires a satisfactory understanding of the role of the root system for the plant as a whole.

The picture developed above provides far too simple an explanation of the changes which really occur. One of the most important drawbacks is the fact that we are working with weight ratios, whereas what we are really concerned with are activity ratios. Why do adventitious roots arise so numerously when the environment of the original root system is unfavorable? Is it due to the accumulation of carbohydrates or are growth substances and other materials concerned (Wilkinson and Ohlrogge, 1962)? Why do the remaining roots of a pruned root system branch so intensively? What factors determine the thickness of a root? These and other questions invite many further physiological investigations on a part of the plant which is too frequently neglected.

Abstract No. 167.

Brown, H. L. 1947. Coaction of jack rabbit, cottontail, and vegetation in a mixed prairie. Kansas Acad. Sci., Trans. 50:28-44.

The utilization and dissemination of native plants by the jackrabbit and cottontail on a mixed prairie near Hays, Kansas, were studied. If recently deposited fecal pellets were found near plants partly eaten it was considered that these plants were utilized by the animal that deposited the pellets.

The jackrabbit was found to utilize a total of 34 species of plants. Even the cottontail secured food from 31 species, but several were of non-important woody plants such as smooth sumac, ill-scented sumac, chokecherry, and prairie rose.

Jackrabbits were most abundant on the grazed areas. This was perhaps due to the succulent herbage for food, the short turf for a quick escape, and the scattered bunches of vegetation to furnish portection. The cottontail preferred areas with a thick growth of the taller grasses and societies of weeds and shrubs accompanied with rocks and burrows for protection.

A close correlation was found between the number of pellets and the abundance of jackrabbits and cottontails frequenting an area. A count of .54 jackrabbit pellets per square foot represented approximately one jackrabbit per acre and .5 pellets per square foot indicated about one cottontail to an acre.

Seeds of several species of plants were taken from pellets of the jackrabbit and the cottontail. Germination tests showed that many of the seeds were viable and that passing through the digestive tracts of rabbits increased the germination of some of the seeds. This was especially true of buffalo grass, cactus, and smooth sumac whereas sand dropseed was affected but very little. The jackrabbit was more important than the cottontail in disseminating seeds in pellets. Approximately 12.75 pounds of seed of the sand dropseed were deposited in jackrabbit pellets on an acre in the natural revegetation type. This is considerably more than is recommended for reseeding abandoned cultivated fields.

It seems reasonable to assume from the preceding data that jackrabbits and cottontails are of considerable assistance in introducing seeds of prairie plants into abandoned cultivated fields and range land denuded by drought or overgrazing.

Abstract No. 168.

Brown, H. R. 1943. Growth and seed yields of native prairie plants in various habitats of the mixed prairie. Kansas Acad. Sci., Trans. 46:87-99.

The purpose of this study was to determine variations in growth and seed yield of native prairie plants in various habitats of the mixed prairie, during the seasons of 1939, 1940, and 1941.

The study was made during three years that were extremely variable in climatic conditions. Precipitation during 1939 was 7.84 inches below normal. In 1940 it was approximately normal, and in 1941 it was 4.44 inches above normal.

The mean annual temperature for 1939 was 3.1°F above normal; in 1940, approximately normal; and in 1941, only 1.2°F above normal.

Water content of soil correlated closely with precipitation. During the summer and fall of 1939 no soil water was available for plant growth in the upper 3 feet of soil. In 1940 soil water was available in only the upper 2 feet of soil, except July and August when it was more available to plant growth in the upper 6 inches. In 1941 it was available to plant growth in the upper 3 feet of soil every month, except July, when it was non-available to plant growth in the upper 12 inches of soil.

All types of vegetation suffered greatly during the fall drought of 1939. The more xeric species, however, suffered least. During the wet season of 1941 most species more than regained their loss of the previous two years.

This study indicates that growth and seed yield correlated very closely with the amount of available soil water during the season growth.

Abstract No. 169.

Brown, J. W., and J. L. Schuster. 1969. Effects of grazing on a hardland site in southern High Plains. J. Range Manage. 22(6):418-423.

The vegetation and soil characteristics of an ungrazed butte are compared with those of a similar site on an adjacent High Plains area. Woody plant cover was greater and more diverse on the butte while herbaceous vegetation was more productive and of higher quality. Species composition and production was representative of shallow hardlands of the Southern High Plains region. Soil characteristic differences reflected the detrimental influence of continued herbage removal and trampling by livestock on the grazed area.

Abstract No. 170.

Brown, L. 1933. Mammal extinction in Kansas: III. The gray wolf. Aerend 4.

An early history of the gray wolf on the plains of Kansas.

Abstract No. 171.

Brown, L. 1945. Evidence of winter breeding of *Peromyscus*. Ecology 26:308-309.

Nowhere in literature has the writer found reference to winter breeding in any species of *Peromyscus* in Kansas.

The number of embryos per gravid female varied from 2 to 5 with an average of 3.64.

Young mice about one-half grown were collected in January from a nest under a pile of Russian thistles (*Salsola pestifer*) and horseweeds (*Leptilon canadense*). Three very small mice also were found in February on the same area.

The temperature was considerably above normal from September to March, inclusive. The mean average was 0.98°F above normal for September, October, and November; 1.36° above for December, January, and February and 7.6° above for March. The mercury did not go below +4°F during the fall and winter whereas the average lowest minimum for the five years previous to this study was -11°F. The total precipitation for the time of study was 5.51 inches which is 2.08 inches below normal over a 76-year period.

Abstract No. 172.

Brown, L. 1946. Rodent activity in a mixed prairie near Hays, Kansas. Kansas Acad. Sci., Trans. 48: 448-456.

The utilization and dissemination of native plants by native rodents on a mixed prairie near Hays, Kansas, were studied. If recently deposited pellets were found near plants partly eaten, it was considered that these plants were utilized by the animals depositing the pellets. Also, the presence of leaves, stems, roots, and seeds stored in caches or burrows furnished information on food habits of these animals.

This study indicates that the white-footed mouse and harvest mouse are beneficial to the farmer and rancher in this part of the Great Plains Region because much of their diet is of destructive insects that feed on native and cultivated vegetation.

Animal numbers vary from year to year, depending upon the ecological factors which benefit or deplete the vegetation that supports them.

Abstract No. 173.

Brown, L. 1947. Censusing wildlife. Kansas Acad. Sci., Trans. 50:322-326.

Censusing is the first step in game management, and it is the scarcity of animals or the overabundance of animal numbers that awakens one to the needs of censusing wildlife.

The technician must select the method of censusing that will give the best results for the particular game count. The observer keeps in mind: time allotted, the number of persons assisting, the season, the topography, the animal or animals involved, and the habits of the species. It would be somewhat difficult to get a line count on nocturnal species; therefore, trapping or some other method of censusing would have to be used.

The technique used may be by direct enumeration of whole areas or samples of areas. It may be by ratio based on trapping and banding and then later recapturing. The latter method has been used quite extensively and is probably the most widely used census method practiced today. This method has been used mostly on migratory birds and especially migratory game birds. Direct observation of the condition or density of population through the use of indices has been used to some advantage.

All the wildlife census work should be done under the supervision of a trained wildlife technician. Unexperienced and untrained men do not collect reliable data. One would not think of consulting a common laborer in regard to illness such as appendicitis. Even in trying times we have our pick of the best of doctors who are well-trained in their profession.

The main purpose of a game census is to invoice and see what the wildlife is doing from a business standpoint, as one would check banking interests or livestock upon a ranch. We are interested in wildlife for monetary and recreational purposes. The abundance or scarcity revealed by a game census has much to do with checking predators and opening and closing of the seasons and helps in preserving species that are approaching depletion. It has turned the minds of people to scientific management of game birds and mammals similar to that applied to domestic livestock.

Abstract No. 174.

Brown, L. 1947. Why has the white-tailed jack rabbit (*Lepus townsendii campanius* Hollister) become scarce in Kansas? Kansas Acad. Sci., Trans. 49: 455-456.

The change in distribution of the two species of jackrabbits in Kansas was gradual. The changes in environmental conditions when man began to break up the prairie and plant crops, especially wheat, seems to be the most reasonable explanation for the decrease in numbers of the white-tailed jackrabbit. The changing of the open prairie to cultivated land seemed to make conditions more favorable for the black-tailed jackrabbit to adapt itself to the new agricultural environment. This thought was reported by several of the early pioneers of western Kansas.

Abstract No. 175.

Brown, L. N. 1966. Reproduction of *Peromyscus maniculatus* in the Laramie Basin, Wyoming. Amer. Midland Natur. 76(1):183-189.

The seasonal reproductive cycle of the deer mouse, *Peromyscus maniculatus nebrascensis*, was studied for 15 months in the Laramie Basin of southeastern Wyoming. Females exhibited one annual breeding season from April through August 1964. Peak reproductive activity occurred in May and June when more than 90% of adult females were pregnant or lactating.

The average numbers of corpora lutea and embryos in females taken in April and May were significantly smaller than the mean numbers in June and July 1964. The overall mean number of corpora lutea per breeding female was 5.57 ± 0.46; the average number of embryos, 5.31 ± 0.49; and placental scars averaged 5.33 ± 0.41. Indicated embryonic loss during gestation ranged from 8.8 to 9.5%. Total litter resorption did not occur. Transmigration of embryos from one uterine horn to the other occurred in a minimum of 25.2% of litters. Females showed a synchrony of timing in the occurrences of the first and second pregnancies at the onset of the breeding season in April and May 1964.

A complete cycle of testis development occurred once annually in adult *P. maniculatus* as indicated by testis length and weight, histology, and seminal vesicle length. Minimal activity of the testis occurred in December 1963. This was followed by a slow but continuous increase in testis development to a peak activity in June 1964. A sharp decline occurred in August and continued through November. Regression of testicular activity and resumption of spermatogenesis did not occur in a synchronous manner in adult males.

The annual reproductive cycle of *P. maniculatus* on the Laramie Plains coincided rather closely with the annual photoperiod cycle in Wyoming. Probably increasing day lengths in spring initiate breeding activity and decreasing photoperiods in late summer and fall are a factor in terminating it.

Abstract No. 176.

Brown, P. E. 1917. Importance of mold action in soils. Science 46:171-175.

The occurrence of molds in soils has been noted many times in the past in connection with bacteriological and other studies and various investigations have dealt in a more or less general way with the action of these organisms. It is only within the last year that an attempt has been made in a logical and comprehensive manner to study the occurrence, distribution, and activities of molds in soils and to solve some of the fundamental problems which arise in connection with the growth of these organisms. The results secured at the New Jersey Agricultural Experiment Station not only furnish a basis upon which future experiments may rest, but they also indicate quite distinctly that the growth of molds in the soil may be of great significance.

The transformation of organic and inorganic compounds in the soil has long been considered the particular function of soil bacteria, but molds may also play an important role in such processes, and indeed it is conceivable that in some instances they may prove largely responsible for the simplification of complex soil materials.

It is the purpose of this paper to call attention in a brief way to the varied action of molds in soils, and to present a compilation of various published data and some of our own unpublished results along this line, with the idea of emphasizing the need of further study of these organisms.

Abstract No. 177.

Bruner, W. E. 1931. The vegetation of Oklahoma. Ecol. Monogr. 1(2):99-188.

Oklahoma is 470 miles long and 225 wide. It consists of a plain which slopes from northwest (altitude, 4500 ft) to southeast (400 ft) and includes portions of 11 physiographic provinces, four of which are mountainous. Most of the precipitation falls during the growing season and varies from 45 inches in the southeast to 15 inches in the northwest. Relative humidity decreases from an average of 53% (2 PM, July) eastward to 40 in the west. Water content of soil available for growth is always present in the east, but often deficient at all depths in the northwest. In central and western parts drought periods of 20 to 30 or more days are frequent. They are accentuated by high evaporation (50 inches or more for the six warmer months) and great wind movement. The *Quercus-Hicoria* association of the *Acer-Fagus* formation occupies the eastern fifth of the state. A *Pinus echinata* consocies is found in the southeast. A broad belt of *Quercus-Hicoria* savannah occupies sandy soil extending centrally across the state from north to south. Various flood-plain forests (*Salix-Populus*, *Ulmus-Fraxinus* associes) are found. A *Rhus-Quercus* chaparral fringes the forests. Four grassland types are represented: an *Andropogon* associes wedged between forests on compact soil in the northeast; true prairie forms a broad belt west of the savannah; and still westward, in order of occurrence, are mixed prairie and shortgrass plains. Rate of growth in the several grassland communities has been determined.

Abstract No. 178.

Brusven, M. A., and G. M. Mulkern. 1960. The use of epidermal characteristics for the identification of plants recovered in fragmentary condition from crops of grasshoppers. North Dakota Agr. Exp. Sta. Res. Rep. 3. 11 p.

A study to determine the food habits and preferences of rangeland grasshoppers was begun in the summer of 1959. The method used was essentially the crop analysis. For the successful determination of the contents of the crops of the grasshoppers, it became mandatory to devise a system of qualitatively analyzing the plant material. To facilitate this, plant species associated with the habitats of the grasshoppers were collected. The epidermal characteristics of these plants were compared and categorized in the form of a key.

Abstract No. 179.

Bryan, G. G., and W. E. McMurphy. 1968. Competition and fertilization as influences on grass seedlings. J. Range Manage. 21:98-101.

Nitrogen and phosphorus starter fertilizer with two levels of weed competition in seedlings of five grass species were evaluated by stand counts, total sod reserves, and subsequent forage yields. Weed competition reduced the stand of fertilized switchgrass, but did not affect the stand of any other grass on any fertilized treatment. Weed competition, primarily crabgrass, reduced total sod reserves in big bluestem, Indiangrass, and M-blend bluestem. The second year's forage production of all species was reduced to 28 to 70% of the production from weed-free plots. Fertilization did not improve the stand establishment, but did increase the forage yield of weeping lovegrass, switchgrass, and Indiangrass.

Abstract No. 180.

Bryant, P. T. 1952. Microclimates of three grassland plots in Central Oklahoma. M.S. Thesis. Univ. Oklahoma, Norman. 42 p.

Microclimates in a virgin prairie, a grazed pasture, and an abandoned field in central Oklahoma were studied for a period of 41 weeks. Ten permanent, one-tenth square meter quadrats were established in each plot and relative rates of greening were determined during the spring.

Abstract No. 181.

Bryson, R. A. 1957. The annual march of precipitation in Arizona, New Mexico, and northwestern Mexico. Univ. Arizona Inst. Atmos. Phys. Tech. Rep. on Meteorol. and Climatol. of Arid Region 6. No. 6. 24 p.

This report is concerned with the annual march of monthly precipitation amount in an area comprising the states of Arizona, New Mexico, Sonora, Sinaloa, Durango, and western Chihuahua. Fourier analysis was used to reduce the twenty-year mean monthly values to six harmonic terms, four of which were then plotted on charts and studied.

The results of this study indicate that an area consisting largely of the Sierra Madre Occidental in northwestern Mexico and the portion of Arizona southeast of Tucson constitute a single rainfall province with a strong summer maximum of rainfall. This province also has a winter maximum, but only in Arizona does the semi-annual term exceed the annual in amplitude. Within the United States the Gila and Rio Grande valleys constitute rainfall provinces of internally similar annual march, while the upland areas tend to resemble the Pacific coastal pattern to the west.

Abstract No. 182.

Bryson, R. A., and W. Wendland. 1967. Tentative climatic patterns for some late-glacial and post-glacial episodes in central North America, p. 271-298. *In* W. J. Mayer-Oakes [ed.] Life, land and water. Proc., Conf. Environmental Studies Glacial Lake Agassiz Region. Occasional Paper No. 1, Dep. Anthropol., Univ. Manitoba Press, Winnepeg, Canada.

The purpose of this paper is to present a few tentative reconstructions of past airmass regimes. Until more data are brought together in appropriate format and with good time control, these reconstructions will be necessarily rough and subject to improvement. Thus, we have chosen to attempt partial reconstructions for three times: the late glacial period of about 13,000 to 10,000 years ago, the period around 9,000 to 8,000 years ago, and the period around 5,000 to 3,500 years ago, plus some comments on the smaller fluctuations since that time. It appears that in the past five millenia the pattern has been sufficiently close to the present that climatic variations might best be discussed in terms of perturbations from the present.

The authors have attempted to demonstrate, or at least suggest, that an internally consistent matching of climatic pattern and biotic evidence can be made for the past ten thousand years. The treatment has been far from complete, for the material is voluminous, but at least a few highlights and critical times have been indicated. It is probably superfluous to caution the reader that many statements contained in the preceding paragraphs are inadequately researched and possibly premature. It is believed, however, that the general pattern for North America is approximately as indicated. We hope that the readers will supply more evidence, better interpretation, and appropriate corrections.

Abstract No. 183.

Budd, A. C., and K. F. Best. 1964. Wild plants of the Canadian prairies. Ottawa Dep. Agr. Res. Branch Pub. 983. 214 p.

This handbook was written to supply the need for an easily-understood guide to the wild plants of the Prairie Provinces. It is meant for agricultural representatives, field men, weed inspectors, school teachers, farmers, ranchers, and wild-flower lovers in general.

Botanical taxonomy, or the science of plant classification and naming, is not static, but advances with increasing knowledge. Consequently, botanical names may change. We preferred to use the more familiar scientific names where possible. An example of this is wild mustard, for which *Sinapis arvensis* L. is used in preference to *Brassica kaber* (DC.) Wheeler var. *pinnatifida* (Stokes) Wheeler.

Keys for identification and an illustrated glossary are included. The keys were made as practical and simple as possible. They were tested and revised where necessary, and it is believed that they will prove useful to all persons seriously interested in identifying the common native plants. Emphasis is put on the outstanding field characters of the plants described and on their distribution and habits. Technical terms are avoided, so far as possible, but they are used when necessary for an accurate description.

About 1,200 species of plants are described. Most species that are commonly seen in the area are included. Many introduced weeds are included; however, as new weeds are constantly being reported, some may have been overlooked. Cultivated plants, such as cereals, garden and field crops, are generally omitted. Specimens of most species described are in the herbarium of the Dominion Experimental Farm at Swift Current, Saskatchewan.

Abstract No. 184.

Buechner, H. K. 1944. The range vegetation of Kerr County, Texas, in relation to livestock and white-tailed deer. Amer. Midland Natur. 31:697-743.

Once almost entirely grassland, the present range vegetation of Kerr County is an open oak grassland with an interspersion of cedar brakes covering about 24% of the county. In accordance with physiographic and edaphic factors, the various oaks segregate into well-defined communities. Generally, the arborescent vegetation is determined by soils and physiography, while the ground vegetation is determined by livestock grazing pressures. Cedar has become widespread since the introduction of livestock. A definite succession associated with various grazing intensities exists among the grasses and forbs. Not more than 50 animal units should be placed on one section of 640 acres if the desirable curly mesquite or grama grasses are to be maintained. Deer provide a substantial portion of ranch income and should be included in range management plans.

Abstract No. 185.

Buechner, H. K. 1950. Life history, ecology, and range use of the pronghorn antelope in Trans-Pecos, Texas. Amer. Midland Natur. 43(2):257-354.

The primary objective of the 15-month investigation was to determine antelope food habits and antelope-livestock competition.

Abstract No. 186.

Buffum, B. C., and C. J. Griffith. 1963. The feeding value of beet pulp and feeding beet pulp and sugar beets to cows. Colorado Agr. Exp. Sta. Tech. Bull. 73. 87 p.

An experiment has been carried out on the substation at Rockyford to show the value of beet pulp combined with alfalfa for lamb feeding. In the present bulletin we give a brief resume of the value of beet pulp as determined in other places and report some trials in which beets and pulp were fed to cows on the College farm at Fort Collins.

Abstract No. 187.

Bugbee, R. E., and A. Riegel. 1945. The cactus moth, *Melitara dentata* (Grote), and its effect on *Opuntia macrorrhiza* in western Kansas. Amer. Midland Natur. 33(1):117-127.

In the fall of 1942 the authors became actively engaged in studying the life history of the cactus moth, *Melitara dentata* (Grote), in response to a request from the United States Department of Agriculture for some information about the distribution and prevalence of this insect in western Kansas.

The request was in behalf of the State of California, who wished some live specimens of the moth in order to determine whether it could help in the control of a species of prickly pear cactus. In October 1942 a representative of the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, came to Hays and accompanied by the authors spent a day in the field collecting larvae of the moth to send to California. The larvae were easy to find and many were collected. A search of the literature revealed that very little is known about the more detailed habits of the moth. The authors, therefore, made repeated trips into the field to make observations under natural conditions, as well as to collect material to work with in the laboratory. The study continued from the fall of 1942 to September 1943. This paper presents a summary of the results.

Abstract No. 188.

Bugbee, R. E., and A. Riegel. 1945. Seasonal food choices of the fox squirrel in western Kansas. Kansas Acad. Sci., Trans. 48:199-203.

Observation of the fox squirrels by the authors at Hays, Ellis County, Kansas, over a 4-year period (1939-1943), has uncovered some additional interesting food habits. The squirrels were observed, for the most part, on the campus of Fort Hays Kansas State College or in the immediate vicinity. Hays is located in the mixed-grass prairie region where stands of timber, suitable for fox squirrel habitation, are found only along stream banks or where artificial plantings have been made. The campus has a nice stand of endemic American elms, cottonwoods, and a few hackberries. Smaller numbers of non-endemic species are mixed in among the elms. In addition, Big Creek cuts across the southern end of the campus, and along its banks occur cottonwoods, elms, hackberries, and occasional sycamores, among others. In the heart of the campus proper, there were at least four pairs of squirrels in residence.

Abstract No. 189.

Bukey, F. S., and J. E. Weaver. 1939. Effects of frequent clipping on the underground food reserves of certain prairie grasses. Ecology 20(2):246-253.

The percentage of ash and acid insoluble ash gave no insight into the quantity of food reserves of the plant.

The ash content varied between 4.4 and 9% and the acid insoluble ash between 3.6 and 7.6%.

There was a marked decrease in the percentage of invert sugar, water-soluble hydrolyzable material, and water-insoluble hydrolyzable material under conditions of severe clipping.

Drought during 1934 and 1935 had a similar but smaller effect on the stored nutrients of the control plants for comparable periods (June and July).

The pentosan determination, owing to the formation of furfural from stem parts, proved of little value in the determination of nutrients.

The percentage of nitrogen was almost constant, varying approximately between .42 and .78% under all conditions of growth studied.

Severe clipping of *Andropogon scoparius* and *A. furcatus* decreases the amount of foods stored by the plants in their roots, thus resulting in their destruction in a period of a few years.

Abstract No. 190.

Bullen, F. T. 1966. Locusts and grasshoppers as pests of crops and pasture--A preliminary economic approach. J. Appl. Ecol. 3:147-168.

The amount of damage caused by locusts and grasshoppers is a function of a number of complex variables such as the amount of vegetation eaten daily by a single insect, differences in food preferences between species, the fluctuations of population sizes, and the relative mobility of the insect stages. The last factor is governed, in the case of the Desert Locust, mainly by meteorology which is, in turn, influenced locally by topography. The quantitative loss in yield for many crops depends upon the stage of growth of the crop when attacked.

In estimating the effect of crop damage upon the economy of a country a distinction must be made between subsistence and cash crops, which require different evaluations. Cost-benefit ratios for control campaigns can only be evaluated when both the immediate and longer-term effects of control upon locust population dynamics have been measured and crop damage more accurately estimated.

New locust and grasshopper problems are created and existing ones aggravated by agricultural development in areas of natural vegetation.

A system of estimating the vulnerability of a crop to damage by a locust species in a unit area is described. It amalgamates some of the major variables upon which the vulnerability of a crop depends into a single "Crop Vulnerability Index" value for each unit area.

Abstract No. 191.

Bunger, M. T., and H. J. Thompson. 1938. Root development as a factor in the success or failure of windbreak trees in the southern high plains. J. Forest. 36:790-803.

The early settlers who came to the southern and central high plains from the more humid regions where shelterbelts could be established by merely planting the trees and waiting for them to grow followed these same practices in this treeless region, but without success. They soon learned that trees could neither be established nor maintained as easily in these treeless plains as at home. As a result, the idea that trees could not be grown in this region became widely accepted. For this reason only a few trees have been planted in recent years. In order to obtain better survival and growth, a few farmers have tried various cultural methods, such as clean cultivation. Some farmers even have used dynamite to break the calcareous layers underlying the surface. In spite of these practices, which are doubtless of some value, most of the trees do not withstand the severe drouth conditions existing in this region. Fortunately, some of the species that were planted in these original shelterbelts have survived even the severe drouth period of 1930-1937. From these survivors much can be learned.

Abstract No. 192.

Burgy, R. H., and J. N. Luthin. 1956. A test of the single- and double-ring types of infiltrometers. Amer. Geophys. Union, Trans. 37(2):189-191.

The results of field experiments with ring-type infiltrometers are reported. Infiltration rates obtained with the rings were compared to the infiltration rates obtained by flooding the entire area to determine the number of ring measurements required to characterize the infiltration rate of the area. It was found on a uniform soil profile having no layers restricting the downward movement of water that six infiltrometers gave an average figure that was within 30% of the true mean. The single-ring infiltrometers were compared with the double-ring infiltrometers. There was no significant difference in the results obtained with the two types of infiltrometers on a uniform soil under the conditions of the tests.

Abstract No. 193.

Burzlaff, D. F. 1962. A soil and vegetation inventory and analyses of three Nebraska range sites. Univ. Nebraska Agr. Exp. Sta. Res. Bull. 206. 33 p.

The vegetation defining the grasslands of the Nebraska sandhills may be subdivided into range sites on the basis of the individual species' ability to adjust to factors of the environment and its interrelations with the other components of the plant community.

Using vegetation cover as a measure of forage production, these sites, in respect to their potential, are the dry valley, the rolling sands, and choppy sandhill range site. Each of these sites possesses a set of model soil and vegetation characteristics with definable limits.

When soil characteristics were measured and analyzed, highly significant differences were recorded among areas, among sites within areas, and among depths at the same site. These differences supported the delineation of range sites on the basis of soil characteristics.

Abstract No. 194.

Burzlaff, D. F. 1969. The role of the abiotic factors in the structure and function of the grassland ecosystem, p. 117-123. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The biota of the grassland ecosystem functions through broad fluctuations in each abiotic component of the environment. Such ecosystems are analyzed through a study of various abiotic components and an assessment of biotic response to changes of one or more of these environmental variants. Many of these limits are well documented. The major voids of understanding exist in the very complex interrelationships of the abiotic components and the subsequent impact on the biota. Thus, comprehension of grassland ecosystems will involve complex models of which the abiotic factors are integral components. Simple correlations are not likely to yield additional insight into the structural and functional aspect of grasslands. Investigators pursuing such objectives must select those factors upon which soil and vegetation are most dependent, since it is impossible to study all environmental entities in detail. The nature of interrelationships must be established and interpreted. Studies relative to biota--soil water relationships will prove to be most useful in developing the functional and structural aspects of grassland ecosystems. This will involve both chemical and physical characterization of the soils. In the study of net energy balance, standard meteorological data must be supplemented with measurement of net solar radiation. Detailed documentation of evapotranspiration losses must be obtained. The most relevant information concerning soil water disappearance will be achieved through techniques in precision lysimetry. Complete understanding of soil biodynamics requires measurement of oxidation-reduction levels and gas composition and exchange within the soil atmosphere.

Abstract No. 195.

Burzlaff, D. F. 1971. Seasonal variations of the in vitro dry-matter digestibility of three sandhill grasses. J. Range Manage. 24(1):60-63.

Investigation of the seasonal variation of in vitro dry-matter digestibility of forage of three range grasses was completed. The in vitro dry-matter digestibility declined in all grasses with advance in maturity. Crude protein content declined with advance in maturity and was more highly correlated with dry-matter digestibility than was lignin. Predicted digestibility based on Van Soest's summative equations seemed unrealistically high for forage collections made in late season. No consistent or significant variations in cell-wall constituents or acid-detergent fiber were measured.

Abstract No. 196.

Burzlaff, D. F., and L. Harris. 1969. Yearling steer gains and vegetation changes of western Nebraska rangeland under three rates of stocking. Nebraska Agr. Exp. Sta. Bull. 505. 18 p.

Ten years of heavy stocking (.73 AUM/acre) at the Scotts Bluff experimental range resulted in no major changes in vegetation or livestock performance. The key to maximum production from rangeland without destruction of the grazing resources lies in proper seasonal use and uniform distribution of grazing over the area. The rate of stocking study was discontinued after the 1967 season in favor of an investigation of grazing management systems that incorporated deferred-rotation grazing and heavy stocking rates.

Yearling steers grazing the native ranges at the Scotts Bluff Station gained at rates that averaged in excess of 2.0 lb per day over the period May 15 to July 15. The daily gains declined with advance in season. This was associated with a general decline in nutritive value of the forage and reduced intake of forage.

Providing a 32% protein block as a supplement to forage after July 15 resulted in increased gains for yearling steers. This gain was approximately .6 lb for each 1 lb of crude protein consumed.

Blue grama decreased in its contribution to total cover under the light rate of stocking, but remained constant at other rates. Needle and thread grass increased on all treatments because of favorable precipitation and a delayed "turnout" date in the spring.

Average forage production did not vary significantly between treatments. The drought year had a greater impact on composition and productivity of forage than did variation in stocking rate.

Abstract No. 197.

Burzlaff, D. F., and J. L. Stubbendieck. 1970. Nature of phytomer growth in *Bouteloua gracilis*. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

In this study an individual blue grama (*Bouteloua gracilis*) plant is defined as a shoot that was separated from the other plant material by the presence of a prophyllum and had at least one nodal root. A phytomer is a segment of a shoot, or phyton unit. It is an internode together with the leaf at its upper end and the bud at its lower end.

Mature plants had an average of 16 internodes. The first two basal internodes had scales associated with them. Elongated leaves were associated with the next five basal internodes. The following seven internodes of an average mature plant were elongated and made up the reproductive culm. The last two internodes were located directly below and between the nodes to which the rachises of the spikes were attached.

After initiation of the reproductive growing point, the internodes of the reproductive culm elongated at a relatively rapid rate. The data show that, generally, the internodes did not elongate before the sheath and blade of the leaf reached maximum length.

The leaves of the first seven phytomers were initiated during the growing season previous to the one in which the plant reached maturity. The leaf of phytomer 8 was the first to be initiated after spring growth started in April. The last to be initiated was phytomer 14 just prior to the middle of June.

Abstract No. 198.

Burzlaff, D. F., and D. C. Clanton. 1971. Production of upland hay in the sandhills of Nebraska. Univ. Nebraska Agr. Exp. Sta. SB 517. 13 p.

Annual mowing of upland sandhills is an undesirable practice. Six years of annual mowing decreased yields 26% over biennial mowing at the Reed Hamilton ranch near Thedford.

Late mowing had a 12% advantage in yield over early mowing, but was 2 to 6% lower in digestible dry matter.

Round baling was superior to windrowing or bunching for the storage of upland hay until fed to livestock. This fact was substantiated by the greater decline in digestible dry matter of the bunched and windrowed hay after harvest.

Application of nitrogen and phosphorus fertilizer increased yields of upland hay in the year of application. High rates of nitrogen resulted in a residual response in the year after application.

Abstract No. 199.

Butler, L. G. 1948. Effect of different intensities of grazing on native prairie. M.S. Thesis. Univ. Nebraska, Lincoln. 37 p.

This thesis deals with the composition and condition of vegetation in a native pasture of known grazing history. The pasture is located nine miles northwest of Lincoln and consists of 290 acres of rolling upland, almost surrounded by native prairie.

Abstract No. 200.

Butler, P. F., and J. A. Prescott. 1955. Evapotranspiration from wheat and pasture in relation to available moisture. Australian J. Agr. Res. 6: 52-61.

The changes of soil water to a depth of 5 ft in a simple crop rotation and under permanent pasture during 1948-1949-1950 have been followed in detail. Calculations have been made on a monthly basis of the water storage in the soil and of the evapotranspiration from wheat and pasture and of losses from a bare fallow.

It is shown that in these experiments the relationship between evapotranspiration, evaporation from water, storage of water in the soil, and rainfall can be expressed in the form

$$dI_{tr}/dW = c(2.4 - I_{tr}),$$

where $I_{tr} = E_{tr}/E_w 0.75 = 2.4$ when available water is no longer limiting, and c = 0.12 for wheat, c = 0.10 for pasture, E_{tr} = evapotranspiration, E_w = evaporation from a free water surface, W = stored water plus rainfall = available water.

Water losses from a bare fallow were found to be determined principally by rainfall and soil storage.

Abstract No. 201.

Butterfield, J. D. 1969. Nest site requirements of the Lark Bunting in Colorado. M.S. Thesis. Colorado State Univ., Fort Collins. 59 p. (Advisor: Paul Baldwin).

By looking at the characteristics of the vegetation at the nest site, some of the characteristics of nest site selection have been shown for the Lark Bunting for the shortgrass plains. In this environment a protective plant is found by each nest. Saltbush is "used" more often in this plant and nest association than any other plant. It is associated nearly as much as are all the rest of the plants together, apparently because of greater protective value afforded by its generally dense foliage and the resulting shade and concealment. Browse type vegetation is associated with the nest in a protective role more often than grass and the annual forb types. The birds' nests were associated most often with plants from 6 to 11 inches in height.

The placement of nests on the lee side of the protective plant reduces impact of the physical environment.

Nest densities were highest in the Class III areas (bush and grass). The Class III areas were followed by Class II (shortgrass) and finally by Class I areas (generally taller vegetation). The nest densities were 0.125, 0.10, and 0.06 birds per acre.

The young spend less time (8 to 9 days) on the nest than do comparable bush and tree nesting passerines (10 to 19 days). This is indicative of the relative insecurity of nests on the ground as a whole, as compared with nests located above ground.

Shading of the nest by an associated plant allows the highly-visible, darkly-colored male to participate to considerable extent in the nesting activities. The male was found to share incubation and brooding with the female.

Abstract No. 202.

Caldwell, M. M., and M. L. Caldwell. 1970. A fine wire psychrometer for measurement of humidity in the vegetation layer. Ecology 51(5):918-920.

A small, compact, fine wire thermocouple psychrometer was tested under controlled conditions in a climatized wind tunnels. The unit was found to be free of radiation errors and fully ventilated at only 1 cm sec^{-1}. Because of the simple construction and favorable response characteristics, this psychrometer is recommended for measurement of humidity in the vegetation layer.

Abstract No. 203.

Campbell, J. B., R. W. Lodge, and A. C. Budd. 1954. Poisonous plants of the Canadian prairies. Canada Dep. Agr. Pub. 900. 29 p.

There are a few points that need to be emphasized. These are:

1. Of the 60 or so poisonous plants collected, only 12 to 15 are abundant and have a widespread distribution.

2. Many of the plants that are abundant have a short growing season.

3. Poor pasture management practices, including very early spring grazing, carelessness during moving from one pasture to another, and overgrazing, are responsible in part for losses that occur.

4. Losses may increase during periods of drought because poorer quality feeds are eaten, both as pasture and as roughage.

5. Eradication of many poisonous plants is possible, although no one method is applicable to all species.

6. Good pasture management, based on a knowledge of the growth habits of the different species, is effective in reducing losses.

When poisonous plants kill livestock, it can be expected that other animals in the flock or herd will be affected to some degree. It is possible to count deaths, but it is difficult to measure losses due to chronic conditions. Good pasture management will reduce the number of deaths and maintain livestock in a thrifty condition.

Abstract No. 204.

Campbell, J. W., R. W. Lodge, A. Johnston, and S. Smoliak. 1962. Range management of grasslands and adjacent parklands in the prairie provinces. Canada Dep. Agr. Pub. 1133. 31 p.

The total number of livestock raised in the Prairie Provinces has not changed greatly since 1920, but cattle have largely replaced horses. However, the stock load per acre is less than 35 years ago because additional range has been developed.

Although cattle have increased at the rate of 60,000 per year since 1920, the increase has followed a cyclic pattern. This pattern depends partly on the amount of pasturage, which in turn is related to the rainfall.

Some 47,500,000 acres of range and 3,000,000 acres of cultivated pasture are used for grazing. Five types of grassland and an extensive parkland contribute to this acreage.

The principles of range management apply to all vegetational types, although application of them may mean slightly different practices in different districts. These are two critical periods--during the early spring when grass growth is slow and in the fall when the crude protein content of the vegetation is less than required. Two- or three-field rotations do *not* produce more gain per animal than continuous grazing. Strong grass stands can be maintained by spring protection and by leaving a sufficient carry-over.

Cultivated pasture crops are recommended for complementary grazing. For the shortgrass and mixed prairies, a mixture of crested wheatgrass and Rambler alfalfa makes the best spring pasture, and a mixture of Russian wildrye and Rambler alfalfa is the best supplement for summer and fall. In the fescue and true prairies and in the parkland, creeping red fescue, brome grass, timothy, and Rambler alfalfa are the best pasture crops to complement range.

The present livestock population of about 5,200,000 cattle, 270,000 horses, and 750,000 sheep is a light load on the range resources in years when rainfall is higher than average. However, the same load is a very heavy one when drought reduces grass growth. More pasturage is required if cattle numbers are to be increased substantially.

Abstract No. 205.

Campbell, R. S. 1936. Climatic fluctuations, p. 135-150. *In* The western range. U.S. Senate Doc. 199.

The hardships of the great 1934 drought were too severe to leave any doubt that extreme climatic fluctuations contribute greatly to range depletion. Forage production on ranges was so scant in 1934 that wholesale removal of livestock was necessary in parts or all of nearly every western state. Where the drought prevailed, range vegetation simply failed to produce sufficient feed to support the numbers of livestock being grazed. Tall grasses in Nebraska, grama grasses in Montana and New Mexico, and bunchgrasses in California, in the drought areas, either failed to grow or dried up early in the season.

What happened in 1934 has happened before, and the cumulative effect is no less than widespread depletion of the range resource already outlined--devastating in its immediate effects and far-reaching in its consequences. Each time, climate has played an integral part in the depletion. It is obvious that a sound program of management to restore and maintain the range must include an evaluation of (i) climate and its fluctuations and (ii) the influence of such fluctuations upon range vegetation and use.

Abstract No. 206.

Campbell, R. S., and E. H. Bomberger. 1934. The occurrence of *Gutierrezia sarothrae* on *Bouteloua eriopoda* ranges. Ecology 15:40-61.

Bouteloua eriopoda, the most important forage grass in southern New Mexico, and of considerable value as range forage throughout the semiarid southwest, is subject to serious depletion as a result of drought or over-grazing or both. Its revegetation ordinarily is quite slow because it reproduces poorly by seed and migrates almost entirely by vegetative processes.

Gutierrezia sarothrae has been observed to replace the *Bouteloua* on areas continually over-grazed. This dominance of the worthless shrubs is due largely to the fact that usually they are not relished by range livestock under ordinary conditions, while the palatable forage grasses may be killed entirely by injudicious grazing, especially during drought. Nevertheless, these shrubs have a definite soil protective value. A study of the occurrence of *G. sarothrae* in a representative *B. eriopoda* association on gravelly sand was started in 1924. The area had been badly depleted by severe drought and some over-grazing. Three quadrats, each containing three square meters were established and charted every year from 1924 to 1930, inclusive.

Abstract No. 207.

Canfield, R. H. 1934. Stem structure of grasses on the Jornada Experimental Range. Bot. Gaz. 95: 636-648.

1. In the species of grasses observed, the types of stem structure in the Jornada Range grasses apparently reflect the moisture requirements and the periods of growth.

2. The solid stem is characteristic of the grasses which are apparently best able to survive under the semiarid conditions of the Jornada region.

3. Almost three-fourths (74%) of the grasses collected have solid stems.

4. Tribes commonly reported as having solid stems, Andropogoneae and Nazieae, are represented by one genus each.

5. Solid stemmed perennial grasses produce 85% or more of the forage.

6. Hollow stemmed grasses either grow only in the more favorable locations or escape drought by completing their growth during a few weeks of highly favorable moisture conditions.

7. Hollow stemmed grasses have not the ability to withstand the long dry periods.

8. There are strong indications that the solid stem is an index which may be employed in the selection of grasses for introduction into semiarid regions.

Abstract No. 208.

Canfield, R. H. 1939. The effect of intensity and frequency of clipping on density and yield of black grama and tobosa grass. U.S. Dep. Agr. Tech. Bull. 681. 32 p.

Clipping experiments on semidesert black grama range indicate clearly that persistent cropping of all herbage of this grass to a 2-inch height or less eventually results in destructive reduction of tuft area regardless of frequency of seasonal harvesting; it reduces forage yield to zero; it prevents survival and even establishment of reproduction of the forage grass; it entirely outweighs all beneficial effects of above-average rainfall; and the end result is rapid and critical deterioration of the black grama site through excessive wind and water erosion.

Abstract No. 209.

Canfield, R. H. 1948. Perennial grass competition as an indicator of condition of south-western mixed grass ranges. Ecology 29(2):190-204.

The floristic composition of native grass populations reflects the condition of the range and the history of past use. The various stages of range condition are characterized more or less by distinct perennial grass population patterns. Examples of grass population patterns are presented for guidance in the management of two types of south-western semidesert grassland ranges. These examples demonstrate the value of perennial grasses as range condition indicators and add precision to the judgment of the range manager. Shrubs and woody noxious plants move in too slowly and persist too long to be of any great value as indicators in detecting the early stages of either range recovery or range deterioration.

Abstract No. 210.

Carder, A. C. 1970. Climate and the rangelands of Canada. J. Range Manage. 23(4):263-267.

Climate is only one of several forces that promote rangelands, but it is often predominant. Climatic factors that favor the development of grass include the occurrence of extremes, recurring drought, prolonged periods of heat and cold, high winds, and prehumid conditions. Most of the grasslands of Canada fall within Köppen's climatic type "middle latitude dry" and summer drought plays a major role in their existence. There are other grasslands which evolve under quite different climatic regimes. These are much less extensive; and, with some, climate is not the dominant cause. With one grassland form, however, climate does play a more direct role, and the factors involved are almost the antithesis of those which have produced the vast rangelands of the semiarid Canadian west.

Abstract No. 211.

Cardon, P. V. 1949. The mild west. Agron. J. 41(1): 1-8.

A speech was presented on the general program at the annual meeting of the American Society of Agronomy at Fort Collins, Colorado, August 24, 1948 by the current research administrator, ARS, USDA. The highlights were a definition of the West, a brief history, major physical aspects, inter-relation of land areas, arable land, and prospectii for the future.

Abstract No. 212.

Cardwell, A. B. and S. D. Flora. 1942. Kansas weather and climate. Kansas Agr. Exp. Sta. Bull. 302. 108 p.

Located in the geographical center of the United States, Kansas has a climate generally typical of the American Great Plains Region. Removed from the immediate influence of extensive water areas, its air is dry, its temperature ranges large, and its sunshine abundant. Unobstructed by mountains, its winds flow freely. And its location between the atmospheric moisture supply of the Gulf of Mexico and the vast sources of less humid air from the north and west favors it with a normal sufficiency of precipitation and provides the variety of its wide seasonal ranges in snow and rainfall.

Though the state as a whole is noticeably drier than those to the east, its normal rainfall in every section is fully sufficient for staple crops. Winters are drier, with less snow, than in states lying to the east, and less rigorous than in those to the north. Few parts of the country are favored as Kansas is in the combination of abundant late-spring and early-summer rain and sunshine; and, except for occasional spells of abnormal heat in midsummer and outstanding cold in winter, temperatures over the state are normally pleasant in every season of the year.

Abstract No. 213.

Carley, C. J., E. D. Fleharty, and M. A. Mares. 1970. Occurrence and activity of *Reithrodontomys megalotis*, *Microtus ochrogaster*, and *Peromyscus maniculatus* as recorded by a photographic device. The Southwestern Natur. 15(2):209-216.

Activity patterns of *Reithrodontomys megalotis*, *Microtus ochrogaster*, and *Peromyscus maniculatus* in a relict grassland were investigated utilizing a photographic technique. *Reithrodontomys megalotis* and *P. maniculatus* are shown to be nocturnal while *M. ochrogaster* is largely diurnal. *Reithrodontomys megalotis* and *M. ochrogaster* seem to have activity suppressed by moonlight. Rodent activity could not be shown to relate to any specific microclimatological data collected.

Abstract No. 214.

Carpenter, J. R. 1939. Fluctuations in biotic communities. V. Aspection in mixed-grass prairie in central Oklahoma. Amer. Midland Natur. 22:421-435.

1. As representative of the southern mixed-grass prairies an area in McClain County, Oklahoma, was studied from the standpoint of the aspectional phenomena of the subdominants and influences.

2. The community here was found to be an *Andropogon scoparius-Panicum oligosanthes* mixed-prairie community with local faciations of *Bouteloua gracilis* on the hill tops, *Manisuris cylindrica* on the uplands and sloping prairie, *Andropogon furcatus* and *M. cylindrica* on low upland prairie, and *Bouteloua hirsuta* and *Amphiachyris dacunculoides* forming an erosion facies.

3. Aspection was studied from September 1933 through June 1935. The biotic seasons or aspects of 1934, as expressed by the seasonal organisms, were as follows: prevernal, March 29-April 21; vernal, April 21-May 26; estival, May 26-July 8; serotinal, July 8-September 7; autumnal; September 7-November 30.

4. Seasonal activity on the part of the insects and spiders followed in general the fluctuation pattern characteristic of prairie areas, with a major peak of invertebrate population abundance in the estival period, and a minor peak during the autumnal period, in spite of the extremely dry period of the summer.

5. Observations were likewise made in an area close by which had been burned during the previous spring. It was found that the invertebrate population here was greatly increased during both the estival and autumnal periods on burned high areas, while on burned sloping areas the population was slightly greater throughout the rest of the year. The taxonomic composition, however, was somewhat changed, and study of the additions and deletions of insect species under burn conditions showed that certain forms were indicators of a plagiosere resulting from burning.

Abstract No. 215.

Carpenter, J. R. 1940. The grassland biome. Ecol. Monogr. 10:617-684.

This review of papers on the ecology, habits, and community relations of the more important dominants (grasses), predominants (mammals and birds), subdominants (seasonal plants), and influents (invertebrates) shows that this community has the rank, extent, and stability of a biome (biotic formation) since it has throughout common physiognomy, constant growth form of dominants, similar ecological structure, essentially similar climographic patterns, and homogeneity of predominants and possibly of influents in most cases. Named in terms of its most characteristic and important forms, it is the *Andropogon-Bouteloua-Bison-Canis* (grassland) Biome. Three climax types (associations) are recognized on the basis of distribution of areas of dominance and influence of ecologically important forms: *Andropogon-Bison-Canis* (tallgrass prairie) Association, *Andropogon-Bouteloua-Bison-Antilocapra* (mixed-grass prairie-plains) Association, and *Bouteloua-Bulbilis-Bison-Antilocapra* (shortgrass plains) Association. On a similar basis, three prairie faciations are recognized: northern, southern, and eastern, a portion of the latter (the *Andropogon-Silphium-Citellus* Associes of Illinois) being considered as a postclimax relict, preclimax to the deciduous forest biome. The prairie presociations correspond closely to the faciations. Edaphic woodland inclusions of the prairie are considered as belonging to the same complex of associes as found in Illinois. The shortgrass plains present more major faciations than do the prairie, but the presociations are more uniform. The mixed-grass prairie-plains have faciations which appear to be those of the adjoining associations although most of the principal dominants are important throughout this association. The study concludes with an outline of the structure of this biome.

Abstract No. 216.

Carr, D. J. and D. F. Garff. 1961. The role of the cellwall water in the water relations of leaves, p. 117-125. *In* Plant-water relationships in arid and semi-arid conditions. UNESCO, Arid Zone Res. 16. Proc. Madrid Symp.

The suction pressure of young and old leaves of the Eucalyptus globulus does not seem to vary much according to standard conditions. The relationships that exist between suction pressure, the diffusion pressure deficit, and the relative turgescence have been studied. The suction pressure was measured by using an improved refractory method and the diffusion pressure deficit by the equalization of the water vapor. For all suction pressures and all diffusion pressure deficits, the corresponding values of the relative turgescence vary considerably. This is explained by the role played by the cellwall water when the diffusion pressure deficit is measured by the equalization of water vapor. The quantity of cellwall water of the leaf and the way it acts by conforming to the forces of dehydration are such that, in effect, and according to evidence, this variation is justified. The authors have studied the regulating action of cellwall water in the water relations of the leaf and its incidence in physiology as well as ecology.

Abstract No. 217.

Carter, F. L. 1939. A study in jackrabbit shifts in range in western Kansas. Kansas Acad. Sci., Trans. 42:431-435.

There are two species of jackrabbits found in western Kansas: the whitetail, *Lepus townsendii campanius* Hollister, and the blacktail, *Lepus californicus melanotis* (Mearns). The blacktail is a southern species, and the whitetail is a northern species. Their respective ranges are distinct, but adjacent. The boundary line between their ranges overlaps as little as could be expected with no actual physical barrier between them.

It has been evident to observers for many years that there has been a shift in range of these two species in western Kansas. What has been the extent of this shift in population? Why has it occurred? In an attempt to answer these questions, especially the first one, a study has been made of the history of the two jackrabbit species as they have been observed by early settlers and others over a period of 65 years.

The causes for the shift in range of the two species were not definitely ascertained. Some of the suggestions made by the early settlers of this region are indicated by the following: Climatic changes, human intrusion, and relative numbers of predatory animals. It would be of great biologic and economic value to study further the reasons for this shift in range of the two species of jackrabbits.

Abstract No. 218.

Cassel, J. F. 1952. Breeding bird populations at various altitudes in north central Colorado. Ph.D. Thesis. Univ. Colorado, Boulder. 147 p.

In 1948 the altitudinal distribution of breeding birds in north central Colorado was investigated. Population censuses were made of the birds on thirteen 25-acre plots located in the major plant communities from plains to above timberline. Field studies were conducted between April 12 and August 27, 1948. About 450 hours were spent in taking the censuses.

Three of the study plots were located in the Colorado Piedmont section of the Great Plains Physiographic Province and 10 in the Front Range of the Southern Rocky Mountain Provinces. Two were in Weld County and 11 in Larimer County, Colorado. Six were within Rocky Mountain National Park.

Standard methods of field study and of analyzing the data were used in this study. By field observation during repeated trips the number of breeding territories on the area were determined, and then the population density in equivalent pairs per 100 acres was computed. The latter unit is the standard used for comparison of bird populations.

The habitats censused fall into three main groups: (i) meadow and shrub communities, (ii) coniferous forest communities, and (iii) flood plain deciduous communities.

Comparisons of the populations of these communities were made with others reported for this region and from similar habitats in North America.

Abstract No. 219.

Catlett, R. H., R. G. Beidleman, and G. W. Esch. 1958. An analysis of long-eared owl pellets from northern Colorado. J. Colorado-Wyoming Acad. Sci. 4. 48 p.

This report is based on an examination of pellet remains collected in an isolated ponderosa pine woodland about five miles southeast of Boulder, Colorado. The area where the owls were roosting is an encarpment surrounded by semiarid grassland.

During the winter from December 26, 1956 to February 10, 1957, 61 intact pellets plus additional loose material were collected.

Comparing the food preference of this study with findings from other parts of the country, these owls followed the same pattern in catching the most abundant species. This is evident since the area contains more suitable habitats for *Peromyscus* than for any other species.

It is interesting to note that *Microtus ochrogaster* ranked much lower than *Microtus pennsylvanicus* in an area which has habitats more suitable to the former species. Also, in seven out of eight studies elsewhere in the United States the percentage of *Microtus* taken by long-eared owls was considerably higher than that of *Peromyscus*.

Abstract No. 220.

Cavender, B. R., and R. M. Hansen. 1970. The microscope method used for herbivore diet estimates and botanical analysis of litter and mulch at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 18. Colorado State Univ., Fort Collins. 9 p.

This technical report describes the microscope technique used in the identification of plant fragments in herbivore diets, litter, mulch, and other complex plant species mixtures. This report also shows how to estimate the percentage dry weight each species of plant may contribute in complex mixture.

Abstract No. 221.

Chapline, W. R., and C. K. Cooperridge. 1941. Climate and grazing, p. 459-476. *In* Climate and man. U.S. Dep. Agr. Yearbook.

Many people have tried to fight the climate on the range, but in the long run it gets them. On the other hand, it is a pretty good friend if you learn how to get along with it. Here is an article on that subject in relation to the cattle and sheep business. It includes a brief discussion of pastureland in relation to climate, but most of it is about the range.

Abstract No. 222.

Chilcott, E. C. 1927. The relation between crop yields and precipitation in the Great Plains area. U.S. Dep. Agr. Misc. Circ. 81. 94 p.

At the present stage of these investigations the results seem to indicate certain outstanding features.

Notwithstanding the fact that annual precipitation is a vital factor in determining crop yield, it is seldom if ever the dominant factor; but the limitation of crop yield is most frequently due to the operation of one or of several inhibiting factors other than shortage of rainfall.

It is highly desirable that the fullest possible knowledge be acquired concerning the climatic conditions of the Great Plains. Such information is indispensable to the farmers of this region when planning their cropping systems. Many of the inhibiting factors which limit crop yields are meteorological in character; and others, such as insects and diseases, are very susceptible to climatic conditions.

The Great Plains area has been and should continue to be chiefly devoted to stock raising; and all agencies interested in the agricultural, social, and economic development of this vast region of more than 450,000 square miles should unite in bringing about conditions that will make possible the fullest development of its natural resources for stock production. Crop production should be aimed to supplement livestock production rather than to compete with it.

In its present state of agricultural development, land prices and local taxes in general are too high in proportion to the revenue-producing capacity of the region.

For the homeseeker with small capital and without practical agricultural experience on the Great Plains the chances of success are remote. But where practical experience and adequate capital combine, and when a real economic demand for increased agricultural production develops, the Great Plains of America are destined to become one of the world's greatest food-producing regions.

Abstract No. 223.

Chilcott, E. F. 1937. Preventing soil blowing on the southern Great Plains. U.S. Dep. Agr. Farmers' Bull. 1771. 28 p.

Soil blowing is often a serious problem in the southern Great Plains. The best preventive and control of soil blowing on cultivated land consists in keeping on the surface materials such as crops, crop residues, or clods, that resist soil movement.

Abstract No. 224.

Choate, J. R., and E. D. Fleharty. 1972. Habitat preference and spatial relations of shrews in a mixed grassland in Kansas. Southwestern Natur. (In press).

A field study of *Blarina brevicauda* and *Cryptotis parva* was conducted on a remnant prairie in Ellis County, Kansas. Habits and habitat preference of the shrews was reviewed in terms of preferred plant communities, species types, and relative moisture content, and spatial distribution within the area of home range.

Abstract No. 225.

Choguill, H. S., and J. Dodd. 1959. Paper chromatography of carbohydrate reserves. Kansas Acad. Sci., Trans 62:58-61.

In an ecological study of the growth of two grasses, blue grama (*Bouteloua gracilis*) and sideoats grama (*Bouteloua curtipendula*), it was necessary to make a determination of the carbohydrate reserves. Both a qualitative identification and a quantitative estimation of sugars were needed to find growth and storage trends.

Paper chromatography has been utilized in many instances for both qualitative and quantitative analysis of sugars with sufficient reliability and accuracy to be applicable to this study. Because a very large number of procedures are given in the chemical literature, with varying degrees of success reported in separation and identification, several were investigated and the methods which gave results that were reproducible and provided adequate separation were selected for the study and are described in the experimental discussion.

Abstract No. 226.

Christiansen, J. E. 1944. Effect of entrapped air upon the permeability of soils. Soil Sci. 58: 355-365.

When soils packed in cylinders for laboratory permeability determinations are wetted, some air is trapped in the soil, regardless of whether the water is applied from the top, from below by capillarity, or under a head.

A means of avoiding this air entrapment is to evacuate the dry soil and wet it in the absence of air. For some soils, this method of wetting greatly reduces the final permeability obtained.

Upward flow of water in the permeameter is no assurance of air elimination.

Having once become immobilized, this entrapped air can escape only by dissolving in the water.

Entrapped air causes a large reduction in permeability compared with completely saturated soils. In some instances an increase of more than 30 times the previous minimum rate has been obtained with the elimination of this air.

The presence of air in the soil results in permeability values being affected by variations in pressure and temperature. The increase in volume of entrapped air with increase in temperature results in a relative decrease in flow, which partly compensates for the increase in flow due to the decrease in viscosity of the water.

Abstract No. 227.

Christiansen, M., and A. M. Scarborough. 1969. Soil microfungi investigations, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 23. Colorado State Univ., Fort Collins. 18 p.

In view of an abundance of fungal mycelia in both cultivated and undisturbed soils and their known capacity for decomposition of organic matter, it seems probable that fungi have an important role in elemental and energy cycling within ecosystems. Recent studies have revealed that variations in the existing assemblages of dominant species correlate with such measurable community characteristics as vegetation composition, soil water parameters, soil pH, and litter calcium content.

To our knowledge, the Pawnee Site study, herein reported, is the first quantitative soil microfungal survey for a shortgrass community in the United States. Our objectives in this initial survey were (i) to determine the principal species present and their relative frequencies-of-occurrence in one area of the grassland, using the dilution plate technique, and (ii) to assess the effect of heavy grazing of the cover vegetation on species composition in the soil microfungal population.

Abstract No. 228.

Clark, F. E. 1969. The microflora of grassland soils and some microbial influences on ecosystem functions, p. 361-376. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The soil microflora is the single most important group in the annual turnover of the energy trapped by photosynthesis. The component groups of the microflora are the bacteria, actinomycetes, fungi, and algae. Biomass values for these groups taken in conjunction with metabolism calculations suggest that the great majority of the microorganisms present in soil are dormant or inactive at any given time. Even so, in the course of their periods of intense activity they have tremendous influence on diverse biotic and abiotic components of the grassland ecosystem. Species composition of grassland microfloras, the role of the soil microflora as decomposer organisms, and their participation in those portions of the grassland carbon cycle dealing with the decomposition of plant residues and the formation of soil organic matter are discussed.

Abstract No. 229.

Clark, F. E. 1970. Decomposition of organic materials in grassland soil. U.S. IBP Grassland Biome Tech. Rep. No. 61. Colorado State Univ., Fort Collins. 23 p.

Burial and retrieval of cellulose filter paper or of herbage materials, in conjunction with gravimetry and ignition, has been found an operationally simple procedure for studying microbial responses to the field environment. It has been observed that decomposition at the Pawnee Grassland Site occurs during bursts of microbial activity elicited by favorable conditions of moisture and temperature. During the growing season, decomposition of organic material occurred in a stepwise pattern, with intense activity during seasonal droughts. No soil decomposer activity was observed during the winter months.

Data were also accumulated concerning both the susceptibility of the herbage of different plant species to decomposition and the changes in susceptibility within a given species during the course of the growing season. Grasses were distinctly more resistant to decomposition than were annual forbs. For individual species of either grasses or forbs, early season herbage collections were more susceptible to decomposition than were late season collections. Some good correlations have been observed concerning the fate of herbage materials in soil microbial systems in comparison with their fate in herbivore microbial systems.

Abstract No. 230.

Clark, F. E. 1970. The microbial component of the ecosystem. U.S. IBP Grassland Biome Tech. Rep. No. 52. Colorado State Univ., Fort Collins. 14 p.

Recently, I undertook to draw up from the literature a table to show that, excepting for the dominant primary producers, the microflora is not only the major component of the total biomass, but also is the major furnace for burning up the energy materials stored annually by photosynthesis. I was confident that such a table, once constructed, could also be used to show the high rate of metabolic activity of the microflora. As one progressed down the size scale from large mammals to microbes, one would expect the ratio between the standing crop of a given component group and the annual flow of energy through that component to become progressively larger. Instead, there is a precipitous narrowing, to a value even lower than that given for elephants. Clearly, a discrepancy of this magnitude demands some attempt at explanation.

Abstract No. 231.

Clark, F. E., and E. A. Paul. 1970. The microflora of grassland. Advance. Agron. 22:375-435.

The role of microscopically small organisms in numerous soil processes, particularly those affecting plant productivity, is well recognized. Less well known is a quantity of recently gathered information concerning microorganisms as components of major plant communities and the extent to which they participate in the total energy flow therein.

Although the soil microflora is the single most important group in the annual turnover of energy trapped by photosynthesis, to the authors' knowledge no broad general review of the microflora of grassland has heretofore been compiled. Indeed this review itself achieves little more than fragmentary coverage of the existing literature on the microflora present in grassland soils or associated with either the living or dead vegetation thereon. It makes no attempt to discuss those influences on the ecosystem that the bacteria and fungi may exert in their role as causative agents of plant or animal disease. In several instances in which review discussions do exist on specific aspects of the grassland microflora, citation of such literature is used in lieu of duplicate discussion. In other instances, data are cited for nongrassland soils or communities. This may be either for comparison with similar data for grassland or, if comparable data are not available for grassland, to point up the need for such data. In the context of this review, grassland denotes any landscape which supports mainly grasses as its native vegetation or, if exploited by man, is used mainly for graminous plants.

Abstract No. 232.

Clark, O. R. 1940. Interception of rainfall by prairie grasses, weeds and certain crop plants. Ecol. Monogr. 10(2):243-277.

Long, narrow pans placed beneath the plants were used to determine the amount of water which penetrated the foliage cover. The percentage of interception varied with the intensity of rainfall, density of foliage cover and environmental conditions, of which wind movement and condition of the sky were especially important. *Andropogon furcatus* grassland intercepted 47% of the water applied to simulate rainfall at the rate of an inch during an hour and larger percentages with applications of lower intensity. About two-thirds of precipitation was intercepted during heavy natural rains and as much as 97% of very light showers. Upland forbs intercepted from 20 to 50% of the rainfall, depending upon the intensity. Lowland forbs withheld from the soil as much as two-thirds of the water during light showers. Interception by common weeds ranged from 34% with 1/2-inch rains to nearly 70% with 1/8-inch showers. *Triticum aestivum* withheld nearly 60% of the water during heavy rains and as much as 90% with the lowest intensity. *Avena sativa* intercepted from 43 to 73% of the water applied as showers of varying intensity. During natural rains, from 45 to 73% of the precipitation was prevented from reaching the soil. *Melilotus alba* intercepted the following percentages during an hour: 1/8 inch, 94; 1/4 inch, 92; 1/2 inch, 57; 1 inch, 47; 2 inch, 44. Interception by mat-forming weeds ranged from 9 to 50%. *Eragrostis ciliianensis* and *Buchloe dactyloides* intercepted 16% of heavy rains and 74% of light showers. The maximum capacity of interception of living plant materials ranged from 47 to 261 grams per square foot of area and dead plants held from 156 to 446 grams. During light showers *Medicago sativa* intercepted 89% and during a heavy rain 26%, and *Spartina pectinata* varied from 72% with a 1/8-inch rain to 55% with a 1/2-inch rain during 30-minute periods. Extent of the leaf surface and the number of levels at which water may be held are important factors in determining the percentage of interception. The foliage area of prairie vegetation is 3 to 20 times as great as the soil surface, and leaves are displayed at many levels. In these experiments, the amount of water reaching the soil by running down the stems was found to be small. Interception of rainfall by herbaceous vegetation has an important retarding effect upon runoff and erosion, but causes an important loss of water to the soil.

Abstract No. 233.

Clarke, S. E. 1930. Pasture investigations on the shortgrass plains of Alberta and Saskatchewan. Sci. Agr. 10:732-749.

The shortgrass plains of southwestern Saskatchewan and southern Alberta comprise the largest range areas in western Canada at the present time. The topography of these plains is gently rolling, and in places they are cut by deep river valleys and by canyon-like coulees. The soil varies from a light sandy loam to a heavy clay loam, with certain areas strongly alkaline. Large areas are spotted with so-called "burn-out" depressions which vary in size from a square foot to several square rods and on which there is no humus and little or no vegetation. The average annual precipitation is approximately 13 inches. When not overgrazed, these plains produce a fairly good cover of palatable and nutritious grasses, except on such portions as may be strongly alkaline or badly eroded.

Abstract No. 234.

Clarke, S. E., and E. W. Tisdale. 1936. Range pasture studies in southern Alberta and Saskatchewan. Herbage Rev. 4:51-64.

In southern Alberta and southwestern Saskatchewan there are certain areas of considerable extent that are unsuited for cultivation, due to conditions of climate, topography or soil. Lack of soil moisture due to scanty precipitation and a high rate of evaporation is the limiting factor over most of the area, while in certain localities roughness of topography or unfavourable soil conditions make cultivation impracticable. Attempts to produce cultivated crops in these areas have been generally unsuccessful, and it is now generally recognized that the native vegetation constitutes the best crop which can be obtained from them.

During the early settlement of western Canada most of the prairie sections were used at one time or another for the production of livestock under range conditions. With the advent of more settlers came the change to cultivation and crop production, especially of the cereal grains. At one time it appeared that all of the west might be so transformed and that the ranching industry would give way to grain farming. However, the natural conditions mentioned above halted the march of the plough and assured the range livestock industry of a permanent place in western agriculture.

At present there are about 12 million acres of native range pastures in southern Alberta and Saskatchewan and an estimated four million acres of abandoned farm lands, most of which will revert probably to their original state. In addition, there are several million acres of marginal land, the correct utilization of which has not yet been decided upon, and whose owners will probably continue to fluctuate between dry land farming and ranching, influenced largely by climatic cycles and the relative price of wheat and livestock. During years of above-normal precipitation even the driest portions of the prairie region will yield fair crops, and it is usually during such years that much unwise settlement occurs.

Abstract No. 235.

Clarke, S. E., and D. H. Heinrichs. 1941. Regrassing abandoned farms, submarginal cultivated lands, and depleted pastures in the prairies areas of western Canada. Canada Dep. Agr. Pub. 720. 23 p.

If in future years there should be an increased demand for wheat, some of the grasslands could be brought under cultivation, and they will yield more abundantly after being in grass for a number of years.

This regrassing program will produce additional feed for livestock. At present the livestock population is on the increase. If the acreage devoted to forage crops is not correspondingly increased, and dry years are experienced in the near future, an acute shortage of feed will develop.

Considerable progress has been made in the regrassing program, but much remains to be done. The work should be speeded up and developed to the stage where the regrassing of a portion of their lands will be adopted by farmers in perpetuity as a regular farm practice.

The regrassing program has been in progress during the past six years. During that time regrassing over wide areas and under a great variety of conditions has been accomplished, and considerable information has been recorded. There is an urgent need for the regrassing of additional areas, and to those who contemplate the seeding of dry land to forage crops it is hoped that this bulletin may prove a useful guide.

Abstract No. 236.

Clarke, S. E., J. A. Campbell, and J. B. Campbell. 1942. An ecological and grazing capacity study of the native grass pastures in southern Alberta, Saskatchewan, and Manitoba. Canada Dep. Agr. Pub. 738, Tech. Bull. 44. 31 p.

A survey of the grasslands in southern Alberta, Saskatchewan, and Manitoba was commenced in 1937. The purposes of this survey are to determine the botanical composition of the native grass pastures, to estimate their carrying capacity, and to determine how they can be utilized to the greatest advantage. To date, surveys have been conducted on some three million acres of land located largely in community pastures and on individual ranches. This bulletin presents certain information relative to the types of grassland found within the region, with methods employed in the study of the vegetational cover and in the calculation of carrying capacity, and with some of the results obtained.

Abstract No. 237.

Clarke, S. E., E. W. Tisdale, and N. A. Skoglund. 1943. The effects of climate and grazing practices on short-grass prairie vegetation in southern Alberta and southwestern Saskatchewan. Dominion Canada Dep. Agr. Pub. 747:1-54.

Results of studies of native vegetation at the Dominion Range Experiment Station, Manyberries, Alberta, from the time of its establishment in 1927 up to 1939, are presented. The experimental area consisted of 18,000 acres of native grassland in a semi-arid region of southeastern Alberta. Mean annual precipitation during the period was 10.7 inches while the average seasonal evaporation from an open tank was 33 inches. The soils are of the Brown zonal type and exhibit considerable surface erosion. The principal native grasses, in order of basal area occupied, were *Bouteloua gracilis*, *Stipa comata*, *Agropyron smithii*, *Koeleria cristata*, and *Poa secunda*. The most abundant forbs were *Artemisia frigida* and *Phlox hoodii*. A dwarf clubmoss, *Selaginella densa*, was very abundant but of only minor importance. *Stipa comata* ranked first in total forage production with *Agropyron*, *Bouteloua*, *Koeleria*, and *Poa* following in order. Soil moisture was the principal limiting factor for plant growth, and was usually deficient after mid-July or earlier. A close relationship was found between the seasonal precipitation: evaporation ratio and annual yields of range forage. The mean annual production from clipped plots (during the period 1931-1939) was 279 lb. per acre of air-dry forage. A 7-year experiment at different rates of stocking indicated that the grazing capacity was approximately 30 acres per mature cow for a 7-month season (April to October, inclusive). With heavier rates of use, the plant cover deteriorated and gains of the cattle were reduced. Results of tests of a 3-field system of deferred and rotational grazing were not conclusive. There appeared to be some benefit to the plant cover, but not the livestock, while costs of fencing and water development were increased. The principal effects of overgrazing on the native vegetation consisted of a decline in the abundance, vigor, and productivity of the native grasses, especially the mid-grasses such as *Stipa*, *Agropyron*, and *Koeleria*. Unpalatable herbs and shrubs increased with overgrazing. Marked changes in plant cover occurred during the study period as a result of climatic fluctuations. Decreases in abundance of desirable forage species occurred during a series of drought years even on lightly grazed or protected areas. However, recovery was fairly rapid, and there was no sign of permanent injury except on fields grazed beyond proper capacity. Applications of barnyard manure to native range resulted in marked increases in yield, with benefits from one treatment persisting for as long as 10 years. Burning of range pastures, either in spring or fall, caused reductions in forage yield for a period of 3 to 5 years under moderate grazing use.

Abstract No. 238.

Clarke, S. E., J. A. Campbell, and W. Shevkenek. 1944. The identification of certain native and naturalized grasses by their vegetative characters. Dominion Canada Dep. Agr. Tech. Bull. 50. 129 p.

A key for identification of 102 native and naturalized grasses occurring in pastures and meadows in the Prairie Provinces uses characters of vegetative parts such as sheath, collar, auricles, ligule, and leafblade for their separation. Diagrammatic drawings, emphasizing structural characteristics, and descriptions of these parts are presented for each species. Information is given on growth characteristics, underground portions of the plant, and habitat conditions. Indexes to botanical and common names are included. Nomenclature is in accordance with that used by Hitchcock.

Abstract No. 239.

Clarke, S. E., and E. W. Tisdale. 1945. The chemical composition of native forage plants of southern Alberta and Saskatchewan in relation to grazing practices. Canada Dep. Agr. Pub. 769. 60 p.

The results of chemical analyses of slightly over one thousand samples, representing the principal native forage plants of southern Alberta and Saskatchewan are presented in this publication. The relation of these data to livestock production and grazing practices in the area is discussed.

Abstract No. 240.

Clausen, J. J., and T. T. Kozlowski. 1965. Use of the relative turgidity technique for measurement of water stresses in gymnosperm leaves. Canadian J. Bot. 43:305-316.

Adaptations of Weatherley's relative turgidity technique (Weatherley, 1950), fitting it for use with red pine (*Pinus resinosa* Ait.), white pine (*P. strobus* L.), balsam fir (*Abies balsamea* (L.) Mill.), and eastern hemlock (*Tsuga canadensis* (L.) Carr.) are described. Results of preliminary investigations of sampling variation between trees, whorls, and needle ages in red pine are presented.

Abstract No. 241.

Clements, F. E. 1920. Plant indicators: The relation of plant communities to process and practice. Carnegie Inst. (Washington) Pub. 290. 388 p.

The present book is intended to be a companion volume to "Plant Succession." The latter was planned to contain several chapters on the applications of ecology, but these were omitted on account of the lack of space. Chief among these was the consideration of succession as the primary basis for a system of indicator plants, and this has been made the theme of the present treatise. For the sake of clearness, it has been necessary to give a concise account of the climax communities of the region concerned. The original plan included a brief summary of the priseres and subseres of the various climaxes, but the limitations of space have precluded this. The same reason has made it desirable to deal with principles and examples in the three fields of practice, rather than to attempt a complete account of the host of climax and seral communities which serve as indicators. The general principles and specific indicators have been tested repeatedly during the field work of the past five years, and the treatment has profited from the fact that a special inquiry into indicator relations throughout the West was made during the season of 1918.

Abstract No. 242.

Clements, F. E. 1921. Drought periods and climatic cycles. Ecology 2(3): 181-188.

Relating the annual rings of trees to rainfall and to the sun-spot cycle first suggested the possibility of using the latter for forecasting rainfall from year to year. Practically all the groups of trees studied gave a clear record of growth cycles corresponding closely to the period of the sun-spot cycle. They confirmed the hypothesis that the years of sun-spot maxima were generally marked by deficient rainfall, and those of sun-spot minima by rainfall above the normal. A preliminary examination of the rainfall records for the states west of the Mississippi River showed that the two major drouth periods of 1893-95 and 1870-73 coincided with sun-spot maxima. It also became evident that excessive precipitation had occurred frequently, if not regularly, at the sunspot minima. These facts suggested the probability of an excess of rainfall following the exceptional sun-spot minimum of 1913, and of a marked drouth period centering on the sun-spot maximum of 1917. The excess did not occur until 1914, and became general only in 1915, but its intensity was the greatest recorded for the region as a rule. This partial confirmation of the working hypothesis seemed to warrant a definite forecast of drouth at the 1917 maximum, a drought made more critical by the remarkable excess of 1915.

Abstract No. 243.

Clements, F. E. 1929. Climatic cycles and changes of vegetation, p. 64-71. *In* Report of the conferences on cycles. Carnegie Inst. (Washington) Pub. 129:3-4.

Various types of cycles, as physical, geological, biotic, economic, and climatic, are discussed. The advantage derived from the study of cycles is that of prediction, especially in the case of the weather, a climatic cycle. It may be possible in the future to correlate sun spots and rainfall, so that it will be possible to anticipate drought with some definiteness. The study of tree rings is giving the paleontologist a chance to investigate the climates of the recent past, and it may be possible, by use of the climax plant community as a universal indicator, to reconstruct climates of the geologic past in sequences corresponding to major cycles.

Abstract No. 244.

Clements, F. E. 1936. Nature and structure of the climax. J. Ecol. 24: 252-284.

This is a discussion of the climax as the basis of the dynamic system in vegetation, or for the treatment of biotic communities when animals are also considered. The climax is at once the outcome and the indicator of a major climate and not of a local edaphic compensation or modification of it. When communities of such situations assume some degree of permanence, they are termed proclimaxes. These are distinguished as relicts of former climates, persistent stages of succession, or as consequences of disturbance, chiefly by man or stock. As the community of the widest extent, the climax reflects the subclimates of its climate in corresponding subdivisions or associations. These in turn fall into faciations and the latter into lociations, both characterized likewise by climax dominants and responding to successively smaller divisions of the climate. In addition, each climax exhibits minor communities composed of subdominants, illustrated by composites in grassland. For these, the general term is society, aspect societies being known as sociations and layer ones as lamiations.

Abstract No. 245.

Clements, F. E. 1938. Climatic cycles and human populations in the Great Plains. Sci. Monthly 47:193-210.

The most significant outcome of the practice of testing soil moisture is that it permits an early and impersonal decision as to the advisability of abandoning the growing crop and conserving water for the next one by means of fallow, which serves to keep down weeds. In short, it gives the farmer two chances for a good wheat yield, since fallow usually produces twice as much as continuous cropping. An important item is that moisture determinations render a fairly decisive judgment at a time when the farmer is still inclined to gamble on rain. With the water-content low and rainfall deficient to April first, abandonment of the crop and the use of summer fallow is strongly indicated. To harvest the wheat crop in good years and abandon it in poor ones gives the flexibility needed in a region where dry years are not rare and drought periods are recurrent. It is a type of crop insurance that requires neither subsidy nor enormous granaries, and is peculiarly adapted to maintain the independence of the farmer while it stimulates his thinking processes.

A necessary adjunct to the combined method of anticipation and prediction is the adjustment of crops to seasonal differences in rainfall and soil moisture.

The most serious defect in the past has not been that of climate, natural vegetation, or potential crop production. It has been the common failure to realize that the price of continued use is conservation and that conservation can be secured only by means of the most thorough cooperation. First of all this must embrace all the official agencies, federal, state, and county, in any way concerned with the problem; this unification has already been accomplished to a considerable degree. It has shown farmers the necessity of cooperation among themselves, and it is upon this new development that the conservation of tomorrow should build an enduring system of use without abuse.

Abstract No. 246.

Clements, F. E., and J. E. Weaver. 1924. Experimental vegetation. Carnegie Inst. (Washington) Pub. 355. 172 p.

An endeavor has been made to determine experimentally the factors operating in the composition and sequence of the climax grassland associations lying between the Missouri River and the Rocky Mountains. Lincoln, Nebraska, was selected as representative of true prairie, Phillipsburg, in north-central Kansas, of mixed prairie, and Burlington, in eastern Colorado, of shortgrass plains. The altitude rises from 1,100 ft at Lincoln to 1,900 ft at Phillipsburg and 4,160 ft at Burlington. Since the associations are zoned from east to west, precipitation is the chief factor in determining the type of grassland; it decreases through this series of stations from 28 through 23 to 17 inches annual mean. A fourth station was maintained in the edge of the subclimax prairie at Nebraska City, 50 miles southeast of Lincoln, where the precipitation is 33 inches. In addition to these climatic stations, a series of edaphic ones ranging through gravel-knoll, high prairie, low prairie, salt-flat, swamp, and cultivated field was maintained at Lincoln. Moreover, some reciprocal transplants from Colorado Springs, Colorado; Tucson, Arizona; and Berkeley, California, were made at several of these stations.

Abstract No. 247.

Clements, F. E., J. E. Weaver, and H. C. Hanson. 1930. Plant competition--An analysis of community functions. 5. Competition in the ecotone between woodland and prairie. Carnegie Inst. (Washington) Pub. 398:154-202.

This treats of the experimental analysis of competition as the paramount function of the plant community, together with reaction as its inevitable concomitant. A considerable number of new methods have been devised and the technique perfected in connection with the comprehensive study of this process under both natural and cultural conditions, involving the utilization of climax and seral communities in nature, field crops, and greenhouse control. The initial chapter traces the growth of ideas in this field, especially in relation to ecology, forestry, and agriculture, while the final one discusses the concepts and principles involved. The latter also indicates the path of future progress in connection with the application of principles and methods to forest, grazing, and agronomic research. Four chapters are devoted to the results obtained from experimental cultures in prairie and woodland. These were typically cultures of two species based upon life-form or ecological behavior, and comprised all of the primary relations in the community, namely, dominant vs. dominant; dominant vs. subdominant; subdominant vs. subdominant; tallgrass vs. tallgrass, mid-grass, or shortgrass; etc. The competition between trees and shrubs on the one hand and grasses on the other was analyzed by means of sowing and planting under semi-controlled conditions, as well as under those entirely natural. *Helianthus*, *Triticum*, and *Xanthium* were studied in four densities under field and control conditions with especial reference to water, nutrients, and light; and a number of control series were employed in determining the relative importance of these factors in competition as a process.

Abstract No. 248.

Clements, F. E., and R. W. Chaney. 1937. Environment and life in the Great Plains. Carnegie Inst. (Washington) Suppl. Pub. 24. 54 p.

During recent years the untoward effect of climate has been strikingly in evidence throughout the Great Plains and adjacent regions. The most dramatic phenomenon has been a succession of bewildering dust storms driven by the wind from soil stripped of its protecting grass cover and parched by excessive heat and drought. The failure of crops and the extensive removal of top-soil has led to the abandonment of farms on a large scale and to the belief that a great portion of the land is permanently unsuited to agriculture.

Such views are the outcome of too short a perspective, and hence it becomes imperative to analyze the situation in the light of changes of climate and life as revealed by the geological record. The most definite and reliable data regarding past climates are afforded by the record of fossil plants, and these are reinforced by evidence drawn from fossil animals, sediments, and related sources. Hence, there would seem to be no other basis for predicting future climatic changes and related crop production than to survey the climatic trends of the immediate and more remote past and to correlate them with the responses of plant and animal life. The writers have in preparation a comprehensive statement of this record in western America and its interpretation in terms of changing environments. Meanwhile, it seems appropriate to present a general summary of the results of these studies.

Abstract No. 249.

Clements, F. E., E. S. Clements, F. L. Long, and E. V. Martin. 1939. Ecology, p. 134-140. *In* Carnegie Inst. (Washington) Yearbook 38.

The studies reported in this monograph were conducted at the transplant gardens on Pikes Peak and in a coastal garden at Santa Barbara, California, and a dune garden nearby. Instruments and transplants were maintained at both places throughout the growing seasons, and a large number of perennials have become permanently established to yield further results in adaptation. Results of the study are discussed relative to analyses of the climatic and soil factors of the dune habitat, measurements with scaled and free phytometers, transpiration rates of native species, the structural relations of leaves and root systems, and correlations, including the role of physical factors, growth and life forms, leaf structure and holard, stomatal frequency, significance of salt content, xerophytes of dune and desert, nature of xerophytes, and criteria of xerophytes.

Abstract No. 250.

Clements, F. E., and V. E. Shelford. 1939. Bio-ecology. J. Wiley and Sons, New York. 425 p.

From the beginnings of life, organisms have lived together in some kind of grouping. Since the differentiation of plants and animals, communities in which both occurred and interacted have undoubtedly characterized the arrangement of living things on the face of the earth. We know now that there are no habitats in which both plant and animal organisms are able to live, in which both do not occur and influence each other. In contrast, the development of the science of ecology has been hindered in its organization and distorted in its growth by the separate development of plant ecology on the one hand and animal ecology on the other.

The authors were brought together in this task of attempting to correlate the fields of plant and animal ecology by the common belief that it would tend to advance the science of ecology in general.

The phenomena under discussion naturally bring up the question of the community processes, concepts, and nomenclature. A zoologist may be unfamiliar with various ecological terms in use among plant ecologists, and the reverse is also usually true. Here the writers have not introduced all the terms which they are inclined to use in their individual papers, designed for a more limited group of readers, but have attempted to substitute less technical terms.

Abstract No. 251.

Cockerill, P. W., B. Hunter, and H. B. Pingrey. 1939. Type of farming and ranching areas in New Mexico. New Mexico Agr. Exp. Sta. Bull. 267. 134 p.

In the first part of this study New Mexico was differentiated into 25 type-of-farming and ranching areas and 33 subareas. In delimiting the state into type-of-farming areas and subareas, a wide range of information was used. The distribution of the crops, livestock, and types of farms over New Mexico is largely the result (1) of such physical factors as topography, altitude, type of soil, rainfall, and natural vegetation, and (2) of such economic factors as distance to market, available transportation facilities, and relative profitableness of the enterprises adapted to the state. All these factors, as well as current farm and ranch practices, were given due consideration in locating the boundary lines of the type-of-farming areas and subareas.

The discussion in this bulletin (Part II) describes in considerable detail the type-of-farming and ranching areas into which the state has been divided, portrays the nature of the agriculture in each area and subarea, and enumerates the more pressing problems and needed adjustments.

Abstract No. 252.

Cody, M. L. 1966. The consistency of intra- and inter-continental grassland bird species counts. Amer. Natur. 100:371-376.

The number of species and the bird species diversity, for the first 14 areas, fall between 3-4 and 2.44-3.83, respectively, exhibiting remarkable constancy. The only non-grassland plot, #15, a very uniform needlerush marsh, has two species. Habitats with four passerine species have a mean height $\overline{h}$ of less than .5 ft, with one exception (.71 ft). Three species are present in areas where $\overline{h}$ is .5 or more feet. Therefore, the closer the physical similarity between habitats, the more alike are the species counts. The phenomenon is even more striking when one considers the taxonomic differences and origins of the faunae involved. Families represented in North American plots are, in order of abundance in the censuses, Fringillidae, Icteridae, Alaudidae, Troglodytidae, and Motacillidae. In Iceland the Turdidae contribute to the three species in the census, while in South America most species are members of the Furnariidae (four), and three each of the Tyrannidae and Fringillidae. There is, however, a complete turnover in the finch genera, as with the Icterids.

The non-passerines may be divided into the rather arbitrary categories "water-types," "grouse-types," and raptors, with a view to facilitating the recognition of ecological homologues. Most areas have at least one species in each of the first two categories, and often two or more in the third, in which case one is usually a "searcher" and the other a "pursuer." The heath-tundra regions, characteristic of either high latitudes or high altitudes mostly have two waders, a long-billed and a short-billed form, as do other shortgrass areas. In general, the nonpasserines are inadequate for testing the hypothesis because these birds receive relatively more attention from man and are correspondingly of more patchy occurrence.

If the number of species per habitat seems to have reached a saturation point in these areas, it is reasonable to infer that the kinds of species occupying the habitat are those most appropriate, and hence are better adapted than an equal number of a rather different set of species, as well as better than a different number of species.

The phenotypic convergence observed between these otherwise distinct communities only serves to increase our faith in this inference. A quantitative evaluation of the extent of this convergence, both of morphologic and behavioral characteristics, is being prepared; but, to one familiar with the species concerned, it will already be apparent.

Abstract No. 253.

Cody, M. L. 1966. Spatial and associated patterns in grassland bird communities. Ph.D. Thesis. Univ. Pennsylvania, Philadelphia. 105 p.

Bird species coexist in communities by virtue of some stable subdivision of the resources of the environment. The alternative methods of resource division are relative habitat selection (differential selection of territory sites based on differences in habitat variables) and food specialization (more or less great interspecific differences in food and feeding ecology); intermediate strategies also exist. Study areas were selected in natural grasslands in North and South America with a view to determine from the resident bird communities (a) the habitat variables important in habitat selection; (b) their relation (in magnitude) to habitat selection; (c) the relation between coexistence mechanisms, habitat selection, and food specialization, and (d) the parameter invariance quality of this relation with geographic location and species composition.

Of a wide range of parameters tested, chosen for their connection with the configuration of the habitat, vertical grass density was found to be the most consistently used as an indicator in habitat selection; in North American study areas grass height was also important. Using a discriminant function of grass height and vertical density, a value to the habitat selection, or lack of interspecific territorial overlap, was assigned to each community; a range in this figure over three orders of magnitude was obtained.

A quantification of the relative food specialization was derived for each community, and all factors which might be involved in food finding and actual intake were considered. These amounted to two bill factors (bill length and shape), three behavioral factors (average speed of progression, duration of average stop, and percent of time stationary) and a feeding height factor (representing the distribution of times spent feeding within certain horizontal "layers"). To each factor was assigned a range and a spacing component, and a geometric combination of the three groups of factors was taken as the desired quantity. All communities fall on a straight line plot (inverse relation) of habitat selection against food specialization, when the former axis is scaled logarithmically.

Bird species in short grasslands had a high relative food specialization value, due mostly to behavioral, and less to bill, factors and a small habitat selection figure. In fields of mean heights greater than three feet, a low habitat selection figure was again obtained, but in this case all food specialization resulted from a subdivision of the grassland into horizontal layers, to which species were restricted in feeding activities. Communities resident in medium to tall grasslands (intermediate between the first two) had very high values of habitat selection, but little, if any, relative food specialization. It was thought that neither behavioral nor feeding height differences could be employed in this habitat, as apparently vegetation was too long and dense for the former and too short for the latter.

A model is presented which unifies these results. Using only the possible modes of food resource division and their variation with mean vegetation height as empirical data, all other observed results are predicted and verified. Given a field with a particular mean height and diversity (range in height), it becomes possible to predict the number of species which would occupy the field, or any part of it, the amount of habitat selection employed by the community, and the type (and amount) of food specialization which would be found there. These predictions were possible because of the striking parameter invariance (for all communities in North and South America) shown by the relations obtained in the study.

Abstract No. 254.

Cody, M. L. 1968. On the methods of resource division in grassland bird communities. Amer. Natur. 102(924):107-147.

The birds in 10 different types of grassland, 6 in North America and 4 in South America, were studied over 2 breeding seasons. On each species in each habitat measurements were made on vertical feeding range, feeding behavior and grass type occupied by territories. These are called "coexistence mechanisms" because species can reduce competition between them by differing in any or all of the above three ways. Data is expressed so that each pair of species in a field can be ecologically separate by various amounts from 0 to 100%, per coexistence mechanism. The average ecological difference between species pairs in grasslands was constant between grasslands, including those of both continents. At low grass heights species differ mainly in feeding behavior; at medium heights mainly by choosing different parts of a field and thus separating territories interspecifically; at larger values of grass height by partition of the field into two horizontal feeding layers. With knowledge of grass height and its variance, it is possible to predict the number of species and which coexistence mechanisms will be employed to what extent in the bird fauna which occupies the field. It is speculated that all habitats are equally "saturated" and adapted toward an "optimum" state.

Abstract No. 255.

Coile, T. S. 1936. Soil samples. Soil Sci. 42(2): 139-142.

In studying some of the physical properties of soils, with particular reference to those influencing the movement and availability of water, it is often desirable to obtain soil samples the natural structure of which is undisturbed. Two types of cylinders have been devised and used with success by the writer in the soils of the Duke Forest.

Either of the two cylinders described can be used for obtaining samples of undisturbed soil for moisture equivalent determinations. Sub-samples are cut out to fit the moisture equivalent cups in the laboratory.

Abstract No. 256.

Cole, G. F. 1956. The pronghorn antelope: Its range use and food habits in central Montana with special reference to alfalfa. Montana Agr. Exp. Sta. Bull. No. 516. 63 p.

The range use and food habits of the pronghorn antelope, *Antilocapra americana*, were investigated on a 62,160 acre study area in central Montana where the principal land use was stock raising integrated with alfalfa forage and seed production. Antelope depredations on alfalfa fields in the area were frequently reported by landowners. Field investigations extended through spring, summer, and early fall during 1953 and 1954. Laboratory work was conducted during the two winters.

Abstract No. 257.

Collins, D. D. 1969. Macroclimate and the grassland ecosystem, p. 29-39. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Vegetational distribution in the Great Plains is primarily determined by macroclimatic factors. Of the various climatic factors involved, the amount and seasonal distribution of moisture are the major determining factors. The north-south orientation of high mountain coastal ranges in North America effectively restricts the movements of maritime air inland past the continental divide. At the same time, the lack of east-west topographic barriers allows for free mixing of the warm, humid gulf air mass and the cold polar air mass of the arctic, making the great plains a major region of cyclogenesis and strong cyclone activity. Differences in seasonal patterns and total amounts of precipitation are directly related to the patterns of wind-flow for the three major air streams in the Great Plains. The widespread droughts which occur infrequently in the summer result from a replacement of the moist maritime gulf flow by the dry continental westerlies.

Abstract No. 258.

Collins, D. D. 1970. Comprehensive Network Site description, BRIDGER. U.S. IBP Grassland Biome Tech. Rep. No. 38. Colorado State Univ., Fort Collins. 10 p.

Bridger Site is on U.S. Forest Service land; however, there is a cooperative agreement with Montana State University. The Site is located in southwestern Montana about 14 air miles northeast of Bozeman, Montana (approximately 33 miles by road). The actual research area is approximately 35 acres; the entire bangtail ridge is approximately 15 miles long by 10 miles wide. Census experiments may be conducted over large portions of the entire range. The actual research site has been enclosed by fence and used as an occasional horse pasture by U.S. Forest Service personnel on infrequent occasions since the 1930's.

Abstract No. 259.

Collins, D. D. 1971. The Bridger Site, 1970 progress report. U.S. IBP Grassland Biome Tech. Rep. No. 84. 40 p.

Field data from investigations of aboveground primary production during the 1970 growing season at the Bridger Site are summarized and tabulated. Included are results from grazed and ungrazed areas, as well as two locations on which snow accumulation was artificially increased. Results from a sample of belowground biomass of plant material are also presented, as well as summary charts of air and soil temperatures through the growing season.

Abstract No. 260.

Collins, R. W., and L. C. Hurtt. 1943. A method for measuring utilization of bluestem wheat-grass on experimental range pastures. Ecology 24:123-125.

An objective method for measuring degree of grazing is under development as a first step in defining the proper degree for utilizing forage plants and for better range management. The development of a composite curve is briefly described which shows the height-weight relationship of bluestem wheatgrass, *Agropyron smithii*, using both culmed and culmless forms combined in the correct ratio for the site and year in question. After the percent of plants grazed and their stubble heights are determined by sampling the pastures along transect lines, the total percent utilization for grazed plants is read from this curve. The method is objective and reveals slight differences in degree of grazing.

Abstract No. 261.

Conrad, E. C. 1954. Effect of time of cutting on yield and botanical composition of prairie hay in southeastern Nebraska. J. Range Manage. 7: 181-182.

The effects of five cutting treatments on the yield and botanical composition of a native upland meadow in eastern Gage County, Nebraska, were studied for an eight-year period, 1945-1952. The cutting treatments involved early (early July), midseason (early August), and late (mid-September) cutting each year and early and midseason cutting in alternate years during the six years, 1945-1950. In five of the six years, an aftermath crop was harvested in mid-September from the plots cut early that year. All the plots were cut in midsummer in 1951 and 1952 to determine the cumulative effects of the cutting treatments on yield and botanical composition.

Abstract No. 262.

Cook, C. W. 1942. Insects and weather as they influence growth of cactus on the central Great Plains. Ecology 23(2):209-214.

The recent drought of 1930-1940 has brought a very noticeable increase of cacti in grazing lands of the central Great Plains. Owing to the increasing prevalence of these plants a study was made during the years 1937 to 1940 to determine the causes of cactus increase with dry years and the reverse process during the moderately wet years.

It was found that insects played an important role in the control of cactus, and that rodents, especially rabits, were important agents of seed dispersal.

Three insects, *Chelinidea vittiger* (Uhl.), *Dactylopius* sp., and *Melitara dentata* (Grote), were studied. Only the latter two were considered of great importance.

It was concluded that drought is the primary factor controlling the balance between cactus and insects, but that proper grazing of the native forage greatly aids in producing a favorable habitat for the insects thus inducing an increase in their numbers and a decrease in cactus.

Abstract No. 263.

Cook, C. W. 1966. Carbohydrate reserves in plants. Utah Agr. Exp. Sta. Res. Ser. 31:1-47.

Reserve substances are organic materials that, during certain periods, are elaborated in the leaves but stored in other parts of the plant for later use in energy and growth requirements. They consist largely of carbohydrates and are sometimes referred to as carbohydrate resources or food reserves.

Concentration of carbohydrates in plant storage organs changes with the input of photosynthetic products and translocation of materials from aerial portions of the plant. The rate of carbohydrate use and export from storage to other areas of the plant also changes this concentration. Thus, any factor affecting photosynthesis or utilization of carbohydrates for respiration or growth will affect the level of plant reserves.

Abstract No. 264.

Cook, C. W. 1970. Ecosystem approach to teaching range science. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Range management today is an integral part of land resource management. The range scientist will have an area of competence only after he demonstrates to other related disciplines that he has a sound understanding of the ecosystem, its structure and its function. He must know how manipulation or modification of the ecosystem affects the various components of the system. In decision making the range scientist must defend his action logically and scientifically so that his views are clearly understood by people.

Abstract No. 265.

Cook, C. W. 1970. The ecosystem concept in an undergraduate curriculum in range science. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Rangelands involve about one-third of the land area of the world. These lands are hillier, rockier, drier, and more remote than most croplands. The value of the range resource is more than just forage for livestock. The range resource is being shared with recreationists, managed for watershed values, and protected for wildlife habitat. Never, in the history of civilization, has a natural resource needed greater scientific attention throughout the world. Social changes and political implications have brought about a reevaluation of conventional land use systems.

The range manager of tomorrow must relate the use of the forage resource to modern needs of society, and his management methods must be compatible with limitations of the biological system--the range ecosystem.

Range departments and staff have become academically and scientifically complacent, and as a result they are resistant to change and are reluctant to recognize the fate of the discipline of Range Science. Universities must have the fortitude and foresight to change curriculum. Even though changes in information taught and procedures in doing it are slow and tedious, they must be made. Attention should be given to reorienting course material to make education more comprehensible and usable. The curriculum most be relevant to changing times and demands of a dynamic and fastidious society. Revised curriculum should include new material, be presented in a new approach and be taught by more skilled teachers. The curriculum should reflect modern technology and the concepts of tomorrow's resource management needs. Training must present specialization comparable to contemporary disciplines.

Course material should be refined, meticulously organized and precisely presented. Advanced study should require more involvement by the student in new concepts, techniques, and methods. It is the academic responsibility of the universities to furnish new knowledge, teach this effectively to young eager minds, and graduate competent students.

Man must learn to live as a component within a biological system and not as an outsider who simply manipulates the processes of the system to suit his whims. The range resource of the world represents tremendous wealth and deserves more than secondary consideration. Therefore, the range scientist must come forth and demonstrate his area of competence or be willing to let other related disciplines usurp his profession.

Abstract No. 266.

Cook, C. W. 1970. Seeding methods for Utah road sites. Utah Agr. Exp. Sta., Utah Resource Ser. 52. 23 p.

The following guide lines from a cooperative study of Utah State University, the Utah State Department of Highways Road Commission, and the U.S. Bureau of

Public Roads. The study was concerned with methods and techniques of establishing grass stands on new road construction and involved the use of mulches, fertilizer, methods of planting, weed control, and the testing of adapted species.

Abstract No. 267.

Cook, H. L. 1946. The infiltration approach to the calculation of surface runoff. Amer. Geophys. Union, Trans. 27(5):726-743.

(1) The infiltration approach, while a very useful tool, is still in the earlier stages of development, and before it can be generally employed, many problems must be solved and large quantities of data published.

(2) Only surface runoff may be determined by the use of infiltration data. Conversely, infiltration data cannot be derived from measurements of runoff containing subsurface flow.

(3) A rigorous application of the infiltration approach requires that the runoff be separately calculated for each complex and these values summed to obtain the runoff from a multiple-complex area. Obviously, this process cannot be reversed. It follows that infiltration curves for individual complexes cannot be derived from the runoff and rainfall records of a multiple-complex watershed.

(4) The only rational way to calculate the runoff from a single complex is by the use of infiltration curves.

(5) There are three kinds of infiltration curves: (a) Those showing the variation of the actual infiltration rate through a rain or storm period; (b) those showing the variation of infiltration capacity, with time; and (c) standard infiltration-capacity curves.

(6) Infiltration indices, if wisely selected and properly used, yield runoff estimates suitable for many purposes. For a single complex, these indices have a comprehensible physical meaning. For a multiple-complex watershed, the physical significance is obscure. Whether used for single or multiple-complex areas, the results obtained with indices must be considered empirical.

(7) All infiltration data should be accompanied by a full description of the procedure used in their derivation. Only in this way can correct application of the data be insured.

Abstract No. 268.

Cook, O. F. 1908. Change of the vegetation of south Texas prairie. U.S. Dep. Agr., Bur. Plant Ind. Circ. 14. 7 p.

In south Texas, extensive regions which were formerly grassy open prairies are now covered with a dense growth of mesquite, prickly-pear cactus and many other shrubby plants of intermediate size. It differs locally only in the number of years since the bushes began to grow subsequent to the establishment of the grazing industry on a large scale, the annual burning of the grass by the cattlemen, and finally the fencing of the land for still more intensive grazing. Before the prairies were grazed by cattle the luxuriant growths of grass could accumulate for several years until conditions were favorable for accidental fires to spread. Settlers in south Texas early adopted the practice of burning over the prairies every year; partly to protect their homes against the fires, partly to give their cattle readier access to the fresh growth of grass. While the grass was still abundant these annual burnings were able to keep the woody vegetation well in check though no longer able to drive back the forest or even to prevent a slow advance. In spots where the grass is thin, seedling mesquites and oaks escape the flames and in a year or two begin to shade the ground and gain more protection against the dangerous proximity of the combustible grass. Burning has to be done in the winter when the grass is dry, but the young trees are then in a dormant condition and are much less injured by the fire.

With the building of barbed-wire fences and the provision of permanent supplies of water by wells and reservoirs cattle were greatly increased. There were a series of very dry seasons when the cattle left little grass to burn, often none at all. This was a time of notable prosperity for the bushes and cacti. When the huisach and smaller shrubs and cacti become numerous enough to kill out the grass, the pasturage rapidly diminishes. The ranch owner then encounters the problem of clearing his pastures anew at much expense of labor and time or of selling the more fertile lands in small areas to the truck farmers. This movement toward more intensive agriculture in south Texas is carrying with it the building of railroads and the construction of extensive facilities for irrigation. South Texas was occupied until recently by a few cattle ranches. South Texas is being rushed under the plow to escape the invasion of bushes.

Abstract No. 269.

Cooper, H. W. 1953. Amounts of big sagebrush in plant communities near Tensleep, Wyoming, as affected by grazing treatment. Ecology 34:186-189.

On the area studied, big sagebrush is a dominant in a disclimax which is largely the result of past grazing practices.

Species of natural grazing lands in this area can be grouped according to their behavior under close grazing as decreasers, increasers, and invaders and their relative amounts used as a quantitative measure of departure from climax.

Relative amounts of big sagebrush in excess of 10 percent of total coverage indicated ecological degeneration.

Increase in relative amount of bluebunch wheatgrass afforded a measure of secondary succession on the site studied.

When conservative grazing and occasional resting (deferring) of pastures is practiced on this site, climax grasses can largely replace big sagebrush without artificial aid.

Under favorable weather and grazing conditions, climax grasses can displace big sagebrush on this site within a decade or less.

Abstract No. 270.

Cooper, H. W. 1957. Some plant materials and improved techniques used in soil and water conservation in the Great Plains. J. Soil Water Conserv. 12:163-168.

Observations arising from the use of plant materials for conservation purposes in the Great Plains indicate that the high-producing, improved exotic species and domesticated natives have their greatest value on deep, fertile, arable land where their high potential can be realized through fertilization, crop rotation, and reestablishment. Where soils are not arable or, for other reasons, the objective is a permanent protective and productive cover with a minimum of maintenance, locally adapted climax species best fulfill the needs. Where unnatural species are introduced they must be considered temporary and must normally be maintained artificially.

Abstract No. 271.

Cooper, J. P. 1963. Species and population differences in climatic response, p. 381-403. *In* L. T. Evans [ed.] Environmental control of plant growth. Academic Press, New York. 449 p.

The study of the pattern of variation in contrasting climatic races provides valuable information on the way in which such adapted populations have arisen in the past, and their potentialities for future change. Since the basic objective of crop improvement is to increase the efficiency of utilization of solar energy, such studies should indicate to the plant breeder the most promising sources of climatically adapted material. Much of our understanding of the physiological and genetic mechanisms of climatic adaptation has come from the comparative study of contrasting climatic races within one or closely related species. This approach consists essentially of three integrated stages.

(a) An ecological survey of the pattern of variation in the field or experimental garden, and the correlation of this pattern with known climatic variables.

(b) A more intensive study, often in controlled environments, of the physiological or biochemical responses involved.

(c) An investigation of the genetic basis of these responses and the way in which they have evolved under the selective action of local climate.

Abstract No. 272.

Copley, P. W., and J. O. Reuss. 1970. The quantitative measurement of nitrogen fixation using the acetylene reduction technique. Western Soc. Soil Sci., June 23, Berkeley, California.

Acetylene is a competitive inhibitor of nitrogen fixation. The reduction of acetylene to ethylene is analogous to the reduction of N_2 to NH_3 and can be used to quantitatively estimate rates of nitrogen fixation. This technique was used to measure rates of nitrogen fixation on soil-plant cores from the Pawnee Site of the International Biological Program Grassland Biome. At field capacity moisture levels, fixation was negligible. Rates of nitrogen fixation under saturated or artificially anaerobic conditions ranged from 1 to 5 g/ha/day. Additions of a soluble energy source, coupled with high moisture conditions resulted in substantial rates of fixation, but the efficiency of conversion was low.

Abstract No. 273.

Corbet, E. S., and R. P. Crouse. 1968. Rainfall interception by annual grass and chaparral. USDA Forest Service Res. Paper PSW-48. 12 p.

As the grass stand developed throughout the rainy season the amount of estimated interception loss increased. The loss was high for small storms--especially in spring when warming temperatures stimulate grass growth. When precipitation comes in a series of small storms, interception by grass can be quite large. In Hydrologic Year 1963-64, for example, out of a total rainfall of 15.32 inches, the estimated interception by grass was 13.8% and by brush, 16.6%. Interception loss for large storms, especially if they occur early in the growing season when grass is in its early stages of development, is relatively small. In Hydrologic Year 1953-54, 92% of the 24.92 inches fell in seven storms. The calculated interception loss from grass was 5.0% and from chaparral 10.9%.

Grass in its later stages of growth may give similar or even higher interception values than mature chaparral.

Cattle grazing reduces interception loss from grass by reducing the quantity of vegetation and thus, its interception storage capacity. The interception loss on grazing lands could be estimated by using the interception loss relationship which represents the grass conditions at the time of rain storms. A savings in soil moisture at the same time also would be realized because of the reduced transpiration by the shorter grass plants.

The net water loss to the watershed from grass or chaparral interception can only be surmised. Interception losses from non-transpiring surfaces, such as dead grass or brush stems, would certainly result in a net water loss to the watershed. The net water loss to the plant-soil-water system may not be as high as the gross interception measurements reported in this paper, but its amount is undoubtedly significant in the redistribution of precipitation.

Abstract No. 274.

Cornelius, D. R., and M. D. Atkins. 1946. Grass establishment and development studies in Morton County, Kansas. Ecology 27:342-352.

This study concerns establishment and development of native grasses in revegetation of three problem areas in Morton County, Kansas. Blue grama, side-oats grama, and buffalo grass were planted on hard-land denuded range in 1942, 1943, 1944, and 1945. A mixture of blue grama, side-oats grama, little bluestem, sand bluestem, and sand lovegrass was planted on sand-sagebrush rangeland and on sandy-land farmed areas. These plantings were made in 1941, 1943, and 1945.

The original grass cover of the hard-land denuded range had been destroyed by a combination of drouth, overgrazing, erosion, and soil deposition.

Abstract No. 275.

Cornish, V. 1902. On snow-waves and snow-drifts in Canada. Geogr. J. 20(2):137-175.

On December 5, 1900, I left for Canada in order to study surface forms of snow. My primary object was to continue the investigation of terrestrial surface waves and wave-like surfaces. The forms were studied day by day in the course of snowshoe tramps. Of fresh-fallen snow there appear to be two chief kinds--wet and sticky snow, which falls about 32°F; and dry slippery snow, which falls at about 0°F or at any lower temperature. The subsequent modifications of the snow appear to depend upon pressure, temperature, radiation, and wind. In Canada there was a geographical distribution of the kinds of snow.

Abstract No. 276.

Cosby, H. E. 1960. Rings on the range. J. Range Manage. 13:283-288.

Circular patterns in the vegetation are common on the range lands of North Dakota and Montana. The circles are of different types and have different origins. Data were obtained on two types in 1958 and 1959 and observations were made of these and other types over several years. Of the four types discussed the fungus fairy ring is probably the least widely distributed and is associated with the most mystery and legend.

Circles caused by plowing firebreaks around haystacks often persist long after marking by the plow is obliterated. Single plants which propagate vegetatively, commonly called clones, often form nearly perfect circles on the prairie. These form during periods of secondary succession following great loss of cover, and also during range degeneration when grazable species are kept low in vigor while very short or woody plants advance vegetatively.

Tepee rings are circles of surface stones. Their significance is unknown though it is generally agreed that they were placed by people at a time prior to the advent of white men.

Abstract No. 277.

Cosby, H. E. 1964. Some yield characteristics of range as influenced by soil type and weather. J. Range Manage. 17(5):266-269.

A sampling study was made of herbage yields by specific soil types in the Souris River area of North Dakota during 1958, 1960, 1961, 1962, and 1963. Sampling areas were selected from representative soil types and excellent range condition.

Abstract No. 278.

Cosby, H. E. 1965. Fescue grassland in North Dakota. J. Range Manage.18:284-285.

Local areas of North Dakota grassland are dominated by rough fescue. The composition of the vegetation on these areas is very similar to that of the Fescue Grassland described in Canada. Small amounts of the species are widely distributed across the northern portion of the state.

Abstract No. 279.

Costello, D. F. 1931. Comparative study of River Bluff succession on the Iowa and Nebraska sides of the Missouri River. Bot. Gaz. 91:295-307.

Study of the river-facing bluffs of the Missouri River was undertaken to gain a more accurate concept of the differences that appear to exist between the opposing bluffs.

In order to provide a basis for discussion, a brief description of the order of succession on these river bluffs and their plant associations is given.

The order of succession was found to be the same on opposite sides of the river.

The rate of succession is faster on east-facing bluffs.

East-facing bluffs excel both in number of individuals and in variety of species.

Corresponding associations are found higher on east-facing than on west-facing bluffs.

A greater area is occupied by the linden-ironwood climax on east-facing bluffs than on west-facing bluffs.

These differences, as well as the treelessness of west-facing bluffs, appear to result from the high rate of evaporation caused by prevailing winds during the growing season.

It is hoped to study in detail the environmental factors in the various plant formations and associations on the Missouri River bluffs.

Abstract No. 280.

Costello, D. F. 1941. Pricklypear control on shortgrass range in the central Great Plains. U.S. Dep. Agr. Leafl. 210. 6 p.

More than 5 million acres of range lands in eastern Colorado and eastern Wyoming alone are infested by pricklypear (*Opuntia polyacantha*) to a degree that presents serious problems in range management. This plant has always been present in the central Great Plains, but in recent years it has increased on areas previously infested and has spread to many thousands of acres for the first time.

The pricklypear problem is primarily one of grazing capacity. Not only do the plant's sharp spines prevent the utilization of the cactus by livestock, but also by occupying space where grasses could grow and by keeping livestock from the grasses and other forage plants which grow within the cactus clumps, pricklypear reduces the total amount of forage available. Furthermore, observations indicate that pricklypear not only can withstand drought but can compete successfully with native grasses in favorable years. The only promise of relief from these infestations lies in some method of removal which can be applied effectively and economically.

Abstract No. 281.

Costello, D. F. 1942. Weight gains of cattle strongly influenced by weeds and shrubs as well as by grasses. Colorado Farm Bull. 4(1):14-15.

The importance of weeds, shrubs, and secondary grasses in regulating gains in weight of cattle in the Great Plains is becoming increasingly more evident as a result of studies on the Central Plains Experimental Range, where grazing studies are conducted in cooperation with the Soil Conservation Service. Grazing experiments on this area, located near Nunn in northeastern Colorado, have shown consistent differences of 35 to 60 pounds in seasonal gain of yearling Herefords grazed in a series of 12 pastures of 320 acres each. These differences in gains between pastures are not explainable on the basis of grazing intensity, location of forage, or effect of feeding during the winter. Instead, they appear to be related to the composition of the forage as determined by the percentage of certain grasses, weeds, and shrubs in the pastures.

The rancher should keep in mind that two kinds of weed populations may appear on his pastures: (1) the population composed largely of perennial weeds which remain year after year and fluctuate in luxuriance with variations in rainfall; and (2) the population consisting principally of annual species which dominate in wet years and nearly disappear in dry years. The latter generally are indicators of overgrazing, while the former are normal components of the vegetation and indicate conservative use and a desirable range condition.

The results of this study indicate that abandoned fields which have a good cover of vegetation can profitably be grazed simultaneously with adjoining native blue grama ranges.

No data are available in the present study on the effect of supplemental feeding in connection with the use of ranges consisting of nearly pure grass stands.

Abstract No. 282.

Costello, D. F. 1944. Efficient cattle production on Colorado ranges. Colorado State Coll. Agr. Ext. Bull. 383-A. 16 p.

As an aid to securing increased efficiency in range cattle production, this bulletin presents some of the latest results of investigations made in Colorado by the Rocky Mountain Forest and Range Experiment Station. These results have been obtained on shortgrass ranges and on ponderosa pine-bunchgrass ranges and are applicable in general to most of the plains and mountainous areas of the state. In addition to these research results, some of the important items in ranch operation which should be checked periodically are discussed.

Abstract No. 283.

Costello, D. F. 1944. Important species of the major forage types in Colorado and Wyoming. Ecol. Monogr. 14:107-134.

In order to organize studies and plan the use of range land effectively, it is common practice to base observations of the plant cover on only the most important species present. This selectivity is desirable and essential since critical analysis of the entire plant population is ordinarily impossible or, at least, impracticable.

The principle of selectivity of important species in reference to studies of range forage is illustrated by the work of many investigators.

Therefore, as this combined evidence indicates, it is essential or, at least, highly desirable in dealing with vegetation as forage to select the important species and concentrate observations and conclusions quite generally on these plants. As an aid in this selection for the plant types of a single region, this paper has been prepared.

The data presented are based on numerous recent forage inventories and range surveys in Colorado and Wyoming where more then 2,000 plant species were encountered and recorded. From these data and accompanying observations the following information for each major forage type has been compiled: (1) the most important plants; (2) the frequency of occurrence and relative amount of forage produced by these plants; and (3) a brief statement of the values of these plants in developing range management plans. This information is of immediate use to range administrators and should be of great value to ecologists and range research workers in planning future work in this area.

Abstract No. 284.

Costello, D. F. 1944. Natural revegetation of abandoned plowed land in the mixed prairie association of northeastern Colorado. Ecology 25(3):312-326.

Plant succession on abandoned fields in northeastern Colorado proceeds through the following stages: an initial stage characterized by *Salsola kali tenuifolia*, *Amaranthus retroflexus*, *Chenopodium album*, or other annuals; a forb stage consisting of a large variety of annual and perennial forbs and a few grasses; a short-lived perennial grass stage in which *Schedonnardus paniculatus*, *Hordeum jubatum*, *Sporobolus cryptandrus* or *Sitanion hystrix* are usually abundant; a stage marked by dense stands of *Aristida longiseta* or *A. purpurea*; and the fully developed mixed prairie association, consisting of a mixture of shortgrasses, mid-grasses, forbs, and shrubs.

In relatively undisturbed successions the initial stage lasts from 2 to 5 years; the forb stage, from 3 to 6 years; the short-lived perennial stage, from 4 to 10 years; the Aristida stage, from 10 to 20 years. The transition to climax mixed prairie may require from 10 to 20 years.

Drought cycles and wet years retard or accelerate the rate of succession.

Other factors markedly influencing the rate of succession are topography, intensity and duration of cultivation preceding abandonment, and grazing. Heavy grazing maintains the forb and short-lived perennial grass stages almost indefinitely.

Succession is accompanied by an increase in complexity of the floristic composition. As the various plant species enter in the different stages, they tend to remain so that the climax association contains a large number of the species which have appeared in earlier stages of the sere.

Influents of considerable importance include kangaroo rats, jack rabbits and harvester ants. The small mammals tend to reduce seed production of the mid-grasses. Ants probably affect the seed supply and their mounds provide a substratum for the entrance of shortgrasses into the succession.

Abstract No. 285.

Costello, D. F. 1954. Vegetation zones in Colorado, p. 3-10. *In* H. D. Harrington [ed.] Manual of the plants of Colorado. Sage Books, Denver, Colorado. 666 p.

The elevational range in Colorado varies from 3386 ft at the lowest point in the southeastern plains to 14,431 ft at the top of Mount Elbert in the Rockies. The difference in mean temperature within the state is equal to the difference between southern Florida and Greenland. Annual precipitation varies from less than 8 inches in the low western valleys to more than 40 inches in the higher mountains.

Topographically, approximately two-fifths of Colorado is level and rolling plains, while the western three-fifths is a mixture of mountains, high mesas, narrow valleys, and large upland parks. The San Luis Valley in the southcentral portion of the state is an extensive level basin, once covered by an inland sea.

Because of the extreme topographic relief in Colorado, vegetation zones are sharply delimited and easily recognized. The eastern plains are characterized in general by shortgrasses, but are interrupted by extensive sand hills in which *Artemisia filifolia* is dominant. The foothills at the western edge of the plains support a shrubby mixture, predominantly *Cercocarpus montanus*. Coniferous forest occurs generally between 6500 and 11,000 ft. Above the upper timberline, bluegrasses, sedges, and various depauperate willows give aspect to the alpine flora. Between the lowest elevations and the mountain tops, these plant communities can be observed:

- Plains Area
  - Mixed prairie (mostly shortgrass disclimax)
  - Sand sagebrush
- Semi-desert Area (mostly in western Colorado)
  - Greasewood
  - Saltbush
  - Sagebrush
- Mountain and Plateau Area
  - Pinon-juniper
  - Mountain shrub (*Quercus-Cercocarpus-Amelanchier*)
  - Ponderosa pine-Douglas fir (including the following)
    - Mountain parks, aspen, sagebrush
  - Spruce-fir (including the following)
    - Mountain parks, sagebrush, aspen, lodgepole pine
  - Alpine

Abstract No. 286.

Costello, D. F., and G. T. Turner. 1944. Judging condition and utilization of short-grass ranges on the central Great Plains. U.S. Dep. Agr. Farmers' Bull. 1949. 21 p.

Greatest possible livestock production on western ranges is more essential now than ever before. But maximum livestock production requires adequate range forage or other feed at all times. Because of the relatively high grazing value of the central Great Plains, it is especially important to keep the range in its best possible condition at all times, year after year. For each range, this involves such questions as: Is the range in good shape and growing all the forage it can over the years? Are the important forage plants grazed too closely or are they so utilized that they are able to spread and produce their maximum next year and the year after? Is the forage production above or below normal this year? Is there enough forage on the range to carry the livestock through the growing season?

This bulletin aims to give ranchers of the central Great Plains a basis for judging the condition and utilization of shortgrass ranges, to help them attain maximum sustained production of forage and livestock.

Abstract No. 287.

Cotton, J. S. 1905. Range management in the state of Washington. U.S. Bur. Plant Ind. Bull. 75. 26 p.

Owing to the greatly lowered carrying capacity of ranges in the State of Washington, investigations were begun in the spring of 1901 to determine, if possible, what steps must be taken to preserve these ranges and what methods should be used to bring the badly overgrazed areas back to their original state of productivity.

Abstract No. 288.

Couey, F. M. 1946. Antelope foods in southeastern Montana. J. Wildlife Manage. 10. 367 p.

Stomach samples from 24 prong-horned antelope (*Antilocapra americana*) in Carter County, Montana, were collected during the hunting seasons of 1944 and 1945, mainly during September and October; a few were obtained in November and December. Information is needed to determine the food habits of antelope, about which there is considerable controversy.

Each sample consisted of a pint of stomach contents; this was partly washed in a piece of burlap to get rid of the stomach juices, and then dried in paper envelopes. The foods were classified and visual estimates made as to volume on a percentage basis.

Abstract No. 289.

Coupland, R. T. 1950. Ecology of mixed prairie in Canada. Ecol. Monogr. 20(4):271-315.

Six well-defined communities of the *Stipa-Bouteloua* association are described on the basis of data from 92 relatively undisturbed sites in southern Saskatchewan and Alberta. Detailed studies were made in four Grassland research areas. By the point-transect method, both basal area and percentage composition of the vegetation were ascertained. List quadrats were used to ascertain the relative abundance of subdominants. The *Stipa-Bouteloua*, *Bouteloua-Stipa* and *Stipa-Agropyron* communities occur on loam soils in different parts of the brown and dark-brown soil zones and on different parts of the same slope where relief is pronounced. The *Agropyron-Muhlenbergia* community is subclimax on eroded soils. The *Agropyron-Koeleria* type occurs on heavy soils of lacustrine origin. The *Bouteloua-Agropyron* type occupies clay loam, solonetzic soils. The ecology of each of the principal grasses, forbs, and shrubs is discussed. Grasses and sedges compose 84.5 to 94.8% of the basal cover. Six species are dominant in the climax, namely, *Stipa comata*, *S. spartea* var. *curtiseta*, *Bouteloua gracilis*, *Agropyron dasystachyum*, *A. smithii*, and *Koeleria cristata*. Thirteen other grasses and four sedges are characteristic. Forbs and shrubs compose 5.2 to 15.5% of the cover in different communities. The most abundant forbs are *Artemisia frigida*, *Phlox hoodii*, *Malvastrum coccineum*, *Pulsatilla ludoviciana*, *Gutierrezia diversifolia*, *Solidago glaberrima*, *S. dumetorum*, *Sideranthus spinulosus*, *Chrysopsis villosa*, *Potentilla* spp., *Artemisia gnaphalodes*, and *A. pabularis*. *Rosa* spp. and *Artemisia cana* are the most common shrubs. Four seasonal aspects were observed. Subclimax vegetation of the area is described.

Abstract No. 290.

Coupland, R. T. 1952. Grassland communities in the western Canadian prairies-climax and subclimax. Int. Grasslands Congr., Proc. 6:625-631.

The grassland formation of North America has been divided into six associations by Clements and his associates. These subdivisions are based on the dominant genera of the climax vegetation, as influenced by climate, particularly by the distribution and amount of precipitation. Fortunately, stands of undisturbed or slightly disturbed grassland have been, and in some areas still are, sufficiently frequent to permit a reconstruction of the characteristics of native plant communities.

The Canadian portion of the northern Great Plains is occupied by two of the associations defined by Clements. These are the mixed prairie (*Stipa-Bouteloua* association), which lies west of the 100th meridian, and the true prairie (*Stipa-Sporobolus* association), occupying the grassland area farther eastward. These communities are represented in the Canadian prairies by large expanses of grassland. In addition, the *Festuca scabrella* association occupies the areas bordering the mixed prairie on the west and north. These three grassland associations, as they are expressed in western Canada, will form the basis of the present discussion.

Although characterization of the climax community is of value in planning for utilization and management of vegetation and in indicating potential land use, the importance of the study of secondary succession in disturbed areas must not be overlooked. Subseres occupy the greatest percentage of land area in almost all parts of the North American grassland. For this reason consideration is given here to successions resulting from various types of disturbance.

Abstract No. 291.

Coupland, R. T. 1958. The effects of fluctuations in weather upon the grasslands of the Great Plains. Bot. Rev. 24:274-317.

The purpose of this review is to discuss the effects of fluctuations in weather upon the native steppe grasslands of the Great Plains of North America. While the conflicting reports of early expeditions suggest, and the experiences of settlers confirm, that variations in weather are characteristic of the region, detailed information concerning their effects on the native vegetation has been obtained only during the past third of a century. Previously, quantitative methods of measuring grassland vegetation were in the developmental stage, and the number of grassland investigators was small. Since stands of undepleted native vegetation were still abundant, study in the early part of the century was concerned with the characteristics of the plant cover without much consideration to the extent of change from causes other than overgrazing. The possibility of major changes in floristic composition resulting from variations in weather was probably discounted because of the long-lived perennial habit of the climax dominants. In supporting the theory that the vegetation was in equilibrium with the climate, some workers may have minimized the extent of variations possible.

Studies of the native grasslands of the Great Plains were continuing at the time of the inception of widespread drought in 1933, thus presenting an opportunity to examine the effects on the vegetation of this eight-year catastrophe. While many of these investigations were originally designed to study the influence of grazing animals, reaction to drought could often be separated because of its major effects and the presence of a moderately grazed or ungrazed treatment in the experiment. It is upon the reaction to the drought of 1933-40 that this review is mainly based.

Abstract No. 292.

Coupland, R. T. 1959. Effects of changes in weather conditions upon grasslands in the northern Great Plains, p. 291-306. *In* H. B. Sprague [ed.] Grasslands. Amer. Ass. Advance. Sci. Pub. No. 53. (Symp. on Grasslands, December 27-30, 1956, New York City).

Recent extensive studies in 48 stands of grassland throughout a 250-mile-long section of mixed prairie in the brown soil zone of Saskatchewan and Alberta show that since 1944 the weather has not interfered with continued increases of the species formerly occupying only the more sheltered locations. From 1950 to 1954 the growing seasons favored this increase with precipitation about 20% above average, mean temperatures 3 to to 5°F below average, and 16% lower evaporation.

The mixed (mid and short) grass cover of ungrazed to moderately grazed ranges has responded remarkably to these changes in environment. Since 1944 the percentage of the soil surface occupied by grasses has doubled. The proportion of the grass cover contributed by the two principal species of dry situations (*Stipa comata* and *Bouteloua gracilis*) has declined from 62% in 1944 to 40% in 1955-56, while the portion of the forage yield furnished by these species has declined from 54 to 28%. The two principal species of more favored locations (*Stipa spartea* var. *curtiseta* and *Agropyron dasystachyum*) have increased from 15% to 31% in percentage composition and from 29% to 50% in proportion of the forage contributed. Calculated yielding capacity of these ranges has increased on the average by 137%. Changes in botanical composition have been greatest in areas intermediate in moisture relations, while yield increases have been greatest in areas where the basal cover in 1944 was relatively sparse (in the moistest and driest areas).

These observations suggest that the extent of fluctuations in species composition occurring within vegetation in equilibrium with the climate is much greater in grassland than in forest and is probably greatest in parts of the grassland adjacent to the forest zone, but where droughts are of sufficient frequency to prevent invasion of tree species.

Abstract No. 293.

Coupland, R. T., and T. C. Brayshaw. 1953. The fescue grassland in Saskatchewan. Ecology 34(2): 386-405.

Quantitative data are presented concerning the composition and structure of the fescue grassland in Saskatchewan. On the basis of an analysis of these, the grassland of the Cypress Hills and the northern fringe of the aspen grove region in Saskatchewan is apparently part of the *Festuca scabrella* association in southwestern and central Alberta. In these areas, which are limited to the more moist black soils, *Festuca scabrella* occupies 55% of the basal cover provided by herbs. The principal subdominants are *Agropyron subsecundum*, *Agropyron trachycaulum*, *Danthonia intermedia*, *Helictotrichon hookeri*, *Koeleria cristata*, *Muhlenbergia richardsonis*, *Stipa spartea* var. *curtiseta*, and *Carex* spp. The principal forbs are *Cerastium arvense*, *Achillea millefolium*, *Galium boreale*, and *Anemone patens*. In the Cypress Hills, the presence of an abundant shrub, *Potentilla fruticosa*, is characteristic.

The spermatophytes in the *Festuca scabrella* association occupy 14.1% of the soil surface. The grasses comprise 69.0% of the non-shrubby layers. Sedges are abundant, occupying 24.2% of the herbaceous cover, but are not dominant because of their dwarf habit and short season of growth.

The grassland associated with most of the aspen grove region in Saskatchewan is a transitional type between the *Festuca scabrella* association and the *Stipa-Agropyron* faciation of the mixed prairie (*Stipa-Bouteloua* association). This zone is about 40 miles wide. In this area *Stipa spartea* var. *curtiseta* is codominant with *Festuca scabrella* in the northern dark-brown soils. With penetration of the black soil zone a rapid transition to the *Festuca scabrella* association takes place until *Festuca* finally becomes the only dominant. Within the transition zone many associated species are those typical of mixed prairie. Notable among these are *Solidago glaberrima* and *Artemisia frigida*.

The modifications in the vegetative cover associated with depressions and the proximity of groves of *Populus tremuloides* are characterized. Within the transition zone, a slight increase in moisture causes a shift to the typical *Festuca scabrella* community.

The distribution of the root systems of *Festuca scabrella*, *Stipa spartea* var. *curtiseta*, and *Koeleria cristata* is described in relation to depth and soil horizon.

The conclusion is reached that the *Festuca scabrella* community of Alberta and western Saskatchewan cannot be considered to be allied to any of the six grassland associations previously described in North America and should therefore be considered as a seventh association of the grassland formation.

Abstract No. 294.

Coupland, R. T., N. A. Skoglund, and A. J. Heard. 1960. Effects of grazing in the Canadian mixed prairie. Int. Grassland Congr., Proc. 8:212-215.

Only three reports have previously appeared on the effects of grazing in the Canadian Mixed Prairie. These are supplemented by the present study, in 1952 and 1959, of eight natural pastures in relation to the adjoining climax vegetation. The principal effects of grazing were a decrease in the proportion of the more highly productive mid-grasses, an increase in low-growing grasses and sedges, a decrease in cover of grasses and sedges as a whole, a reduction in protective mulch, a decrease in the rate of infiltration of water into the soils of fine texture, a reduction in seed supply in soils, and some evidence of reduced root production. An attempt was made to apply to these grasslands the ecological methods of range evaluation used in the USA. Difficulties arose due to the great abundance, in the climax, of increasers which also comprise the latest stages of degradation. A suggestion is made that the rating of range condition in this area should be based only on the proportional survival of decreasers under grazing.

Abstract No. 295.

Coupland, R. T., and R. E. Johnson. 1965. Rooting characteristics of native grassland species in Saskatchewan. J. Ecol. 53:475-507.

The purpose of this study was to examine the nature and extent of development of underground parts of each of the principal species of native grassland of southern Saskatchewan, to discover the extent of variation of root development of each species effected by differences in climate and microclimate, and to interpret these findings in relation to the relative competitive ability of these species in various habitats. The root systems of 914 plants of 56 species were examined by the trench-bisect method in 27 excavations along a transect 300 miles long. This is the first report of the nature of the root system for 33 of these species.

No differences were evident in the depths of the dominant grasses of different soil zones (climates). However, when the same species was considered along a climatic gradient, there was a definite trend among both grasses and forbs toward deepest penetration in the drier climate of the brown soil zone and least in the black soil zone. In the exposed positions at the top of knolls many species were more shallowly rooted than on the slopes, while few were more deeply rooted. However, no difference was shown between the depth of rooting of the same species on mesic slopes and xeric slopes in the same locality, while the species associated with them (but not present in both habitats) tended to be deeper in the xeric positions of south slopes and tops of knolls, and shallower in the more mesic habitats of north exposures and lower slopes. Some species developed more deeply in sand, particularly if they were of mesophytic nature, while more xerophytic species tended to have superficial development of the root system in sand. Lateral roots of species of forbs were more abundant and longer in sandy soil than in loam soil, while for grasses no difference was noted.

Abstract No. 296.

Coupland, R. T., and G. M. Van Dyne [ed.]. 1970. Grassland ecosystems: Reviews of research. [Proc. September 1969 Meeting PT Grasslands Working Group, International Biological Programme, Saskatoon and Matador, Saskatchewan, Canada]. Range Sci. Dep. Sci. Ser. No. 7. Colorado State Univ., Fort Collins. 208 p.

These are the proceedings of the second meeting called by PT Section for discussions under the grassland theme of IBP. The first meeting was held, also in Saskatoon, in September 1967 for the purpose of discussing methodology and agreeing on the nature of the research programme. The purpose of the present meeting has been to discuss progress in IBP grassland studies to date and to arrange for increased international coordination within this theme.

The meeting was comprised of one day of sessions on the campus of the University of Saskatchewan at Saskatoon and three days at the Matador Field Station at Matador, Saskatchewan, of the Canadian IBP. Eighty-six persons attended the meeting, many of these being from countries outside Canada. PT Section assisted in travel costs for a limited number of participants, while the Canadian Committee for the IBP (CCIBP) provided for travel to and from the Field Station and for accommodation and meals at and near the Station. The working sessions were followed by a visit to the Pawnee Site in Colorado of the US IBP Grassland Biome study by several participants from overseas.

Abstract No. 297.

Cowan, F. T. 1959. The range grasshopper problem in eight states of the Great Plains. USDA, Agr. Res. Service, Bozeman, Montana. 8 p. (Unnumbered Mimeo. Rep.).

The figures presented in this report were compiled for the purpose of providing a base for evaluation of control and future research in the range grasshopper problem. Range grasshoppers are of economic importance in all of the 17 natural grass states of the west; but because the available records concerning populations and species complex were confined to the central and northern Great Plains, all other western states were excluded from this study.

Abstract No. 298.

Cowan, I. R., and J. H. Troughton. 1971. The relative role of stomata in transpiration and assimilation. Planta 97(4):325-336.

The ways in which transpiration and assimilation depend on stomatal aperture are compared. It is shown that transpiration and assimilation are equally sensitive to change of stomatal aperture when the internal resistance to assimilation is equal to an effective resistance to evaporation which exists because of the coupling of heat and vapor exchanges between leaf and atmosphere. Generally the ratio of transpiration to assimilation changes with stomatal aperture in a manner which is determined by the relative magnitude of these resistances and on temperature. Some possible implications in relation to the optimal behavior of stomata are discussed.

Abstract No. 299.

Cox, M. B. 1952. Recording the intake of water into the soil. J. Soil and Water Conserv. 7(2):79-80.

Infiltration of water into the soil with concentric ring infiltrometers has been studied by scientists since the 19th century. The rate of water entering the soil was obtained by recording both the time and amount of water drawn from a calibrated bottle, but this report shows how these measurements can be made with a rain gage.

The instrument consists of the concentric rings, two-carburetor floats, a ten-gallon oil drum, and the recording rain gage. Accurate rates of infiltration were obtained for periods of time as great as 60 hours. A distinct advantage of this equipment is the use of the rain gage for the recording instrument. No altering of the gage is necessary.

Abstract No. 300.

Coyne, P. I., and C. W. Cook. 1971. Seasonal carbohydrate reserve cycles in eight desert range species. J. Range Manage. 23(6):438-444.

Delineation of seasonal carbohydrate reserve cycles in important range plants is fundamental to development of a physiological index to proper season and intensity of range use. Carbohydrate reserves were studied with relation to growth stage of eight desert range plants in northern Utah. Most species showed definite seasonal trends. Results indicated that maximum plant vigor in relation to carbohydrate reserves depends upon reserve storage sometime at the end of the growth period.

Abstract No. 301.

Craddock, G. W., and C. K. Pearse. 1938. Surface runoff and erosion on granitic mountain soils of Idaho as influenced by range cover, soil disturbance, slope, and precipitation intensity. U.S. Dep. Agr. Circ. No. 482. 24 p.

During 1934 and 1935, four of the important herbaceous range cover types on this portion of the watershed were selected for study and their relative effectiveness in controlling run-off and erosion under conditions of soil disturbance, slope, and rainfall intensity was determined. To overcome the difficulty of making such tests under natural conditions of precipitation, a specially designed rain-making apparatus was employed. This report presents an analysis of the data collected. The studies were designed to yield information concerning this particular problem area, but the results and principles brought out, as well as the experimental technique employed, should be of value in coping with similar range-watershed problems elsewhere.

Abstract No. 302.

Crafts, E. C. 1938. Height-volume distribution in range grasses. J. Forest. 36(12):1182-1185.

The relation of height to herbage volume (or air-dry weight) of 11 important southwestern range grasses was studied by clipping at various heights. A similar concentration of herbage volume was found for all species at the lower heights; degree of utilization of the forage cannot be inferred directly from the percent of total height that is grazed. Line charts relating height to volume for eight species are given.

Abstract No. 303.

Creighton, P. D. 1971. Nesting of the Lark Bunting in north-central Colorado. U.S. IBP Grassland Biome Tech. Rep. No. 68. Colorado State Univ., Fort Collins. 17 p.

Despite its local abundance on the shortgrass prairies of the plains states, there is relatively little information recorded of the nesting ecology of the Lark Bunting, *Calamospiza melanocorys*. Bailey and Niedrach (1965) did present a general description of this species in Colorado, and secondary information on the Lark Bunting is best summarized by Baumgarten (1968); but even this contribution draws on preliminary, fragmentary, and often conflicting data, i.e., Cameron (1908), Langdon (1933) and Roberts (1936). Current field study information is presented here to clarify and to enlarge upon various aspects of nesting Lark Buntings, such as parental roles of sexes, nestling foods, and growth rates of young.

Abstract No. 304.

Creighton, P. D. 1971. Progress report, work on bird feeding and nesting behavior at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 67. Colorado State Univ., Fort Collins. 40 p.

The research scope during the summer of 1970 was changed from a specific study of the Lark Bunting (*Calamospiza melanocorys*) to a multispecies approach involving, in addition, McCown's Longspurs (*Rynchophanes mccownii*), Chestnut-collared Longspurs (*Calcarius ornatus*) and Horned Larks (*Eremophila alpestris*). The inter-relationships of these species were investigated in the field along two lines: (a) are there temporal segregations of breeding cycles, and (b) is there a spatial distribution of these songbirds?

Laboratory studies were initiated with young of each of the four species to determine daily growth rates, amount of foods consumed, and selection of food sizes.

Abstract No. 305.

Cressler, L. 1942. The effect of different intensities and times of grazing and the degree of dusting upon the vegetation of range land in west central Kansas. Kansas Acad. Sci., Trans. 45: 75-91.

This study was made to determine the effect of a number of different kinds of treatments upon the native vegetation of central and western Kansas. The different intensities of grazing were the most significant. That, with the different rainfall for the different parts of the region, produced a definite vegetative cover.

Abstract No. 306.

Crockett, J. J. 1960. Effects of intensity of clipping on three range grasses from grazed and ungrazed areas in west-central Kansas. M.S. Thesis. Fort Hays Kansas State College, Hays.

A number of studies concerning the effects of frequency and/or intensity of clipping on vigor of range grasses have been made. Additionally, some studies have been carried out concerning the effect of actual grazing on vigor. However, few of these studies have been done in the mixed prairie and few have attempted to study the effect of intensity of clipping on plants that had previously been subjected to different degrees of utilization. It was the purpose of this problem to study these factors and try to relate the results with the results of previous investigations.

Abstract No. 307.

Culler, R. C. 1961. Hydrology of the upper Cheyenne River Basin. U.S. Geol. Surv. Water-Supply Paper 1531A. 135 p.

The objective of this investigation was to determine the effect on runoff of the many stock reservoirs in the Cheyenne River basin above Angostura Dam. As a first step it was necessary to determine, within reasonable limits of accuracy, the number of reservoirs in the basin, the storage capacity, the drainage area, and the water loss from each. A sampling method was adopted because the size of the basin, 9,100 square miles, prohibited examination of all reservoirs within the drainage area. Forty-nine sample areas of 9 square miles each were selected as a 5% sample of the 955 complete quarter townships within the basin above Angostura Dam. All reservoirs located within the sample quarter townships were surveyed.

A network of observation reservoirs was operated during the four runoff seasons from 1951 to 1954. The number of reservoirs observed ranged from 48 to 57 and produced a total of 212 station-years of record. A complete record for each observation reservoir is included in this report.

An analysis of the observation-reservoir records permitted the computation of volume of annual inflow to reservoirs in all parts of the basin, volume of inflow retained by reservoirs, and volume of retained inflow depleted by evaporation and seepage. Complete computations were made of one each of the two types of runoff producing storms, typical of the Cheyenne River basin.

Water retained by reservoirs is subjected to two major types of depletion--evaporation and seepage. Water evaporated from the water surface constitutes a complete loss chargeable against the reservoirs; but, because seepage may contribute in some degree to ground-water recharge, reservoir loss from this source may in part be recovered. The collected data permitted a fairly comprehensive analysis of the variations of runoff and storage within the basin. Based on this analysis, estimates of losses chargeable to the reservoirs range from 19,000 acre-feet in a dry year to a maximum of 80,000 acre-feet in a very wet year. Discharge from the basin ranges from 50,000 to 180,000 acre-feet.

Abstract No. 308.

Currie, P. O., and D. L. Goodwin. 1966. Consumption of forage by black-tailed jackrabbits on salt-desert ranges of Utah. J. Wildlife Manage. 30(2): 304-311.

Preference and consumption of forage by the black-tailed jackrabbit (*Lepus californicus*) and the probable levels of competition between jackrabbits and domestic sheep were studied on salt-desert rangelands from March 1959 through May 1960. Grasses, forbs, and shrubs were grazed by rabbits in early spring. Grasses were preferred throughout late spring and summer, and shrubs throughout late fall and winter. Principal shrub species consumed were whitesage (*Eurotia lanata*), shadscale (*Atriplex confertifolia*), saltsage (*A. nuttallii*), and big sagebrush (*Artemisia tridentata*). Whitesage and saltsage were most readily grazed during the fall and winter. Shadscale and whitesage were preferred early in spring before grass growth began. This preference order closely resembled that for domestic sheep, and during winter when sheep normally graze these ranges, 5.8 jackrabbits consumed or wasted an amount of forage equaling the food requirement of 1 sheep for an equivalent period of time.

Abstract No. 309.

Curtis, J. T. 1955. A prairie continuum in Wisconsin. Ecology 36(4):558-566.

The prairies of Wisconsin were studied from presence lists in 157 remnant stands on varied topographic sites in 34 counties covering about 22,000 square miles. In 57 of the stands, quadrat frequencies based on 20 quadrats each 1 m^2 were also determined. Soils were analyzed for volume-weight, moisture-holding capacity, pH, and available nutrients. Several groups of indicator species were chosen for high percent of occurrence in a topographic type. An index for each stand was calculated from the relative occurrence of each indicator group and a weighted summation of values. When the stands were arranged by the index, all species, both indicators and nonindicators, formed smooth curves of occurrence, with a peak in some restricted point of the stands. Some species had broad amplitudes of occurrence while others were narrowly limited. No groups of species of similar behavior were found. The entire species complement formed a continuous series, from species growing best in the wettest sites to those growing best in the driest sites. As a result of this spread in species behavior, the stands themselves formed a continuous series, or vegetational continuum, with no discrete community entities present. When the stands were grouped into classes based on water-retaining capacity, and the percent presence calculated for each species for each class, the resulting curves showed the same relations as before. No significant correlation between species composition and any soil nutrient could be demonstrated in the range studied.

Abstract No. 310.

Cwik, M. J. 1970. Identification of insects and density determinations of the stomach contents of small mammals. U.S. IBP Grassland Biome Tech. Rep. No. 53. Colorado State Univ., Fort Collins. 10 p.

This report presents a microanalytical method for (1) insect identification in small mammal stomachs and (2) visual estimates of the stomach contents in terms of the relative densities of the insects positively identified and the total plant:animal ratio. Identification of insects by their fragments was verified by T. O. Thatcher, CSU entomologist; P. H. Baldwin, CSU ornithologist; and use of reference vials of specific insect fragments. Stomachs used were of the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus arenicola* Howell), Ord's kangaroo rat (*Dipodomys ordii luteolus* Goldman), northern grasshopper mouse (*Onychomys leucogaster arcticeps* Rhoads), prairie deer mouse (*Peromyscus maniculatus osgoodi* Mearns). These animals were trapped at the Pawnee National Grasslands and surrounding areas, located in northeast Colorado.

Abstract No. 311.

Dahl, B. E. 1963. Soil moisture as a predictive index to forage yield for the Sandhills range type. J. Range Manage. 16(3):128-132.

The principal grasses of the area are *Bouteloua gracilis*, *Calamovilfa longifolia*, and *Stipa comata*, and the average annual rainfall is approximately 17 inches (range 10 to 27 inches). Correlation data for a 6-year period are given for herbage production during various parts of the growing season and various soil moisture and rainfall parameters. Significant positive correlations were obtained between early spring production, May 1 to June 20, and rainfall of previous 2 years, and between production from May 1 to August 7 (96% of the total in five of the years studied) and depth of visibly moist soil on April 15. These correlations were increased by combining these two parameters.

Abstract No. 312.

Dahlman, R. C., and C. L. Kucera. 1965. Root productivity and turnover in native prairie. Ecology 46:84-89.

Quantitative measurements of root systems on a seasonal basis for a 34-inch profile in Central Missouri Prairie ranged from 1,449 g/m^2 prior to resumption of growth in the spring to 1,901 g/m^2 at the end of the growing season. Underground parts in the upper 2 inches of the profile varied from 48% of the total quantity in April to 60% in July. Over 80% of the root mass occurred in the A_1 horizon, or the top 10 inches of the profile. Annual increment in the A_1 horizon or surface 10 inches was 429 g/m^2. In the A_2 horizon, 10 to 18 inches, the measurement was 40 g/m^2 and in the B_2 horizon, 18 to 30 inches, 41 g/m^2. These values were approximately 25% of the maximum dry matter measurement for each profile level, suggesting a turnover for the root system as a whole every 4 years. Variations in turnover for different parts of the root system were indicated, however, as shown by an annual loss of 22.8% for rhizomes, and 40.8% for roots in the 0- to 2-inch zone. Decomposition constants showed a marked decrease with depth ranging from 4.3% in the A_1 horizon to 0.8% in the B_2 horizon. Estimated time required to reach 99% organic matter equilibrium under present conditions of production and breakdown was 110, 420, and 590 years for the A_1, A_2, and B_2 horizons, respectively. Increasing time values would be expected with increasing depth as the reduction in annual increment was proportionately greater at lower levels in the profile than that for the total root-humus product.

Abstract No. 313.

Dahlman, R. C., and C. L. Kucera. 1968. Tagging native grassland vegetation with Carbon-14. Ecology 49:1199-1203.

Techniques using a plastic tent to contain $C^{14}O_2$ gas over herbaceous vegetation were effective for applying a tracer to Missouri tallgrass prairie. The grasses incorporated 67 to 41 μCi of C^{14}/m^2 from a single exposure to 151 μCi of $C^{14}O_2$/m^2 for 6 hours on clipped and unclipped areas, respectively. Regenerated shoots, which had been clipped 6 weeks earlier, possessed eight times higher specific activity than unclipped shoots (0.134 vs. 0.017 μCi/g of carbon in foliage biomass). The root systems of both areas possessed over 50% and the roots of mature vegetation as much as 85% of the assimilated C^{14} remaining in the plant biomass 8 weeks after tagging, thus illustrating the tendency for food reserves to accumulate in underground storage organs late in the growing season. Specific activities in the root systems were similar (0.02 vs. 0.016 μCi/g C) for both revegetated and mature areas and were adequate for study of later translocation, transfer to soil, and in situ decomposition of organic material in soil.

Abstract No. 314.

Dale, T. 1947. When drought returns to the Great Plains. U.S. Dep. Agr. Farm Bull. 1982. 14 p.

It is because of the threat of another dust bowl that this bulletin is written. We learned a lot about controlling wind erosion during the long drought of the thirties. This bulletin points out some of the methods that proved successful then. It tells about some of the things that farmers and ranchers are doing now to prevent another dust bowl and take some of the hazards out of plains farming.

Abstract No. 315.

Dalrymple, R. L., and D. D. Dwyer. 1967. Root and shoot growth of five range grasses. J. Range Manage. 20:141-145.

Five range grasses were studied at relatively young ages. Sideoats grama had the most rapid root and shoot increase and produced the most quantity. Root growth of all species was initially rapid. Root: shoot ratios were consistently above 1.0 for all grasses.

Abstract No. 316.

Daniel, H. A. 1935. A study of certain climatic factors that may affect crop yields in the high plains of Oklahoma. Panhandle Agr. Exp. Sta., Panhandle Bull. 57. 10 p.

A study was made of the seasonal evaporation, mean maximum, mean minimum and mean temperature, average daily annual wind velocity, and total rainfall at Goodwell, Oklahoma.

The daily seasonal evaporation of water from an open tank was compared to wheat yields grown on fallow soil during the last 10 years and a negative correlation was found to exist. Very little relation was found between milo grain yields grown on heavy silt loam soils and seasonal evaporation.

Although the data reported did not show a very close relation between crop yields and seasonal rainfall, the six years' yield data obtained from land continuously planted to wheat seemed to be more closely related with this factor than either the yield from milo or wheat grown on fallowed soil.

Data were obtained which showed that the mean annual temperature was gradually increasing and that the total rainfall from 1930-34 was 2.46 inches less than the average from 1915-19 at Goodwell, Oklahoma.

Very little change was found in the wind velocity during the last 10 years.

Abstract No. 317.

Dano, L. 1952. Cottontail rabbit (*Sylvilagus auduboni baileyi*) populations in relation to prairie dog (*Cynomys ludovicionus ludovicianus*) towns. M.S. Thesis. Colorado State Univ., Fort Collins. 132 p.

Cottontail rabbits of the Auduboni group and the black-tailed prairie dogs share the same ecological habitat, the broad, treeless prairie known as the Great Plains. In this region, vegetative cover suitable for cottontails is sparse or lacking; therefore, rabbits use deserted burrows of other animals for protection. A great number of the available burrows on the plains are those excavated by prairie dogs. These gregarious rodents, which are about the size of cottontails, live in colonies called towns, and their burrows often number 50 per acre.

The principal objective of this investigation was to determine what influence prairie dog towns have upon cottontail rabbit populations.

This study was based on a comparison of the cottontail rabbit population density, in and around prairie dog towns, with the abundance of cottontails on comparable areas without prairie dogs or their burrows. Eleven prairie dog towns selected for the study were designated study areas, and the eleven areas to which they were compared were called check areas.

Abstract No. 318.

Dansereau, P. 1957. Biogeography; an ecological perspective. Ronald Press, New York. 394 p.

The scope of this book extends across the fields of plant and animal ecology and geography, with many overlaps into genetics, human geography, anthropology, and the social sciences. All of these together form the domain of biogeography.

The principal objective is to provide senior and graduate students in these fields with a new synthesis of the environmental relationships of living organisms. It is my hope that the book's comprehensive approach will also gain an audience of natural scientists, geographers, and social scientists in search of an ecological inventory.

To illustrate some of the many ways in which living organisms are adapted, and to provide a review of the kinds of environment and the variety of responses, can only be done within the framework of a consistent ecological approach and methodology. The plan of the book and its essential preoccupations follow certain implications:

1. The floristic group (or element) and the vegetation zone to which a species or a community belong have, in the course of time, conditioned their adaptation, often more narrowly or more broadly than the present environment seems to allow.

2. The plant association, as defined, is a truly adaptive unit which bears internal cohesion structurally and floristically.

3. The factors of the habitat, taken in their actual conjunction, exert the only real limiting power upon individual organisms and whole communities.

4. Ecological processes are everywhere at work, and tend to develop a series of equilibria which present various degrees of stability. These processes may be inhibited or accelerated.

Abstract No. 319.

Darland, R. W., and J. E. Weaver. 1945. Yields and consumption of forage in three pasture-types: An ecological analysis. Nebraska Conserv. Bull. 27:1-76.

Monthly and seasonal yields and consumption of forage were ascertained in 3 grazing types in a level lowland pasture on silt loam soil near Lincoln, Nebraska. About one-third of this 50-acre native bluestem meadow (mostly *Andropogon furcatus*) had been covered with dust during drought, and such areas were populated by almost pure stands of western wheatgrass (*Agropyron smithii*). Three years of grazing had permitted the spreading of Kentucky bluegrass (*Poa pratensis*) to form a distinct and extensive bluegrass type. Yields in each type were obtained monthly by handclipping the vegetation in 15 portable exclosures, each 29 sq ft in area. Consumption was ascertained by subtracting the weight of the ungrazed forage in the 29-sq-ft grazed control plot from the amount produced in the exclosure. An exclosure consisted of four 7-ft steel posts, bolted together at the top but spread 5 or 6 ft apart at the base, and heavy woven wire. This highly productive pasture supported 45 head of yearling steers in 1943 and approximately the same number in 1944. Yields of the cool season wheat grass, which grew scarcely at all during summer, far exceeded consumption during the first half of the grazing season, but thereafter consumption was nearly equal to or exceeded current yield. Total consumption of this coarse and only seasonally palatable grass was 1.33 and 1.4 tons during the 2 years, respectively, or 58% and 39% of the yield. In the much overgrazed and rapidly declining bluestem type, yield of forage was exceeded after July by the amount consumed. Total consumption was high, 2.86 and 2.26 tons per acre, or 80.8 and 86.2% of the yield during 1943 and 1944, respectively. In the closely grazed bluegrass type yields in May and June and even in the relatively cool month of July (1943) considerably exceeded consumption. There was no increase of consumption in fall simply because there was no excess of bluegrass, so close was the grazing. Total consumption, 1.68 and 1.65 tons, respectively, averaged 91.2% of the yield. Summer cypress (*Kochia scoparia*) along the banks of a stream was consumed at the rate of 1.6 tons per acre in June and July and 0.8 ton in August and September. Too early removal and too close utilization of the forage of big bluestem (and other native species associated with it) resulted in the rapid replacement of prairie by bluegrass and a consequent reduction of about 35% in the annual yield of forage.

Abstract No. 320.

Davidson, R. L. 1969. Influence of soil moisture and organic matter on scarab damage to grasses and clover. J. Appl. Ecol. 6:237-246.

Second-instar larvae of a melolonthine and a ruteline scarab species in a pot experiment with three temperate grasses and *Trifolium repens* were found to damage roots in proportion to the root density. All plant species suffered equal root damage, which was significantly affected by soil moisture (partly because of the depth of feeding induced by moisture gradients) and by the addition of manure (partly through the mechanical effect on intake by the soil-ingesting larvae). These unexpected responses made the assessment of the relationship between root damage and plant vigor impossible.

The root/top ratios of grasses average 1.8 over all levels of soil fertility in grasses without scarabs, and 0.9 where scarabs were present, suggesting that 50% of the roots were redundant within the experimental conditions. On this basis the calculated depression of foliage yield agreed with the actual damage, which varied between 85% and 16%.

In clover the critical root-top ratio in the presence of scarabs was around 0.4, whereas without scarabs it varied between 3.0 at low fertility and 0.3 at high fertility. The varying proportion of redundant roots explains the disproportionate reduction of foliage yield in clover.

The relationship between scarab larvae and damage to pastures is more complex than earlier work has suggested. Both the plant and the scarab component of this relationship respond in various ways to environmental factors, and the results of empirical experiments may be misleading.

Abstract No. 321.

Davis, D. I., K. M. Barth, C. S. Hobbs, and H. C. Wang. 1970. Relationship between forage intake and gains of grazing steers. J. Range Manage. 23(6):452-454.

Based on a study utilizing total feces collection to estimate forage intake of grazing animals, the "animal gain--forage intake" relationship can be improved by removing a maintenance factor from the intake estimates. These data indicate that differences in digestible dry matter intake explained much of the variation in body weight gain of steers grazing both tall fescue-lespedeza and orchardgrass-clover pastures.

Abstract No. 322.

DeBano, L. F. 1969. Observations on water repellent soils in western U.S., p. 17-29. *In* Proc. Symp. Water-Repellent Soils, May 6-10, 1968. Univ. California, Riverside.

Water-repellent soils are not a new phenomenon and have been reported as early as 1910. The earlier observations also alluded to the possible role of water-repellent soils in the management of agricultural lands.

Water-repellent or nonwettable soils appear to be widely distributed throughout the western part of the United States. Sampling of such soils in the west has not been as intensive as that made in southern California. The prevalence of water-repellent soils and their effect on surface run-off make the phenomenon important to the hydrology of various wild land areas.

Water repellency can be found under a variety of vegetation types, including both tree and brush species; it can also be found on both burned and unburned watershed areas, although it is most conspicuous on burned watersheds.

Future research on the distribution of water-repellent soils would include a more complete survey of the wild land areas in western United States. Such a survey would give a more accurate appraisal of the extent of water-repellent soils and their possible hydrologic importance.

Abstract No. 323.

Dee, R. F., T. W. Box, and E. Robertson, Jr. 1966. Influence of grass vegetation on water intake of Pullman silty clay loam. J. Range Manage. 19(2): 77-79.

Water infiltration rates varied under different plant communities. The soil under blue grama absorbed 8.4 inches of water in a 2-hour period compared with 5.6 inches for windmill grass, 3.8 inches for annual weeds, and 2.1 inches for buffalo grass. High positive correlations existed between water intake and the amount of standing vegetation, litter, and litter and vegetation combined.

Abstract No. 324.

Deters, M. E., and H. Schmitz. 1936. Drought damage to prairie shelterbelts in Minnesota. Minnesota Agr. Exp. Sta. Bull. 329. 28 p.

In the spring of 1934, the Division of Forestry in cooperation with the West Central and Northwest substations undertook a study of the conditions of the shelterbelts in western and southern Minnesota. The determination of the extent to which trees in the region had died was not the only, or the chief, objective of the study. Interesting and important though these data may be, it was felt that the effect of the drought upon tree planting in the prairie region might be regarded as a great natural experiment, not as well controlled as may be desired in scientific work, but nevertheless one from which might be obtained the information necessary to develop sound principles and practices for tree planting in the prairie region. The trees that remain in the region have been subjected to a most severe test, and the survival figures in a general way furnish a satisfactory basis for the choice of tree species and planting and cultural practices.

Abstract No. 325.

Dhillon, B. S., and N. H. E. Gibson. 1962. A study of the Acarina and Collembola of agricultural soils. I. Numbers and distribution in undisturbed grassland. Pedobiology 1:189-209.

The populations of Collembola and Acarina inhabiting the soil of an old meadow were studied during a period of 14 months and the results compared with those of earlier investigations made in similar habitats.

Attention is drawn to the differences in the species composition of the soil fauna of agricultural grass fields in Great Britain, even in those of apparently similar character. Comparison of the literature shows the identity of the dominant species to differ in almost every field studied. This diversity is most marked in the Acarina, where few species have been recorded from more than one field. *Isotoma* (Collembola-Isotomidae) and *Coccupodes* (Acarina-Eupodidae) were overwhelmingly the dominant genera in the present investigation. An unusual feature was the virtual absence of Oribatei, which was possibly related to the comparative dryness of the soil.

The populations of both Collembola and Acarina fluctuated with time and marked differences occurred in the patterns of variation shown by different species. These patterns differed from those found by most other investigators in that they showed no regular seasonal rhythm. There was no evidence that the changes as a whole bore any simple relationship to the fluctuations of soil temperature, moisture, pH, or organic content.

All species of Collembola were more numerous in the top 3 inches (76 mm) of the soil than at greater depths, but *Onychinrus armatus* and, especially, *Folsomia spinosa* differed from the other species studied in being frequently found at depths of between 3 and 9 inches (76 and 229 mm). Among the mites, the Rhodacaridae were exceptional in being most numerous at the lower levels while *Rhizoglyphus echinopus* and the Parasitidae were the most strictly limited to the upper layers. The vertical distribution of the fauna showed an overall similarity to the distribution of pore space in the soil.

Significant changes in the vertical distribution of almost all species occurred from time to time and showed no seasonal regularity. These changes took place at depths where soil conditions were comparatively stable and could not be related to any variations in the soil water, temperature, pH, or organic content.

It is suggested that in the soil of fully established grass fields under British climatic conditions, temperature and humidity are likely to exert an overriding influence only near to the surface and that, at lower levels, the numbers and distribution of Acarina and Collembola are more likely to be determined by the cumulative influence of small changes in several soil factors.

Abstract No. 326.

Dice, L. R. 1930. Methods of indicating relative abundance of birds. Auk 47(1):22-24.

The author suggests a method of keeping lists by half-hours in the field and by habitats, so that the percentage abundance of the various species can be computed.

Abstract No. 327.

Dick, E. 1943. The sod-house frontier, 1854-1890. D. Appleton-Century Co., Inc., New York. 550 p.

The present volume is an attempt to depict the life of the common man on the cutting edge of the frontier immediately following the date when it leaped across the Missouri River into Kansas and across the Red River into the vast domain now known as North and South Dakota. My purpose has been to relate the story of how the residents of the settled regions to the East left their old homes, journeyed to the new land, and conquered the obstacles incident to making new homes. The struggle was a heroic one and brings into view the dominant characteristics of the race.

The sources are largely newspapers, biographies and autobiographies, diaries, personal interviews, monographs, and material such as historical society collections and local histories.

Abstract No. 328.

Dickinson, C. E. 1972. Pawnee Site plant live-dead separation. U.S. IBP Grassland Biome Tech. Rep. No. 140. Colorado State Univ., Fort Collins. 18 p.

For species which were not easily separated in the field, a reconnaissance procedure was used to separate aboveground plant biomass into a this year's growth and a previous year's growth fraction. Checks were made by mechanical and hand sorting methods. A complete data listing is included.

Abstract No. 329.

Dickinson, C., and J. Leetham. 1971. Aboveground insects on the Pawnee Site, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 123. Colorado State Univ., Fort Collins. 9 p.

Biweekly aboveground insect samples were collected on the Pawnee Site from April through October 1970. Numbers and weights of insects by taxa were recorded in the Grassland Biome data bank. Principal groups present were ants (Formicidae) and leafhoppers (Cicadellidae).

Abstract No. 330.

Dickinson, C. E., and C. V. Baker. 1972. Pawnee Site field plant list. U.S. Grassland Biome Tech. Rep. No. 139. Colorado State Univ., Fort Collins. 44 p.

This paper gives a series of cross referenced plant code lists for plants occurring on the Pawnee Site. Recent synonyms are given, as are longevity, seasonality, and class of plant. Included are alphabetical lists by code, scientific and common name, as well as presence lists by grazing treatment and replicate. A standardized coding procedure is described. One section of the report provides room for field notes for individual users.

Abstract No. 331.

Dickinson, C. E., T. O. Thatcher, and M. K. Campion. 1972. Statistical analysis and grouping of shortgrass prairie insect biomasses. U.S. IBP Grassland Biome Tech. Rep. No. 32. Colorado State Univ., Fort Collins. 16 p.

The purpose of this study was to determine which insects or groups of insects account for the greatest variation in insect biomass on the shortgrass prairie for the purpose of energy-flow modelling as a part of a grassland systems ecology study. A principal component analysis utilizing family and adult or preadult grouping enabled us to segregate out the family-life stage of four insect taxa from a field of 77. These were adult darkling beetles (Tenebrionidae), adult ground beetles (Carabidae), and both adult and preadult grasshoppers (Acrididae). Regression analysis was used where simultaneous data were available from data-sharing participants in the program in order to interrelate important factors associated with abundance of these insects. Darkling beetles were correlated to plant biomass present two weeks previous, litter two weeks previous, and darkling beetle biomass two weeks previous. Ground beetles could only be weakly correlated to total precipitation for two weeks previous.

Abstract No. 332.

Dick-Peddie, W. A. 1966. Changing vegetation patterns in southern New Mexico. New Mexico Geol. Soc., 16th Field Conf., (Socorro, New Mexico), Guide Book 16:234-235.

The vegetation of southern New Mexico has been described many times. It has been classified as "desert grassland," "desert shrub-grassland ecotone," "semi-desert," "Chihuahuan desert," "creosote-tarbush type," and others. Some of these classifications are merely synonyms, but others indicate differences of opinion regarding either "what was" or "what is" the ecology of the vegetation. This article will examine and evaluate some of these views on the vegetational ecology of southern New Mexico. In the light of some recent investigations, the author will submit additional opinions about this problem.

Abstract No. 333.

Dick-Peddie, W. A., and W. H. Moir. 1970. Vegetation of the Organ Mountains, New Mexico. Range Sci. Dep. Sci. Ser. No. 4. Colorado State Univ., Fort Collins. 28 p.

Cover, constance, and the distribution of major species along ordination axes are given in the four vegetation zones between 5,200 and 9,000 ft elevation in the Organ Mountains. The zones are recognized as upper desert grassland, savanna and woodland, chaparral, and deciduous oak woodland. Dominant shrub species have individualistic modes of distribution that are strongly controlled along open slopes by elevation and slope exposure. The generally steep slopes and microtopographic variation within stands on open slopes produce a large measure of stand heterogeneity which contributes to vegetation in intergradation between zones.

Abstract No. 334.

Diebold, C. H. 1951. Soil layers causing runoff from hardland wheat fields in Colorado and New Mexico. J. Soil Water Conserv. 6(4):202-209.

A portable infiltrometer was used to simulate a storm of 2 inches in 1 hr on hard-land wheat soils possessing medium-textured surface soils in eastern Colorado and eastern New Mexico. Length of cultivation, tillage pans, chiseling when dry and chiseling when wet are related to runoff. Formulas are presented for predicting infiltrometer intake rates using core intake rates, the unfilled storage below field capacity, and 80% of the temporary storage. Under present conditions with a tillage pan, limiting layers affecting intake rates are confined to the surface ft. Volume weight, stability, swelling, effective pores, and structure appear to be the most important factors influencing the intake rates of the medium- and moderately heavy-textured layers studied.

Abstract No. 335.

Dinkel, C. A., J. A. Minyard, F. R. Gartner, G. S. Harshfield, A. L. Musson, and W. R. Trevillyan. 1958. Agricultural research at the Antelope Range Field Station. South Dakota Agr. Exp. Sta. Circ. 140. 30 p.

In the fall of 1946, at the request of livestock men of western South Dakota, representing the Western South Dakota Sheep Growers' Association, the Cooperative Wool Growers' of South Dakota, the Black Hills' Protective Association, Harding County Livestock Improvement Association, South Dakota Purebred Sheep Breeders Association, and the South Dakota Stockgrowers' Association, the Game, Fish and Parks Commission entered into an agreement to permit the South Dakota State College Agricultural Experiment Station to use the Antelope Range Preserve as a livestock experiment field station for range research in problems dealing with beef cattle, sheep, and antelope. Representatives of the organizations formed an advisory council to assist in developing the station and suggesting problems that needed research study.

The original advisory committee and the animal husbandry department research men compiled a list of 21 major problems that would be suitable for development at the Antelope Range Field Station, although not all of these could be handled at once. Actual research work was started in 1947. The first experimental livestock with which the ranch was stocked were sheep, but within the first year a cow herd was added. Of the 21 problems suggested, parasitism in sheep, stocking rate and rotational grazing studies with sheep, supplements for wintering pregnant ewes, and beef cattle breeding research were the ones undertaken and upon which sufficient data have been collected to warrant publication of the results. Many of these studies are still underway.

One of the early goals was to discover basic information on compatibility of sheep and antelope grazing on the same range in respect to carrying capacity of the range, parasites common to both species, and the host parasite interrelationships. Unfortunately this work has yielded little information because of difficulties in handling antelope either in captivity or under controlled conditions on range pastures. The other experiments have been carried forward and the results to date are reported in this bulletin.

Abstract No. 336.

Dirschl, H. J. 1963. Food habits of pronghorn in Saskatchewan. J. Wildlife Manage. 27(1):81-93.

Food habits of the pronghorn (*Antilocapra americana*) in the Matador and Cypress Hills regions of Saskatchewan were studied by analysis of the rumen contents of 49 specimens collected at monthly intervals over a full annual cycle, plus 42 rumen samples from animals killed during the 1960 hunting season. Grasses were found to predominate in April; forbs from May to July; deciduous browse, August to October; and evergreen browse, November to March. Cacti and grain crops were minor items. Pronghorns were dispersed throughout the available range during the growing season, while in the winter they were concentrated in areas where sagebrush (*Artemisia cana*) and creeping juniper (*Juniperus horizontalis*) grew, indicating that antelope distribution is correlated with food distribution and that the abundance of these two key food items on the winter range is a prime factor in the carrying capacity of range units. Chemical analyses made of food plants at intervals throughout the year revealed a positive correlation between their protein content and the degree to which they were utilized by pronghorns. Plants having the highest protein levels were the preferred foods in all seasons.

Abstract No. 337.

Dittberner, P. L. 1971. Soil nutrient-plant nutrient relationships, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 122. Colorado State Univ., Fort Collins. 34 p.

This investigation was initiated to study the soil nutrient-plant nutrient relationships of blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) and wheat (*Triticum aestivum* Z.). This report includes methodology of data collection and the results of chemical analysis for the soil samples.

Abstract No. 338.

Dix, R. L. 1958. Some slope-plant relationships in the grasslands of the little Missouri badlands of North Dakota. J. Range Manage. 11:88-92.

The roles of slope and exposure in determining the species composition of some grassland types in the Badlands of the Little Missouri River of North Dakota were investigated. Four stands, differing in slope and exposure, were selected as study areas; the stands had slopes and exposures of: 16° E, 8° E, 3° W, and 11° W.

The stands were sampled by the frequency method employing 40 1/4-m^2 quadrats per stand. Slopes and exposures were also measured. Similarity coefficients between the stands were calculated and an ordination of stands established.

The behavior of the dominant species along this ordination indicated that it was based upon a moisture gradient. Blue grama and western wheatgrass, species of the more xeric Great Plains, were found to be more important at one end of the gradient, while little bluestem, side-oats grama, and plains muhly, species of the more mesic midwestern prairies, were more important at the opposite end of the ordination. This ordination also correlated with apparent soil water, total number of species which occurred in the quadrats and in the total frequency per stand.

The relationships between the stands appeared not to be successional, since the species composition of the stands was based principally upon physiographic and edaphic factors.

Abstract No. 339.

Dix, R. L. 1960. The effects of burning on the mulch structure and species composition of grasslands in western North Dakota. Ecology 41:49-56.

This paper reports the results of a preliminary quantitative study of the species composition, herbage production, and mulch structure on natural grasslands following fire of known age in western North Dakota. Partner pairs of stands, one burned and the other unburned, were sampled. In three pairs of such stands, the species composition was determined by employing 40 1/4 m^2 quadrats in each stand, and the surficial organic matter was clipped and segregated.

Abstract No. 340.

Dix, R. L. 1964. A history of biotic and climatic changes within the North American grassland, p. 71-90. *In* D. J. Crisp [ed.] Grazing in terrestrial and marine environments. Blackwell Sci. Pub., Oxford. 322 p.

The many causes or influents which were and are responsible for the origin and maintenance of the North American Grassland are discussed according to the following categories: physiographic, climatic, biotic, and historical. Emphasis is placed on the Great Plains and Central Lowlands regions of this vegetation type and the time scale is that of the geologist and archeologist.

Physiographic and climatic changes in the North American Grassland through Tertiary, Pleistocene, and Recent time are briefly outlined, and the origins and time sequences of the development of the major vegetational units are treated. The original grassland is believed to have formed *in situ* in the Central Great Plains area from Arcto-Tertiary and Neotropical-Tertiary stock in late Oligocene or Miocene. Changes in physiography, and more particularly in climate, encouraged the rapid evolution of plant species in this area, and many modifications in this grassland occurred through late Tertiary, Pleistocene, and Recent time, particularly in the woodland-grassland tension zones. The origins of the midwestern prairie, coastal prairie, desert plains grassland, and northern plains grassland are traced.

A brief review of the historical period in the North American Grasslands, up to the present century, is presented.

Abstract No. 341.

Dix, R. L., and R. G. Beidleman [ed.]. 1969. The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins. 437 p.

This report represents most of the written output of the information synthesis project in the first 15-month segment of the Grassland Biome studies in the United States' contribution to the International Biological Program. As noted herein, some papers were not available in time for this report, but they will be produced later in a supplement. The papers were presented in five workshops in an order different from their sequence here.

This report is based on our initial grassland Biome studies which were supported by the National Science Foundation (Grant GB-7824) and the Atomic Energy Commission.

Abstract No. 342.

Dix, R. L., and R. G. Beidleman [ed.]. 1970. The grassland ecosystem: A preliminary synthesis. *A supplement.* Range Sci. Dep. Sci. Ser. No. 2 Supplement. Colorado State Univ., Fort Collins. 110 p.

This report includes two papers which were not available last year to be published with the 437-page volume containing other papers from the information synthesis project. The paper by Thomas was presented at the fourth workshop held in Woodland Park, Colorado, and the paper by Lewis was presented at the fifth workshop held at Buckhorn Mountain, Colorado. Thomas' paper represents a review on amphibians and reptiles as a particular type of consumer in the grassland system. Lewis' paper is an overall review and integration of the other papers on producers, and especially, it contributes special new information at that trophic level. The papers are numbered according to the page after which they fit in the overall volume.

These papers were part of our initial Grassland Biome studies which were supported by the National Science Foundation (Grants GB-7824 and GB-13096) and the Atomic Energy Commission.

Abstract No. 343.

Dodd, J. D., and H. H. Hopkins. 1958. Yield and carbohydrate content of blue grama grass as affected by clipping. Kansas Acad. Sci., Trans. 61(3):280-287.

During recent years revegetation of marginal lands in the Great Plains has received considerable emphasis. Research has been done as to several of the factors affecting establishment, but the effects of varying intensities of grazing on new stands have not been thoroughly studied. Any system of grazing that permits frequent removal of herbage and thus retards manufacture and storage of carbohydrates may result in depletion or destruction of the grass. This is particularly true of recently seeded ranges. It is imperative that grasses store sufficient food during the growing season to carry them through the winter and to produce initial growth in the spring.

This experiment was designed to determine the influence of different intensities of clipping on the yield of herbage and carbohydrate content of roots and crowns of newly seeded stands of blue grama (*Bouteloua gracilis*).

Abstract No. 344.

Dodd, J. D., and G. L. Van Amburg. 1970. Distribution of Cesium-134 in *Andropogon scoparius* Michx. clones in two native habitats. Ecology 51(4): 685-689.

Cesium-134 distribution in native *Andropogon scoparius* clones and in single tillers indicates that each clone consists of a group of tillers each acting as individual plants. Two zones of concentration occur: the upper 5 cm of the roots and the inflorescence, including the florets. Cesium transport from the foliage to the upper portion of the roots occurs with fall dormancy. With the initiation of spring growth the mineral is exported from the roots to the expanding leaf blades. Cesium activity within the plants growing on the Heiden-Hunt clay soil decreases more with time than in plants growing on Tabor fine sandy loam.

Abstract No. 345.

Donoho, H. S. 1971. Dispersion and dispersal of white-tailed and black-tailed jackrabbits, Pawnee National Grasslands. U.S. IBP Grassland Biome Tech. Rep. No. 96. Colorado State Univ., Fort Collins. 52 p.

Dispersion, dispersal, and density were measured on populations of black-tailed (*Lepus californicus*) and white-tailed (*Lepus townsendii*) jackrabbits on a 10.75 sq mile area of native shortgrass prairie. All mammal scientific names used in this report are from *The Mammals of North America* by E. R. Hall and K. R. Kelson (1959). Dispersion information was obtained from a tagging-recapturing program and spotlight counts. Sample size amounted to 136 tagged hares. Black-tails outnumbered white-tails three to one and occupied most of the study area. White-tails occupied a smaller range, mostly overlapping the black-tailed jackrabbit range. Dispersal was measured by a radio telemetry technique which allowed remote monitoring of instrumented hare locations. Individuals of both species exhibited ovate occupation areas (of approximately 640 acres) which did not appear to change in size or location from season to season. Of 28 hares instrumented, six remained active, 14 were lost from radio contact, and eight died from various causes. Density was estimated from counts made on 4.25 sq mile drive plots. The spring (April) and fall (November) counts indicated 33 hares per sq mile and 93 hares per sq mile, respectively. Aerial mapping of hare tracks in snow revealed the greatest hare activity in low shrubby areas with activity gradually diminishing toward higher open grassy areas. Trapping and telemetry failed to show correlation between hare distribution and pastures grazed by cattle at light, moderate, and heavy intensities.

Abstract No. 346.

Dort, W., Jr. 1959. Geomorphology of the southern Great Plains in relation to livestock production. J. Range Manage. 12:292-295.

The present physical environment of the Great Plains is largely the product of past geologic and geomorphic events. An understanding of the processes involved helps to explain the occurrences of different kinds of soils, land forms of various aspects, and ground water supplies. The actual pattern is far more intricate than broad generalizations suggest. Even a single rangeland unit may well contain different soils, different land forms, different water supplies, and therefore require different range management practices.

Abstract No. 347.

Dortignac, E. J. 1951. Design and operation of the Rocky Mountain infiltrometer. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colorado, Paper No. 5. 68 p.

The Rocky Mountain infiltrometer originated from the type FA developed by the Flood Control group of the Soil Conservation Service. This modified infiltrometer is considerably different from the FA, about the only similarity being that it employs a type F nozzle and the plot frame area approximates 2.5 sq ft. The writer has used this instrument since 1946 and added numerous revisions and modifications. All equipment has been streamlined and lightened for ease in handling and carrying. In addition, a plan for placement of equipment on the 1½-ton truck simplifies and speeds up repeated loading and unloading of equipment, allowing a greater number of samples per unit time. Another innovation is the use of this instrument for measurement of rates of erosion in addition to infiltration rates. This infiltrometer can be used successfully for this latter objective though the standard deviation of measurement is greater than for infiltration rates. These larger variations are no doubt associated with variations in slope and rain intensity. Whereas these factors do not influence water-absorption rates it has been demonstrated that they do influence erosion losses. Working with a single soil type, Putnam silt loam, under laboratory conditions, soil losses from a saturated soil increased as the 0.7 power of the slope percent and the 2.2 power of the rain intensity.

Abstract No. 348.

Dortignac, E. J., and L. D. Love. 1960. Relation of plant cover to infiltration and erosion in Ponderosa Pine forests of Colorado. Amer. Soc. Agr. Eng., Trans. 3(1):58-61.

The Rocky Mountain infiltrometer was used to evaluate infiltration and erosion of the most common vegetation cover types found in the ponderosa pine forests of Colorado. Almost 750 tests were conducted at the Manitou Experimental Forest under grazed conditions. One-third as many tests were made elsewhere in the South Platte River watershed and on the Roosevelt National Forest, west of Loveland, Colorado.

On the basis of these tests it was found that infiltration rates varied with cover type. Large pore space of the upper 2 inches of the soil and the quantity of dead organic materials were the two properties that accounted for most of the variation in infiltration rates among cover types.

Erosion indices also varied with cover type, but soil origin and the amount of exposed or bare soil were the main factors affecting erosion.

Infiltration rates increased 1.31 inches per hour in grassland and 1.01 inch per hour in pine-grass after 14 years of protection from grazing at Manitou Experimental Forest.

Infiltration and erosion indices measured with the infiltrometer in the range pastures were compared with rates computed from adjacently located runoff plots. Even though measurements were made at different locations in the Manitou Experimental Forest, infiltration and erosion determined with the infiltrometer compared favorably with results obtained on runoff plots for similar plant-soil conditions.

Criteria are proposed for determining satisfactory infiltration rates and acceptable quantities of erosion in the ponderosa pine forests of Colorado utilizing results from infiltrometer tests and runoff plots.

Abstract No. 349.

Dortignac, E. J., and L. D. Love. 1961. Infiltration studies on Ponderosa Pine ranges of Colorado. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colorado, Paper 59. 34 p.

During the years 1941 through 1954, infiltration studies were conducted on six contiguous range pastures at the Manitou Experimental Forest. Other investigations were carried out on the Elk Ridge Allotment of the Roosevelt National Forest during 1950. Both areas are representative of the ponderosa pine-bunchgrass ranges of the Colorado Front Range.

During the course of the investigation, infiltrometer plots were located at random within the three cover types of pine-litter, pine-grass, and grassland. Infiltration was measured through the use of the Rocky Mountain infiltrometer, a portable "rainmaker" by applying rain at the rate of 4.0 to 5.0 inches per hour on a 2.5-sq-ft plot for a 50-minute duration. Infiltrometer tests were made on plots prewetted 6 to 24 hours before the final wet run was conducted, except for the years 1952 and 1954, when rainfall was applied on dry soil for 50 minutes followed by tests on wet soil 15 to 22 hours later. Most of the analyses and results presented were based on infiltrometer tests on prewetted soils. However, the same basic relationships between infiltration rates were obtained whether infiltration rates on wet or dry surface soils were used. Information was collected on vegetation and soil properties that might in any way affect or be related to infiltration.

The main purpose of the present study was to isolate and evaluate vegetation and soil influences on infiltration on granitic derived soils of the ponderosa pine-bunchgrass range of the Colorado Front Range.

Abstract No. 350.

Doughty, J. L. 1943. Report of investigations. Soil Res. Lab., Swift Current, Saskatchewan. Canadian Dep. Agr. Exp. Farms Service. 63 p.

The subject matter in this report deals, in general, with the soil and climatic conditions found in the prairie areas of Manitoba, Saskatchewan, and Alberta, and particularly with the brown and dark brown soil zones. The climatic conditions prevailing over most of these areas are low rainfall, low humidity, and high evaporation. Particular attention has been given to the conservation and use of soil water and the factors contributing to soil erosion by wind. The frequent occurrence of years of low rainfall when crop production is hazardous and soil drifting is prevalent, emphasizes the importance of these problems.

Abstract No. 351.

Doughty, J. L. 1954. Progress report 1948-1954. Soil Res. Lab., Canadian Dep. Agr. Exp. Farms Service. 46 p.

The Soil Research Laboratory is located at Swift Current, Saskatchewan, and is associated with the Field Husbandry, Soils, and Agricultural Engineering Division of the Central Experimental Farm, Ottawa, Ontario. The present report is the fourth issued from the Laboratory and deals particularly with the period 1948-54, though frequent reference is made to earlier work in connection with long-term projects. For a more detailed discussion of certain problems, the reader is referred to the published papers as set out in the list of references.

The laboratory program includes studies of soil problems arising in the prairie provinces, though owing to location, many of the projects have dealt particularly with the soils and climatic conditions of southwestern Saskatchewan which is in the Brown Soil zone.

Water is the first limiting factor in crop production in the Brown Soil zone and for this reason particular attention has been given to projects dealing with the conservation and use of soil water. This involves such factors as amount and distribution of precipitation, temperature, wind velocity, sunshine, kind of crop, and type of soil. Laboratory, tank, and field experiments have been conducted to determine the importance and interrelationship of these factors. A closely related problem is the movement of water in unsaturated soils.

Data will be presented showing the effect of field shelterbelts on wind velocity, evaporation, snow accumulation, soil water, and crop yield.

Soil erosion by wind must always be guarded against. Considerable time was spent prior to 1948 in the determination of the principles governing soil drifting. Owing to the importance of this problem, brief reference will be made to the previous work. More recently, work has been started dealing with soil erosion by water which is of particular importance in certain areas due to the nature of the topography and soil. There is a natural division in this problem, one phase dealing with excess water due to rapid precipitation and the other, water from thawing snow.

The prairie farmers are becoming more concerned about crop rotations and the use of fertilizers for it is realized that the popular wheat-fallow rotation is not in keeping with soil conservation practices. Data showing the effect of cultivation on the nitrogen and organic matter content of the soil will be presented. Reference is made to the use of commercial fertilizers. Saline soils are a problem in the irrigated areas and have been the subject of investigation.

Since the publication of the third report the program of the Laboratory has been enlarged to include soil microbiology. Particular attention is being given to problems related to soil organic matter and nitrogen.

Abstract No. 352.

Douglass, A. E. 1919. Climatic cycles and tree growth. Carnegie Inst. Washington, Pub. 289. 171 p.

The collection of an enormous amount of material on tree-rings, the development of methods of cross-dating, and the establishment thereby of a system of chronology represent a continued effort toward a knowledge of our past. The correlations of tree-rings with solar and terrestrial data and the intercorrelations of these not only illuminate the past, they offer hope of some future and greater success in forecasting phenomena of scientific importance and, perchance, of immediate significance to man.

So much of the work on cycles which has been done in the past and published with high hope has been found wanting by subsequent investigators, that the scientific world has today a somewhat justifiable scepticism of the validity of similar new work. The author and the Carnegie Institution offer this data and these findings to the critical examination of others to ascertain in how far they may become established in that general consensus which is science and afford a basis for further advances into the mathematical difficulties of cycle analysis, into the perplexing problems of scientific induction therefrom and into those fields of science in which the realization of our present hopes seems bound up with a fuller comprehension and utilization of these methods.

Abstract No. 353.

Downes, R. W. 1970. Effect of light intensity and leaf temperature on photosynthesis and transpiration in wheat and sorgham. Australian J. Biol. Sci. 23(4):775-782.

Wheat stomata offered less resistance to water and carbon dioxide diffusion than sorghum stomata at light intensities of 0.06 and 0.26 cal/cm^2/min (400-700 mm), but resistances were comparable at 0.46 cal/cm^2/min. Consequently, transpiration rates were higher in wheat than in sorghum, except at the high light levels, in leaf chamber experiments described here. Rates of photosynthesis were higher in sorghum than in wheat, with the greatest difference at high light levels. This resulted in a greater efficiency of dry matter production relative to water use in sorghum. Transpiration rate increased with increased temperature in both species. Photosynthesis was independent of temperature in wheat and in sorghum under low light conditions, but otherwise photosynthesis increased with temperature in sorghum. In both species, efficiency of water use decreased as temperature increased at all light intensities. Water vapor concentration difference between the intercellular spaces and the air was comparable in wheat and sorghum and increased with temperature. The carbon dioxide concentration difference between air and intercellular spaces was substantially greater in sorghum than in wheat and increased with leaf temperature. Maximum values were obtained at the intermediate light level in sorghum.

Abstract No. 354.

Downhower, J. F., and E. R. Hall. 1966. The pocket gopher in Kansas. Kansas Univ. Mus. Natur. Hist. Misc. Pub. 44:1-32.

The aims of the study here reported on were the following:

1. Learn why the pocket gopher does not occur in southeastern Kansas.

2. Learn how much (volume and weight) soil per acre a pocket gopher deposits on the surface of the ground in the course of one complete year.

3. Record some other information obtained incidental to work on aims 1 and 2 because it is new or because it is thought to be otherwise pertinent.

4. Provide directions on the best method for removing plains pocket gophers from areas where they are unwelcome.

Abstract No. 355.

Doxtader, K. G. 1969. Estimation of microbial biomass in soil on the basis of Adenosine Triphosphate measurements. Bacteriol. Proc. 14 p. (Abstr.).

The measurement of adenosine triphosphate (ATP) was investigated as a potential means of estimating microbial biomass in soil. ATP was quantitatively determined by use of firefly luciferin-luciferase enzyme system. As little as 6×10^{-4} μG of ATP was detected when a liquid scintillation counter was used to measure light emission from firefly extracts. ATP measurements were made on pure cultures of bacteria, actinomycetes, and fungi freshly isolated from soil. For the first two groups of microorganisms, there was a high correlation between ATP levels and numbers of cells, as determined by plate count techniques; in addition, the ratio of ATP to carbon content and dry weight of viable cells was fairly constant under the cultural conditions employed. Corresponding relationships for fungal species were more variable. To determine ATP levels in the microfloral fraction of the total biomass of soil organisms, the microbial cells were isolated, collected on membrane filters, and extracted, and the extracts were analyzed for ATP. The data obtained in this study permitted the estimation of soil microfloral biomass and a comparison with biomass values obtained by other methods.

Abstract No. 356.

Doxtader, K. G. 1969. Microbial biomass measurements at the Pawnee Site: Preliminary methodology and results. U.S. IBP Grassland Biome Tech. Rep. No. 21. Colorado State Univ., Fort Collins. 16 p.

This report describes studies of microbial form and function at the Pawnee Site of the Grassland Biome program of the U.S. International Biological Program. The major objective of the investigations was to develop sampling and analytical procedures for the estimation of microbial biomass. A secondary area of interest was to measure microbial respiratory activity in soil, with the aim of relating this to microbial biomass values.

Research was conducted in two related areas: (1) direct estimation of microbial biomass in soil and (2) development of an ATP assay as an indirect measurement of biomass.

Abstract No. 357.

Dragoun, F. J., and A. R. Kuhlman. 1968. Effect of pasture management practices on runoff. J. Soil and Water Conserv. 23(2):55-57.

Onsite surface runoff was reduced and soil water was increased by light versus heavy grazing, contour-furrowing versus no treatment and eccentric disking versus no treatment. Contour furrowing was definitely the most effective means of conserving rainfall and reducing surface runoff. Compared with the untreated plots, contour furrowing conserved an average of 1.2 inches of precipitation more annually. The resulting increase in soil water, however, did not produce better stands of perennial grasses. Good grazing management and more intensive pasture renovation measures, such as reseeding and fertilization, were needed to improve intermediate and tall grass production.

Basal area surveys indicated a decline in vegetative density between 1939 and 1941. Average density ranged from a high of 33% to 3% on individual plots. The remainder of the soil surface was bare. Plot treatment had no consistent effect on the decline in perennial vegetation. By 1961 perennial grass stands were similar to those in 1939. Buffalograss and bluegrama grass were typical successors when the better intermediate grasses declined as a result of overgrazing. The basal area of perennial grasses on the nonfurrowed and contour-furrowed plots was 3.7 and 4.7 times greater, respectively, in 1961 than in 1941.

Abstract No. 358.

Dregne, H. E., and H. J. Maker. 1955. Fertility levels of New Mexico soils. New Mexico State Univ., Agr. Exp. Sta. Bull. 396. 11 p.

Several thousand soil samples collected in New Mexico were analyzed for pH, soluble salts, organic matter, available phosphate, exchangeable potassium, and lime.

Most of the irrigated soils are alkaline, particularly in the Rio Grande Valley and Luna County. In only one area, in western Catron County, are the soils acid, and even there the acidity is slight.

Soils with the highest average in organic matter content are found in the mountainous counties, except for Chaves and Union counties. The lowest organic matter levels are found in the eastern and southwestern counties where higher temperatures contribute to a more rapid oxidation of organic matter. The relation between organic matter and other soil characteristics is varied.

The amounts of available phosphate in the surface soils vary in the different sections of the state. Eastern New Mexico soils have the lowest average values; the highest averages are found in the southwestern corner of the state, and the soils in Lincoln County and north central New Mexico are also high in available phosphate.

Exchangeable potassium levels are quite high in most counties. Mora County has the lowest level, and nine counties have intermediate levels.

Most surface soils in the irrigated areas of the state contain some free lime. The largest amounts are found in soils of the Pecos Valley, the Tularosa Basin, and the Sacramento Mountain valleys.

Excessive salt may be a problem in the Pecos Valley, the Tularosa Basin, the Rio Grande Valley, and the San Juan Valley. The average salt levels in many counties are low, but most irrigated areas of New Mexico have potential problems with salt accumulations. Wherever poor drainage occurs, salt is a hazard.

Controlled field tests are in progress to relate soil test results to fertilizer response and to evaluate the differences reported in this bulletin.

Abstract No. 359.

DuBois, A. D., 1935. Nests of horned larks and longspurs on a Montana prairie. Condor 37(2):56-72.

This report contains many details about 141 nests* in Teton County east of the Rocky Mountains. All three species apparently excavate a hollow in which is built a nest of dried grass with a lining of softer parts of grass or other material. The excavated earth is thrown to the eastward of the horned lark's nest and is more or less covered with little pieces of sunbaked mud which may have lichens or moss on them. *Otocoris alpestris leucolaema** and *Rynchophanes mccownii* nest on dry uncultivated ground where the grass is short and scanty, but frequent use is made of a weed or tuft of taller grass to hide the nest partially. Both species have two broods of three or four each, the horned lark nesting from April through June and the McCown longspur from early May into July. *Calcarius ornatus* has the same nesting season as the latter but a clutch of four or five eggs and possibly only one brood. It selects slightly moist land where the grass is taller.

Abstract No. 360.

Duddington, C. L. 1963. Predacious fungi and soil nematodes, p. 298-304. *In* J. Doekson and J. Van Der Drift [ed.] Soil organisms. North Holland Publ. Co., Amsterdam. 453 p.

Predacious fungi attack microscopic animals, including nematodes, in decomposing organic matter and in soil. Some are internally parasitic, while others capture their prey alive by means of various trapping devices. They are common in most soils, but until recently little has been known of their activities under natural conditions. Attempts are being made to use them for the biological control of plant pathogenic nematodes.

Abstract No. 361.

Duley, F. L. 1939. Surface factors affecting the rate of intake of water by soils. Soil Sci. Soc. Amer., Proc. 4:60-64.

During the last two seasons tests have been made on the intake of water by certain Nebraska soils under a variety of surface conditions. Water has been applied artificially by sprinkling, and intake has been calculated as the difference between the application and the runoff.

It appears from these studies that the principal question involved in the intake of water in Nebraska soils is the condition of the immediate surface and the circumstances that may affect surficial changes. So far as our studies have gone the thin compact layer which forms on the surface of bare soils during rains has had a greater effect on intake of water than has the soil type, slope, moisture content, or profile characteristics. If we would maintain a high rate of intake of water by a soil we must make sure that the immediate surface is in condition to absorb water rapidly. It seems that this may be done in practice by maintaining a cover of crop residue on the surface.

Abstract No. 362.

Duley, F. L., and O. E. Hays. 1932. The effect of the degree of slope on runoff and soil erosion. J. Agr. Res. 45(6):349-360.

Determinations of runoff and erosion were made by means of water applied to soil artificially to simulate rainfall.

In one case a tank, which could be tilted so as to vary the degree of slope of the surface, was filled with soil and used to study the effect of slope on runoff and erosion.

In another test the plots were placed at different angles on a hillside so that the slope ranged from level to that of the steepest part of the hill. By properly locating the plots large variations in soil profile could be avoided.

The results from the two methods checked very well and indicate that the one to be used will depend on the type of problem to be studied.

The runoff was found to increase rapidly as the slope increased from 0% to about 3% grade. The increase in runoff was then very slight for each percent of increase in slope.

The soil eroded increased very gradually until the slope was about 4%, then the increase was found to be more rapid up to about 7 to 8%, after which there was a still greater increase in the rate at which the soil was removed from the plots.

The amount of runoff water required to erode 1 lb. of soil decreased rapidly as the slope increased from 1% up to about 10%, after which the decrease was gradual and slight. In some cases the water required to erode 1 lb. of soil was less for the 0 and 1% slopes than for a 2% slope.

Soil erosiveness is shown to depend not merely on the physical properties of the soil, but also on the degree of slope and possibly on several other factors. A silty clay loam gave greater erosion on the lower slopes whereas a sandy soil gave more erosion than did the silty clay loam on steep slopes.

The results obtained on large plots in Missouri and Texas have been shown to correspond reasonably well with the results obtained in these tests. This would tend to indicate that small plots having water applied artificially may be used for studying a large number of problems in connection with soil erosion.

Abstract No. 363.

Duley, F. L., and L. L. Kelly. 1939. Effect of soil type, slope, and surface conditions on intake of water. Nebraska Agr. Exp. Sta. Bull. 112. 16 p.

Applications of water were made to soils by sprinkling 1/200 acre plots. Determinations of infiltration and runoff rates were made on different soil types found in eastern Nebraska. The effects of different degrees of slope and rates of application of water, as well as the initial soil water content, were also determined.

The results indicate that the rate of infiltration taking place on any soil type may be varied between wide limits simply by changing the surface tillage, crop, or crop residue, or by repeating the application of water. This makes it difficult to arrive at any figure that might be used as an infiltration rate characteristic of any given soil. There may be far greater variation between the rates obtained under different surface conditions on a single soil than would be shown by different soils having the same surface conditions. This may make it necessary to think of infiltration rates characteristic of surface conditions rather than of different soils.

Claypan soils like the Pawnee clay loam and Butler silty clay loam absorbed large quantities of water within a short period of time whenever the surface was protected by means of a straw mulch. This would indicate that the heavy layers in these subsoils probably did not retard infiltration to such an extent that they would likely have any appreciable effect on runoff under climatic conditions prevailing in Nebraska.

The breaking down of soil structure, by the compacting effect of the rain and the assorting and rearranging of the soil particles by running water forming a compacted layer at the immediate surface, appears to be the principal reason for the low infiltration rates on cultivated land. The formation of this semi-pervious layer, often only a few millimeters thick, was largely prevented by a covering of straw or by a growing crop.

The rate of infiltration remained at a relatively high level for a considerable period on the various soils when the surface was kept open by means of dense crop or crop residue. On bare soils the infiltration rate was reduced to a very low point and tended to approach approximately a common level on all the soils tested.

Abstract No. 364.

Duley, F. L., and L. L. Kelly. 1941. Surface condition of soil and time of application as related to intake of water. U.S. Dep. Agr. Circ. 608. 30 p.

This circular reports an infiltration study of eight soils in southeastern Nebraska. Complete data for plots on only two soils are given: Marshall silt loam (heavy subsoil) and Lancaster sandy loam. Rates of intake under different surface conditions were wide and differed at successive applications. In determining intake rate no attempt was made to prevent lateral seepage into the soil beneath the 6-inch plot boundaries. The intake rate recorded is the difference between the rate of application and the rate of runoff. Tests on bare cultivated, straw-covered, and grassed plots (on Marshall silt loam) show the intake of water before the infiltration rate became relatively constant to be greater on the straw covered and grassed plots than on the bare plots and the final rate of intake on the straw-covered plots to be greater than on either the bare or grassed plots. Final rates on straw-covered and bare plots ranged from 1.90 to 0.21 inches per hour on Marshall silt loam and from 1.36 to 0.32 inches per hour on Lancaster sandy loam. The low intake rate on bare plots is attributed to the formation of a compact layer on the surface of the soil. Application of water to a plot from which the straw cover had been removed after a test giving a final intake rate of 1.24 inches per hour resulted in a final intake rate of 0.44 inches per hour. The drop is attributed to a change in surface condition rather than "wetness" of the soil. On the grassed plot the final intake rate ranged from 1.63 inches per hour to 0.42 inches in five tests on three consecutive days. The amount absorbed during the first test was 8.95 inches, and the final rate, at the end of the three hours, was 1.63 inches per hour. On the day following the last of the five tests the grass was clipped and swept off the plot and a 3-hour test at approximately the rate of application used in the previous test was made. During this test, 2.09 inches were absorbed; and the final rate was 0.63 inches per hour.

Abstract No. 365.

Duley, F. L., and C. E. Domingo. 1943. Effect of water temperature on rate of infiltration. Soil Sci. Soc. Amer., Proc. 8:129-131.

Water at temperatures of 40°, 70°, and 110°F was applied by sprinkling to soil in a laboratory infiltrometer 16 × 72 inches in size. The water temperature was changed during the course of a given test after the infiltration rate had become essentially constant. The effect of water temperature was noted by any break in the infiltration curve after a change in water temperature. The infiltration rates of water at 40° and 70°F were not significantly different. Water at 110°F gave a consistent but slight increase in the infiltration rate over water at 40°F. The increase was not proportional to change in viscosity, indicating that other factors affecting intake may overbalance the effect of change in viscosity.

Abstract No. 366.

Duley, F. L., and C. E. Domingo. 1943. Reducing the error in infiltration determinations by means of buffer areas. J. Amer. Soc. Agron. 35(7):595-605.

The error encountered in measuring infiltration rates on small plots, due to subsurface lateral movement of applied water was corrected by using a large plot (0.016-acre) and surrounding it with a buffer area and a pre-wetted zone. These precautions were taken to avoid escape of air from beneath the plot and consequent loss of water by lateral movement. Small plots unprotected by these buffers gave much higher intake rates. Moisture determinations indicated that the water applied to the test plot penetrated vertically into the soil; thus the amount absorbed was assumed to represent the possibilities for intake if rain were falling over a wide area under similar conditions.

Abstract No. 367.

Duley, F. L., and C. E. Domingo. 1949. Effect of grass on intake of water. Nebraska Agr. Exp. Sta. Res. Bull. 159. 15 p.

Infiltration tests were made on a number of grassland soils by means of a 16- by 72-inch sprinkler type infiltrometer. Earlier work has shown that results with infiltrometers may be higher than the infiltration from natural rainfall. However, the small infiltrometer has been of value for comparing different conditions or treatments.

Tests were made on native meadow and range pasture land in a moist subhumid to dry subhumid climate.

The various types of grasses tested were effective in inducing a high intake rate of water into the soil. However, the total cover, including live grass and associated litter, was more significant than the kind of grass or the type of soil.

An area of tall grass and also a forest area nearby gave very high intake rates.

Tests made in a dune sand area showed that the grass present had a marked effect on infiltration. The intake on sandhill soil without either the grass or the grass roots on the surface was very much less than where the grass was present. This sandy land with native grass gave infiltration rates similar to those obtained on a heavier cultivated soil when it was protected with a straw mulch.

On an area affected by overflow deposits and trampling by animals, the intake rate on bluegrass land was reduced to a very low point.

Abstract No. 368.

Dunford, E. G. 1954. Surface runoff and erosion from pine grasslands of the Colorado front range. J. Forest. 52(12):923-927.

These two studies were designed to examine the results of grazing and forest disturbances on runoff and erosion. The objective has been to establish limits on the intensity of such uses in Front Range watersheds.

Abstract No. 369.

Durrell, L. W., R. Jensen, and B. Klinger. 1950. Poisonous and injurious plants in Colorado. Colorado Agr. Coll. Ext. Bull. 412-A. 80 p.

It is the purpose of this bulletin to describe and illustrate the poisonous or injurious plants of the state that they may be recognized and that areas infested with them may be avoided. A summary of the available knowledge concerning poisonous properties of plants is also given, with remedial measures where these are known.

Abstract No. 370.

Dusi, J. L. 1949. Methods for the determination of food habits by plant microtechniques and histology and their application to cottontail rabbit food habits. J. Wildlife Manage. 13(3):295-298.

Because histological food habits techniques already in existence were not easily applied to many animals whose food habits necessitate histological analysis, the writer attempted to develop other basic microtechniques for making these studies.

Methods for the preparation of reference microscope slides and photomicrographs and for the mounting and study of food habits slides are given.

Figures illustrate histological methods and some of the striking differences in plant epidermal cells upon which food identification is based.

Abstract No. 371.

Dwyer, D. D. 1958. Competition between forbs and grasses. J. Range Manage. 11:115-118.

The purpose of this study was to determine the loss in weight suffered by big bluestem (*Andropogon gerardi*) as a result of competition from both rhizomatous and taprooted forbs.

Abstract No. 372.

Dyck, G. W., and R. E. Bement. 1971. Herbage growth rate, forage intake, and forage quality in 1970 on heavily and lightly grazed blue grama pastures. U.S. IBP Grassland Biome Tech. Rep. No. 94. Colorado State Univ., Fort Collins. 15 p.

Herbage growth rate, forage intake, and forage quality were measured on heavily and lightly grazed pastures during the summer of 1970. When a growth opportunity occurred, herbage growth was more rapid on the lightly grazed pasture. Forage intake by individual non-fistulated heifers was greatest on the lightly grazed pasture. Heavily and lightly grazed pastures did not differ significantly in forage quality.

Abstract No. 373.

Dye, A. J., and W. H. Moir. 1971. CO_2 exchange over shortgrass sods. U.S. IBP Grassland Biome Tech. Rep. No. 81. Colorado State Univ., Fort Collins. 13 p.

Progress to October 1970 consisted mainly of improving the experimental design of an instrumentation system for monitoring carbon dioxide exchange in plants under field conditions. Initial results are presented for both the open flow and compensating systems. Ambient carbon dioxide concentrations are presented as a seasonal decline from a high of 328 ppm CO_2 in April to 322 ppm in September.

Abstract No. 374.

Dyksterhuis, E. J. 1946. The vegetation of the Fort Worth Prairie. Ecol. Monogr. 16(1):1-29.

The present research, extending over the period 1939-1944, deals with the quantitative relations between the principal species under various influences of the environment. The principal species and their percentages of coverage over the broad area were first determined. This provided a base from which to observe and evaluate deviations. Deviations that were found to be important and recurring included those associated with history of use, relief, and time of year.

Abstract No. 375.

Dyksterhuis, E. J. 1948. The vegetation of Western Cross Timbers. Ecol. Monogr. 18(3):325-376.

The boundary of the western cross timbers of Texas and its major divisions are shown. The area includes a main belt of sandy soils with gentle relief developed upon Cretaceous outcrops covering 2,436,000 acres, and a fringe of rocky and gravelly soils with rough relief developed upon Pennsylvanian outcrops covering 1,680,000 acres. Both divisions have a sparse overstory of *Quercus stellata* and *Q. marilandica*. Basic knowledge of the climate, geology, and soils of the area is summarized. Grazing influences, cultivation, crops, and erosion are considered in relation to use of the land and vegetation since settlement. Sample plots at 350-yard intervals along 76 miles of cross-country transects, as well as hundreds of plots on scores of tracts selected for special study, were analyzed during 9 years. They provide data on coverage by species. These data are supplemented by those acquired at monthly intervals. In the order of decreasing relative coverage, the species or groups are ranked as follows: annual forbs, 19%; *Buchloe dactyloides*, 9%; the 2 oaks, 7%; annual *Aristida* spp., 6%; *Bouteloua hirsuta*, 5%; and some 20 other species, each composing less than 5 but over 0.5% of total coverage. *Buchloe dactyloides* is four times as abundant in the latter. The oaks, *Papsalum ciliatifolium*, annual *Aristida* spp., *Bouteloua hirsuta*, *Andropogon saccharoides*, and *Smilax bonanox* are far more abundant in the main belt. Some 30 species with coverage of over 0.3% in one division show different or virtually no coverage in the other. Physiognomy of the vegetation is associated with certain classes of soils. Floristically there are four broad types of vegetation. They are the *Quercus-Smilax* type of podzolic soils, the *Quercus-Prosopis* type of immature reddish prairie soils, the *Prosopis* type of mature reddish prairie soils, and the old-field type of podzolic soils that have been cleared, cultivated, and abandoned because of erosion. Coverage of over 0.2% is reported for some 50 species occurring in one or more of the types. Species and their relative coverage differ greatly by types. Climax or original vegetation, as determined from relicts, consisted of the mid-grass, *Andropogon scoparius*, as the major dominant and with the 2 tallgrasses, *Sorghastrum nutans* and *A. furcatus*, as lesser dominants. Species composition of relict original vegetation is reported. Differences between vegetation of the different soils are much greater now than they were originally. *Andropogon scoparius* was a universal dominant of the climax, but in the grazing disclimax the oaks predominate on podzolic soils, annual forbs on immature reddish prairie soils, and *Buchloe dactyloides* on mature reddish prairie soils. Grazing by domestic livestock was the primary cause of the modification of cross timbers vegetation. Grazing coactions were determined by monthly studies of both grazing animals and range vegetation under three intensities of grazing. Different species composed an important part of the diet of livestock on lightly, moderately, and heavily stocked range land. Broad implications in range management are discussed. Autecological studies of 14 grasses are reported. Included are studies of *Andropogon scoparius*, *Sorghastrum nutans*, *Bouteloua hirsuta*, *B. curtipendula*, *Sporobolus asper*, *Buchloe dactyloides*, *Aristida* spp. of the Group Purpureae, *Paspalum ciliatifolium*, *Stipa leucotricha*, *Andropogon saccharoides*, *Cynodon dactylon*, *Panicum scribnerianum*, 5 perennial species of *Eragrostis*, and *Andropogon ternarius*. The course of range degeneration in the main belt and its effects on floristic composition of both overstory and understory were determined. Secondary succession on abandoned fields is described and shown to vary depending upon degree of grazing disturbance, proximity of a source of seed of successionally higher species, and the degree of erosion at the time the field was abandoned. A subsere on an old field with ordinary degree of erosion, protected from grazing, and adjoining a source of seed, reached the final stage in 14 years. There are typically four stages, namely, the weed stage, the annual *Aristida* stage, the *Andropogon ternarius* stage, and the *A. scoparius* or final stage. The *A. ternarius* stage is sometimes omitted. Subseres on old fields protected from grazing are commonly arrested in the *Aristida* stage because seeds of the next stage are lacking. This was proven by simply scattering seeds of climax grasses in bands several yards wide. On such bands the climax grasses completely eliminated annual *Aristida* species through moisture competition within 4 to 7 years and volunteered in the adjacent unseeded bands of *Aristida*. Included are notes on: 13 species that did not go dormant in winter at this latitude and 10 that did; 9 with prominent winter rosettes and 5 common winter annuals; time of germination of 22 species; time of flowering of 133 species; and time of mature fruits on 39 species. The "climax-problem" of the transition area between forest and prairie is discussed in relation to climate, soils, grazing, and fire. It is concluded that the area is within a grassland climate though density of the stand of oaks has increased under overgrazing to a point where the landscape now approaches that of forest or woodland rather than the original savannah.

Abstract No. 376.

Dyksterhuis, E. J. 1958. Ecological principles in range evaluation. Bot. Rev. 24(4):253-272.

Utilizing many cited researches, along with widespread experience of the Soil Conservation Service, the synthesis of a new system of range evaluation, based on quantitative ecology, was reported by Dyksterhuis in 1949. Since then there have been amplifications and some modifications among acceptable postulates resulting from experience of many rangemen and from advances in ecology, especially those dealing with theory. Rangemen and ecologists should find continued development and refinement of this range evaluation procedure possible if it is founded soundly upon ecological principles. Yet, there are several limitations in practical application. Acceptable refinements in applied range ecology are dependent upon refinements in range management that are economical and acceptable by stockmen. Modern soil survey information is lacking in many range areas and not all rangemen are able to identify and map soil-groups such as those previously named. Data to properly established gradients of precipitation and temperature are lacking in many mountainous areas. Many, if not most, ecologic descriptions of vegetation in the literature stress climatic and biotic but not edaphic features. Relicts of climax vegetation have not been found as yet or reestablished in certain types of sites, making it necessary to assume a climax vegetation for them from establishing gradation along environmental gradients. Finally, application of ecological principles in range evaluation is limited by the ecological knowledge that professional rangemen have. There is increasing acceptance and use of ecological precepts among rangemen, associated with an increasing number of active ecologists who: (a) seek to be understood by non-ecologists, (b) acknowledge that acceptable examples of climax vegetation may be found or reestablished in the absence of large influent animals such as the bison, (c) recognize that biological data may be useful even though inexact or not subject to exact mathematical expression; (d) discern but endeavor to reconcile polyclimax and monoclimax viewpoints, (e) make it clear that grassland is not necessarily a stage in succession to forest, and (f) accept fire as a part of the environment under which natural grazing lands were evolved and as closely related to climate, hence to a degree a part of climax conditions, particularly of climax grasslands, rather than an unrelated phenomenon. There is increasing awareness: (a) that evaluation of range communities must encompass not only organisms but also the physical factors of the environment, with the whole viewed as representing either dynamic equilibrium or imbalance between living and non-living features (i.e., of ecosystems); (b) that there is parallelism between gradation of climax vegetation and gradients in climate and soil (i.e., of continua); (c) that differences in environment not reflected in different phenotypes may be reflected in different genotypes (i.e., of genetics); (d) that currently climax vegetation is a product of genetic, geologic, and climatic history as well as of current environment (i.e., of interpretive plant geography); (e) that environmental factors produce organic responses while acting collectively, changing through the seasons and years, with action of each factor modified by other factors (i.e., of holocpenotic environment); and (f) that discoveries of parallelism between elements of physical environment and natural vegetation, though not interpretable simply as cause and effect, provide exceedingly useful data for many purposes including (*i*) evaluation of different kinds of range land when based on differences in kind or amount of climax vegetation and (*ii*) evaluation of different kinds of range cover that may occupy each of these kinds of land in range subseres.

Abstract No. 377.

Dyksterhuis, E. J. 1964. Estimated total-annual-yields in climax by sites. U.S. Dep. Agr. Soil Conserv. Service. 8 p.

This data is a mere second step in a process of improvement of range estimates. The process may be expected to continue through decades.

The method of successive approximations is applicable in a problem of this kind. There can be little progress without such recording of data, though criticism and correctness are expected and necessary.

The data do have two merits worthy of note. (1) They are based upon an ecological and consistent conception of how the range landscape of a vast region can be subdivided for practical range management. (2) The estimates submitted by fieldmen were uniformly of total-annual-yields, including all growth of leaves, non-woody stems, twigs, inflorescences, and fruits, to ground-line; but, excluding bark and wood production (except current twigs) of trees and shrubs, and excluding all materials of previous production years.

The yield from all herbaceous species, only, is considered to be "Herbage yield"; while yield from woody species is segregated as "Woody-plant yield"--these two together constituting "Total-annual-yield." This properly leaves out any consideration of "forage yield" and "usable forage" until a specific kind, time, and intensity of grazing on a specific tract, have been stipulated.

Therefore, it was possible to prepare a table based on the combined clipping studies and experience of range conservationists in five states. Their results were interpolated and extrapolated, using plain or semi-logarithmic cross-section paper in straight-line or curved projections, to best fit points provided, until a yield in climax had been predicted for every type of range site likely to be encountered in a named state, even though some sites are currently regarded as too limited in area to justify mapping.

Abstract No. 378.

Dyksterhuis, E. J., and E. M. Schmutz. 1947. Natural mulches or "litter" of grasslands: With kinds and amounts on a southern prairie. Ecology 28(2): 163-179.

Recent important findings concerning effects of surficial mulches and types of studies on plant mulches or litter are reviewed. The meager literature and lack of classification of surficial organic matter of grasslands are pointed out.

Abstract No. 379.

Eckert, R. E., Jr., G. J. Klomp, J. A. Young, and Raymond A. Evans. 1970. Nitrate-nitrogen status of fallowed rangeland soil. J. Range Manage. 23(6):445-447.

Nitrate-nitrogen (NO_3N) accumulated in the soil during the spring, summer, and fall of a fallow year. NO_3N levels in the surface 6 inches in fall, 1967 and 1968, were similar and averaged 43 lb./acre on the atrazine fallow, 27 lb./acre on the mechanical fallow, and 5 lb./acre on the check. Above average precipitation during the winter of 1968-69 resulted in less NO_3N in spring 1969 compared to spring 1968. A comparison between the 2 years at one location showed the following NO_3N levels in the surface 6 inches: spring 1968--atrazine fallow 30 lb./acre, mechanical fallow 29 lb./acre, and check 13 lb./acre; spring 1969--atrazine fallow 5 lb./acre, and check 2 lb./acre.

Abstract No. 380.

Edmonds, F. H. 1950. Geology and its relationship to soils in Saskatchewan. Univ. Saskatchewan Soil Surv., Rep. 13:202-233.

In Saskatchewan the mineral constituents of the soil are geologic deposits of Recent and Pleistocene Age. Recent and Pleistocene deposits have been derived from older formations and thus there is a relationship between the soils and the rocks underlying the country. In a few localities the soil has been formed directly from the weathered material of the underlying rocks. These materials are called Residual. More commonly, the soil has been derived from rock debris which has been transported by ice, water, or wind in recent geologic times. These materials are called Transported. Often the material has been transported long distances; thus much of the mineral matter on the Saskatchewan prairies has been brought by ice from the north and the characteristics of the soil have been influenced by the type of rock found in the north.

While for much of geological time the region now known as Saskatchewan has been dry land, it has on several occasions been submerged. Deposits of limestones, sands, and muds formed at times of submergence contribute to the soils. The accumulation and spread of ice over the area in fairly recent geological times resulted in the formation of unconsolidated materials known as "glacial drift," and these glacial deposits are of the utmost importance as soil-forming materials, and their topographic features have an important bearing upon agriculture. Since glaciation was an event of paramount importance to the Canadian West, it will be discussed in more detail than the other phases of the Geological History.

Abstract No. 381.

Edwards, C. A., E. B. Dennis, and D. W. Empson. 1967. Pesticides and the soil fauna: Effects of aldrin and DDT in an arable field. Ann. Appl. Biol. 60: 11-22.

Aldrin dust (3 cwt of 1½%/acre) or DDT dust (2 cwt of 5%/acre) was applied to small plots replicated four times, and four plots were untreated. All plots were kept fallow for one year. Soil samples were taken at 2 to 3 monthly intervals and the fauna extracted by a flotation method. The insecticides did not affect Lumbricidae, Enchytraeidae, or Nematoda. Nearly 100 species of arthropods were found, and the greatest effects were those of DDT on mesostigmatid mites and of aldrin on entomobryid or isotomid Collembola and on Pauropoda. Most species of Collembola increased in DDT-treated plots, apparently because mesostigmatid mites were reduced. In terms of biomass Coleoptera and Diptera were most affected. Both insecticides killed more pests than predators or beneficial animals. The effects of the insecticides were greatest during late summer or autumn.

Abstract No. 382.

Egoscue, H. J. 1960. Laboratory and field studies of the northern grasshopper mouse. J. Mammal. 41: 99-110.

Methods for maintaining a laboratory colony of northern grasshopper mice are given. In captivity this species bore 3 to 6 litters (average 5.09) annually; litter sizes ranged from 1 to 6 (average 3.54). Puberty in females was not attained until the mice were at least 160 days of age. Breeding habits and behavior of the northern grasshopper mouse in captivity are compared with several other cricetids from western Utah. A list of small mammals associated with the northern grasshopper mouse in two selected areas is included, together with data on habitat.

Abstract No. 383.

Ehlig, C. F., and W. R. Gardner. 1964. Relationship between transpiration and the internal water relations of plants. Agron. J. 56:127-130.

Below a characteristic diffusion pressure deficit value for each plant, the transpiration rate was proportional to the potential transpiration. Above this value, the transpiration rate tended to decrease, rapidly at first and then more slowly, with increasing DPD. The relative rate of water loss from initially turgid detached leaves decreased very markedly with decreasing water content at a water content of about 90% of that at full turgor and corresponding to a DPD of about 10 to 15 bars.

Abstract No. 384.

Ehrenreich, J. H. 1959. Effect of burning and clipping on growth of native prairie in Iowa. J. Range Manage. 12:133-137.

Effects of burning and clipping were studied on growth of some dominant and principal subdominant grasses and forbs on a mesic native prairie in northeastern Iowa. Burning about the first of March had no apparent adverse effects on native vegetation, but did inhibit growth of Kentucky bluegrass. Prairie plants began growth 2 to 3 weeks earlier on burned areas and produced more and taller flower stalks than on unburned areas. Earlier growth and greater seedstalk production probably results from higher soil temperatures in early spring where litter has been removed by burning. Although there were more flower stalks on burned areas, there was no significant difference in total yields due to burning.

Clipping four times during the growing season did more harm to plants than clipping only once at the end of the growing season. A 79% reduction in yield was obtained from 2 consecutive years of frequent clipping compared to only 16% reduction from 2 consecutive years of clipping at the end of the season.

Clipping at the end of the growing season appears to be the best way to get maximum sustained yield.

Abstract No. 385.

Ehrenreich, J. H., and J. M. Aikman. 1957. Effect of burning on seedstalk production of native prairie grasses. Iowa Acad. Sci., Proc. 64:205-212.

A survey of vegetation was carried out in August 1956 in adjacent burned and unburned sections of prairie. Plants were cut, and 3 bundles of each species 5 sq inches in cross-section were collected from burned and unburned areas. The grasses collected were *Sporobolus heterolepis*, *Andropogon scoparius* and *A. gerardii* (the dominant species), *Elymus canadensis* and *Sorghastrum nutans*. In all except *E. canadensis*, burning considerably increased the number and length of flower stalks, decreased the weight of leaf blades and increased the weight of leaf sheaths produced without affecting the photosynthetic area, increased the ratio of flower stalks to leaves, and increased the dry weight per bundle of plants. Earlier growth and consequent increases in carbohydrate availability may have encouraged the differentiation of flower stalks. The growth of *E. canadensis* was practically unaffected by burning. For all species from both burned and unburned areas, percentage seed germination was very low, probably because the seed was not sufficiently mature. Seed of *A. gerardii* and *S. nutans* from burned areas germinated better, and seed of *E. canadensis* worse, than that from unburned areas. Seed of *A. scoparius* from unburned areas did not germinate. No germination occurred in *S. heterolepis* seed.

Abstract No. 386.

Eklund, L. 1970. Insect seeds studies on the Pawnee Grasslands. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

In August 1968 two species of insect larvae were found destroying the seeds of two thistle species on the Pawnee grasslands. Data collected from May to October 1969 has shown that an average of 65% of the seeds were destroyed in one species and 75% in the other. Infestation of the seedheads occurs in the first species of thistle in early June, shortly after the seeds have set. The second species of thistle sets seeds in mid-July, and a second generation of insects infest these at approximately the same time. The insects continue to eat the seeds until late September or early October, and at this time they pupate. 95% of the seedheads are damaged in the first species and 84% in the second species. Preliminary data has shown that each insect consumes approximately 50 seeds over a single season. The data have also given biomass estimation of the insects and estimates of overall efficiency and possibly a new species of insect.

Abstract No. 387.

Elias, M. K. 1935. Tertiary grasses and other prairie vegetation from the High Plains of North America. Amer. J. Sci. 29(169):24-33.

Husks of grasses and nutlets of Boraginaceae have been collected in great numbers from late Tertiary formations in over 20 localities in and near Nebraska. The succession of floral zones, which proves to be invariably the same, can be tied to horizons in which some of the best known vertebrate remains have been found and are middle Miocene to middle (and probably upper) Pliocene. These grasses and husks will be valuable as index fossils. STIPIDIUM is erected to include *Lithospermum fossilium aristatum* Berry and many new but as yet undescribed species. This new genus is referred to subtribe Stipeae of the tribe Agrostideae as is also *Berriochloa* which, due to incorrect orientation of husks, was formerly classed among the Hordeae. *Stipidium* n. sp. and *Berriochloa* n. sp. are figured.

Abstract No. 388.

Elias, M. K. 1942. Tertiary prairie grasses and other herbs from the High Plains. Geol. Soc. Amer. Spec. Paper 41. 176 p.

Seeds of the late Tertiary prairie grasses are fairly common throughout the most arid parts of the prairie states. The most common among these fossil seeds show close relation to the most typical modern prairie grass: the spear-grass or *Stipa*, which has world-wide distribution. The oldest known ancestor of this grass was found in the Harrison formation of lower Miocene in western Nebraska.

Another prairie grass, a millet (*Panicum*), and one of its kin (*Setaria*) appeared here only in the Pliocene, when the prairie was also invaded by numerous forage herbs, ancestors of modern *Lithospermum*, *Krynitzkia*, *Lappula*, which are now also very common among the forbs of the plains.

The preservation of the protective covers of the fossil seeds is so nearly perfect that some fine morphologic details, previously undescribed for Stipeae, were for the first time detected on the fossil *Stipidium* and subsequently on some species of its living descendant, *Stipa*.

Comparative study of the fossil and living forms reveals evolutionary trends of the seeds of the prairie grasses. The rather small and generalized Miocene ancestor gave rise to greatly diversified Pliocene and Recent species. The seeds of these include small and very large, very slender, and very stout forms, all of them variously adapted for protection against drought and for more efficient dispersal.

Abundance, good preservation, and rapid ecologic and evolutionary changes make grass seeds the best index fossils for subdivision of the continental late Tertiary rocks.

Abstract No. 389.

Ellison, L., and E. J. Woolfolk. 1937. Effects of drought on vegetation near Miles City, Montana. Ecology 18(3):329-336.

The extensive drought of 1934 was severely felt in southeastern Montana. U.S. Weather Bureau data for Miles City show 1934 to have been the driest year in the entire 57 years' record. Summer rainfall was only 3.53 inches, 37.9% of average, and temperatures were exceptionally high. It seems likely that the effects of this dry season on the native vegetation were aggravated by the preceding series of dry years.

Injury to woody plants is to be observed near Miles City in stands of pine, juniper, cottonwood, sagebrush, and other species. The 1934 diameter growth in many individuals was less than for any other year. The tops of some were partially or completely killed back, depending on the site. Some like *Artemisia cana* were able to regenerate from below ground more or less successfully in 1935, but others like *Artemisia tridentata* died when the tops were killed. The result has been readjustment and redefinition of consociation boundaries in many places.

The drought, beyond stunting the herbaceous vegetation in 1934, probably affected that of the following year. Phenological observations on *Agropyron smithii* and *Bouteloua gracilis* indicate that flowering in the spring of 1935 was retarded and lessened. Injury to herbaceous vegetation, from the records of charted quadrats, was very great. The most important decreases between 1933 and 1935 were, based on the figures for 1933: *Bouteloua gracilis* 75%, *Agropyron smithii* 74%, *Buchloe dactyloides* 79%, *Stipa comata* 62%, and *Carex filifolia* 12%. In surprising contrast is the increase in area of *Poa secunda* of 179%; and although the established plants of *Stipa comata* suffered heavy decrease from the drought, a large number of deep-rooted seedlings were observed to be coming up in 1935.

The decrease of forage is more than a one-year loss, for, as the record shows, the favorable season following the drought failed to restore the perennial vegetation to anywhere near its former condition. In the agricultural economy of the region, the likelihood of recurrent droughts and slowness of vegetative recovery are fundamental restrictions to the size of the human population. Failure to recognize them has already resulted in much loss and suffering and the abandonment of great numbers of homes. It seems fairly evident that the population, to be in ecological balance with this environment, should be no greater than can use the ranges lightly enough to permit recovery and accumulate a forage reserve against future droughts.

Abstract No. 390.

Ellison, W. D., and W. H. Pomerene. 1944. A rainfall applicator. Agr. Eng. 25(6):220.

During the summer of 1939, experimental work which would lead to the construction of a rainfall applicator was started at the Goshocton, Ohio, project of the U.S. Soil Conservation Service.

The service requirements, as agreed upon at that time, were that the applicator should be suitable for applying rainfall of different drop sizes, drop velocities, and at various intensities. Apparatus was to be constructed in such a way that these rainfall factors could be varied one at a time and studied as independent variables.

Decision on size of applicator was based on plot sizes previously used on the project. Many plots 5 × 6 ft had been used, and the 6 × 7-ft size was chosen so that it would overlap by ½ ft the edges of the 5 × 6-ft plot.

Abstract No. 391.

Ely, C. A. 1970. Mid-winter bird count for 1969. Kansas Ornithol. Soc. Bull. 21(1):1-8.

Twenty-one midwinter bird counts were taken by members of the Kansas Ornithological Society between 20 December 1969 and 6 January 1970. This is about average coverage for the past 10 years. However, the total number of individuals recorded (2,720,085) was more than 10 times the previous high of 228,564 in 1953. The presence of large blackbird roosts at the Cheyenne Bottoms Waterfowl Management Area (Great Bend) and at Kingman State Lake (Kingman) were largely responsible for the high 1969 count. Most count groups fortunate enough to miss bad weather reported higher count totals than in recent years.

The total number of species recorded (126) also exceeds the previous high of 125 in 1965. Counts for the past 10 years have averaged about 111 species (excluding Harlan's Hawk) and have varied from 98 in 1961 to 125 in 1965. Eight species were recorded on the midwinter count for the first time: Whistling Swan (Junction City); Lesser Yellowlegs, Semipalmated Sandpiper, Western Sandpiper, Boat-tailed Grackle, Avocet (all Great Bend); Sprague's Pipit (Udall); Dickcissel (Lawrence).

As in 1965 the unusually high numbers were probably the result of unseasonally warm weather and open water at the beginning of the count period. Groups making counts near the end of the period generally had bad weather and less success. Topeka, for example, recorded 45 species on count day but missed 17 other species seen during the count period. Great Bend had the largest number of species (72), the most individuals and five of the eight species new to the count.

Abstract No. 392.

Ely, C. A., and M. C. Thompson. 1971. Distributional notes from southwestern Kansas. Kansas Ornithol. Soc. Bull. 22(3):9-11.

The authors, accompanied by various students, have made numerous trips to southwestern Kansas, but only a few of the more significant findings were published. All visits were short (one to three days), and most were made between mid-April and mid-May. Unless otherwise stated, all observations were in raparian habitat along the Cimarron River near Elkhart, Morton County, or along the Arkansas River near Syracuse, Hamilton County. A number of the 193 species recorded provided observations pertinent to studies of Kansas bird distribution. Specimens are in the collections of Fort Hays Kansas State College (FHKSC) or Southwestern College (SC).

Abstract No. 393.

Emerson, F. W. 1932. The tension zone between the grama grass and piñon-juniper associations in northeastern New Mexico. Ecology 13(4):347-358.

The piñon-juniper association occupies an intermediate position between the montane forests and the shortgrass plains, appearing most often in rocky places such as the edges of mesas. The juniper is found to be the pioneer of the two species, followed by piñon and occasionally other shrubby plants.

Studies are reported of soils, root systems, rainfall, evaporation rates, temperature, and seed dispersal. Soils in which the piñon-juniper association thrives, vary from fine adobe to outcrops of limestone, sandstone, and igneous gravels. The grasses are always poorly developed in the woodland soils. The combined effects of the condition of the stand of grasses and the efficiency of the agents of dissemination appear to be responsible for the location of the woody plants. Soil character and geological formation are only indirectly important as they control the growth of grasses.

Roots of the piñons and junipers assume both horizontal and vertical positions in any soil they can penetrate. Both sets of roots are found to be capable of active absorption. In rocks lying horizontally, the taproots develop very little, being replaced by laterals that follow the seams in the rocks. Grass roots are mostly in the first foot of soil in direct competition with the horizontal roots of the trees and with all of the roots of tree seedlings. This is probably a principal reason why the woody plants fail to establish themselves in close stands of grass.

Differences in rainfall are too slight and fluctuating to be responsible for the differences in vegetation. Rains seldom affect soil water below the roots of grasses and the horizontal roots of the trees. The vertical roots of trees may reach a continuous supply of moisture that follows the deep rock strata.

Woody plants are found to grow in clumps well separated from each other. On level ground the seedlings practically never develop except near shelters of some kind. On hillsides, on the other hand, they establish themselves in open places below parent trees. This proves that their usual position with older trees is not an obligate shade relation. Seeds dropped by birds and buried by rodents explain the presence of most of the seedlings under the adults and the consequent grouping into clumps.

Abstract No. 394.

Enderson, J. H. 1965. Roadside raptor count in Colorado. Wilson Bull. 77(1):82-83.

Incidental to a current long-term study of the Prairie Falcon (*Falco mexicanus*), I have kept records of all raptors seen in a 70-mile-wide plains area extending south from Fort Collins to Colorado Springs, Colorado, immediately east of the Rocky Mountains. Raptors were counted from an automobile cruising county roads on grazing and wheat land. All observations were made before noon on days when the wind was slight. A total of 12 counts was made in the periods from late September to February 1962-63 and 1963-64, involving 1,675 miles of travel during the count periods.

Abstract No. 395.

Enevoldsen, M. E. 1967. The effect of range site and range condition on the growth and development of western wheatgrass. M.S. Thesis. South Dakota State Univ., Brookings. 149 p.

During the 1964 growing season, studies in the growth and development of western wheatgrass were conducted at the Cottonwood Range Field Station, Cottonwood, South Dakota. The objectives were to determine the effect of range site and range condition on: (1) shoot length and leaf development, (2) seedstalk production, (3) shoot and leaf condition, (4) height and location of the apical meristem, and (5) total available carbohydrate concentrations in western wheatgrass rhizomes. In a lightly grazed summer-use pasture in good range condition, two sampling areas were selected--one in a small drainage-way with silty clay loam soils, the other on a gently sloping upland with silty soils. In a heavily grazed summer-use pasture in poor range condition, a gently sloping upland with silty clay soils was chosen, comparable to the upland in good range condition.

Abstract No. 396.

Enevoldsen, M. E., J. K. Lewis, and L. D. Kamstra. 1966. Studies in the growth and development of western wheatgrass. South Dakota Agr. Exp. Sta., A. S. Ser. 66-10. 11 p.

Enevoldsen, M. E., J. K. Lewis, and L. D. Kamstra. 1966. Studies in the growth and development of western wheatgrass. Presented at the 10th beef cattle field day, April 20.

Western wheatgrass is one of the most important range grasses in the northern Great Plains. Detailed knowledge of its pattern of growth and development is needed in order to make sound grazing management decisions.

Plants on the clayey upland in poor range condition emerged about a month later than those on comparable soils and slope in good range condition. After May 14, plants on the good range grew most rapidly during June when precipitation was greatest, especially from June 11 to June 25. This was true regardless of emergence date. However, in the pasture in poor range condition, maximum growth occurred from May 14 to May 28 and then declined very sharply. The additional water in the drainage way produced more rapid growth than the lightly grazed upland. Growth ceased at all locations by July 13 with the advent of hot weather. This was true regardless of emergence date. The average maximum plant height was 6.3, 8.8, and 10.2 inches, respectively, on the upland in poor, the upland in good, and the drainage way in good condition. Plants which emerged later grew more slowly for a shorter period of time. The average maximum plant height was 7.2, 7.9, and 10.2 inches, respectively, for plants emerging June 1-15, May 1-15, and April 1-15. Some new plants emerged in the drainage way between August 15 to August 31; however, measurements on these plants are not shown.

The average maximum rate of leaf development was slightly more than one leaf in 2 weeks. This rate of development occurred in early May on the pasture in poor range condition but declined rapidly. In the pastures in good range condition, leaf development remained at a maximum until July 13. Leaf development was more rapid in those plants which emerged early in the spring. Leaf development was essentially stopped in all areas by July 13.

Abstract No. 397.

Enevoldsen, M. E., and J. K. Lewis. 1967. Effect of range site and range condition on the height and location of the growing point in vegetative shoots of western wheatgrass. South Dakota Agr. Exp. Sta., A. S. Ser. 67-11:40-47.

Western wheatgrass elevates the growing point of vegetative shoots above the ground surface very early in the growing season. The shoot apex is elevated earlier and higher on taller shoots from good range condition than on shorter shoots from poor range condition. Early in the season, extra run-in water in the drainage-way in good range condition had little effect on shoot apex elevation as compared with the upland in good range condition. However, later in the season the more favorable moisture in the drainage-way resulted in continued shoot elongation and continued elevation of the apical meristem. Information concerning the growth and development of key management species is needed to understand their reaction to grazing and is necessary for the preparation of sound grazing management plans.

The height of the growing point can be predicted with fairly good accuracy by early summer on pastures in high range condition from measurements of shoot length and leaf number.

Abstract No. 398.

Engel, Robert L., and Terry Vaughan. 1966. A coyote-golden eagle association. J. Mammal. 47. 143 p.

Coyotes (*Canis latrans*) are known to associate occasionally with other predators or scavengers. The present paper describes an observation (made by Engel) of an association between the golden eagle (*Aquila chryseatos*) and coyotes. The observation was made on the shortgrass prairie at the Central Plains Experimental Range, 9 miles N and 3 miles E of Nunn, Weld County, Colorado. The vegetation of the area is dominated by blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), pricklypear cactus (*Opuntia polyacantha*), and saltbush (*Atriplex canescens*).

Abstract No. 399.

Engelking, C. T. 1969. Comparison of two static pronghorn antelope herds in southern New Mexico. M.S. Thesis. New Mexico State Univ. 121 p.

This study was conducted to determine some behavior patterns of pronghorn-antelope (*Antilocapra americana*) and to determine what factors were responsible for the static condition of these herds.

The herds under study are located on the Jornada Del Muerto Plains, 23 miles north of Las Cruces, New Mexico, and on Fort Stanton, approximately 5 miles east of Capitan, New Mexico.

Behavior studies included sexual, ingestive, eliminative, bedding, and individual and social behavior patterns. Interspecies relationships of pronghorns and how fences influenced distribution and movement was also studied. As a result of these behavior studies, several management practices have been recommended for pronghorn antelope.

It was concluded that both herds were gradually increasing. The slow growth-rate of the Jornada pronghorn population was attributed to inferior forage as a result of low precipitation levels. A combination of poaching and forage availability was thought to be the cause for the slow growth-rate of the Fort Stanton population.

Abstract No. 400.

England, C. M., and E. L. Rice. 1957. A comparison of the soil fungi of a tall-grass prairie and of an abandoned field in central Oklahoma. Bot. Gaz. 118:186-190.

1. The soil fungi of two grassland plots in central Oklahoma were compared during 1952. Species numbers were determined for each of 9 months in an abandoned field and a prairie.

2. The average number of fungi per gram (based on the total number of colonies per plate) was greater in the field plot throughout the year. The difference in numbers between plots was greatest in early summer and winter and least in spring and late summer. Numbers in both plots were lowest in summer and highest in spring.

3. Usually a greater number of species was found in the abandoned field. The average percentage of species common to both plots was 35.2. A greater number of species was found in the abandoned field only (average 37.4%) than in the prairie only (average 27.9%).

4. Although a few species appeared with a high frequeny throughout the year, most species were of seasonal or sporadic occurrence. This means that the species composition of each plot changes from season to season and, to a lesser degree, from month to month. Some definite differences were found between the fungous populations of the two plots on a monthly or seasonal basis. These differences included variations in the principal species of the two plots and the presence of species which occurred in high numbers in only one of the plots.

5. Individuals of a species did not have a Poisson (random) distribution.

Abstract No. 401.

Epstein, E., W. J. Grant, and R. A. Struchtemeyer. 1966. Effect of stones on runoff, erosion, and soil moisture. Soil Sci. Soc. Amer., Proc. 30(5): 638-640.

Studies on a caribou silt loam at Presque Isle, Maine, were conducted to determine the effect of stones on runoff, erosion, and soil water. The three treatments consisted of a control, stones over 3.81 cm in diameter removed, and stones over 3.81 cm removed, crushed, and reincorporated into the soil. Removing the stones increased soil and water losses over a 4-year period. Infiltration and soil water was decreased as a result of stone removal. Crushing and returning the stones resulted in soil losses similar to that obtained under normal soil conditions. During 1961-1964, 20 storms produced 75% of the total soil loss and about 55% of the total runoff.

Abstract No. 402.

Evanko, A. B., and R. A. Peterson. 1955. Comparisons of protected and grazed mountain rangelands in southwestern Montana. Ecology 36:71-82.

Comparisons of five areas, each with parts open to and protected from grazing, were made in the Idaho fescue-bluebunch wheatgrass type in southwestern Montana. Various elements of the vegetation and water absorption by the soils were measured to determine effects of grazing and protection treatments. Measurements which could have been affected directly by current grazing, such as height growth and yield, were restricted to ungrazed plants. Detailed findings from the study are reviewed.

Abstract No. 403.

Evans, D. D., D. Kirkham, and R. K. Frevert. 1951. Infiltration and permeability in soil overlying an impermeable layer. Soil Sci. Soc. Amer., Proc. 15:50-54.

As a preliminary step in the establishment of a controlled drainage experiment, where a small field would be tiled and flooded, an experiment was performed to gain pertinent information regarding the quantity of water needed for the flooding operation. At the same time, characteristics of water flow in a soil with an impermeable layer were studied. The soil in question was a Winterset silty clay loam which is a loessial derived soil with an impermeable layer at a depth of 150 to 200 inches. It was found that on this type of soil approximately 0.20 cubic feet per hour seeps out laterally per linear foot of border of a ponded region. The permeability of this soil was measured to a depth of 4½ ft. Large unexpected and unexplained variations in permeability were observed. The dissipation of pressure from a large cylinder was measured horizontally and vertically and was found to be essentially horizontal. A smooth flow net could not be drawn from the field data so a theoretical case similar to the field case was solved and the flow net is presented. A discussion on permeability and infiltration rate relationships is also given.

Abstract No. 404.

Evans, R. A., and J. A. Young. 1970. Plant litter and establishment of alien annual weed species in rangeland communities. Weed Sci. 18:697-703.

Plant litter that covers the soil surface acts as a layer of insulation moderating temperature and moisture and creating favorable microsites for germination and the establishment of annual weed species in rangeland communities. Litter cover is an important factor in succession among annual species which culminates in dominance by downy brome (*Bromus tectorum* L.) and medusahead (*Taeniatherum asperum* (Sim.) Nevski) in these communities.

Abstract No. 405.

Everson, A. C. 1969. Replacement of native plant communities with introduced communities and its impact on ecosystem function, p. 261-267. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Native plant communities have been replaced with introduced plant communities throughout the history of man. The primary objective of the replacements has been to supply a greater quantity, quality, and variety of foodstuffs for human and domestic livestock consumption. Sometimes the community replacement has been gainful; sometimes it has not been successful. Results of the replacements, until recent years, have usually been measured only in yield of human food products or forage per unit of area. Within the last two decades the role of all biotic populations and all abiotic factors within the complex ecosystem and the impact of community replacement on function of the ecosystem have received attention. After community replacement the original abiotic factors assume different dimensions. The biotic populations are subjected to a new environment, and there is a dynamic response. Respective biotic populations may decrease or increase. The ultimate objective of replacing native plant communities with introduced communities is to make the most efficient use of solar energy and maximum use of all climatic and edaphic characteristics.

Abstract No. 406.

Fagan, R. E., and R. D. Pettit. 1971. Herbage dynamics studies at the Pantex Site. U.S. IBP Grassland Biome Tech. Rep. No. 78. Colorado State Univ., Fort Collins. 40 p.

Herbage biomass has been sampled at 2-week intervals for aboveground biomass and at monthly intervals for belowground biomass at the Pantex, U.S. IBP, Site since June 15, 1970. Hand clipping of aboveground biomass with field separation of the major species, blue grama (*Bouteloua gracilis*), plains prickly pear (*Opuntia polyacantha*), little barley (*Hordeum pusillum*), and pepperweed (*Lepidium* spp.), was the sampling technique used. A "Bull" hydraulically operated soil corer was used for root biomass studies.

Twelve aboveground and belowground plots were sampled in each of three treatments--ungrazed, moderately grazed, and grazed 1969/ungrazed 1970. Brushes were used to sweep all plots for litter collection. Root cores were pulverized by hand, then washed, to obtain belowground biomass.

Blue grama and prickly pear made up from 70 to 90% of the total aboveground biomass. Maximum aboveground biomass--362 g/m^2--was found in the grazed 1969/ungrazed 1970 treatment on July 13. The least biomass, likewise, was found on this treatment on August 24, when only 80 g/m^2 were recorded. At all clipping dates (except one) least biomass was found on the ungrazed site. Higher biomass on the grazed sites was attributed to the increased quantity of prickly pear found on these treatments.

Maximum litter accumulation was found on the ungrazed site, where approximately 30% more was found than on grazed sites. Up to 154 g/m^2 of litter were present on the ungrazed site on June 29; however, only 90 g/m^2 were collected on August 10.

Root biomass estimates indicate more roots to be present in the grazed than ungrazed treatments. A maximum of 952 g/m^2 was found in the grazed 1969/ungrazed 1970 treatment on June 30. Least biomass came from the ungrazed treatment on June 30, when only 399 g/m^2 was found.

Precision of all data collected was very poor. Standard errors in many cases exceeded the means. Modifications of sampling techniques and increased sampling intensitv should correct this in 1971.

Abstract No 407.

Fenneman, N. M. 1931. Physiography of the western United States. McGraw-Hill Book Co., Inc., New York 594 p

The central theme of the work is the land forms of western United States and how they came about.

It may be assumed that geologists and geographers have equal interest in land forms, but the quality of their interests is very different. To the geologist land forms are a kind of final product, the end of a story. To the geographer they offer a beginning, a point of departure. To the former, land forms depend on all the physical processes of geology. To the latter, they depend on nothing; almost everything else depends on them in some measure.

According to the above-made statement of our central theme this book is mainly geological. It treats land forms as effects, not as causes. But before doing so, or while doing so, it is necessary to devote a large share of space to the description of forms as they are. Such descriptions have equal interest to the geographer. Moreover, to a writer who shares the geographic interest there is a constant temptation to clothe these land forms with life by pointing out their influence on climate and life and habitation and civilization. No attempt has been made to resist this impulse; but, on the other hand, there is no attempt to treat such matters systematically or symmetrically for all parts of the territory.

Abstract No. 408.

Fernald, M. L. 1950. Gray's manual of botany. Amer. Book Co., New York. 1632 p.

By the time the present edition is off the press 42 years will have elapsed since the publication of the seventh edition. This epoch has been one of fundamental changes, both in understanding of plants and in the requirements of the International Rules of Botanical Nomenclature. As was well recognized, Gray and Watson were not primarily active field-students of our flora. Gray was almost overwhelmed by the endless collections sent him for critical study from all parts of the continent, as well as from eastern Asia, by his active (largely unassisted) part in teaching and in the development of the then appreciated and fruitful Botanic Garden, his philosophical and editorial writing, and his trenchant reviews and appreciative biographical notes. He depended on others, rarely more than one or two from each of a few states, for material from the "Manual-range." Watson's field-work had been on the western side of the continent during the survey by the Clarence King Exploring Expedition. When he became Curator of the Gray Herbarium (then the Harvard Herbarium, including all groups of plants), his extra-curatorial activities were little concerned with the plants growing about him, but with detailed bibliographic work and monographic studies covering groups of broad geographic areas. Coulter's brief period of field-work, likewise, had been chiefly in an area far removed from the range covered in the Manual. Robinson took over from Watson extensive study of the Mexican flora, based on collections of others, the continuation and editing for a time of unfinished monographic studies by Gray and, later, monographic studies of large genera of Mexico or South America. Physically unable to carry on extended field-work, his pèrsonal familiarity in the field with most plants of the northeast was necessarily limited.

Abstract No. 409.

Ferrel, C. M., and H. R. Leach. 1950. Food habits of pronghorn antelope of California. California Fish Game 36(1):21-26.

Fifty-six antelope stomach samples were obtained from hunter kills taken in Lassen and Modoc Counties during the seasons of May-June 1942 and August-September 1949.

Analysis of this material revealed over 98% of the food consumed to be browse and forbs. Common sagebrush was the most important single item taken. Few species of browse plants were utilized, but forbs were eaten in great variety. Grass was a minor item in the diet.

Abstract No. 410.

Ferrell, J. 1956. Grazing ruins shelterbelts. South Dakota Agr. Coll. Ext. Service Circ. Leafl. 176. 2 p.

Grazing animals can destroy a tree planting as certainly as fire. The only difference is that grazing takes a little longer. Studies in South Dakota and in other states prove that tree plantings start to go downhill as soon as livestock is turned into them. This applies to both young and old plantings.

Damage is caused by packing the soil, browsing and breaking branches, and rubbing against the trees. Killing off the lower limbs and underbrush allows wind and snow to blow through the shelterbelt. Loss of lower leaves, branches, and underbrush allows sun to bake the soil and wind to sweep leaf litter out of the planting.

Importance of leaf litter is shown by a state-wide survey of South Dakota tree plantations made in 1935. Those plantings with a ground cover of leaf mold had 66% of their trees living; those with a cover of weeds, 51%; and those covered with grass, 46%.

Abstract No. 411.

Findley, J. S. 1956. Mammals of Clay County, South Dakota. Univ. South Dakota Biol. Pub. 1:1-45.

Clay County, South Dakota, lies in the extreme southeastern corner of the state. The county is bounded on the south by the Missouri River which separates Nebraska from South Dakota and on the east by Union County, South Dakota, which separates Clay County from Iowa by a distance of 10 to 18 miles. The county seat, Vermillion, is the home of the University of South Dakota.

Studies of the mammals of Clay County were carried out from August 1954 to June 1955. In the course of this time approximately 200 specimens of mammals were collected and added to the permanent research collections of the Zoology Department and the University Museum. These specimens and data associated with them form the basis of the present report. In addition, over 400 residents of the county were questioned on matters concerning local mammals with special emphasis on the economic importance of various species. To support these data and specimens use was made of the collection of the University of Kansas Museum of Natural History. The use of this collection enabled me to make accurate subspecific identifications of specimens from Clay County where this identification was in doubt.

The purpose of the study is to provide an accurate list and description of each kind of wild mammal occurring in Clay County together with comments on abundance, ecological distribution, economic importance, and taxonomy.

Abstract No. 412.

Finnell, H. H. 1928. Effect of wind on plant growth. Amer. Soc. Agron. J. 20:1206-1210.

1. A portion of the tender foliage was actually destroyed by wind whipping.

2. Deformation of the main stem was marked in early growth stages.

3. Rate of growth as measured by height of plant was immediately reduced.

4. Time of maturity was increased by wind about 10 days in a 60-day growing period.

5. Yield of dry matter was reduced 48.8% by wind.

6. Total water requirements per pot did not vary significantly.

7. Water requirements per unit of dry matter produced were approximately doubled by exposure of plant and pot to wind.

8. The number of secondary branches formed was apparently increased 42.8% by wind.

Abstract No. 413.

Finnell, H. H. 1948. The dust storms of 1948. Sci. Amer. 179(2):7-11.

The dust bowl is developing on the arid western plains, west of the land of the Oakies. Its cause is not primarily drought, although below-average rainfall (as measured at Amarillo, Texas) during the past three years may accelerate the disaster. The major cause is the great war-time plow-up of marginal soils. After two or three crops the soil begins to break down. This year's outbreak of dust storms along the Texas-New Mexico line was the harvest of the quick decline of stability of the sandy soils.

Will a new cycle of dust be permitted to blow itself out? It need not. We have learned from the dust storms of the past that with scientific controls they can be stopped. It took the lessons of the 30's to drive home the truth that dust storms are less an act of nature than a product of ruthless farming.

The answer to the blizzards of dust was eventually found in that vast acreage of farmed land that stayed put in spite of the winds. Experiment in field experience demonstrated that land could be kept safely in cultivation even in the high-hazard areas of wind erosion provided only that a cover of vegetation was maintained continuously on the land. The ideal way is to use the residues of productive crops, leaving a stubble of stalks and straw to tide over the soil from one crop to another. It is surprising to observe how small a quantity of the amount of litter it takes to protect the land against a 60-mile-per-hour wind.

Abstract No. 414.

Finnell, H. H. 1949. Land use experience in southern Great Plains. U.S. Dep. Agr. Circ. 820. 18 p.

The limitations of land must be recognized clearly before good judgment in land use choices can be used. For the areas represented in this study they may be summarized as follows:

Experience has proved that shallow, moderately sandy and deep, loose sand-hill soils of gentle slope or steeper cannot be kept productive under cultivation anywhere in the 14- to 20-inch rainfall belt.

Shallow-depth hard lands, both flat and sloping, have failed in all areas of less than 18 inches average rainfall. Nearly level medium-depth moderately sandy lands, on the other hand, stood up well with suitable practices under rainfall as low as 16 inches.

Medium-depth hard lands have a fair to good record of performance throughout the territory sampled, but below 17 inches of rainfall a program of alternate cultivation and restoration under sod would be required to avoid the unbearable losses sustained heretofore. This brings out the question as to how long class IV lands may be safely kept in cultivation. Experience indicates that the hard lands of this class go into an unmanageable condition somewhat more slowly than the sandy lands.

In any event the signs of overuse, such as difficulty of maintaining crop residues and difficulty of getting crop stands, should be promptly heeded. The length of safe periods of cultivation must necessarily vary both with soils and with climatic conditions. Deep loamy sands with 18 to 20 inches of rainfall offer fair possibilities of maintaining fertility and stability against wind erosion by the use of manure crops in the rotation.

Deep, nearly level hard lands, the best of the High Plains wheat soils, can be farmed with appropriate precautions wherever found. But in this study they do not occur in sample areas having less than 16 to 18 inches of rainfall.

At the same time, the cost of indulging in careless mistakes, which induce serious wind erosion unnecessarily on good lands, has been shown to be astonishingly high. Results show that the productivity of high-capability lands can be as seriously affected by topsoil removal as that of low-capability lands.

Special attention should be given quickly to the gently sloping lands already under cultivation in areas subject to water erosion, that is to say, those having anywhere above 17 inches average rainfall. If these lands are to be saved from abandonment, terracing with contour farming is imperative. Specifically, these practices apply to medium-depth gently rolling hard lands of which there were 86,760 acres in cultivation in the 20-county area of the Joel survey. The same urgency applies to the shallow, gently rolling, moderately sandy lands, but in this case permanent retirement to grass is the thing needed. Until recently 222,500 acres of these soils were being farmed.

No new sloping hard lands should be brought under the plow for cultivation on either a temporary or permanent basis without the protection of terracing and contour tillage. Otherwise they are just as sure to be put out of production by water erosion as are the low-capability lands of the arid belt by wind erosion.

Abstract No. 415.

Finzel, J. E. 1964. Avian populations of four herbaceous communities at various elevations in southeastern Wyoming. Condor 66(6):496-510.

A study of bird populations in four open areas in southeastern Wyoming was carried out from the summer of 1958 through the summer of 1960. The Cheyenne area, a slightly rolling shortgrass plains, was at an elevation of 6400 ft. The Laramie area was mixed-grass prairie at an elevation of 7350 ft. The Pole Mountain area, located on a dissected plateau, was 8500 ft in elevation and was transitional between plains and coniferous forest. Libby Flats, an alpine meadow on a high plateau, was 10,500 ft in elevation.

On each of the four areas, two 20-acre plots were staked out in acre blocks. Bird censuses were conducted by use of a plot census method. Densities were expressed as average numbers of individual birds present per census and pairs per 100 acres during the breeding season. Bird populations were considered in terms of prebreeding, breeding, postbreeding, and winter seasons, with main emphasis being placed on the species of birds that were residents on the four areas.

Abstract No. 416.

Fisser, H. G. 1969. Plant pattern and distribution in ecosystems and relationships to function, p. 183-196. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Historically, distributional aspects of vegetation on a multitude of levels were evaluated on a subjective basis, with little emphasis given to factors responsible for observed characteristics of location or functions inducing variations in dispersal. The contention for the analysis of pattern lies with the implication that the distribution of the organisms may be utilized to evaluate the forces responsible for non-random dispersion. Pattern thus becomes a legitimate object of ecological investigation if used to determine causative factors in plant distribution, or as an aid in the establishment of tolerance ranges.

Quantitative analyses of intracommunal distribution characteristics emphasized that random distribution was the exception rather than the rule. The form of vegetation pattern can be related to two general classes of non-randomness: contagious and regular. In most cases analyses of distribution properties have shown that contagious distributions are the most common.

The term pattern may imply repeatability, but it does not necessarily imply uniform repeatability, since the factors causing non-random plant dispersions need not repeat themselves uniformly over geographic space. The evaluation of vegetation distributional form must be conducted in light of the kinds of possible causative factors and their form of pattern as related to the configuration of plant dispersal.

For the detection of non-randomness by application of mathematical expectations, early workers utilized the Poisson and binomial distributions with a great number of modifications. Analysis for association has been conducted to determine the existence of similar biological groups and the degree to which they shared similar ecological amplitude to environmental forcing functions. Common analytical procedures for association testing are the contingency and correlation analyses. A rather new and promising development in the description and analysis of organism dispersion criteria has been the use of multivariate analysis. By integration of many forms of quantitative data, the derived ecologically meaningful groups lead to a technique for determination of pattern causality more sensitive than earlier procedures. Studies to evaluate patterns and their causal relations seem doomed to failure if not incorporated into an integrated systems analysis approach.

Abstract No. 417.

Fisser, H. G. 1969. Preliminary report of methodology and results for analysis of plant pattern subproject research on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 9. Colorado State Univ., Fort Collins. 65 p.

Distributional forms and dispersion characteristics of *Opuntia polyacantha* were examined in areas subjected to three grazing treatment rates (light, medium, and heavy). Determinations of non-randomness were made from comparisons of observed numbers of individuals per quadrat to the expected number per quadrat derived from a Poisson series. Frequency data were obtained from transects of 256 contiguous decimeter square quadrats in 30 m × 30 m study plots within each grazing treatment. The analysis of variance technique applied to the frequency data gave an estimate of the clump sizes within each treatment. Mean area of clumps for the light, medium, and heavy grazing treatments were: 4, 16, and 128; 4 and 128; and 8, 32, and 128 DM, respectively.

Abstract No. 418.

Fisser, H. G. 1970. Distribution of plant biomass to plant organs. Plant Spec. Meeting, Desert Biome, U.S. IBP, Proc. p. 34-42 and 110-115.

Fisser, H. G. 1970. Distribution of plant biomass to plant organs. U.S. IBP Desert Biome Plant Spec. Meeting, January 3, Las Vegas, Nevada.

We are often prone to use such terms as ecosystem, dynamics, and productivity with little thought to what they constitute semantically and empirically. In a discussion concerned with the distribution of biomass to plant organs, we must consider the complexities of the entire biological cycle in the ecosystem. A broad concept of this cycle may be described as constituting the uptake of elements from the soil and the atmosphere by living plants, biosynthesis involving the formation of new complex compounds, and the return of elements to the soil and atmosphere with the litter fall including both above and belowground constituents, of part of the organic matter or with the death of the organism.

The biological cycle must be viewed, in addition, as an intricate, polycyclic process comprising cycles differing in duration and effect on the environment. Periods of cycles may be designated as intraseasonal, seasonal, annual, long-term, and secular. (i) Whether we should be at all interested in the long-term and secular phases with respect to the IBP Desert Biome Program is conjectural at this point. (ii) A problem that soon becomes evident in our work with energy transfer and distribution of biomass is that related to definition of the various organic components present in the ecosystem.

Abstract No. 419.

Fisser, H. G. 1970. The IBP and its implications for natural resource management. Wyoming Game and Fish Commission Biologists Meeting, June 24, Lander, Wyoming.

In brief, this speech reviewed the International Biological Program and its implications for natural resource management. General administrative organization of the IBP and its basic intent, the United States Program and more specifically the grassland and desert biomes were discussed.

Abstract No. 420.

Fisser, H. G. 1970. Significance of plant patterns in ecosystem functioning. U.S. IBP Grassland Biome Annu. Rev. Meeting, November 14, Fort Collins, Colorado.

The spatial arrangement of plant individuals, and indeed all biological individuals, is not a haphazard situation and random distribution is seldom observed. That patterns exist in nature is not questioned, and it is readily accepted that the dispersal characteristics of any and all species occur as a function of a multitude of both biological and physical environmental factors. In essence then, biological patterns, which exist in reality, are significant to the evaluation of ecosystem processes and functions, because these spatial arrangements are expressions of given sets of environmental conditions, dynamically perpetuating and modifying through time. Patterns, or perhaps a better term would be spatial arrangements, are thus a legitimate object of ecological investigation, especially those related to ecosystem function and process studies, if utilized to define functional relationships of environmental factors and biological tolerance limits.

Abstract No. 421.

Flake, L. D. 1969. A study of rodents in northeastern Colorado. U.S. IBP Grassland Biome Tech. Rep. No. 15. Colorado State Univ., Fort Collins. 29 p.

Although there have been numerous studies on small mammal populations, few have had simultaneously available extensive information about the environment. Selected for intensive ecosystem analysis, the Pawnee Site in northeastern Colorado provides a unique opportunity to study small mammals. Data are available concerning a number of biotic and abiotic factors in the environment that may be related to small mammal populations. Further, rodents other than the northern pocket gopher and plains pocket gopher have received little attention in eastern Colorado.

Abstract No. 422.

Flake, L. D. 1971. An ecological study of rodents in a shortgrass prairie in northeastern Colorado. Ph.D. Diss. Washington State Univ., Pullman. 103 p. (Advisor: Vincent Schultz).

Four rodent species (*Dipodomys ordii*, *Onychomys leucogaster*, *Peromyscus maniculatus*, and *Spermophilus tridecemlineatus*) were studied on the shortgrass prairie of northeastern Colorado during 1969 and 1970 in conjunction with the International Biological Program's grassland biome studies. Three half-section pastures (intensive study pastures) subject to long-term cattle grazing at light, moderate, and heavy intensities, respectively, were live trapped to determine possible effects of grazing on rodent populations. Traps within each pasture were stratified into the three main soil types (Vona and Ascalon sandy loam, Midway-Renohill complex, and undifferentiated bottomland soils) to examine rodent abundance and distribution in relation to these soils. Live-trap data also provided information on sex ratios, annual population cycles, and population levels between years. Rodents were snap trapped in areas adjacent to the intensive study pastures and used for estimating litter size (embryo counts), reproductive seasons (presence of embryos, placental scars, and mean testis length), and sex ratios. Stomachs of snap-trapped rodents were collected and food habits examined using microscopic techniques. Habitat relations, reproduction, and food habits were emphasized in this study.

Abstract No. 423.

Flake, L. D. 1972. Food habits of four rodent species on a shortgrass prairie in Colorado. U.S. IBP Grassland Biome Preprint No. 36. Colorado State Univ., Fort Collins. 33 p.

Food habits of four rodents (*Dipodomys ordii*, *Onychomys leucogaster*, *Peromyscus maniculatus*, and *Spermophilus tridecemlineatus*) of a shortgrass prairie ecosystem in northeastern Colorado were studied during 1969 and 1970 through microscopic analysis of stomach contents. Mean percent volumes of animal matter in diets of rodent species over the entire study were as follows: *D. ordii* (4.4%), *O. leucogaster* (73.9%), *P. maniculatus* (39.0%), and *S. tridecemlineatus* (44.0%). The greatest amount of seasonal variation in percent volume animal matter in the diet was in *P. maniculatus*. Animal matter in the diets of all four species was composed almost entirely of arthropods with a few vertebrate parts present. Arthropods commonly identified in the diets included Coleoptera adults, Lepidoptera larvae, Coleoptera larvae, and grasshoppers (except in *D. ordii*). Plant matter in the diets of all species included leaves, stems, and flowering parts of various species of grasses, sedges, forbs, and shrubs, unidentified seeds, and tissues of mosses, lichens, and fungi. Seeds were by far the most common type of plant matter in diets of *D. ordii* and *P. maniculatus* while plant matter in *S. tridecemlineatus* and *O. leucogaster* was more equally divided between seeds and non-seed parts of grasses and sedges, and forbs. Much seasonal variation in types and relative amounts of different kinds of plant and animal matter was noted.

Abstract No. 424.

Fleharty, E. D. 1972. Some aspects of small mammal ecology in a Kansas remnant prairie. Second Annu. Midwest Prairie Conf., Proc. (In press).

The four most numerous small mammals species (*Sigmodon hispidus*, *Peromyscus maniculatus*, *Reithrodontomys megalotis*, and *Microtus ochrogaster*) were studied by live-trapping from April 1965 through February 1969. *Sigmodon* and *Peromyscus* populations generally oscillated from high densities in the fall and early winter to low densities in the spring and early summer. *Microtus* densities peaked in spring and early summer and attained a low point in the fall and winter while *Reithrodontomys* attained highest trappable densities in the winter and spring with a low in the fall. All species underwent an 85 to 95% turnover in 6 months.

The highest ecological densities in animals per acre per favored habitat attained were 26.5 (*Sigmodon*), 18.2 (*Peromyscus*), 9.6 (*Reithrodontomys*), and 24.7 (*Microtus*). Exclusive boundary strip male home ranges averaged larger for *Sigmodon* and *Peromyscus* but smaller for *Reithrodontomys* and *Microtus*. However, based on greatest distance traveled, males of all species tended to be more nomadic than females.

Sigmodon preferred habitats with a dense undergrowth and a protective overstory as found primarily in the *Andropogon gerardi/Kochia scoparia/Helianthus annuus* community. *Peromyscus* preferred tall to mid-height grass areas found in the *Andropogon gerardi* and *A. gerardi/A. scoparius/B. curtipendula* community. *Microtus* preferred areas of dense ground cover found in the *Buchloe dactyloides/B. curtipendula/Sporobolus asper*, *A. gerardi*, and *A. gerardi/A. scoparius/B. curtipendula* communities and generally exhibited a negative preference for communities preferred by *Sigmodon*.

Vegetational clipping remains, resulting from *Sigmodon hispidus* activity, were collected and analyzed for vegetational composition, dry weight, and calorie content over a one-year period. *Sigmodon* clipped 315.05 kg of vegetation on the study area. This amounted to 136.4×10^4 kcal. Grasses (mainly *Andropogon gerardi*, *A. scoparius*, and *Bouteloua curtipendula*) accounted for 54% of the vegetation clipped, *Ambrosia psilostachya* and *Kochia scoparia* 40%, and *Helianthus annuus* 6%. Some 72% of the clippings occurred in the fall (September to November).

The amount of clipped material/rat/month varied from zero in May to 1.3 kg in October. The amount of material clipped may not be solely dependent on a high *Sigmodon* density or activity, but possibly also on the condition of the vegetation and nest building activities of the rat. Of the net primary production in this area during the study period, 0.4% was clipped by *Sigmodon*.

Abstract No. 425.

Fleharty, E. D., and K. Andersen. 1964. The meadow vole, *Microtus pennsylvanicus* (Ord) in Kansas. Kansas Acad. Sci., Trans. 64(1):129-130.

Twenty-six specimens of the meadow vole, *Microtus pennsylvanicus* (Ord), were obtained by us in Jewell County, Kansas. Three specimens were taken on June 20, 1963, and 22 were captured on November 1, 1963 south of the Republican River at R6W, T2S, SW¼ Section 4. One meadow vole was taken north of the Republican River at R6W, T1S, Section 5 on September 27, 1963.

To our knowledge this constitutes the first known record for the meadow vole in Kansas. This species has been recorded in northern Missouri, south central and southwestern Nebraska, and in eastern Colorado. The nearest locality is 4 miles N, 2 miles E of Hastings in Adams County, Nebraska. The collecting sites in Kansas represent a range extension of approximately 55 miles south southeastward of the Nebraska locality.

Abstract No. 426.

Fleharty, E. D., and D. R. Ittner. 1967. Additional locality records for some Kansas herptiles. Southwestern Natur. 12:199-200.

Recently increased collecting in parts of Kansas has added to our knowledge of the geographic distribution of certain species. Although not all records listed herein are extensive range additions they should serve to fill in some gaps in the distribution of the species listed. All specimens are preserved in the Museum of the High Plains, Zoology Department, Fort Hays Kansas State College, Hays.

Abstract No. 427.

Fleharty, E. D., and D. L. Stadel. 1968. Distribution of *Peromyscus leucopus* (woods mouse) in western Kansas. Kansas Acad. Sci., Trans. 71:231-233.

The affinity of *Peromyscus leucopus* (Rafinesque) for a wooded habitat in Kansas has been noted by many workers. Thus, in the more arid regions of western Kansas this species has a dendritic distributional pattern being limited primarily to the riparian communities.

P. leucopus is absent from many counties in west-central Kansas and shows no additional localities in western Kansas. Collecting since 1962 has revealed the presence of the woods mouse in many counties heretofore unrecorded. These distributional county records are probably due more to extensive and intensive collecting in favorable habitats rather than in any major movement of the woods mouse into the area.

The presently known distribution of *Peromyscus leucopus* suggests that it probably occurs in most of the favorable habitat throughout western Kansas. However, such habitat is not always available even along water courses, and as a result these mice have a discontinuous distribution. Most notable among the *Peromyscus leucopus* collected was a single lactating female in Wallace County. This locale is approximately 50 miles west of the nearest recorded population in Gove County.

Three subspecies, *P. l. aridulus* Osgood, *P. l. noveboracensis* (Fisher), and *P. l. tornillo* Mearns, occur in Kansas. Cursory examination of pelage color indicates that subspecific designations may be as shown. We emphasize that these are tentative assignments, and additional work is planned on the subspecific affinities of *P. leucopus* populations in western Kansas.

Abstract No. 428.

Fleharty, E. D., and L. E. Olson. 1969. Summer food habits of *Microtus ochrogaster* and *Sigmodon hispidus*. J. Mammal. 50:475-486.

Stomach contents were analyzed for 97 *Microtus ochrogaster haydenii* and 86 *Sigmodon hispidus texianus* to determine what plant species were utilized, the effect of plant availability on diet, and the degree to which both species utilized identical foods. Based on percent volume consumed, *Sigmodon* utilized *Triticum aestivum*, *Kochia scoparia*, *Sporobolus asper*, *Bromus japonicus*, *Rumex crispus*, and *Xandhium commune* the most during June and July from two areas. In the same areas, *Microtus* concurrently found *S. asper*, *K. scoparia*, *Bouteloua gracilis*, *B. japonicus*, *R. crispus*, and *Digitaria sanguinalis* the most palatable. Availability of plants was found to be an influencing factor on what was eaten, but certainly was not the only factor, because many plant species that were not dominant were seemingly selected on the basis of their growth stage and palatability. Although the same species of plants comprised most of the food eaten by the two rodents, it is likely that competition existed for space rather than food, as ample food was available throughout the study.

Abstract No. 429.

Fleharty, E. D., and J. R. Choate. 1972. Bioenergetic strategies of the cotton rat, *Sigmodon hispidus*. J. Mammal. (In press).

Bioenergetic strategies of hispid cotton rats on a relict grassland in west-central Kansas were assessed for the period December 1967 through November 1968. Less than 1.0% of the yearly net primary production of the grassland was ingested by cotton rats. Of the energy assimilated throughout the year, all but 2.2% was utilized in maintenance. Energy flow channeled into secondary production ranged from a low of -2.4 kcal/ha per day in January to a high of 22.6 in September. Accordingly, population density was at a low of 8.8 rats/ha in April, but increased to 19.4 by September. Seasonal fluctuations in relative amounts of energy utilized in secondary production probably reflect physiological adaptations to withstand adversities of climatic seasonality.

Abstract No. 430.

Fleharty, E. D., M. E. Krause, and D. P. Stinnett. 1972. Body composition, energy content, and lipid cycles of four species of rodents. J. Mammal. (In press).

Gross body composition, energy content, and lipid cycles of *Peromyscus maniculatus*, *Reithrodontomys megalotis*, *Sigmodon hispidus*, and *Microtus ochrogaster* were studied. Ash values for adults ranged from 14.2 to 16.1% of dry body weight, and water content varied from 61.5 to 74.2%. Lipid content ranged from a low of 14.6% dry body weight in *M. ochrogaster* to a high of 25.6% in *S. hispidus*. Annually, kilocalories per gram live weight averaged 1.61 in *P. maniculatus*, 1.65 in *R. megalotis*, 1.74 in *S. hispidus*, and 1.42 in *M. ochrogaster*. Energy content of subadults and adults of *S. hispidus* differed significantly during summer, autumn, and winter; no such differences were noted for age categories of the other species. The four species exhibited three different types of lipid cycles: in both *P. maniculatus* and *R. megalotis*, lipid content was lowest in summer and highest in winter; in *S. hispidus*, the lowest readings were in spring and the highest in winter; in *M. ochrogaster*, lipid content fluctuated on a monthly basis but exhibited no annual cycle. It is postulated that annual lipid cycles reflect the zoogeographic history of the species and might thus serve as a measure of physiological adaptation to climatic conditions unlike those that existed at the respective times and places of evolution of the four species.

Abstract No. 431.

Fleharty, E. D., and M. A. Mares. 1972. Habitat preference and spatial relations of *Sigmodon hispidus* on a remnant prairie in west-central Kansas. Southwestern Natur. (In press).

During a 47-month live-trap study conducted in a remnant grassland in west-central Kansas, *Sigmodon hispidus* preferred habitats with dense undergrowth and protective overstory and used less favored habitats primarily when population densities were high. Seasonal home ranges based on the exclusive boundary-strip method averaged significantly larger ($p < 0.01$) for males (0.96 acre) than for females (0.54 acre). Males were more nomadic than females, but both sexes traversed smaller areas during periods of high density than during low density. No indication of territorial defence was evident.

Abstract No. 432.

Fleharty, E. D., M. A. Mares, and J. R. choate. 1972. Population fluctuations in *Sigmodon hispidus*: Factors influencing a "crash." Amer. Midland Natur. (In press).

A population of *Sigmodon hispidus* inhabiting a remnant grassland in west-central Kansas, near the northern limit of the range of the species, was live-trapped from April of 1965 through February of 1969. Until 1968, the population exhibited a pronounced annual cycle of abundance, varying from most abundant in autumn to least abundant in spring. Annual declines began at the time of normal cessation of breeding with the onset of winter, and were augmented by harsh winter weather. Monthly ecological densities ranged from 0.0-65.5 rats/ha in the favored habitat. Population turnover was 92% complete in 6 months. In 1968 the population continued to exhibit the seasonal pattern of fluctuation until autumn, but then underwent a "crash" that completely decimated the population. Environmental and biotic factors that might have influenced the crash included normal autumnal cessation of breeding coupled with predation, parasitism, and severe weather conditions. The balance between adverse winter weather and physiological and behavioral adaptations to survive suboptimal weather conditions probably is largely responsible for the location of the northern limit of the geographic range of *S. hispidus*.

Abstract No. 433.

Fletcher, J. E., and W. P. Martin. 1948. Some effects of algae and molds in the rain-crust of desert soils. Ecology 29(1):95-100.

1. An infestation of the rain-crust of some desert soils by algae and molds is described.

2. Algae present were all Cyanophyceae of the genera: *Oscillatoria*, *Nodularia*, *Microcoleus*, *Nostoc*, and several members of the family Chroococcaceae. Molds identified by hyphal transfers to Czapek's agar were *Rhizopus*, *Mucor*, and probably *Botrytis*.

3. Rain-crust stabilization by microorganisms made possible its removal for mechanical analyses. Silt and clay contents increased and sand content decreased over a comparable depth of soil just below the crust indicating that a mechanical sorting and rearrangement of the particles had taken place to form the rain-crust and not a mere packing.

4. Increases of as high as 300% in organic carbon content and 400% in nitrogen content occurred in the crusts where microbial growth had been extensive. The largest increases in nitrogen were in the crusts containing the nitrogen-fixing algae, *Nostoc*. The free-living, aerobic, nitrogen-fixing *Azotobacter* were not present in any of the soils tested.

5. It is believed from observational evidence that the microfloral invasion of the rain-crust improves infiltration, decreases erosion, and aids in the establishment of plant seedlings under rigorous desert conditions.

Abstract No. 434.

Flinders, J. T. 1971. Diets and habitats of jackrabbits within a shortgrass ecosystem. Ph.D. Diss. Colorado State Univ., Fort Collins. 75 p. (Advisor: Dick Hansen).

This study considers the diets selected and the feeding habitats occupied by black-tailed (*Lepus californicus*) and white-tailed (*Lepus townsendii*) jackrabbits, in sympatry, within a shortgrass ecosystem in northeastern Colorado. Black-tailed jackrabbits immigrated into the study area prior to the turn of the century and now outnumber white-tailed jackrabbits by about five to one.

Microscopic analysis of stomach contents indicated that western wheatgrass (*Agropyron smithii*) was the most common food in the annual diets of both hares. Each hare behaved differently in selecting cultivated crops as food; alfalfa (*Medicago sativa*) was the second most important food item in the annual diets of black-tailed jackrabbits; and winterwheat (*Triticum aestivum*) was the second most important food item in the annual diets of white-tailed jackrabbits.

There was 53% similarity in the percent dry-weight and composition of plant species in the mean 2-year diets of these hares. There was 57% similarity in the percent dry-weight and composition of plant species in the mean 2-year feeding habitats of the two species of jackrabbits. Annual diets of black-tailed jackrabbits corresponded more closely to the availability of food plants in their feeding habitats then did the annual diets of white-tailed jackrabbits to the availability of food plants in their feeding habitats. Thus, white-tailed jackrabbits are slightly but significantly more selective as "primary consumers" than black-tailed jackrabbits.

From these data it is proposed that black-tailed jackrabbits are more efficient than white-tailed jackrabbits in foraging for food and thus, potentially, have a competitive advantage. White-tailed jackrabbits now occupy a small segment of the overall feeding habitat of jackrabbits, and the herbage in this segment is not strongly compatible with the annual diets normally selected by black-tailed jackrabbits.

Abstract No. 435.

Flinders, J. T., and R. M. Hansen. 1971. An area-estimate for censusing rabbits and hares. U.S. IBP Grassland Biome Preprint No. 17. Colorado State Univ., Fort Collins. 11 p.

The area-estimate method is a refinement of the flush census method for determining densities of wildlife populations. It was developed to study populations of black-tailed and white-tailed jackrabbits and desert cottontail rabbits on the shortgrass prairie of northeastern Colorado. The late December 1970 population densities for these leporids, respectively, were 18.4, 3.5, and 6.6 per square mile. Black-tailed jackrabbits and cottontail rabbits showed significant clumping ($P = .05$) in some transects (approximately 112 acres or 45.3 ha/transect). All leporids demonstrated high fidelity to the 10 transects that were censused on three consecutive nights. The area-estimate method is a fast, repeatable, field method for obtaining statistically dimensioned estimates of population density.

Abstract No. 436.

Flinders, J. T., and R. M. Hansen. 1971. Diets and habitats of jackrabbits within a shortgrass ecosystem. U.S. IBP Grassland Biome Tech. Rep. No. 98. Colorado State Univ., Fort Collins. 53 p.

Black-tailed (*Lepus californicus*) and white-tailed (*Lepus townsendii*) jackrabbits play a large role in the utilization of vegetation within the shortgrass ecosystem. They affect the occurrence, abundance, and distribution of vegetation within their habitats.

Both hares demonstrated a high degree of preference for certain plant species. Western wheatgrass (*Agropyron smithii* Rydb.) was the most highly preferred plant by both species of jackrabbits. Four plant species comprised greater than 50% of the diets of hares for each season of the year. A total of 83 plant species were identified in the combined diets, and a total of 120 plant species were found in the combined habitats of the two species of jackrabbits. Fifteen plant species were intrinsic to the diets and 15 intrinsic to the habitats of black-tailed jackrabbits; 12 plant species were intrinsic to the diets and 10 intrinsic to the habitats of white-tailed jackrabbits.

Abstract No. 437.

Flinders, J. T., and R. M. Hansen. 1971. Diets and feeding habitats of jackrabbits within a shortgrass ecosystem. U.S. IBP Grassland Biome Preprint No. 22. Colorado State Univ., Fort Collins. 75 p.

This study considers the diets selected and the feeding habitats occupied by black-tailed (*Lepus californicus*) and white-tailed (*Lepus townsendii*) jackrabbits, in sympatry, within a shortgrass ecosystem in northeastern Colorado. Black-tailed jackrabbits immigrated into the study area prior to the turn of the century and now outnumber white-tailed jackrabbits by about five to one.

Abstract No. 438.

Flinders, J. T., R. M. Hansen, and T. E. Lines. 1971. The chromogen method applied to determining digestion in wild jackrabbits. U.S. IBP Grassland Biome Preprint No. 15. Colorado State Univ., Fort Collins. 6 p.

This study was to determine if the chromogen technique would yield acceptable estimates of the coefficients of digestion of free roving white-tailed jackrabbits. Winter wheat and other grasses made up 93% of the April diets of these hares. The mean coefficient of digestion was 34%, and this compares closely with coefficients determined for penned domestic rabbits on diets of grass hay.

Abstract No. 439.

Floate, M. J. S. 1970. Decomposition of organic materials from hill soils and pastures. II. Comparative studies on mineralization of C, N, and P from plant materials and sheep feces. Soil Biol. Biochem. 2:173-185.

Four plant materials obtained from *Nardus* and *Agrostic-Festuca* hill pastures, and the sheep feces derived from these materials, were incubated at 30°C for periods up to 12 weeks. The evolution of CO_2 and the production of mineral nitrogen and phosphorus were measured: 10 to 20% and 30 to 55% of the original carbon was evolved as CO_2 from feces and plant materials, respectively. Of the total original nitrogen, up to 8% was mineralized from feces, and up to 25% was mineralized from plant materials. Grass from monthly cut treatments decomposed more rapidly than annually accumulated grass, and mineralization was greater from *Agrostis-Festuca* than from *Nardus*. More than half of the nitrogen which was mineralized was evolved as NH_3. Throughout most of the incubation period plant materials immobilized phosphorus while between 3 and 34% of the total phosphorus in feces was mineralized. The results are discussed in relation to the role of sheep in the soil-plant-animal nutrient cycle.

Abstract No. 440.

Floate, M. J. S. 1970. Decomposition of organic materials from hill soils and pastures. III. The effect of temperature on mineralization of C, N, and P from plant materials and sheep feces. Soil Biol. Biochem. 2:187-196.

Plant materials obtained from *Nardus* and *Agrostis-Festuca* hill pastures and the sheep feces derived from these materials were incubated for periods up to 12 weeks at 30°, 10°, and 5°C. The amounts of CO_2 evolved from plant materials were reduced from an average of 40% of the original C content at 30° to 25% at 10°C, and 12% at 5°C. For feces the corresponding amounts were 16% (at 30°C), 4% (at 10°C), and 2% (at 5°). Of the original total-N in plant materials, the mean amount of 5.4% was mineralized at 30°C while at 10°C and 5°C only 0.9% and -0.3%, respectively were mineralized. The largest amounts of mineral-N (up to 10%) were produced from feces at 10°C. Phosphorus mineralization was reduced from a mean value of 0.2% of the original total-P in plant materials at 30°C to -27% at 10°C and -41% at 5°C. For feces the corresponding values were 10% at 30°C, 2.5% at 10°C and -12% at 5°C. The significance of these results is discussed in relation to nutrient re-circulation and the annual cycle of hill soil temperatures.

Abstract No. 441.

Flory, E. L. 1936. Comparison of the environment and some physiological responses of prairie vegetation and cultivated corn. Ecology 17(1):67-103.

This study deals with a comprehensive comparison of the environments and certain physiological responses of native prairie vegetation and cultivated corn at Lincoln, Nebraska, during three consecutive growing seasons. Six years of cultivating listed corn after breaking the sod of the Lancaster loam increased the volume weight of the soil, decreased porosity 12% and retarded the rate of percolation 42% or more. This resulted in greatly increased runoff and erosion. There was a closer relationship between precipitation (mean annual 27.8 inches) and available soil water at all depths in the prairie of *Andropogon scoparius* than in the field. Available moisture at all depths to 4 ft was usually greater in the field until tasseling of the corn, after which moisture was nearly always greater below 2 ft in the prairie. Monthly production of dry matter in prairie showed a close relationship to percent of yearly precipitation for the month. Mean day temperatures in the prairie averaged 3.9°F lower than in the cornfield and during very hot weather 7°F lower. Average daily temperature ranges were 26°F and 38°F, respectively. Maximum daily temperature by weeks was sometimes 10 to 11°F higher in the field. Average daily humidity was 4.6% higher in the prairie. Differences between average daily maximum and minimum humidities were 43.2% in the field but only 34.5 in the prairie. Under maximum foliage development light intensity at the soil surface was 51% in the cornfield and 5% in the prairie. Evaporation losses were much less in the grassland. Soil temperatures at 3-inch depth averaged 8.2°F lower in the prairie and at 8-inch depth 2.2°F lower. Thus a cover of prairie grass is a great stabilizer of environmental factors. Leaf surface per sq ft of soil at maturity of prairie vegetation was 950, 1,050, and 1,014 sq inches during three consecutive years. Maize developed a maximum of 546 and 467 sq inches of leaf surface per unit area of soil. Average daily loss of water (transpiration + soil evaporation) per sq ft of prairie for the three seasons was 1.46 lb. Average daily transpiration loss of plants per sq ft of soil surface averaged .59 lb in the prairie and .39 lb in the cornfield. Total amount of water used or lost in the production of 1 g of dry matter in the prairie was 1,376 g; in the cornfield it was 786 g. In the prairie about 32% of this was lost in runoff and surface evaporation, in the cornfield about 65%. Approximately 52% more dry matter was produced per sq ft of soil in the cornfield than in the prairie.

Abstract No. 442.

Fly, C. L. 1946. Natural agricultural resource areas of Kansas. Soil Conserv. Kansas, Kansas State Board Agr. Rep. 65:126-195.

Primarily an agricultural state, with 94% of her area devoted to cropland, grassland, or woodland use, Kansas has 25 physically distinct agricultural areas within her borders. Some of the nation's most productive lands are included. The soils are as variable as the rocks from which they originated and the climate under which they developed. All but three of the great soil groups of the United States are represented.

The 25 distinct agricultural resource areas of Kansas which resulted and are described here are delineated on the basis of their physical characteristics--topography, geology, climate, and soils. Their characteristics and present use, and the problems of use, conservation, and management are discussed under headings which are identical to the area and sub-area titles on the map.

Abstract No. 443.

Fraley, L. P., and F. W. Whicker. 1970. The effect of ionizing radiation on a shortgrass plant stand. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

An 8750 Ci Cesium-137 source was installed in a shortgrass plant stand on the Central Plains Experimental Range near Fort Collins, Colorado. The exposure rate varied from at least 650 R/hr to less than 10 mR/hr. The effect of the ionizing radiation on the community structure during the growing season was studied using density and frequency measurements. The effect on development of individual species was studied using a phenological index. The radiation had a significant effect on the diversity index with the exposure rate that resulted in a value 50% of control changing from 54 R/hr after 10 weeks exposure to 28 R/hr after 24 weeks exposure. Similar results were obtained using coefficient of community calculations. The phenological index data were analyzed for three species: *Bouteloua gracilis*, *Opuntia polyacantha*, and *Tradescantia occidentalis*, representing a resistant, moderately resistant and sensitive species, respectively. These data indicate that delay in plant development can be a very sensitive indicator of radiation damage. The exposure rate that resulted in a detectable delay was approximately one-tenth that which resulted in death. Comparison of the overall results with studies in other plant communities indicates that the shortgrass plains plant community is among the most resistant to ionizing radiation.

Abstract No. 444.

Francis, R. C. 1971. A study of the weight estimate method of botanical analysis as a double-sampling procedure. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tempe, Arizona.

The weight estimate method of determining plant standing crop, by species, was applied to data from the Pawnee Site of the IBP Grassland Biome. The procedure was evaluated as a double sampling technique for reducing the variance, for a fixed cost, of the estimate of aboveground plant biomass, by species, over the standard plot clipping procedure. Two statistical estimators were used. In addition, a computer simulation model of the estimation procedure was developed in order to study the distributional properties of the two double sampling estimators.

Abstract No. 445.

Francis, R. C., C. V. Baker, G. M. Van Dyne, and J. D. Gustafson. 1971. A study of the weight estimation method of botanical analysis. U.S. IBP Grassland Biome Tech. Rep. No. 117. Colorado State Univ., Fort Collins. 147 p.

The weight estimate method of determining standing crop by species is reviewed and applied to data from the Pawnee Site of the IBP Grassland Biome. The procedure is evaluated as a double sampling technique for reducing the variance for a fixed cost of the estimate of aboveground plant biomass by species, over the standard plot-clipping procedure. Two statistical estimators (regression and ratio) are used. In addition, a computer simulation model of the estimation procedure is developed in order to study the distributional properties of the two double sampling estimators. Double sampling is effective in reducing the variance of the estimate in a majority of the cases tested.

Abstract No. 446.

Francis, R. C., and M. Campion. 1972. Statistical analysis of intraseasonal herbage dynamics in a variety of grassland communities. U.S. IBP Grassland Biome Tech. Rep. No. 141. Colorado State Univ., Fort Collins. 142 p.

Intrasite comparisons of aboveground plant biomass were made using data from the 1970 field season. Ordinations were made using analysis of variance and principal component analysis in an attempt to reveal the structural components of the herbage biomass across the grassland. The nine sites analyzed were Bison, Bridger, Dickinson, Cottonwood, Hays, Jornada, Pantex, Pawnee, and Osage.

Abstract No. 447.

Franco, C. M., and A. C. Magalhaes. 1965. Techniques for the measurement of transpiration of individual plants, p. 211-224. *In* F. E. Eckardt [ed.] Methodology of plant eco-physiology. UNESCO, Paris. 531 p.

The authors discuss the different ways of measuring transpiration: the gravimetrical method utilized by potted plants, the gasometrical method, and the method of rapid weighing.

Abstract No. 448.

Franklin, W. T. 1969. Mineralogy of representative soils at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 30. Colorado State Univ., Fort Collins. 10 p.

This report gives the results of particle size fractionations of soil samples taken to characterize the mineralogy of soils within the Pawnee Range Site. The objectives of the work are to identify and quantify the mineral types in the clay, silt, and sand fractions. The results will furnish basic information for moisture and nutrient cycling studies. The results also pertain to the characterization of sediment movement in a microwatershed area.

Abstract No. 449.

Franks, J. W., and H. H. Hopkins. 1954. Upland depressions in a mixed prairie. Kansas Acad. Sci., Trans. 57:48-54.

The purpose of this study was to compare vegetation and various soil properties on ordinary mixed-prairie upland and upland depressions.

Buchloe dactyloides and *Bouteloua gracilis* each occupied about half the total basal area of 60% on ordinary upland. In the depressions basal area was reduced to 23% and *Buchloe dactyloides* furnished 93% of the perennial cover. Several annuals and short-lived perennials were also important. Yield of grass during 1953 was 1,619 and 698 air-dry pounds per acre on the upland and depressions, respectively.

The upland soil profile was deeper and better developed than the depression profile. Comparative percentages of clay in the A horizon was 35 in the former and 45 in the latter. Aggregate stability was relatively poor in the depressions. Volume-weight was 1.17 on the upland and 1.26 in the depressions. This alone is probably of little significance, but when added to other unfavorable factors, including slow permeability and tendency of the soil to puddle when wet and to become hard and cracked when dry, the depression soil is not a good habitat for either xeric or hydric plants.

Abstract No. 450.

Franzke, C. J., and A. N. Hume. 1942. Regrassing areas in South Dakota. South Dakota Agr. Exp. Sta. Bull. 361. 46 p.

The findings of this bulletin indicate that it is practicable to take measures which will promote the reestablishment of grass in locations comprising a considerable part of the three outlined areas of South Dakota. Attempts at regrassing therefore become a feasible project in smaller or larger scale operations of land management.

Regrassing must obviously be brought about with the use of species that are adapted to the conditions of growth within the specific area. It is indicated herein that the number of species is indeed small, confined largely to the familiar native grasses, western wheatgrass, blue grama, buffalo grass, feather bunchgrass, side-oats grama, big and little bluestem, sand dropseed, Sandberg blue, and June grass.

Introduced species (proved well adapted for many conditions) are bluegrasses, smooth brome, crested wheatgrass, Russian wild-rye, and intermediate wheatgrass. Eight detailed illustrations are included which may serve to make characteristics of the predominant species familiar and more recognizable.

In addition to discussing adaptability of these species, cultural methods are described both from the standpoint of observation and experiment. The object of cultural methods is to provide optimum conditions of germination and growth. A firm seed bed for seeding grasses and residue covers for protection against wind erosion and soil incrustation is necessary.

The drilling of grass seed is superior over broadcasting of seed due to the fact that this method insures placing of seed at an even depth with shallow covering.

As a general rule warm-season grasses should be seeded in the spring. Optimum conditions for germination and growth of cool-season grasses is more difficult to determine. It is not attempted, therefore, to state an invariable time based on season when cool-season grasses should be seeded.

Abstract No. 451.

Free, G. R., G. M. Browning, and G. W. Musgrave. 1940. Relative infiltration and related physical characteristics of certain soils. U.S. Dep. Agr. Tech. Bull. No. 729. 51 p.

This study was designed to determine the relative infiltration of 68 soils and related characteristics.

The relative infiltration of soil in situ was determined by the tube method. The data are from 68 sites scattered from Georgia to Oregon and from New York to New Mexico. These sites include soils having a wide range of texture and representative of most of the great soil and parent-material groups. They are representative also of most of the climatic provinces of the United States.

Samples from each site were forwarded to a central laboratory, where certain important soil characteristics were determined.

Abstract No. 452.

Free, G. R., and V. J. Palmer. 1940. Interrelationship of infiltration, air movement, and pore size in graded silica sand. Soil Sci. Soc. Amer., Proc., 5:390-398.

Pore size and pore-size distribution are generally considered the most important factors governing the rate of entrance of water into soils. There is also widespread belief that the movement of soil air is important in the infiltration process. This laboratory study, using six grades of silica sand ranging in equivalent grades from 0.061 to 0.719 mm., was a preliminary investigation of this problem to determine interrelationships between infiltration, air movement, and size of pore. Comparisons were made of the rates of entrance of water into the various grades of sand when the containers holding the sands were open at the base and when they were closed, and also when the sands were air dry and when they were moist. The effects of rate and evenness of the application of water also were studied. Rates of infiltration were affected by pore size in both open and closed containers, but the magnitude of rates and uniformity of trends varied greatly under the two conditions. In containers closed at base there must be release of entrapped air upwards before penetration of water can proceed except by slow capillary action. The time required to entirely wet the various grades of sand in open containers ranged from approximately 1 min to nearly 2 hr and in closed containers from 15 min to 55 hr. Pressures of air compressed below the downcoming water ranged from 13.6 to 104 cm of water, although the total height of the test columns of sand was only 57 cm. Ease and time of release of entrapped air were dependent on pore size, initial moisture content of the sand, and rate and evenness of the application of water. Based upon the principles and trends evidenced, it seems possible to predict those conditions in natural field soils which should make air of practical, or of lesser, importance in the infiltration process.

Abstract No. 453.

Free, J. C., R. M. Hansen, and P. L. Sims. 1970. Estimating dryweights of foodplants in feces of herbivores. J. Range Manage. 23:300-302.

The dry weight composition of foodplants was estimated by a microscope technique for esophageal samples from steers, fecal samples of steers, and fecal samples from sheep fed on the esophageal samples. Perennial species of foodplants forming more than 5% of the diets could be identified and quantified by the analysis of 100 microscope fields at 125 power magnification. The diagnostic features of fragile forbs were not as prominent in feces as they are in non-digested plants.

Abstract No. 454.

French, N. R. 1970. Chronic low-level gamma irradiation of a desert ecosystem for five years, p. 1151-1165. *In* A. Grauby [ed.] Actes du symposium internationale de radioecologie. Centre d'etudes nucleaires de cadarache du 8 au 12 Septembre 1969.

Populations of vertebrate animals, certain insects, and plants have been studied in three enclosed 8-ha areas located in the Mojave desert. They were enclosed by a fence to prevent rodents from entering or leaving the study areas. One area was irradiated almost continuously at a dose rate of 80 to 500 mr/hr. Animal populations were examined by capturing, marking, and releasing individuals. Plants were examined for growth and for production of leaves, flowers, fruit, and seeds. The life span of the population of pocket mice, *Perognathus formosus*, in the irradiated area was shorter than in the other areas. No difference was detected in the numbers of a small lizard, *Uta stansburiana*, that survived from year to year. Females of a larger but less numerous species of lizard have become sterile in the irradiated area.

All vertebrate animals in the irradiated area have received exposures of 1 to 2 r/day. Certain species of plants have produced fewer flowers and fruits in the irradiated area. Plants have received exposures of 4 to 7 r/day. Although wild populations of small mammals are surprisingly sensitive to damage from chronic low-level radiation exposure, they are evidently able to persist under these conditions. There may be certain compensating mechanisms that become operative when the population is subjected to radiation stress.

Abstract No. 455.

French, N. R. 1970. Field data collection procedures for the Comprehensive Network 1970 season (Revised). U.S. IBP Grassland Biome Tech. Rep. No. 35. Colorado State Univ., Fort Collins. 37 p.

One of the primary objectives of the comprehensive network is to obtain data from a variety of grassland types which will permit testing of the method and results of models emanating from the efforts at the intensive site. A second and equally important objective is to evaluate function and structure of the grassland ecosystem under various environmental conditions. To achieve these objectives a series of sites was selected through the cooperative efforts of scientists at a number of universities and research institutions. Each of these sites fulfills a minimum set of requirements that are necessary in order to obtain comparable information from the different environments represented.

If the objectives of the comprehensive network program are to be attained, then it is essential that the work at different sites be as nearly comparable as possible. Only if this plan is followed can comparisons of the function and structure of the grassland ecosystem under widely differing environmental conditions be made. Likewise, the generality of the ecosystem model and the comparative value of results from the investigations at the intensive site will hinge on the applicability of these data obtained from the comprehensive network sites. For these reasons, the methods and techniques are being spelled out in detail in this manual.

Abstract No. 456.

French, N. R. [Coordinator]. 1971. Basic field data collection procedures for the Grassland Biome 1971 season. U.S. IBP Grassland Biome Tech. Rep. No. 85. Colorado State Univ., Fort Collins. 87 p.

This report comprises an outline of techniques and methods that will be used in the data collection of the Comprehensive Network during the 1971 collecting season. Participants at the intensive site (Pawnee) are also attempting to incorporate these procedures as a subset of their own activities. Sample field data sheets are also included to indicate the manner of data collection and the basic format of data in the information storage and retrieval system. This report is an outgrowth of Tech. Rep. No. 35, "Field data collection procedures for the Comprehensive Network 1970 season." Participants met to revise the former report in individual groups during the month of December: producers, invertebrates, small mammals, and decomposers. A joint meeting in January with representatives from each group further refined the plans and procedures and included discussion of abiotic measurements, avian studies, and laboratory analytical procedures. Outlined herein are the collection procedures, preliminary analytical procedures, and data collection procedures for evaluating above and belowground plant biomass, litter, litter accumulation, invertebrate sampling, small mammal sampling, bird investigations, studies of decomposers, micrometeorological data acquisition, and laboratory analysis requirements.

Abstract No. 457.

French, N. R. [Ed.]. 1971. Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins. 387 p.

One of the accomplishments of the U.S. IBP Grassland Biome program has been the assembly and storage in readily retrievable form of data sets collected with both temporal and procedural simultaneity from several major grassland types. This required the efforts of approximately 90 scientists and as many research assistants and graduate students. It is they who have provided the main intellectual and investigative drive to the program. It is their efforts that have made possible the following analyses and syntheses. Comparisons among the different grassland types of the biotic responses to abiotic variables provide not only important structural definition of the grassland ecosystem but also are of great value in guiding the modelling effort under the Systems Analysis group of the program; through this they help define further experimental effort required in the field. For this reason, even though the data are considered preliminary and hence any conclusions must be tentative, it was considered important to digest the results of the first season of full field effort.

To accomplish this a few individual participants in the program were requested to explore and analyze certain types of available data. This was no mean task, as each individual was given the responsibility of compiling and summarizing information resulting from the full season's effort of many investigators. To undertake analysis of data collected by your colleagues and present your results and conclusions, not only to them but also to the scientific community, requires a considerable degree of temerity. Fortunately, the individuals selected for this task responded, almost without exception, in a conscientious and generous manner. The following pages are the results of their efforts. Assistance and stimulation were also provided by the American Institute of Biological Sciences which, through its director, Dr. John R. Olive, invited these results to be presented as a symposium during their 1972 annual meeting as a portion of the program of the Ecological Society of America, arranged by the program chairman, Dr. William S. Osburn, Jr. These meetings were held at Colorado State University during August and September 1971.

The results presented in this report represent a progress report rather than conclusions. They are recorded here for the dissemination of this information among the participants in the program, upon whose data it is based. Considerable effort has been devoted to ascertain that original data were properly evaluated and interpreted. To this end the authors of the papers have been in close contact with those who generated the data. The editor and the authors assume responsibility for any errors and misinterpretations that remain.

Abstract No. 458.

French, N. R. 1971. Small mammal studies in the U.S. IBP Grassland Biome. Ann. Zool. Fennici 8:48-53.

The Standard Minimum grid is used both for live trapping and removal trapping. Several methods of population estimation are applied to the data. Of those tested, the Jolly procedure gave best estimates based on live trapping, and the Hansson method gave best results from removal trapping. Results are based upon a test of the procedures conducted in two large enclosures with known population densities of rodents.

Abstract No. 459.

French, N. R., R. McBride, and J. Detmer. 1965. Fertility and population density of the black-tailed jackrabbit. J. Wildlife Manage. 29(1):14-26.

Data on reproduction of the black-tailed jackrabbit (*Lepus californicus*) in southeastern Idaho, collected by autopsy of specimens from 1955 through 1960 and data on movements and longevity, obtained by marking and releasing live animals, show that, as the population increased, the length of the breeding season apparently decreased, and there was a decline of population reproduction, measured by the average number of embryos per mature female. In a population decline, the opposite occurred. It is concluded that reproduction of the jackrabbit population is controlled in density-dependent fashion through frequency of pregnancy of females and to some extent through litter size. Litter size and frequency of pregnancy seemed to vary independently. Litter size in 1956-60 was maximum in May, and this timing appears to be innate. Frequency of pregnancy among females generally was maximum at least 1 month earlier. During the 1957 and 1960 seasons, when the onset of breeding was delayed, maximum frequency of pregnancy coincided with maximum litter size, resulting in apparent compensation for the late start. Comparison of these results with those from studies of the jackrabbit in California, Kansas, and Arizona indicates a shorter breeding season in regions with more severe winter climate and an inverse correlation between litter size and length of breeding season. Marked hares were seldom retrieved at a distance greater than ¼ mile from the release point, indicating a home range of less than 40 acres. Dispersal movements to greater distances are estimated to affect approximately 18% of the population. The greatest distance moved by an animal was 28 miles in a 17-week period. Seasonal movements involved short distances, but might result in dense local concentrations. In a winter population, approximately two-thirds of a marked cohort disappeared from the population each week. Over a longer period approximately 3.5% of a marked cohort remained after 1 year.

Abstract No. 460.

Frolik, A. L., and W. O. Shepherd. 1940. Vegetative composition and grazing capacity of a typical area of Nebraska sandhill range land. Nebraska Agr. Exp. Sta. Res. Bull. 117. 39 p.

A vegetative survey of a typical sandhill range area was conducted in the eastern part of Cherry County during 1937. The survey covered a total of 114,759 acres, including the land of the Valentine Migratory Waterfowl Refuge.

The vegetation of the five major range types of grassland was mapped on a scale of 6 inches to the mile. The survey was conducted according to a modified combination of the two commonly accepted methods of vegetative analysis used by range examiners. These two methods are the ocular reconnaissance method and the square-foot-density or point-observation-plot method. Composition as to density and as to productivity and livestock carrying capacity were determined. The types were identified and designated as follows: dune sand vegetation (D), dry valley or bunchgrass of dry meadows (M3), wet phase of tallgrass meadows (M1), dry phase of tallgrass meadows or transition type (M2), and saltgrass or alkali meadows (M1D).

Total vegetative density and composition of each of the types were computed by determining the percentage of ground cover contributed by the foliage of each species.

The productivity of each type was evaluated by determining its forage factor (species composition × utilization rating × density). The percentage contribution of each type to the total productivity of the area was calculated. The livestock carrying capacity of each type was obtained by calculating the number of forage acres (number of surface acres × forage factor) and dividing this figure by a forage acre requirement per animal month. The latter was determined by a supplemental study of a number of pastures whose capacities were established by use records.

Abstract No. 461.

Fry, J. C., and A. B. Leonard. 1952. Pleistocene geology of Kansas. State Geol. Surv. Kansas Bull. 99. 230 p.

Deposits of Pleistocene age underlie much of the surface of Kansas. They contain more than 60% of the state's ground-water supplies, most of our sand and gravel and volcanic ash, and important deposits of ceramic materials. This report presents data on the general geology of Kansas Pleistocene deposits and is intended to serve as background for work by the Geological Survey and others on the utilization of these many materials and as an aid to soil scientists in their study and mapping of surface soils in Kansas.

A brief summary of the geologic processes that have produced the Pleistocene deposits is followed by a review of principles governing the classification and correlation of sedimentary strata. Stratigraphically, Kansas is the transition region joining three provinces: (1) the area of continental glaciation to the northeast, (2) the area of fluviatile and eolian deposits to the west and southwest, and (3) the Ozark province to the southeast. Kansas possesses representative deposits of each Pleistocene Stage with glacial deposits of Nebraskan and Kansan Ages. The Kansan Stage is appropriately the most extensive in Kansas, and the Wisconsinan Stage is characterized by extensive loess deposits. All Pleistocene stages in Kansas contain abundant faunas of fossil mollusks and more than 100 species are listed from more than 200 localities.

A review of the drainage history of Kansas describes the progressive evolution of the present stream pattern from a general southern drainage that existed in the central and west during early Pleistocene time. The existing landscape of Kansas is a result primarily of geologic processes operating during Pleistocene time.

Abstract No. 462.

Frydendall, M. 1961. Occurrence of *Peromyscus leucopus aridulus* in Ellis County, Kansas with some notes on their activities. Kansas Acad. Sci., Trans., 64(1):36-40.

For the first time white-footed mice were taken in Ellis County, Kansas. The five trapping areas netted a total of 52 white-footed mice. The purpose of this investigation was to study their distribution in various areas in Ellis County. No extensive study was carried out as to their density or life histories.

The capture of white-footed mice in Ellis County should increase interest for further study of their distribution along the streams in western Kansas. However, further trapping is needed to complete their distributional pattern in the mixed prairie region and to extend the previously established range.

Abstract No. 463.

Fudge, J. F., and G. S. Fraps. 1944. The chemical composition of forage grasses from the Gulf Coast prairie as related to soils and to requirements for range cattle. Texas Agr. Exp. Sta. Bull. 644. 39 p.

Sufficient phosphoric acid (phosphorus) for best results is frequently not supplied to grazing animals by forage grasses grown on the soils of the Gulf Coast Prairie. Protein in the forage may be insufficient for best results at times, especially when the grass is old or dried up. Sufficient lime (calcium) is supplied by nearly all forages.

Fertilization of pastures can increase the protein and phosphoric acid content of the grasses, as well as increase the yields. The grass which grew after mowing contained more phosphoric acid and protein than unmown grass available at the same time.

Chemical analyses were made of 1,140 samples of different species of forage at various stages of growth from nearly 100 locations in the Gulf Coast Prairie of Texas. The chemical composition of the samples varied widely with differences in species, stage of maturity, and location. Protein and phosphoric acid decreased markedly with advancing maturity, crude fiber and nitrogen free extract in general increased slightly, and changes in lime were irregular. Protein and phosphoric acid in nearly all of the samples ranged from fair to very deficient. As the plants became older, the proportion of samples which were deficient or very deficient in protein and phosphoric acid increased markedly. At the mature stage of growth, 92% of the samples were deficient in protein, and 96% were deficient in phosphoric acid. Very few of the samples were deficient in lime. Johnson, Dallis, and Bermuda grasses were in general higher in protein, phosphoric acid, and lime than were the principal native species sampled.

Soils which contained relatively high percentages of nitrogen, active phosphoric acid, and active lime produced young grass which contained higher percentages of protein, phosphoric acid, and lime than were found in grass produced on soils which contained lower amounts of these constituents. The relation of the composition of the soils to the composition of forage at intermediate and mature stages of growth was not so clear as for young forage.

Abstract No. 464.

Fudge, J. F., and G. S. Fraps. 1945. The chemical composition of grasses of northwest Texas as related to soils and to requirements for range cattle. Texas Agr. Exp. Sta. Bull. 669. 56 p.

Young grasses from ranges in northwest Texas usually contain sufficient phosphoric acid for range cattle, but the more mature grasses are frequently deficient in phosphoric acid and are sometimes deficient in protein. Practically all of the grasses contain sufficient lime for range cattle.

Chemical analyses were made of 1,916 samples of different species of grasses at various stages of growth from more than 100 locations in northwest Texas. The chemical composition of the various grasses according to species, stage of maturity, and location are presented. Protein and phosphoric acid decreased markedly with advancing maturity; crude fiber and nitrogen-free extract usually increased slightly; changes in lime were small and irregular. As the plants became older, there was a marked increase in the proportion of samples which were deficient in protein and phosphoric acid for range cattle. Protein was sufficiently high for range cattle in over 99% of the young grasses, but was deficient in 73% of the mature grasses. Phosphoric acid was deficient in 34% of the samples of young grass and in 91% of those of mature grasses. Lime was not deficient in any samples. In general, protein, phosphoric acid, and nitrogen-free extract were higher, and lime and crude fiber were lower in short grasses than in tall grasses.

There was no relation between total nitrogen in the soils of this area and the percentage of protein in the grasses. Soils which contained relatively high percentages of active phosphoric acid and lime produced grasses which contained higher percentage of phosphoric acid and lime than grasses produced on soils which contained lower amounts of these constituents. This relation between composition of the soils and the composition of the grasses was more pronounced in the young grasses than in grasses at the intermediate or mature stages of growth. Other factors besides the composition of the soil affected the percentages of protein, phosphoric acid, and lime in the grasses.

Abstract No. 465.

Fuller, H. J. 1948. Carbon dioxide concentration of the atmosphere above Illinois forest and grassland. Amer. Midland Natur. 39:247-249.

The results of this investigation suggest that, at near-soil atmospheric levels in forests under a condition of low light intensity, carbon dioxide is present in such concentrations that it is not the limiting factor in photosynthesis, but that light intensity probably sets the maximum rate of this process. This aspect of the carbon dioxide-light-photosynthesis relationship, which is commonly over-looked in instruction in general botany and plant physiology, deserves greater emphasis.

Abstract No. 466.

Fults, J. L. 1936. Blue grama grass for erosion control and range reseeding in the Great Plains and a method of obtaining seed in large lots. U.S. Dep. Agr. Circ. 402. 7 p.

Until recently, the use of blue grama (*Bouteloua gracilis* (H.B.K.) Lag.) in range reseeding and for reseeding abandoned cultivated lands was discouraged because it was believed good clean seed could not be obtained at a reasonable cost.

Harvesting trials with horse-drawn and motor-driven bluegrass seed strippers at North Platte, Nebraska, in October 1934 and at O'Neill, Nebraska, in August 1935 have shown that these machines can be economically used to harvest the tops of blue grama.

Threshing trials were made with a bluegrass threshing machine, a hammer mill and fanning mill, and an ordinary grain separator. Seed with a purity of 19 and 94% was obtained from a bluegrass thresher at a cost of 79 cents a pound. Seed harvested on a large scale was most economically threshed in an ordinary grain separator, after making certain adjustments. Seed with a purity of 15 and 24% was obtained at a cost of 19 cents a pound.

Abstract No. 467.

Fults, J. L. 1942. Somatic chromosome complements in *Bouteloua*. Amer. J. Bot. 29:45-55.

The somatic chromosome complements in the genus *Bouteloua* have been investigated in 18 biotypes belonging to seven species. Some 114 plants from 85 seed sources were included in the study.

Abstract No. 468.

Galbraith, A. F. 1969. Soil water study of a shortgrass prairie ecosystem, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 6. Colorado State Univ., Fort Collins. 51 p.

The hydrology of the grassland ecosystem is an abiotic element of the model with initial state levels and dynamic behavior, influencing many biological processes elsewhere in the model. The hydrology is designed to investigate the cycling of water through the grassland ecosystem, represented at the Pawnee Site. The occurrence of precipitation by duration, intensity, and amount; the disposition of precipitation by interception, infiltration, and surface runoff; and the redistribution of soil water by evaporation, transpiration, percolation, and lateral flow are the pathways in the water cycle of primary interest. Of these infiltration is the key mechanism in the transfer of water within the ecosystem.

Abstract No. 469.

Galbraith, A. F. 1971. The soil-water regime of a shortgrass prairie ecosystem. Ph.D. Diss. Colorado State Univ., Fort Collins. 127 p. (Advisor: Dave Striffler).

The author monitored the change in soil water content at a shortgrass prairie site subjected to 30 years of variable grazing intensity. Measurements of precipitation, runoff, and soil water (by the neutron probe) were made at eight ½-ha microwatersheds located in northeastern Colorado at the Pawnee Site of the Grassland Biome study, International Biological Program, from June 1969 to September 1970.

Results showed that a simplified water balance, eliminating the drainage component, applied to this shortgrass prairie. It was possible, therefore, to show an effect upon the water balance due to heavy grazing. The analysis of evapotranspiration showed a close correlation to the root distribution of the vegetation, but no effect due to plant pattern nor slope position was found. A mathematical model to predict evapotranspiration was developed, and initial testing of this model gave reasonably precise results.

Abstract No. 470.

Gardner, W. 1920. A capillary transmission constant and methods of determining it experimentally. Soil Science 10:103-126.

A capillary transmission constant has been defined on theoretical grounds. This constant is similar to the specific electrical conductivity of metals and to the specific thermal conductivity of heat conductors.

Methods have been described for the measurement of this constant in the laboratory.

Preliminary results have been obtained from the various methods for the Greenville soil, including values for soil under field conditions, the latter not corrected for the influence of gravity. The values obtained for this soil under various conditions of porosity range from -1.8×10^{-3} for a very loose unpacked soil to -8.7×10^{-3} for a field plot, with a mean value of -5.8×10^{-3} cgs units.

An illustrative calculation has been made indicating that approximately 12 inches of water may be available from a 12-ft water-table in a period of 30 days. This figure has not been corrected for the influence of gravity.

Emphasis is laid on the general method of attack rather than upon the finality of results obtained.

Abstract No. 471.

Gardner, W. R. 1967. Development of modern infiltration theory and application in hydrology. Amer. Soc. Agr. Eng., Trans., 10(3):379-381, 390.

A discussion is given on the development of infiltration, the theory of water movement in unsaturated soils, and how it has been related by experimental data interpretation, solutions and tests of the diffusion equation, and application of flow theory, to hydrology.

Abstract No. 472.

Gaskill, A. 1906. Why prairies are treeless. Soc. Amer. Forest., Proc., 1(3):158-178.

The theory that prairies are made by forest fires is by no means new, yet none of those who have advanced it furnish the evidence that is thought necessary to establish it as at least a reasonable probability. In consequence, most writers treat the idea with scant courtesy, or ignore it entirely, and, since none of the other theories is acceptable, consider the problem still unsolved. I think, however, that from the many investigations that have been made in recent years along various lines--geological, physiographical, climatological, and silvical, it is now possible to gather facts that, to me, are strongly indicative of the fire origin of all true prairies.

I consider first the prairies of the United States, and then to see what points of similarity there are in other regions of the world where a like problem is presented.

Abstract No. 473.

Gates, F. C. 1930. Principal poisonous plants in Kansas. Kansas Agr. Exp. Sta. Bull. 25. 67 p.

With the increasing attention that has been paid to feed and feed products, together with the increasing congestion on farms and ranches, the subject of poisonous plants has been attracting more and more attention. Since the war there has been considerable experimental work in the field of poisonous plants. The increased activities along this line of work, however, have brought out many new and interesting facts. This, taken together with the increasing number of requests for information, made it seem worth while to prepare a bulletin on the principal poisonous plants of this state.

It should be clearly recognized that the treatment of poisoned animals can be more wisely undertaken by a veterinarian than by the average person without experience, but there are many points relative to the subject that will assist the average stockman in handling his animals to better advantage. In many cases even limited information may enable him to entirely avoid having his animals exposed to poisonous plants.

While some of the things that can be done are indicated in this bulletin, its primary purpose is to enable one to recognize, at sight, plants which are known to be important poisonous plants and to have some knowledge of those additional plants which, under certain conditions, cause trouble.

Abstract No. 474.

Gehlbach, F. R. 1967. Vegetation of the Guadalupe Escarpment, New Mexico-Texas. Ecology 48:404-419.

The Guadalupe Escarpment, a Permian limestone reef, is the eastern face of a semiarid-mesothermal mountain mass that rises 1,000 to 4,000 ft above the southwestern edge of the Great Plains. Phytocenoses range from xerophytic (*Larrea*, *Flourensia*, *Acacia* dominance types) on the silty to gravelly plains, through less xerophytic (*Agave*, *Dasylirion*, *Juniperus* dominance types) on gravelly to bouldery lower slopes, to comparatively mesophytic (*Juniperus*, *Quercus*, *Pinus* dominance types) on rocky upper slopes and the escarpment peneplain. This general gradient is a vegetational continuum in which species' ecologic amplitudes are distinct but form overlapping assemblages of similar structure.

Special environmental gradients are produced by topographic discontinuity. On low elevation canyon slopes, south-facing exposures support more xerophytic dominance types than north-facing exposures, although floristic differences are minimal. At highest base levels and slope elevations, south-facing exposures support the most xerophytic of all canyonside vegetation, and floristic differences between slopes are maximal. Dominance types with a tree stratum are well developed inside canyons; they form a continuous streambed-stream terrace-canyonhead sequence of increasing mesophytism. Canyon depth and water are important in supporting relict woodland dominated by *Acer*, *Quercus*, *Juniperus*, and *Juglans*.

Height and coverage as stratal features plus growth form contribute to a synusial description of the vegetation. Based on relative concordance of synusiae, shrub desert, succulent desert, evergreen woodland, and deciduous woodland plant formations are present. Microphyllous vs. succulent-semisucculent shrubs and half-shrubs distinguish the two desert formations. Narrow and broadleaf evergreen trees vs. broadleaf deciduous trees distinguish the two woodland formations. A mid-gradient predominance of structural diversity characterizes the ecosystem.

Comparisons with other southwestern desert regions reveal that dominance types vary considerably; but the same formations recur, although in differing patterns based largely on regional edaphic differences. Formations are shifted toward the xerophytic end of an environmental gradient in the igneous-based Chisos Mountains, Texas; and succulent desert is not well developed on the north side of these mountains. Succulent desert of the Chihuahuan Desert region may not be classable with that of the Sonoran Desert region, because a tree stratum is added in the latter region. Succulent desert and evergreen woodland of the Guadalupe Escarpment could have had a common Madro-Tertiary origin based on evergreen-succulent dominance and paucity of deciduous growth forms.

Abstract No. 475.

Gerard, J. B. 1965. Factors and treatments affecting fruit fill, seed germination and seedling emergence of fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.). M.S. Thesis. New Mexico State Univ., Las Cruces. 60 p.

The objectives of these studies were to determine factors and treatments affecting fruit fill, fruit and seed germination and seedling emergence of fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.).

These studies indicate that fourwing saltbush exhibits wide variation in fruit fill, seed and fruit germination from plant to plant and from site to site. Total annual rainfall or combinations of rainfall by months did not serve to predict either fruit fill or germination of fruit or seed. Abundance of fruit produced per plant is also of no value in predicting these characteristics.

Abstract No. 476.

Gernert, W. B. 1936. Native grass behavior as affected by periodic clipping. Amer. Soc. Agron. J. 28:447-456.

The material used in the study here reported was supplied by a virgin grass clipping project which has been under way at the Oklahoma Agr. Exp. Sta. during the past 6 years. The present report deals with a special study of 12 of the 96 plats in comparison with the idle roadside and a pastured area with regard to certain perturbing questions which have become prominent and vital to a more complete understanding and clearer vision in the continuation of the project and to further research in this field.

Abstract No. 477.

Gesink, R. W., G. W. Tomanek, and G. K. Hulett. 1970. A descriptive survey of woody phreatophytes along the Arkansas River in Kansas. Kansas Acad. Sci., Trans., 73(1):55-69.

The study was conducted to determine the distribution, structural characteristics, and total and relative amounts of woody phreatophytes which occurred along 250 miles of the Arkansas River Valley in Western Kansas.

Floodplain phreatophytes in the arid and semiarid regions of the western states present a dual problem; through transpiration they waste large quantities of water in river basins, and by choking river channels they create a flood hazard.

Three communities of woody phreatophyte vegetation, based on dominant species, were arbitrarily established and mapped on aerial photographs.

Seventeen line transects, spaced approximately two townships apart, were systematically located along the river. The lines were positioned perpendicular to the river channel and extended through the entire band of woody vegetation on both sides. Foliage cover and height were determined for each woody species along each transect.

The woody vegetation consisted primarily of cottonwood (*Populus sargentii*), salt cedar (*Tamarix ramosissima*), and willow (*Salix* spp). In the extreme western counties salt cedar dominated the woody vegetation whereas cottonwood became increasingly important eastward. Willow was less abundant, but quite consistent throughout the entire area. In the extreme eastern region there was an increase in various other woody species.

Abstract No. 478.

Ghilarov, M. S. 1967. Abundance, biomass and vertical distribution of soil animals in different zones, p. 611-629. *In* K. Petrusewicz [ed.] Secondary productivity of terrestrial ecosystems. Polish Acad. Sci., Warsaw. 879 p.

The secondary productivity of soil invertebrates depends on zonal climatic and vegetation conditions, that the greater the secondary production and activity of the soil stratum biocenose, the greater is its influence on the soil itself and on primary productivity.

Although the secondary production of the soil stratum of any communities is of no immediate practical importance, its indirect significance is very high and must be studied in the framework of the IBP.

The elaboration of methods to increase the abundance and activity of soil forming animals must be a primary practical problem of soil zoology.

Abstract No. 479.

Gibbens, R. 1954. Root and top development of five native Kansas legumes during first season of growth. Kansas Acad. Sci., Trans., 57:23-40.

This study was undertaken to obtain more basic information on top and root development during the first season. The plants selected for study were: *Psoralea tenuiflora* Pursh, *Psoralea cuspidata* Pursh, *Petalostemon purpureus* (Vent.) Rybd., *Petalostemon candidus* (Willd.) Michx., and *Vicia americana* var. *linearis* S. Wats. This species of vetch is given as *Vicia sparsifolia* in Rydberg (1932), but the seeds received were labeled as above, and this name was retained. In the following pages it is referred to as *Vicia americana* for briefness.

Abstract No. 480.

Giezentanner, J. B. 1970. Avian distribution and population fluctuations on the shortgrass prairie of north central Colorado. U.S. IBP Grassland Biome Tech. Rep. No. 62. Colorado State Univ., Fort Collins. 113 p.

Birds of the shortgrass prairie of north central Colorado were studied during 1969-70 to determine species, numbers, standing crop biomass, and population fluctuations on the central plains experimental range. Two systems of counts were used: a roadside count and a census of six 20-acre plots which were used to determine the effects of grazing by cattle on the distribution of birds. Total populations, breeding-pair populations, standing crop biomass, and bird-use days were determined for two breeding seasons, a post-breeding season, and winter. The breeding population (65.5 and 48.4 pairs/100 acres in 1969 and 1970, respectively) was composed of eight species of which five provided 95% of all nesting. Horned Larks and Lark Buntings were the most abundant nesters. Horned Larks and McCown's Longspurs were the primary post-breeding species. Horned Larks and Lapland Longspurs were the primary winter species. Plots heavily grazed by cattle received the greatest use by birds for nesting and foraging; lightly-grazed plots received the least use. The composition of populations using each plot varied considerably in numbers and species. Conclusions about the avifauna of the prairie are offered.

Abstract No. 481.

Giezentanner, J. B., and R. A. Ryder. 1969. Avian distribution and population fluctuations, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 28. Colorado State Univ., Fort Collins. 29 p.

Since July 1, 1968, two methods of censusing the avian population of the shortgrass prairie have been used regularly. These counts have the primary objective of determining the avian biomass on the Central Plains Experimental Range, IBP Intensive Site, and preparing these data for incorporation into models of the ecosystem. One count was refined further to relate the effects of cattle grazing on vegetation to the distribution of the bird population.

All species of birds seen on the counts were recorded, but major emphasis has been placed on analysis of the fluctuations of only the dominant species: Lark Bunting (*Calamospiza melanocorys*), Horned Lark (*Eremorphila alpestris*), Western Meadowlark (*Sturnella neglecta*), McCown's Longspur (*Rhynchophanes mccownii*), Mountain Plover (*Eupoda montana*), Mourning Dove (*Zenaidura macroura*), Loggerhead Shrike (*Lanius ludovicianus*), and Brewer's Sparrow (*Spizella breweri*). Fluctuations by season and vegetative cover have been recorded and are summarized in this report.

Abstract No. 482.

Gile, L. H., and J. W. Hawley. 1966. Periodic sedimentation and soil formation on an alluvial-fan piedmont in southern New Mexico. Soil Sci. Soc. Amer., Proc., 30:261-268.

Gullies cut in alluvial-fan piedmont deposits at the southern end of the Jornada del Muerto basin, New Mexico, reveal evidence of periodic sedimentation and soil formation. The gullies show a succession of four major sediments, each of which has a distinct soil, indicating that each period of sediment deposition was followed by a period of stability and soil formation. The two youngest sediments are restricted primarily to a broad drainageway position and have soils with relatively weak Bt and carbonate horizons. The next older sediment, buried in the broad drainageway, has a soil that has prominent textural B and carbonate horizons and that emerges at the land surface on either side of the drainageway. Towards the basin axis the sediment is thin, and there is mergence of the land-surface soil with the oldest soil exposed in the gullies.

The land-surface soils overlie much older soils, and in places are so thin that the buried soils must be considered in classification of the land-surface soils. Gradual mergence zones of major sediments can conceal complexities greater than might be suggested by the generally smooth relief. Filling of channels in old sediments by younger sediments can cause prominent and abrupt soil changes not suggested by the smooth relief and uniform slope which crosses the soil boundaries. These phenomena are especially prevalent in and adjacent to drainageways and in areas of thinning of major sediments.

Abstract No. 483.

Gist, G. R., and R. M. Smith. 1948. Root development of several common forage grasses to a depth of eighteen inches. J. Amer. Soc. Agron. 40:1036-1042.

Root samples of bromegrass, orchard grass, Kentucky bluegrass, timothy, and deer's tongue were collected from experimental plots on the agronomy farm at Morgantown, West Virginia. These plots were on shallow Rayne silt loam. The root and soil samples were taken by means of a core type sampler 3 inches in diameter. Cores were taken to a depth of 18 inches and cut into 3-inch segments for soil testing and root removal by washing.

In some cases solid sandstone rock was encountered at depths from 16 to 18 inches, in others a loose porous sandstone or shale was found to extend below the 18-inch level. Except in cores where solid rock was encountered, some roots extended below the 18-inch level.

In the 0- to 3-inch layer deer's tongue had the greatest root development with 4,481 lb. of roots per acre inch as compared to 1,247 for orchard grass, 1,126 for Kentucky bluegrass, 717 for bromegrass, and 680 for timothy. In all samples, weights of roots per acre inch decreased rapidly with depth. At depths below 6 inches, bromegrass had greater root development than the other grasses studied. In the 12- to 18-inch layer, bromegrass had 106 lb. of roots per acre inch; orchard grass, 29; deer's tongue, 16; timothy, 6; and Kentucky bluegrass, 3.

The organic matter content of the soil decreased consistently with depth. It was significantly higher in the 0- to 3-inch layer than in the 3- to 6-inch layer, even though the plots were plowed to a depth of about 6 inches 3 years earlier. This higher organic matter content in the 0- to 3-inch layer was evidently the result of the build-up by the grasses and clover. It was greatest for the grasses with the heavier root systems in the surface layer.

Abstract No. 484.

Gleason, H. A. 1922. The vegetational history of the Middle West. Ann. Ass. Amer. Geogr. 12:39-85.

Migration of a species depends on an environmental change within or beyond its range. Migrations in progress now or in the recent past are indicated by historical evidence or by observation of successions. The principal vegetational and floristic elements of the Middle West were differentiated during the Tertiary Period and have continuously maintained their present relative position.

Abstract No. 485.

Glendening, G. E. 1942. Germination and emergence of some native grasses in relation to litter cover and soil moisture. Amer. Soc. Agron J. 34:797-804.

During the summer of 1938 seeds of 10 native perennial grasses were planted in replicated plots under eight different treatments, including cultivation and covering of the surface soil with various kinds of litter on a depleted semidesert grassland range south of Tucson, Arizona. At the same time provision was made on an adjacent plot to obtain moisture samples at surface-inch, 6-inch, and 12-inch depths of bare soil, soil covered with straw litter, and soil covered with open-mesh gauze fabric.

Results showed that moisture content at all levels was consistently greater under the straw and gauze than on the bare ground and that the length of time during which moisture content of the surface soil was above the calculated W. C. was greatest under the straw litter.

Germination and emergence of grass seedlings was increased from 4 to more than 20 times over that on the bare ground by the various surface-soil treatments.

Abstract No. 486.

Glover, F. A. 1969. Birds in grassland ecosystems, p. 279-284. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Birds are important in the ecology of grasslands because of their roles in the food web and flow of energy. A wide variety of birds serve as primary, secondary, and mixed consumers in the Grassland Biome. The ecology of birds in grasslands is an area in need of serious research. The major areas of research should be concerned with mobility of birds, biomass variations, and interrelationships with abiotic and biotic factors.

Abstract No. 487.

Glover, R. K., G. W. Tomanek, and G. L. Wolter. 1968. Soil and vegetation relationships on four slopes of the Ogallala formation in Trego County, Kansas. Kansas Acad. Sci., Trans., 71(1):69-86.

Vegetation and soils were studied on a large hill rising abruptly from a level plain in Trego County, Kansas. Composition of the vegetation was determined by use of the point frame transects, and soil profile descriptions were made on top of the hill and on upper and lower slopes of north, south, east, and west facing slopes.

Soils are forming in calcified, highly calcareous, old alluvium of the Ash Hollow member of the Ogallala formation. Soils are quite similar when comparing them in relation to slope direction. However, the soils of the upper slopes and hilltop are shallower than those on the lower ·lopes.

The vegetation was dominated by four species--blue grama (*Bouteloua gracilis*), sideoats grama (*B. curtipendula*), little bluestem (*Andropogon scoparius*), and big bluestem (*A. gerardi*). The more drought resistant grasses, blue grama and sideoats grama, were most common on the hill top and south and west facing slopes. Blue grama, the most drought resistant grass, was most common on the hill top and upper portions of the slopes. The two bluestems were abundant along the entire north facing slope and lower east facing slope, but were not common on the other two slopes.

The distribution of the vegetation indicates that the most mesic slope is the north facing followed in order by the east, west, and south facing slopes. Microclimatic data from other studies help substantiate these assumptions. However, this study reveals the necessity of studying the soils as well as the microclimate in evaluating the factors causing variations in vegetation on different slopes.

Abstract No. 488.

Goetz, H. 1963. Growth and development of native range plants in the mixed grass prairie of western North Dakota. M.S. Thesis. North Dakota State Univ., Fargo. 67 p.

The native mixed grass prairie of western North Dakota in the vicinity of the Dickinson Experiment Station was characterized as to species of plants present and their rates of growth and development over the 8-year period, 1955-1962. Measurements of leaf and stalk heights of 15 major grass and sedge species were made at approximate 7- to 10-day intervals from early May to mid-September of each of the growing seasons during this period.

Phenological observations were made on the grass and sedge species, including dates of fruiting stalk initiation, anthesis, seed development, seed maturity, earliest observed date of seed shedding, and estimation of degree of leaf drying.

Abstract No. 489.

Goetz, H. 1969. Composition and yields of native grassland sites fertilized at different rates of nitrogen. J. Range Manage. 22:384-390.

Four range sites were fertilized at three different rates of nitrogen (33, 67, and 100 lb. nitrogen per acre) in southwestern North Dakota. Increasing the production of a range site with nitrogen fertilization is closely associated with the inherent production potential of the site. In general, greatest increases in total dry-matter yields for a given increment of fertilizer were observed at the 67-lb. nitrogen application. Total basal cover was reduced by fertilization on the Vebar and Havre sites, but increased on the Rhodes and Manning sites. In general, reduction in total cover was due to a decrease in cover of the blue grama grass. An increase in cover and density of western wheatgrass and the sage species was generally observed on all sites.

Abstract No. 490.

Goetz, H., and W. C. Whitman. 1961. Some aspects of grassland microclimate in southwestern North Dakota. North Dakota Acad. Sci., Proc., 15:44-45. (Abstr.).

Records of temperature, relative humidity, evaporation, and wind movement at heights of 5 inches and 5 ft over native-grass sod were made at the Dickinson Experiment Station in part of the 1959 growing season and during the period from June 1 to August 29 in the 1960 season. Continuous records of temperature and relative humidity at the two heights were obtained with recording hygrothermographs. Miles of wind were measured with standard 3-cup anemometers, and evaporation losses from Livingston porous bulbs were obtained at both heights.

The data thus far obtained indicate substantial microclimatic effects in this type of grassland even though the average height of the grass cover is less than 10 inches. Average temperatures at the 5-ft level were slightly lower than at the 5-inch level from 7:00 PM to midnight, but were slightly higher from 2:00 AM to 6:00 PM. Relative humidity was appreciably higher at the 5-inch level than at the 5-ft level during the daylight hours, but was lower at the 5-inch level at night.

The most significant differences in climate at the 5-inch and the 5-ft levels were in wind movement and evaporation. Wind movement at 5 ft was over twice that at 5 inches and evaporation averaged about 20% more at 5 ft than at 5 inches.

More refined instrumentation and continuous observation of additional factors such as soil temperatures, soil water, and solar radiation are needed before the general pattern of grassland microclimate can be established, and the relations between microclimate and grass growth can be evaluated.

Abstract No. 491.

Goldman, E. A., and R. T. Moore. 1945. The biotic provinces of Mexico. J. Mammal. 26(4):347-360.

Based on consideration of the geographic distribution of selected lists of mammals and birds as indicators, botanical and other data, the Mexican mainland and certain insular areas are subdivided into biotic provinces, named as follows: (1) California; (2) Guadalupe Island; (3) Vizcaino Desert; (4) Southern Baja California; (5) Revilla Gigedo; (6) Sonora; (7) Sierra Madre Occidental; (8) Chihuahua-Zacatecas; (9) Tamaulipas; (10) Sinaloa; (11) Nayarit-Guerrero; (12) Sierra Madre Oriental; (13) Transverse Volcanic; (14) Vera Cruz; (15) Sierra Madre del Sur; (16) Tchuantepec; (17) Chiapas Highlands; (18) Yucatan Peninsula.

Abstract No. 492.

Goldsworthy, A. 1970. Photorespiration. Bot. Rev. 36(4):321-340.

This work is intended as a brief introduction for the newcomer to what is still a complicated and controversial field. It attempts to condense the work of many years into about as many pages.

A very large number of plants exhibit photorespiration, although its accurate measurement presents some difficulty. Its biochemical mechanism is now becoming understood, but whether it performs a useful function within the plant is debatable.

Photorespiration may be defined in various ways, but for the purpose of this review I shall define it as that process, or group of processes, by which certain plants release CO_2 in the light. The phenomenon can be demonstrated most easily if a photorespiring plant is illuminated in a closed environment. Initially, the rate of photosynthesis will be greater than the rate of photorespiration, and the plant will deplete the CO_2 concentration within that environment. As the CO_2 becomes used up, the rate of photosynthesis will become slower and slower. At a particular point the rate of photosynthetic CO_2 uptake will become equal to the rate of photorespiratory CO_2 output, and no further net CO_2 exchange will be observed. The CO_2 concentration at which this occurs is called the CO_2 compensation point. If a plant does not photorespire, it will be able to remove all the CO_2 from its environment and will have a zero compensation point. As a result of measurements of their compensation points plants have been divided into two groups, those with high compensation points, somewhere in the region of 50 ppm CO_2, and those with low compensation points, typically less than 5 ppm CO_2. To what extent these low compensation points are due to a reduced photorespiration, and to what extent they are due to an efficient refixation of photorespired CO_2 is still a matter for debate. However, the initial part of this review will be concerned largely with the phenomenon of photorespiration in high compensation point species, where it can be more easily measured and studied. A later section will then deal specifically with photorespiration in low compensation point species.

Abstract No. 493.

Goldsworthy, A., and P. R. Day. 1970. A simple technique for the rapid determination of plant CO_2 compensation points. Plant Physiol. 46:850-851.

This technique was developed to screen large numbers of plants for individual ones with low CO_2 compensation points. It was thought that low compensation points might be correlated with high photosynthetic efficiency and that plants possessing them might provide useful material for a breeding program. The technique was designed originally for use on excised leaf segments from tobacco, but has since proved adaptable for use with detached leaves and leaf segments from a variety of plants. It calls for the use of one infra-red CO_2 analyzer and will produce results at rates of up to one a minute.

The principle underlying the method is extremely simple. The plant material is allowed to photosynthesize in a CO_2-impermeable Mylar bag. When it reaches its compensation point, the gas in the bag is squeezed out into an infra-red analyzer, and the CO_2 concentration is measured.

This technique has a built in check that sufficient time has been allowed for incubation since each of the two replicates start from either side of the compensation point and can give identical results only if the compensation point has been reached. The method has the advantage over the conventional closed circuit gas flow system in that the CO_2 analyzer is not tied to one sample throughout the experiment and so permits a larger number of determinations to be made with the instrument. Also, subatmospheric pressures cannot be developed within Mylar bags as they are at points within closed circuit flow systems. This, coupled with the very low permeability of Mylar film to CO_2, makes the method inherently free of errors due to leaks.

Temperature control within the Mylar bags is good. When under illumination at 1000 ft-c in the growth chamber at 24C, the temperature of the water in which the leaf was floating was less than one degree above the temperature of the chamber after 1 hr of incubation.

With this method, it is the rate at which bags can be filled and subsequently analyzed which limits the throughput of the system. For large scale use, it is suggested that the incubation period be carried out in a growth room at the periphery of a large turntable rotating at one revolution per hour. One person could fill the bags and load them onto the turntable at a fixed point, and a second person could analyze them when they passed him after 1 hr of incubation. By this means it should be possible to obtain results at a steady rate of one a minute.

Abstract No. 494.

Goode, W. E., and J. E. Christiansen. 1945. Obtaining soil cores for permeability tests. Agr. Eng. 26:153-155.

Methods and equipment for obtaining large undisturbed soil cores for permeability tests have been devised, and more than 50 cores have been obtained and tested. Sealing the space between the core and wall of the cylinder with dry, sieved soil has proved satisfactory. The use of transparent plastic cylinders has made it possible to obtain tight-fitting cores which eliminate the necessity for sealing. In taking cores in the field in metal cylinders the conclusion that a good core has been obtained is based on circumstantial evidence. By using the transparent plastic cylinders the condition of the core is evident as soon as the jacket is removed, and if defective, it can be discarded at once and another core taken. In the laboratory the rate of saturation of cores in transparent cylinders can be seen and controlled, and during the permeability test the retention or absorption of air, any structural changes, any "blowing out" or channeling around manometer openings, or other phenomena taking place may be observed and recorded.

Abstract No. 495.

Goodman, C. L., G. W. Tomanek, and G. K. Hulett. 1967. Survey of phreatophytes at Cedar Bluffs Reservoir, Kansas. Kansas Acad. Sci., Trans., 70(4):451-463.

The purpose of this study was to identify and study the phreatophyte communities that occurred at Cedar Bluffs Reservoir. The extent and nature of each community were studied along with their relation to water table depth, soil texture, pH, and salinity.

Cedar Bluffs Reservoir is on the Smoky Hill River in the southeast corner of Trego County, Kansas. When the water line is at the irrigation pool level, the lake is 9 miles long, 5 miles wide, and has a surface area of 6,600 acres. The lake also has a shoreline of a 54 linear miles at irrigation pool level.

Saltcedar was the most abundant species with plains cottonwood, peach leaved willow, and sandbar willow ranking second, third, and fourth, respectively. Cottonwood and willow were the most evenly distributed with saltcedar occurring mainly in small concentrated stands.

Abstract No. 496.

Grant, W. E. 1971. Comparisons of aboveground plant biomass on ungrazed pastures vs. pastures grazed by large herbivores, 1970 season. U.S. IBP Grassland Biome Tech. Rep. No. 131. Colorado State Univ., Fort Collins. 19 p.

This report presents a comparison of floral composition (live aboveground biomass) between different grazing treatments at nine U.S. IBP Grassland Biome research sites. A similarity index developed by Shannon and Weaver (1949) is used to compare ungrazed pastures to those grazed by large herbivores based on data collected in 1970 at the nine sites. The data indicate that the proportional plant species composition is relatively unaltered by grazing at three of the sites while at five of the sites it is altered significantly. One site is intermediate to the two groups mentioned above.

Abstract No. 497.

Grant, W. E. 1971. Comparisons of small mammal biomass at eight U.S. IBP Grassland Biome research sites, 1970 season. U.S. IBP Grassland Biome Tech. Rep. No. 130. Colorado State Univ., Fort Collins. 19 p.

Small mammal population density estimates are made for Bison, Bridger, Cottonwood, Dickinson, Jornada, Osage, Pantex, and Pawnee sites based on 1970 field data. Small mammal biomass at these sites is quantitatively compared by means of a similarity index and cluster analysis.

Abstract No. 498.

Grant, W. E. 1971. Site comparisons of aboveground plant biomass, 1970 season. U.S. IBP Grassland Biome Tech. Rep. No. 83. Colorado State Univ., Fort Collins. 28 p.

Intersite comparisons of live aboveground plant biomass were made using data from the 1970 field season. The nine sites compared were the following: Bison, Bridger, Dickinson, Cottonwood, Pawnee, Hays, Osage, Pantex, and Jornada.

Abstract No. 499.

Gray, D. M., D. I. Norum, and J. M. Murray. 1969. Infiltration characteristics of prairie soils. Annu. Meeting Amer. Soc. Range Manage., February 10-13, Calgary, Canada.

The paper outlines the fundamentals of the infiltration process including several accepted theories defining the time variation in the infiltration rate of a soil. A comparison of the infiltration rates of several prairie soils derived by the different theoretical equations using field data is presented. The inherent danger of direct extrapolation of the infiltration rates of "texturally-similar" soils encountered on the prairies is exemplified by the results.

Consideration is also given to the infiltration process to frozen soils under prairie conditions. Differences in prairie snowpacks compared to mountainous snowpacks as they affect the process are described. Measured values of the volumetric infiltration amounts to frozen soils under different conditions are given.

Abstract No. 500.

Gray, J. R. 1961. Sheep enterprises in northern New Mexico. New Mexico Agr. Exp. Sta. Bull. 454. 17 p.

This report describes one of the nation's oldest agricultural enterprises in an area that was settled 50 years before the Jamestown settlers arrived in Virginia. Sheep have grazed ranges in north-central New Mexico almost continuously since 1605. Despite this long history of grazing use, little has been written of sheep enterprises in the area. Most written accounts describe the people and their social and political institutions. This report deals with the present organization, costs, and returns of the sheep enterprise. An analysis is made to pinpoint opportunities to improve income from this enterprise.

Abstract No. 501.

Gray, J. R., and C. B. Baker. 1951. Commercial family-operated sheep ranches range livestock area, Northern Great Plains, 1930-1950: Organization production practices, costs and returns. Montana Exp. Sta. Bull. 478. 94 p.

The purpose of this study is to analyze the organization, operation, costs, and net returns from commercial family-operated sheep ranches in the Range Livestock Area of the Northern Great Plains over the period 1930 through 1950.

Sheep and cattle ranches are important in the agricultural economy of the Northern Great Plains Region. In the study area, 67% of the classified farms and ranches were units having either beef cows or ewes older than 6 months of age. Some 33% of these units had sheep and 67% had cattle. This study, covering only commercial family-operated ranches, includes more than 75% of the sheep units.

Although the study is designed to examine operations of sheep ranches within a defined range livestock area, data presented have general application to all family-operated sheep ranches found throughout the Northern Great Plains.

Range livestock production in the Northern Great Plains has, in the past, been subjected to much economic stress. This has been due in part to maladjustment of institutional arrangements (particularly size and tenure of land holdings) to the environment of the region. Problems of adjustment will continue into the future. To guide readjustments along appropriate lines, knowledge of past trends in organization and management practices, as well as volumes of physical production, costs, and returns, will be valuable.

It is hoped that, from the data reported herein, relationships can be established which will shed light on the economic characteristics of sheep ranches of the region.

Abstract No. 502.

Gray, J. R., and C. B. Baker. 1951. Sheep ranching in the Northern Great Plains. Montana State Coll. Agr. Exp. Sta., Circ. 196. 19 p.

The purpose of this circular is to describe the organization, costs, and returns over a 21-year period of the average of commercial family-operated sheep ranches in the Northern Great Plains. Data for these averages were obtained from other studies and directly from ranches in eastern Montana, northeastern Wyoming, and western South Dakota, an area in which stock ranching is the chief industry.

Abstract No. 503.

Gray, J. R., and C. B. Baker. 1953. Cattle ranching in the Northern Great Plains. Montana Agr. Exp. Sta. Circ. 204. 19 p.

From 1930 to 1940 cattle ranchers in the Northern Great Plains experienced extremely poor physical and economic operating conditions. As a result, they operated at an annual loss of about a thousand dollars per ranch per year. From 1930 to 1935 their equities in ranch real estate dropped from an average of 64 to an average of 42%. Likewise, their equities in livestock dropped from 94 to 60%. It is evident that the ranch business was carried on during this period only with the aid of borrowed money. Many ranchers were forced out of business. Probably many more would have sold out if they could have located buyers. Prices were so low that a good ranch, now selling for upwards of $70,000 was then valued at about $15,000, or only 21% of the present value. One of three possible alternatives was adopted: (1) continue in the business although at a loss, (2) shift to sheep, or (3) sell out. Many were forced to accept the first alternative because of a reluctance to follow the second and an unwillingness to accept the extremely low prices connected with the third alternative.

Abstract No. 504.

Green, J. L., and C. V. Cole. 1971. Growth of *Bouteloua gracilis* in a biosynthesis chamber. U.S. IBP Grassland Biome Tech. Rep. No. 69. Colorado State Univ., Fort Collins. 33 p.

Blue grama grass sods, 10-cm in depth, having a total surface area of 0.62 m^2 were grown in a closed system to which $^{14}CO_2$ of 0.3 µCi/mmole specific activity was added. Uniformly labeled top regrowth was collected in three successive harvests. Measurements of soil and plant respiration and net CO_2 assimilation (photosynthesis) were made. Proposed use of the material produced within the biosynthesis chamber environment in a study to estimate field decomposition rates is discussed.

Abstract No. 505.

Green, W. H., and G. A. Ampt. 1911. Studies in soil physics, Part I, Flow of air and water through soils. J. Agr. Sci. 4:1-24.

The permeability and capillarity constants of soil have been defined.

The movements of air and water through three types of soil have been measured and shown to conform to equations connecting the rate of motion with the above constants.

It is suggested that the measurement of S, P_a, P_w, and K is of more importance than, and should replace the determination of the sizes of the soil particles as in the usual "mechanical analysis" of soils.

Abstract No. 506.

Gregory, F. G. 1956. General aspects of leaf growth, p. 3-17. *In* F. L. Milthorpe [ed.] Growth of leaves. Buttersworths Sci. Pub., London.

1. The initiation of the leaf primordium.
2. The further development of the individual leaf.
3. The growth of the leaf surface as a whole in relation to the life history of the plant.
4. Mechanisms controlling leaf growth and initiation.

Abstract No. 507.

Gringorten, I. I. 1966. A stochastic model of the frequency and duration of weather events. J. Appl. Meteorol. 5:606-624.

A simple Markov chain has been demonstrated to be a potentially useful device for making estimates of the frequencies and durations, from several hours to several weeks, of a large variety of weather events. In order to answer the practical questions, it was found necessary to simulate probability distributions by a Monte Carlo exercise. The resulting eight sets of charts have wide applicability.

Abstract No. 508.

Griswold, S. B. 1942. A study of the woody plants along the streams which cross Ellis County, Kansas. Kansas Acad. Sci., Trans., 45:98-106.

The soil was best along Big Creek, followed by the Saline River soil; then the Smoky Hill River soil, which was very sandy.

In general, larger and older trees were found nearer the stream, especially within the first ten feet.

The condition of the soil for anchorage and retention of moisture as well as furnishing nutrients may account for the noticeable difference of tree, woody vine, and shrub growth in this county.

The total of all species along Big Creek was 149 as compared to 80 on the Saline River and 35 on the Smoky Hill River.

The total number of the major kinds of trees along Big Creek was 96 as compared to 51 on the Saline River and 34 on the Smoky Hill River. The percentages of the major kinds of trees were as follows: Big Creek 53%, Saline River 28%, and Smoky Hill River 19%.

The percentages of each major kind was as follows: ash 38%, hackberry 26%, elm 15%, cottonwood 12%, willow 9%.

The major kinds of trees in order of size from the largest average were as follows: cottonwood 21.5 inches, elm 9.0 inches, hackberry 3.0 inches, ash 2.9 inches, and willow 1.6 inches in diameter.

The major kinds of trees in order of average age from the oldest were as follows: cottonwood 61.3 years, elm 27.3 years, hackberry 17.2 years, ash 14.3 years, and willow 6.5 years.

The Saline River had more shrubs and more woody vines than the other streams with Big Creek next and the Smoky Hill River last, having little other than false indigo.

The ash, elm, and cottonwood apparently showed more evidence of dead material than the other species, and this material was about evenly divided between the Saline River and the Smoky Hill River.

There were more seedlings along Big Creek than the other streams. The Saline River was next with quite a few and the Smoky Hill River last with practically none.

Abstract No. 509.

Griswold, S. M. 1936. Effects of alternate moistening and drying of germination of seeds of western range plants. Bot. Gaz. 98:243-269.

1. The seeds used in this study comprise 9 grass, 26 weed, and 7 woody species of Utah range plants. Some 23 of the 42 species studied gave little or no germination at temperatures of 22° to 29°C. Other conditions must be used for them before the effect of alternate moistening and drying can satisfactorily be determined.

2. The effect of alternate moistening and drying on the germination of seeds varies with the individual species. Of the 19 species which germinated at 22° to 29°C, alternate moistening and drying had little effect upon the germination of *Bromus polyanthus*. It increased the germination of *Stipa lettermani*, *Artemisia incomptl*, *Lepidium densiflorum*, and *Plantago tweedyi*. It decreased the germination of *Geranium vixcosissimum*, *Pseudocymopterus montanus*, *Chrysothamnus lanceolatus*, and *Stipa columbiana* (slightly).

3. Rapid drying had little effect upon the germination of *Poa interior*, *P. secunda*, and *Chenopodium album*, but increased the germination of *Achillea lanulosa*, *Androsace diffusa*, *Pentstemon rydbergii*, and *Rumex mexicanus*; in all of these species slow drying decreased the percentage of germination. Rapid drying decreased the germination of *Bromus anomalus*, *Lupinus parviflorus*, and *Rudbeckia occidentalis*, while slow drying increased the germination of *Rudbeckia* but had little effect upon *Bromus anomalus* and *Lupinus*.

4. Increased germination was usually accompanied by a hastening of the germinative process, and decreased germination was accompanied by a retardation. In five species, however, *Poa secunda* no. 1, *Androsace*, *Plantago*, *Rudbeckia*, and *Rumes*, retardation was followed by increased germination.

5. Some seeds after they have absorbed water will withstand short periods of alternate drying and moistening, and some will withstand a long period of drying without injury. The time at which drying begins in relation to the stage of development of the germinating seed is a very important factor in determining whether drying is harmful or beneficial. The effect of drying is also influenced by the rate at which drying takes place.

Abstract No. 510.

Gross, J. E. 1969. Jackrabbit demographic and life history studies, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 16. Colorado State Univ., Fort Collins. 8 p.

This report includes: (1) a brief description of field installations, designs, and procedures; (2) a partial analysis of black-tailed jackrabbit (*Lepus californicus*) and white-tailed jackrabbit (*Lepus townsendii*) population dynamics and life history data collected to date in the vicinity of the Central Plains Experimental Range; and (3) a brief description of objectives to be completed in FY 1970.

Abstract No. 511.

Gross, J. E. 1969. The role of small herbivorous mammals in the functioning of the grassland ecosystem, p. 268-278. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Small herbovorous mammals (rodents, hares, and rabbits) undoubtedly exert appreciable influences on the functioning of the grassland ecosystem. A model of these influences and functions is a necessary component for the grassland ecosystem macro-model. However, despite considerable research on the impact of small herbivorous mammals on their habitat, the nature and extent of many discernible plant-animal ecological interactions have been clouded by narrow research orientation, study-period limitations, and faulty experimental design.

The actions of small herbivorous mammals on their habitats may be divided, according to the literature, into three broad categories. Vegetative interactions include: (1) range composition, range condition, and succession; (2) plant consumption and wastage; and (3) animal dietary composition. Soil interactions include: (1) structure, (2) altered vegetation structure; (3) water infiltration; and (4) flow and cycling of nutrients and minerals, respectively. Animal interactions include: (1) livestock consumption equivalents; and (2) interspecific cohabitation and exclusion.

Many early ecologists (ca. 1930) concluded that the small herbivorous mammals were universally responsible for range deterioration and were also responsible for inhibited succession, accelerated succession, and altered plant speciation. Recent investigators recognize the small herbivores may be either a cause or a symptom of all the foregoing conditions.

The nature and extent of the small herbivorous mammals' impact on range vegetation depend in part on associated influences of domestic livestock, geographic location, and weather, particularly the former. Although food consumption by small herbivorous mammals is frequently converted to domestic livestock equivalents, the results are confounded by complex seasonal intraspecific changes in diets and by divergent interspecific diets.

The impact of small herbivorous mammals on soil was viewed by early investigators as hopelessly complex and beyond precise description. The bulk of quantified information on animal-soil interactions is on soil-movement resulting from burrowing. Likewise, only limited qualitative information is available on interspecific cohabitation and exclusion.

The lack of conceptual mechanisms describing interaction of plants on animals necessitates reforming the modelling approach to one of delineating the impact of plants on the animals.

Abstract No. 512.

Gross, J. E., and C. J. Walters. 1970. Summary report on initial small-herbivorous-mammal modeling efforts. U.S. IBP Grassland Biome Tech. Rep. No. 4. Colorado State Univ., Fort Collins. 57 p.

The small herbivorous mammals are a conspicuous element in the grassland ecosystem and presumably exert a significant role in the functioning of the ecosystem. The small mammal modeling effort has as a primary objective the delineation of this role. Small herbivorous mammals form one of several arbitrarily-separated groups which have been designated as primary consumers on the Pawnee Site of the Grassland Biome. The small-herbivorous-mammal complex on the Pawnee Site is made up by about 25 to 30 species, ranging in size from 40 g mice, through 1,000 g prairie dogs, to 3,000 g jackrabbits. Eleven of these 25 to 30 small herbivores have been selected for study, the selection being made on the basis of estimates and opinions of relative densities, with the hope that the majority of the small mammal biomass will be included in a model simulating the demographic behavior of the 11 species. Eight of the species are rodents, and three are rabbits or hares.

Abstract No. 513.

Gustafson, J., and G. Innis. 1972. SIMCOMP: A simulation compiler for biological modelling. U.S. IBP Grassland Biome Preprint No. 33. Colorado State Univ., Fort Collins. 11 p.

In the development of large-scale simulation models for biological systems one often encounters the problem that, as in many other modelling activities, the programming bookkeeping and overhead far exceed the problems of describing the biological system for simulation on the computer. Yet if one goes to some of the better known simulation languages, one finds that the language lacks the power and versatility of a language like FORTRAN for the expression of some of the more complicated mechanisms of interest to the modeller. The development of this modelling technique was approached, therefore, with the specific idea in mind of retaining much of the versatility of FORTRAN while reducing, insofar as possible, the amount of nonbiological information that the modeller was required to provide. As a starting point, a difference equation flow orientation was used. The compiler is, therefore, somewhat similar to DYNAMO yet contains a large number of restrictions which are appropriate to biological modelling and which result in a much simpler programming representation.

The compiler is implemented in FORTRAN as a two-pass system. The first pass takes the input and provides as output a FORTRAN model of the biological system. The second pass is then the compilation and execution of this FORTRAN program. This two-pass system provides some other interesting opportunities for the modeller. We have found in the development of large-scale biological models that the majority of the cost associated with these models resides in the development phase of the activity. The compiler is designed to reduce significantly the development phase while sacrificing, perhaps, efficient execution of the model. However, since the resulting model is written in FORTRAN, it is a very easy step for the modeller, once he has the version of the model that he intends to run many times, to optimize and to modify the FORTRAN model to improve its execution characteristics. This system has been extensively tested in a number of modelling activities, some of which are the topic of other papers at this conference.

Abstract No. 514.

Gustafson, J. D., and G. Innis. 1972. SIMCOMP version 2.0 user's manual. U.S. IBP Grassland Biome Tech. Rep. No. 138. Colorado State Univ., Fort Collins. 62 p.

SIMCOMP is a computer programming system which is designed to aid biologists with a limited knowledge of FORTRAN programming to design and execute comparmental-flow simulations. The system is designed to minimize the programming overhead required by any computer language while maintaining sufficient flexibility to solve most problems. A simulation is defined by specifying the flow rates between compartments and may be in either difference or differential equation form. Tabular and graphical output may be requested. The design and mathematical formulation of a simulation is described. The syntactical rules for writing SIMCOMP programs and the solution technique is explained.

Abstract No. 515.

Haberman, C. G., and E. D. Fleharty. 1971. Energy flow in *Spermophilus franklinii*. J. Mammal. 52: 710-716.

The energy flow value of *Spermophilus franklinii* based on results from oxygen and food consumption experiments for an estimated one animal per hectare for 1 day was 123.8 kcal. This value would be nearly equivalent to the energy of maintenance as a negligible amount would be used for growth in such a brief period. Actual metabolizable energy calculated from food consumption experiments was about double the estimated resting metabolizable energy ascertained from oxygen consumption. Oxygen consumption can be expressed as $Y = 1.73 - 0.041 X$ for metabolic responses to ambient temperature changes below 26.5°C. The thermoneutral zone (26.5 to 31°C) gave a value of 0.64 cm^3 of oxygen per g/hr. These values were close to those predicted by relating metabolism to body weight.

Abstract No. 516.

Haberman, C. G., and E. D. Fleharty. 1971. Natural history notes on Franklin's ground squirrel in Boone County, Nebraska. Kansas Acad. Sci., Trans., 74(1):76-80.

The Franklin ground squirrel (*Spermophilus franklinii*) is common in central Nebraska in low-lying areas of silty soil overgrown with *Bromus inermis*, which provides concealment and nest material for the squirrels. The burrows range from simple to complex in structure but seldom vary in depth (17 inches) and diameter (3¼ inches).

Emergence from hibernation in 1969 and 1970 was in early May; and, thereafter, the daily activity occurred predominantly about 4 and 7 hours after sunrise and 5 hours prior to sunset. Weather conditions did not seem to affect the daily life patterns of *S. franklinii*.

Abstract No. 517.

Hafen, L. R., and C. C. Rister. 1941. Western America. Prentice Hall, Englewood Cliffs, New Jersey. 698 p.

This volume is devoted primarily to the exploration, settlement, and development of the trans-Mississippi West. As closely as possible, the authors have followed a chronological sequence. Thus, the first four chapters are concerned with the achievements of the Spaniards and the French in establishing themselves in the Southwest, on the Pacific Coast, and in the Mississippi Valley.

To explain that primacy and achievement, a brief survey of the Anglo-American background is given in the next four chapters.

The remaining chapters are concerned with the gradual emergence of the new Westerner, his problems, his institutions, his interests, and his culture.

The Indian deserves space in any history of Western America. The authors have confined their attention largely to a presentation of his relations with the white man.

Concerned primarily with the problems of conquest and settlement of the West, the authors have devoted most of their space to pioneering achievements. When the country was won and settled, when free land disappeared, the pioneering period ended. Thereafter, the history of the region merges into that of the country at large. Only those movements, therefore, that are peculiarly western, such as reclamation and the agrarian revolt, are followed well into the twentieth century.

Abstract No. 518.

Hagmeier, E. M. 1966. A numerical analysis of the distributional patterns of North American mammals II. Re-evaluation of the provinces. Syst. Zool. 15:279-299.

In an earlier paper, numerical techniques were developed and used to analyze distribution patterns of the native terrestrial mammals of North America. An error in method is here corrected, indicating that 35 provinces, 13 superprovinces, four subregions, and one region may be recognized. The methods used are relatively objective, quantitative, and suited to computerization.

Abstract No. 519.

Hagmeier, E. M., and C. D. Stults. 1964. A numerical analysis of the distributional patterns of North American mammals. Syst. Zool. 13:125-155.

North America has been subdivided into natural "areas" on the basis of either biogeographic or ecologic data. The biotic province concept suffers in that it has been used in both ways. It is suggested that when these natural areas are used as biogeographic units they be termed biogeographic provinces, or named according to the taxonomic group on which they are based. The work reported here deals with the mammal provinces of the continent.

Abstract No. 520.

Haise, H. R., W. W. Donnan, J. T. Phelan, L. F. Lawhon, and D. G. Shockley. 1956. The use of cylinder infiltrometers to determine the intake characteristics of irrigated soils. U.S. Dep. Agr., Agr. Res. Service, 41-7. 10 p.

Cylinder infiltrometers have been found suitable for use in determining the intake characteristics of irrigated soils. While much is still to be learned about the relationship of these characteristics to needed water management practices with the various methods of irrigation, it is felt that if uniform procedures are followed in making intake studies, these relationships may be determined. At the present time, intake characteristics, as measured with cylinder infiltrometers, are extensively used for the development of irrigation layouts and irrigation water management criteria for the border and other controlled flooding methods of irrigation. The suitability of such data for these uses is generally accepted but needs refinement. Correlations of infiltrometer data with furrow and sprinkler intake rates have not been developed. These relationships should be investigated.

One means of studying the relationship between cylinder infiltrometer data and field irrigation practice requirements is through careful intake studies made in connection with field irrigation practice evaluation trials. Procedures for evaluation trials with border, furrow, and sprinkler methods of irrigation have been developed and are used uniformly by technicians throughout the irrigated areas of the country. For greatest usefulness in analysis, uniform procedures for the use of cylinder infiltrometers, also, should be followed.

The following procedural suggestions were developed from field observations by the authors and from the studies and suggestions of other technicians who have been working in this field.

Abstract No. 521.

Halcrow, H. G., and H. R. Stucky. 1949. Procedure for land reclassification in Montana. Montana Agr. Exp. Sta. Bull. 459. 37 p.

It is the purpose of this publication to provide references and a working outline for use in reclassification of agricultural land for assessment purposes in Montana. The bulletin was developed as a result of studies of the classification work done from 1919 to 1923 and of the reclassification work which has been carried on in more recent years. The authors and others have held many meetings with Montana County commissioners, assessors, special reclassification deputies, and committees, community and county planning committees, and the Montana Board of Equalization. The major part of this publication is based on information obtained from these meetings and from tax studies conducted over the state by the Montana Agricultural Experiment Station and the Montana Extension Service. Special studies of methods used in reclassification have been made in counties where work has been in progress in recent years.

Abstract No. 522.

Halkias, N. A., F. J. Viehmeyer, and A. H. Hendrickson. 1955. Determining water needs for crops from climatic data. Hilgardia 24(9):207-233.

Studies were made on the relation of the use of water by crop plants in irrigated areas to climatic data. The relationships between the use of water by crops and evaporation as recorded by various instruments are discussed. The difference in evaporation as measured by black and white atmometers and the solar radiation as measured by an Eppley pyrheliometer showed high correlation with use of water by crops. The best measure of water use by crops is by soil sampling to obtain the changes in soil water.

Abstract No. 523.

Halstead, E. H., and D. A. Rennie. 1965. The movement of injected P^{32} throughout the wheat plant. Canadian J. Bot. 43(11):1359-1366.

Specific activity (counts per minute per gram dry matter) measurements, autoradiographs, and densitometer tracings on the autoradiographs indicated that P^{32}, injected into the stem of wheat plants, moved rapidly into the root system and was distributed uniformly throughout it. Although root weights varied with depth, the specific activity of the washed root material remained relatively constant. The stage of plant growth markedly influenced the translocation of the P^{32} into the roots. Quantitative measurements indicated that approximately five times as much activity moved into the root systems of 40-day-old compared with 60-day-old plants. A soil water stress increased the specific activity of the roots. A linear increase in the specific activity of the root material was obtained by increasing the number of tillers injected per wheat plant (amount injected constant). The addition of indoleacetic acid, $NH_4H_2PO_4$, or H_3PO_4 to the carrier-free P^{32} reduced, rather than increased, movement to the roots.

Abstract No. 524.

Hamilton, J. W. 1958. Role of native forage plants in cattle and sheep nutrition. Univ. Wyoming Agr. Exp. Sta., Circ. 66. 8 p.

Millions of acres of the state of Wyoming are covered with native vegetation. This large area of grazing land furnishes food for hundreds of thousands of sheep, cattle, and game animals. The meat and animal products furnished by animals feeding partially or wholly upon this native vegetation represent an important fraction of the state's agricultural production.

Cultivation and reseeding this native vegetation with introduced grasses, legumes, or other forage plants is impractical on much of the land and impossible on some of it. Since it represents an important natural resource of the state, a better understanding of its chemical composition should be helpful. This circular deals with the chemical composition and nutritional value of these native plants.

Most of the plants studied were browse (woody perennial plants); some forbs and grasses were also studied.

Abstract No. 525.

Hanks, R. J., and K. L. Anderson. 1957. Pasture burning and moisture conservation. J. Soil and Water Conserv. 12(5):228-229.

It is true that burning off land cover had some advantages when it was first practiced. But with the coming of better tillage implements and commercial fertilizer, the advantages of burning rapidly disappeared in most areas. Now, the authors cite research data to show that burning pastures also has an important effect on moisture conservation. In general, the longer cover was left on the land, the more it contributed to moisture conservation.

Abstract No. 526.

Hanks, R. J., H. R. Gardner, and R. L. Florian. 1969. Plant growth-evapotranspiration relations for several crops in the central Great Plains. Agron. J. 61:30-34.

Lysimeters, which eliminated runoff and percolation below 90 cm, caused about 10 cm of additional water to be available for growth of grain sorghum in 1967. This additional water doubled yields, with an increase in evapotranspiration of only 50%. Evaporation from soil in the lysimeter was only 32% of the evapotranspiration, compared with 50% for the soil surrounding the lysimeter. Evaporation from the soil within a winter wheat crop during the actively growing period in the spring was estimated to be 15 and 37% of evapotranspiration for 1966 and 1967, respectively. Evaporation from the soil within the actively growing crop was estimated to be 34 and 20% of the evapotranspiration for oats and millet, respectively. Estimates of the amount of water evaporated from the soil within a crop allowed for estimation of transpiration from measurements of evapotranspiration. This data indicate that production and transpiration are directly related in this dryland area.

Abstract No. 527.

Hansen, R. M. 1970. Forage removal by jackrabbits on midgrass ranges. Annu. Meeting Colorado Sect. Amer. Soc. Range Manage., December 4-5, Denver, Colorado.

Jackrabbit fecal pellets were harvested from permanent plots in eastern Colorado for two consecutive years. If the mean digestibility of forage in winter by rabbits was 55%, the jackrabbits were removing about 0.16 lb./acre/day. If the mean digestibility of forage in summer by rabbits was 75%, the jackrabbits were removing about 1.2 lb./acre/day. Jackrabbits may have removed about 180 lb. of forage per acre per year during the study period.

$$\text{Forage Removed} = [\text{dry weight of feces produced}/(1 - \text{digestion index})] \times \text{time}$$

$$\text{Forage Removed} = \text{jackrabbit live weights} \times 0.06$$

Jackrabbits appear to have removed about 180 lb./acre/year of forage at the Eastern Colorado Range Station during the time of this study.

Abstract No. 528.

Hansen, R. M. 1971. Drawings of tissues of plants found in herbivore diets and in the litter of grasslands. U.S. IBP Grassland Biome Tech. Rep. No. 70. Colorado State Univ., Fort Collins. 69 p. (Artist: Anne S. Moir).

This report supersedes Tech. Rep. No. 18 and describes in greater detail the microscope technique used in the identification of plant fragments. This report explains how percentage density is converted to relative percentage density. It shows how to estimate the percentage dry weight of each species of plant in herbivore diets, litter, mulch, and other complex plant species mixtures using the microscope technique. The complete report also consists of drawings of plant fragments commonly found in the samples that have been processed in the Grasslands Ecology Research Laboratory.

Abstract No. 529.

Hansen, R. M., T. A. Vaughan, and D. F. Hervey. 1960. Pocket gophers in Colorado. Colorado State Univ., Exp. Sta. Bull. 508S. 26 p.

This bulletin deals with the pocket gophers in Colorado. It describes the animals, tells where and how they live, what they eat, and some of the basic information necessary for a control program. This is a "progress report" which brings together much information heretofore not available on pocket gophers in Colorado. However, the reader should be aware that there is much information needed through continued research.

As land and range management practices change so does the relationship change between the field rodents and agriculture and grazing. We have attempted to present the most accurate information available on pocket gophers in Colorado and to make available new information on how to control pocket gophers.

Abstract No. 530.

Hansen, R. M., and J. T. Flinders. 1969. Food habits of North American hares. Range Sci. Dep. Sci. Ser. No. 1. Colorado State Univ., Fort Collins. 18 p.

Jackrabbits and hares of the genus *Lepus* are widely distributed throughout North America. They occur in almost every type of vegetation ranging from the arid desert shrub of the southwest to the cold tundra at the northern extent of the North American continent. There are 10 species of this genus occurring in North America. The dietary habits of hares follow definite seasonal trends that are influenced by the availability and maturity of forage. With a few exceptions, hares are strictly herbivorous.

Abstract No. 531.

Hansen, R. M., J. T. Flinders, and B. R. Cavender. 1969. Dietary and energy relationships of jackrabbits at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 14. Colorado State Univ., Fort Collins. 43 p.

Jackrabbits as herbivorous consumers may play a large role in the utilization of vegetation within the shortgrass ecosystem. The purpose of studying black-tailed (*Lepus californicus*) and white-tailed (*Lepus townsendii*) jackrabbits on the Pawnee National Grasslands is to determine the year-round partitioning of herbage and energy by jackrabbits and the ecological ramifications of such partitioning.

The objectives of this study are as follows: (1) to determine the year-round dietary habits of each species of jackrabbit; (2) to delimit habitats of occurrence for both species of jackrabbits, based on measurements taken at kill sites; (3) to investigate interspecific competition between the two species of jackrabbits and with other herbivores; (4) to relate the dietary habits of these jackrabbits to the disturbing effects of man on the native vegetation of the shortgrass ecosystem.

Abstract No. 532.

Hansen, R. M., and B. R. Cavender. 1970. Assimilation rates of small mammal herbivores. U.S. IBP Grassland Biome Tech. Rep. No. 51. Colorado State Univ., Fort Collins. 7 p.

This technical report was prepared to make it possible for the programmers in the Grassland Biome to calculate the probable energy demands made by a population of small mammals on the grassland ecosystem.

Abstract No. 533.

Hansen, R. M., and J. C. Free. 1970. Minimal observations needed to determine dry-weight composition in herbivore diets by microscopic methods. Annu. Meeting Amer. Soc. Range Manage., February 9-12, Denver, Colorado.

Twenty-four samples were hand-compounded so they each contained known amounts of grasses and forbs. The plants included both live, dormant, and dead material. The foodplants used were those common in the diets of cattle and jackrabbits. The mixtures varied for species and amounts of species of plants and contained from two to five species each. We used 10 species of grasses or grasslikes and 15 species of forbs in the mixtures. Regression equations that express the relationship between estimated percentage of dry weight (X) and actual percentage of dry weight (Y) were developed for grasses, forbs, and grass-forb combinations. Percentage dry weights of each plant in the mixtures was determined.

Abstract No. 534.

Hansen, R. M., and D. N. Ueckert. 1970. Dietary similarity of some primary consumers. Ecology 51:640-648.

The dry-weight composition of the diets of Richardson ground squirrels (*Citellus richardsonii*), Mormon crickets (*Anabrus simplex*), and six species of grasshoppers (*Xanthippus corallipes*, *Circotettix rabula*, *Aeropedellus clavutus*, *Melanoplus infantalis*, *Melanoplus bruneri*, and *Melanoplus alpinus*), collected at Prairie Divide, Colorado, was determined. Many food plants were shared by these herbivores. Vetch (*Astragalus* spp.), sandwort (*Arenaria fendleri*), fungi parry oatgrass (*Danthonia parryi*), bluegrass (*Poa* spp.), fringed sagebrush (*Artemisia frigida*), dandelion (*Taraxacum officinale*), and sedge (*Carex* spp.) were major foods. Bluegrasses, vetch, and sandwort would probably become limiting if population peaks of several of these herbivores coincided. The ranking of the food niches of these herbivores from specialized to generalized based on mean indices of dietary similarities is *X. corallipes*, *A. clavatus*, *C. rabula*, *M. alpinus*, *A. simplex*, *M. bruneri*, *C. richardsonii*, and *M. infantalis*. Males ate fewer species of food plants than females of the same orthopteran species, and the diets of males and females of the same orthopteran species were occasionally less similar than were the overall diets of different species on the same date.

Abstract No. 535.

Hansen, R. M., D. G. Peden, and R. W. Rice. 1971. Leaf fragments in feces indicates diet overlap. U.S. IBP Grassland Biome Preprint No. 23. Colorado State Univ., Fort Collins. 16 p.

The occurrence of recognizable leaf fragments in the feces of livestock and wild animals has been used in scientific literature for reporting diets for over twenty years. Some researchers have fed leaf-eating herbivores mixed diets of leafy plants and have showed that useful quantitative botanical dietary information could be obtained by microscopic examination of the feces. As a general rule the relative discernibility of leaf fragments in the feces decreased as the plant's digestibility increased (Casebeer and Koss, 1970; Free et al., 1970; Grenet, 1966; Regal, 1960; Stewart, 1967). By using a polarizing microscope and new slide preparation techniques practically all the plant leaf fragments can be recognized (Storr, 1961, 1968; Williams, 1969), and the amount of digestion that has occurred can be estimated (Regal, 1960) from the thickness of the walls of cells from a sample of solid excreta.

The anatomic-histological analyses referenced here have not been evaluated for their usefulness in describing dietary overlap and potential estimates of dietary competition between similar herbivores feeding on common rangeland. The purpose of this paper is to describe the potential for measuring dietary overlap between herbivores from the frequency of leaf fragments that are microscopically discernible in fecal samples.

Abstract No. 536.

Hanson, C. L., A. R. Kuhlman, C. J. Erickson, and J. K. Lewis. 1970. Grazing effects on runoff and vegetation on western South Dakota rangeland. J. Range Manage. 23(6):418-420.

Four 2-acre watersheds were established in 1962 on each of three pastures that had been grazed at different intensities (heavy, moderate, and light) since 1942. These watersheds were located at the Cottonwood Range Field Station, Cottonwood, South Dakota. The mean seasonal runoff from May 14 through October 31 for 1963 through 1967 was 0.79, 0.56, and 0.42 inch for the heavily, moderately, and lightly used watersheds, respectively. The mean weight of live and dead standing crop of vegetation plus mulch in late July was 1,752, 2,092, and 3,700 lb./acre for the heavily, moderately, and lightly used watersheds, respectively.

Abstract No. 537.

Hanson, H. C. 1934. A comparison of methods of botanical analysis of the native prairie in western North Dakota. J. Agr. Res. 49(9):815-842.

The methods tested were area-list, count-list, weight-list, frequency-abundance, and the point method. A study was also made of various sizes and shapes of sample areas and plots. The use of sample areas located in plots was recommended in place of sample areas not in plots. The minimum desirable size was found to be 2 × 3 rods containing 24 sample areas, each sample area being 0.1 m^2. It is concluded that reliable quantitative results may be secured when listing is done on sample areas arranged in plots, both in sufficient numbers for systematic treatment. Valuable supplementary information will be furnished by use of the point and frequency-abundance methods since with them it is possible to cover large areas quickly. For extensive studies and where time and assistance are limited, the point and frequency-abundance methods, supplemented by permanent quadrats, are recommended.

Abstract No. 538.

Hanson, H. C. 1938. Ecology of the grassland. Bot. Rev. 4(2):51-82.

Methods and criteria in ecological study, especially of grassland, are discussed.

Abstract No. 539.

Hanson, H. C. 1950. Ecology of the grassland II. Bot. Rev. 16(6):283-360.

This review supplements that in Bot. Rev. 4:51-82, 1938. Restricted largely to plant community composition (floristics and structure) and methods of measurement, it has a bibliography of 304 citations.

Abstract No. 540.

Hanson, H. C. 1955. Characteristics of the *Stipa comata*, *Bouteloua gracilis*, *Bouteloua curtipendula* association of northern Colorado. Ecology 36(2): 269-280.

The purpose of this study is to characterize the *Stipa comata-Bouteloua gracilis-B. curtipendula* community on the basis of descriptions of stands occurring within a limited region. The chief analytical characteristics used are species composition, herbage cover, and the dispersal or frequency of individuals of each species. Attention was also given to stratification, periodicity, vitality, life-form, and height. The synthetic characteristics, constancy and presence, were also used. The data are summarized in an association table and were analyzed by means of the frequency classification, species number-area curves, and Sörensen's index of similarity. Data on soil characteristics, including texture, approximate lime content, pH, and color were secured.

Abstract No. 541.

Hanson, H. C., and L. D. Love. 1930. Comparison of methods of quadrating. Ecology 11:734-738.

Pantograph-chart, count-list, density-list, area-list (basal area), and weight-list methods of determining vegetative changes were studied. Results of each method differ. To determine proportion of each species, the weight-list method is best with temporary quadrats, but not practical with permanent quadrats. To determine changes from year to year for single stalked or even-sized clump species, combining pantograph-chart and count-list methods is most desirable. For mixtures, combining pantograph-chart and area-list methods is most desirable. In mixed prairie or irrigated pastures, area-list and count-list methods appear more accurate and faster than the pantograph-chart method.

Abstract No. 542.

Hanson, H. C., and L. D. Love. 1930. Size of list quadrat for use in determining the effects of different systems of grazing upon *Agropyron smithii* mixed prairie. J. Agr. Res. 41:549-560.

In order to determine the most suitable size of quadrat to use in studying differences in the abundance and frequency of species in adjacent pastures grazed by two different methods, data were secured on six sizes of quadrats, ranging from 0.25 to 4 m^2. Thirty quadrats, distributed fairly uniformly and at random, were used for each size of quadrat in each pasture.

The first three methods that were used to analyze the data indicated that the size of the quadrat should not be smaller than one or two square meters. Curves showing the total number of species found in the 30 quadrats for each size of quadrat showed a decided flattening at the 1 m^2 size. This continued in the 2 m^2 size. The graph, then, indicates that the size of the quadrat should not be smaller than 1 m^2, that 2 m^2 is somewhat better, but that the use of larger quadrats does not warrant the extra expense involved.

The second method of analyzing the data was to secure the ratios of the total number of stalks of plants in each size quadrat between the two pastures. Since the average of these six ratios was between those of the 1 and 2 m^2 sizes it indicates that, of the sizes used, either one of these would be satisfactory.

The third method was to secure weighted average ratios of relationship in frequency of each size of quadrat to the next larger size for both pastures. Since the averages were again between those of the 1 and 2 m^2 size it may be concluded that the quadrat should not comprise an area less than 1 m^2.

The fourth method, by which the data were analyzed according to Raunkiaer's law of frequency, failed to indicate any advantage in using any particular size of quadrat.

Because of the evidence secured by the first three methods and because the use of larger areas would not yield results commensurate with the additional expense, it appears that the most suitable size of quadrat to use in this type of vegetation is 2 square meters lying adjacent to each other.

Abstract No. 543.

Hanson, H. C., L. D. Love, and M. S. Morris. 1931. Effects of different systems of grazing by cattle upon a western wheat-grass type of range near Fort Collins, Colorado. Colorado Agr. Exp. Sta. Bull. 377. 82 p.

The purpose of this experiment was to determine the effects of two different systems of grazing, the continuous system and the deferred and rotation system, upon the range vegetation near Fort Collins, Colorado.

Abstract No. 544.

Hanson, H. C., and W. Whitman. 1937. Plant succession on solonetz soils in western North Dakota. Ecology 18:516-522.

Plant succession on bare areas resulting, according to the theory described by Kellogg, from salinization, solonization, and solodization on solonetz complexes in western North Dakota is described.

The invaders on these bare areas are weedy forbs and low shrubs.

The second stage in succession is characterized by grasses as *Agropyron*, *Puccinellia*, and *Poa buckleyana*.

The third stage is dominated by *Buchloe dactyloides*, which is followed by the climax in which *Bouteloua gracilis*, *Stipa comata*, *Koeleria cristata*, *Agropyron smithii*, and *Carex* spp. are the chief dominants.

The course of succession toward the climax may cease at any stage due to the reoccurrence of salinization. All parts of an active solonetz area show continuous repetitions of the cycle of salinization, solonization, solodization, erosion, invasion, aggregation, reaction, succession, and partial reconstruction of the soil.

During the course of plant succession from the bare area on the exposed B_2 horizon of the soloth toward the climax vegetation on normal soil the colloids change from the dispersed condition to flocculated, and the hard, columnar horizon becomes more or less prismatic and readily friable.

Abstract No. 545.

Hanson, H. C., and W. Whitman. 1938. Characteristics of major grassland types in western North Dakota. Ecol. Monogr. 8:57-114.

The grasslands of the Little Missouri region of North Dakota were studied on 36 areas, in 1935, and classified into 9 types according to dominant species: *Bouteloua gracilis-Agropyron smithii-Carex* spp.; *A. smithii-B. gracilis-Carex* spp.; *Andropogon scoparius*; *Calamovilfa longifolia*; *Artemisia cana*; *Distichlis stricta-Agropyron smithii*; *D. stricta-Puccinellia nuttalliana*; *Buchloe dactyloides*; and *Andropogon furcatus*. Analyses were made by the frequency-abundance and point methods, soil profiles described, and soil samples analyzed chemically and physically. The vegetative types differed in botanical composition, in depth and character of soil profile, and in chemical and colloidal content of soils. There were definite relationships between soil and vegetation heterogeneity of the types. Topographic position as well as textural soil differences were responsible for the different types. Duration of available soil water, depth of water table, concentration of salts, and successional stages were all important factors in determining the types. The *Bouteloua gracilis-Agropyron smithii-Carex* spp. type seemed to have reached the highest degree of stabilization in relation to climate, and its soil most nearly approached the typical profile of the dark brown soils. The *Andropogon furcatus* type appeared to depend upon moisture in addition to that received by precipitation.

Abstract No. 546.

Harlan, J. R. 1956. Theory and dynamics of grassland agriculture. D. Van Nostrand Company, Inc., Princeton, New Jersey. 281 p.

Grassland agriculture is a system of agriculture in which a major emphasis is placed on grasses, legumes, and other fodder or soil-building crops. The system may be extensive, as in many natural grassland or desert shrub areas, or it may be extremely intensive. The sod crops may be permanent or simply part of a rotation. The principal feature of grassland agriculture is the dependence of the system on grass crops for soil building and animal nutrition.

Grassland agriculture is, therefore, a dynamic system in which the soil, the plant, and the animal are intimately and inseparably interlocked. The purpose of this book is to consider the integral system from all three points of view--soil, plant, and animal--and to elaborate the principles involved. Little attention shall be given to practice which varies so widely from place to place, from site to site, and from one economic and social condition to another. Such considerations as seeding rates, fertilizer applications, and grazing systems, will be encountered here only insofar as they illsutrate or are derived from more basic principles. This book is devoted to the basic theory and dynamics from which practical application may be derived. It is intended primarily to assist in instruction at the level of a second course in forage crops or an advanced course in pasture and range management, and to meet the needs of the practical farmer or extension man interested in this increasingly important subject.

Abstract No. 547.

Harlan, J. R. 1960. Native range: Production characteristics of Oklahoma forages. Oklahoma Agr. Exp. Sta. Bull. B-547. 34 p.

Despite the volume of work completed and published, no attempt has been made to characterize native range as a forage in any definitive way.

The native ranges of Oklahoma are characterized by a rich grassland flora. While there are many problems concerned with floristics, population dynamics, and general ecology which have not been studied, the gross characteristics of production are reasonably well understood. We know about how much forage is produced on the average and how much this production varies from year to year and site to site and from one management treatment to another. We know what kind of forage is produced in terms of nutritive value and convertibility into beef or dairy products. We know the principles of management required for sustained yields and the most important factors limiting production. These gross production characteristics are described in this bulletin.

Abstract No. 548.

Harrington, H. D. 1954. Manual of the plants of Colorado. Sage Books, Denver, Colorado. 666 p.

The primary purpose of this book is to provide a means of identifying the plants of Colorado. In order to attain this objective within the limits of reasonable size some important taxonomic information of interest to the professional botanist had to be omitted, such as a more complete list of synonyms and the exact citation of widely distributed specimens. The main foundation for the work was the plant collections in the general Colorado area, but many plants were borrowed from more distant herbaria. Colorado has been reasonably well botanized, at least for a western state, but certain sections have been neglected. Most of the specimens encountered in this study were collected in the vicinity of colleges and universities, or along railroads and highways. In general the plants of the mountainous areas of the state are better represented in herbaria than those from the eastern plains.

Abstract No. 549.

Harris, J. O. 1971. Microbiological studies at the Osage Site 1970. U.S. IBP Grassland Biome Tech. Rep. No. 102. Colorado State Univ., Fort Collins. 39 p.

A review is given of the 1970 microbiological investigations at the Osage Site. Data is presented covering microbial biomass measurements by the plate count and direct microscopic measurement of bacteria, actinomycetes, and fungi decomposition rates of buried filter paper and standard litter samples, and respiratory activity by carbon dioxide release and oxygen uptake measurements.

Abstract No. 550.

Harris, L. D. 1971. Small mammal studies and results in the grassland biome, p. 213-240. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Three types of information are conveyed: (i) an outline of the Grassland Biome small mammal studies, (ii) exemplary results from each of the subprojects, and (iii) summary analyses and observations drawn from the entire data bank. Significant differences in rodent catches are reported for different grazing treatments, soil types, and water stress treatments, but density estimates, home range, and areas-of-occupation charts reflect no such responses for jackrabbits on the intensive site in northeastern Colorado. Bimonthly dietary analyses of six small mammal species reflect a high degree of overlap between the herbivores, but strong niche segregation in general.

Live trap and snap trap grid surveys of the small mammal communities at nine sites in the Grassland Biome reveal a maximum biomass of about 2.1 kg/ha (live/weight) on a desert site to a low of 0.4 kg/ha on the northern shortgrass plains. It is tentatively concluded that the Jolly estimator is most accurate for live trap censuses. Excluding the two desert grasslands, there appears to be a direct relationship between the average summer rodent biomass and mean annual precipitation; with each centimeter increase in precipitation there is a 16 g increase in rodent biomass. Although the average number of species caught seems to be inversely related to latitude and altitude this does not hold for indices of diversity such as H'. Certain rodent communities appear to be distinctly "dominance" communities while the southern shortgrass community seems quite diverse. The dominance attribute seems to be related to vegetation diversity and rodent productivity. Similarity indices reveal that the montane and desert rodent communities do not strongly resemble the Great Plains communities. While heteromyids were found to predominate in the two desert environments, grass and geomyids in the montane situations, there is a dramatic shift from carnivores constituting only 5% of the total biomass in the tallgrass to over 55% in the southern shortgrass. A simple equation for predicting energy transfer is developed, and it is concluded that an average of 1.7% of the aboveground net primary production is consumed by the Grassland Biome rodents.

Abstract No. 551.

Harris, L. D. 1971. Structural relationships of a semi-arid East African herbivore community. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

From late 1964 through mid-1967 extensive large herbivore studies were conducted as part of an ecosystem analysis in the semiarid Mkomazi Game Reserve of northern Tanzania. Vegetation was categorized into four major types and the herbivore species diversity reflected a direct relationship with accessible net primary production. Tallgrass savanna supported the greatest diversity (H' = 1.68) while the montane community supported the lowest (H' = 0.74). Both areal and temporal patterning within the large herbivore array is a major attribute of the animal community. Although 22 species of large herbivores inhabit the reserve, a maximum of 12 and a median of four species ($\bar{x}$ = 4.26) were recorded in local areas at any one time. Rhinoceros (*Diceros bicornis*) reflected the greatest niche breadth on the habitat dimension (B' = 3.42) with eland (*Taurotragus oryx*), warthog (*Phacochoerus aethiopicus*), giraffe (*Giraffa camelopardalis*) and elephant (*Loxodonta africana*) next in order. Eland, gerenuk (*Litocranius walleri*), reedbuck (*Redunca redunca*), and giraffe had the greatest niche breadths on the time dimension. Niche overlap (on the habitat dimension) was greatest between hartebeest (*Alcelaphus buselaphus*) and impala (*Aepyceros melampus*) (0.86) while that of bushbuck and other species was as low as 0.04.

Abstract No. 552.

Harris, L. D. 1972. An ecological description of a semi-arid East African ecosystem. Range Sci. Dep. Sci. Ser. No. 11. Colorado State Univ., Fort Collins. 80 p.

From late 1964 through mid-1967 climatological, soils, vegetation, and animal studies were conducted in the semiarid Mkomazi Game Reserve of northeastern Tanzania. An elevational gradient from 230 m in the east to mountain tops of nearly 1600 m above sea level in the northwest underlaid similar rainfall and temperature gradients. Aridity coefficients, based on the different temperature and rainfall conditions alone, were about 50% greater in the central section of the reserve than in the higher elevation northwest.

The soils were classified by the American 7th Approximation to a Comprehensive Classification System and were found to consist of about 75% camborthids (aridisols), 20% pellusterts (vertisols), and 5% miscellaneous types. Soil texture, organic matter content, permeability, and profile depth, all reflected a gradient of conditions from west to east.

The vegetation was categorized into four major types: (i) dry montane forest, (ii) bushed and wooded grassland, (iii) seasonally inundated grassland, and (iv) bushland. Grass-forb aboveground standing crop values ranged from approximately 600 g/m^2 in the 500 mm rainfall regions of the bushed and wooded grassland to about 200 g/m^2 in the 350 mm rainfall regimes of the central-section bushland. Minimal estimates of aboveground net primary production varied from about 400 g/m^2/year on previously unclipped plots in the northwest to about 170 g/m^2/year in the east central section, while denuded plot productivities were about 300 and 150 g/m^2/year, respectively. Differences in forage-density and ground-cover indices reflected generally poorer rangeland conditions in the central and eastern sections of the reserve.

While the mean annual large herbivore density ranged from 12 animals/km^2 (5,548 kg/km^2) in the northwest to about 0.5 km^2 (700 kg) in the central and eastern sections, the dry season densities ranged from 23.7 animals/km^2 (12,705 kg/km^2) to much less than 1 animal/km^2 in the eastern sections. Seasonal herbivore biomass distribution patterns reflected a large wet season ingress of elephants (*Loxodonta africana*), zebra (*Equus burchellii*), oryx (*Oryx beisa*), and Grant's gazelle (*Gazella granti*) from adjacent Kenya as well as an eastward movement of herbivores from the dry season water source in the northwest. The east-west herbivore density gradient was nearly extinguished during the wet seasons.

Both spatial and temporal patterning within the large herbivore array is a major attribute of the animal community structure. Although 22 species of large indigenous herbivores inhabit the reserve, these are partially segregated by their affinities for the different vegetation types. A maximum of 12 and a median number of four species ($\overline{x}$ = 4.26) were recorded in local areas at any one time. Rhinoceros (*Diceros bicornis*) were most equitably distributed among the four major vegetation types (niche breadth index = 3.42) with eland (*Taurotragus oryx*), warthog (*Phacochoerus aethiopicus*), giraffe (*Giraffa camelopardalis*), and elephant next in order. Bushbuck (*Tragelaphus scriptus*), duiker (*Sylvicapra grimmia*), and buffalo (*Syncerus caffer*) were the least equitably distributed. Eland, gerenuk (*Litocranius walleri*), reedbuck (*Redunca redunca*), and giraffe were most equitably distributed through time. Herbivore species diversity was greatest in the bushed and wooded grassland and lower in the open grassland, bushland, and dry montane communities.

The niche overlap (on the habitat dimension) of hartebeest (*Alcelaphus buselaphus*), impala (*Aepyceros melampus*), and ostrich (*Struthio camelus*) was great (>0.8, limit = 1.0) while that of bushbuck, klipspringer (*Oreotragus oreotragus*), and duiker with most other species was slight (as low as 0.04, limit = 0.00). Of the carnivores, jackals (*Canis adustus*) reflected the greatest time and space overlap with the herbivores, while hunting dogs (*Lycaon pictus*) reflected the least.

From an ecosystem point of view, three of four species were found to dominate the structure (numbers and biomass) as well as at least one measure of community function, i.e., energy exchange. About 17.5% of the aboveground primary production (in terms of biomass) was estimated to be channelled through the large herbivore-carnivore pathway. The independent effects of elephants, cattle (*Bos indicus*), and fire on the vegetation are illustrated as are the combined effects of elephants, cattle, herbivores, and fire.

Abstract No. 553.

Harris, L. D., and G. L. Swartzman. 1971. A preliminary model for consumer predation. U.S. IBP Grassland Biome Tech. Rep. No. 119. Colorado State Univ., Fort Collins. 27 p.

In this paper a generalized multi-species consumer predation model is developed. Predation is seen as a function of kill rate, predator preference, and prey numbers. Consideration is made in the model for predator abundance, predator switching to different prey, prey abundance, and cover conditions. Kill rate also includes information about relative predator and prey advantages. The model is compared with previous models, and some of the matrices are derived from Pawnee Site data to relate the model to a specific example.

Abstract No. 554.

Harvery, L. H. 1908. Floral succession in the prairie-grass formation of southeastern South Dakota. Bot. Gaz. 46(2):81-108.

The western part of Iowa, the eastern and northeastern counties of Nebraska, and southeastern South Dakota lie in the drainage basin of the Missouri. This tri-state area is well within the prairie region of that vast and far-reaching prairie province of the middle west. This area is only a part of the Ponca District, being more strictly Dakotan than Nebraskan, and may be considered as representing a transition between the more mesophytic eastern areas of Iowa and those dominantly xerophytic somewhat to the west, with which it shows the closer floristic agreement. Its composition is thus twofold, pointing to the primitive and more xerophytic stages of the past and at the same time prophetic of the mesophytic stages to come. This aberrant character links it strongly to the xerophytic prairie to the west and southwest, from which it is genetically descended, and the prophetic character links it to the more mesophytic prairie of western Iowa, which has encroached ever westward. Under this migration tension from the southeast and east the primitive prairie has retreated, civilization always being a potent factor in this succession.

Abstract No. 555.

Harvey, A. D. 1936. Rootsprouts as a means of vegetative reproduction in *Opuntia polyacantha*. J. Amer. Soc. Agron. 28:767-768.

The habit of reproduction of *Opuntia polyacantha* Haw. by rootsprouts first came to the attention of the writer while engaged in work of cactus eradication for pasture improvement on the ranges of eastern Colorado. The first plants examined were found in a pasture located 5 miles east of Ellicott, Colorado. Since then, several other specimens have been examined from other localities around Colorado Springs, Colorado.

The heavy invasion of *O. polyacantha* on range pastures of eastern Colorado, where it often forms as high as 40% of the vegetative cover, is greatly accelerated by the rootsprout method of reproduction. The root systems of the plants examined disclosed two definite types of roots, *viz.* (1) a comparatively small type of lateral root which is rather succulent and with numerous ramifications, and (2) a larger type of main lateral which is of a woody nature and not so extensively ramified. The main laterals are coarse in appearance and are covered with a papery surface which flakes off readily.

The main laterals which separate from the parent plant run to varied lengths close to the surface of the ground. Occasional sublaterals are produced which are also capable of plant development. The longest main lateral recorded extended to a distance of 1.6 m and had three plant-bearing sublaterals of lengths ranging from 2.5 to 5 dm or more. One sublateral had an additional subdivision bearing a new plant.

From the main laterals and its subdivisions young plants are borne which show the initial development from minute areolae with a compact cluster of fine glochids. There is apparently no definite location for these new outgrowths, some main laterals having as many as 10 new plants within a root length of a few decimeters.

Abstract No. 556.

Hase, C. L. 1941. The effects of clipping and weed competition upon the spread of pasture grass seedlings. Kansas Acad. Sci., Trans., 44:104-115.

1. Clipping and weed competition were very detrimental to all the grasses used.

2. Clipping aided the spread of buffalo grass.

3. The yield was the greatest on the unclipped quadrats.

4. Clipping killed nearly half the tillers in the blue grama and side-oats grama.

5. The root systems of all grasses used were reduced somewhat by clipping.

6. The root systems were greatly reduced by clipping plus weed competition.

Abstract No. 557.

Haskell, H. S., and H. G. Reynolds. 1947. Growth, developmental food requirements, and breeding activity of the California jackrabbit. J. Mammal. 28(2):129-136.

Data on the growth, development, breeding, and food requirements of a number of California jackrabbits raised in captivity are presented.

The ear and hind foot of these animals reached maturity at 15 weeks, weight at 32 weeks, and total length at 28 weeks.

Ear length was the only measurement which differed perceptibly between sexes: It was greater in males.

Forage consumption showed a curvilinear relationship to age from 3 to 28 weeks, after which an average constant amount equivalent to 0.27 lb. of air-dry native forage was consumed.

Females born early in one breeding season, although maturing before the end of the breeding season, did not produce young until the following year.

The average gestation period in captivity was 43 (41 to 47) days.

Active breeding apparently occurs throughout normal life, since some captive animals were still actively breeding when released at an age of seven years.

The maximum breeding potential for these rabbits was calculated to average 13 to 14 young per female per year.

Abstract No. 558.

Hatch, M. D., and C. R. Slack. 1970. Photosynthetic CO_2-fixation pathways. Annu. Rev. Plant Physiol. 21:141-162.

The view has long been held that the Calvin cycle operates ubiquitously in higher plants, algae, and probably photoautotrophic bacteria, but there is now evidence for alternative pathways in some plants and bacteria. In the present article, particular emphasis will be placed upon the alternative process in higher plants, but some aspects of current interest concerning the operation of the Calvin cycle will also be considered. Topics relating to photosynthetic CO_2-fixation that are treated in detail in other chapters of this volume have been either excluded or dealt with only briefly. There have been several recent reviews, books, and symposia dealing with aspects of photosynthetic CO_2-fixation.

Abstract No. 559.

Hathaway, I. L., H. P. Davisand, and F. D. Keim. 1945. Carotene content of native Nebraska grasses. Nebraska Agr. Exp. Sta. Res. Bull. 140:1-15.

The carotene content of 24 grasses native to Nebraska were determined at approximately monthly intervals from June to November. While the carotene concentration of most of the grasses was moderately high during the growing season, it declined to a rather low point by late November.

With the exception of switchgrass, hairy grama, little bluestem, and prairie dropseed, all of the grasses contained enough carotene to supply the needs of range cattle until late November. However, only 18 of the grasses still contained enough carotene by the latter part of September to furnish the carotene required by dairy cows. Even as early as July the northern reedgrass, buffalo grass, bluejoint, and lovegrass were unsatisfactory as a source of carotene for dairy cows. While the carotene values observed during the periods of greatest concentration varied from 511.6 ppm (sandhill bluestem) to 122.6 ppm (northern reedgrass), these values ranged from 60.7 ppm (June grass) to 1.6 ppm (little bluestem) during the periods of lowest concentration.

Abstract No. 560.

Haug, P. T. 1969. The International Biological Program--The grassland ecosystem analysis. J. Colorado-Wyoming Acad. Sci. 6:4-5. (Abstr.). 45 Annu. Meeting, Southwestern and Rocky Mountain Div., Amer. Ass. Advance. Sci. and the 40th Annu. Meeting, Colorado-Wyoming Acad. Sci., May 7-10, Colorado Springs.

The International Biological Program (IBP) began in 1966 under the aegis of the International Council of Scientific Unions (ICSU). It is sponsored in the United Stated by the National Academy of Sciences. More than 70 countries are currently participating. The overall purpose of the IBP is to examine the biological basis of productivity in human welfare. Major objectives include worldwide studies of: (1) organic production on the land, in fresh waters, and in the seas, so that adequate estimates may be made of the potential yield of new, as well as existing, natural resources, and (2) human adaptability to the changing conditions. One of the major IBP subprograms in the U.S. is the analysis of ecosystems, of which the Grassland Biome study is an important part. Scientists from various academic institutions and federal agencies began work on the grassland last June at the Pawnee Site northeast of Nunn, Colorado. Other aspects of the study include an information synthesis project and a comprehensive network of sites throughout the Great Plains. Information from the entire network will be channeled to a central data bank, where it will be analyzed, shared, and compared with information from other biomes and made available to researchers on similar projects throughout the world. Data will be used to build mathematical models of grassland ecosystems to describe such functions as nutrient cycling, energy flow, and man's manipulations: cultivation, irrigation, fertilization, and grazing.

The comprehensive program was begun last fall, and currently investigators are preparing for their first field season. Sites are located in North Dakota, South Dakota, Kansas, Oklahoma, Texas, Montana, New Mexico, California, and Washington. At each location, measurements comparable to some of those being taken at the Pawnee Site will be made, but the intensity and variety of research at the Pawnee Site will not be duplicated. Sites are located in different types of grasslands to compare data and make valid generalizations about grasslands. Investigators at each network site will concentrate on a few of the essentials that are also being studied at the intensive site. Still other research in the comprehensive program will involve roving teams of investigators gathering comparable data on certain processes from the several locations.

At the biome office, a central data storage and retrieval bank is available for the use of anyone within the program and other scientists as well. Data exchange and comparison is one of the fundamental concepts of the program. In addition, programmers, data analysts, and mathematical modellers are available for consultation with any investigator. Besides consulting, they work closely with field investigators in building and testing the submodels of various compartments of the ecosystem and incorporating them into an overall model to describe the essential processes and dynamics of the grassland biome.

This, then, is a broad and bold departure from conventional ecology. Man's rapidly growing ability to alter the face of the earth has outstripped his understanding of the biological basis of productivity. Hopefully, the approaches being explored in the grassland biome study not only will lead to better understanding, but also will contribute to a new era of integrated ecology.

Abstract No. 561.

Haug, P. T. 1970. Analysis of the American Grassland Biome: An overview of an integrated research program. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

The International Biological Program was conceived several years ago, partly because of a tremendous need for coordinated international cooperation in biology and partly as a biological successor to the International Geophysical Year. The overall purpose of the IBP is to examine "the biological basis of productivity and human welfare." Among the several major integrated research programs that constitute the United States' contribution is an Analysis of Ecosystems program. One of the ecosystems being studied is the grassland.

The integrated research on the grassland biome is divided into two phases: an intensive study located at the Pawnee Site near Nunn, Colorado, and a comprehensive study, which comprises a network of sites and a number of different process studies.

Work on the Pawnee Site began in the summer of 1968. Pilot studies were begun, major study areas and construction sites were laid out, and species lists were compiled. More than 30 scientists primarily from institutions and agencies in Colorado and Wyoming are participating. They range from engineers to entomologists, and areas of study include small mammals, large mammals, climate, soil water relationships, insects, amphibians, birds, plant patterns, photosynthesis, herbage dynamics, fungi, and bacteria.

Abstract No. 562.

Haug, P. T. 1970. Succession on old fields--A review. M.S. Thesis. Colorado State Univ., Fort Collins. 473 p. (Advisor: George Van Dyne).

Much of the ecological literature on secondary succession in abandoned croplands written in this century is reviewed, reorganized, and synthesized in this thesis. Methods, organization, and some definitions are discussed in Chapter I. Chapter II reviews successional theory from a historical perspective. The more popular concept of succession viewed as discrete stages is discussed as the orthodox view, which is then criticized by various authors. Some other views of succession are then presented, including the concepts of initial floristic composition and vegetational continuum.

Chapter III discusses the abiotic influences in oldfield succession. Some of these include the duration and intensity of cultivation, the season of cultivation and crop type, fertilization practices, and the effects of cultivation on soil. The effects of climate are discussed as precipitation, temperature, humidity, wind, evaporation, and light. Geography and topography affect succession as general regional location, uplands and lowlands, and slope and aspect. The following characteristics of soil influence the succession, also: depth, texture, structure, erosion, moisture, temperature, pH, and organic matter and nutrient content. Fire is also considered.

Plant characteristics and vegetational stages are discussed in Chapter IV. Adaptive mechanisms that affect plant succession include seed production and dissemination, germination, and growth habits, nutrient cycling, vegetative reproduction, root habits, and crowding and growth forms. Plants influence the course of succession through competition and other plant-plant relationships, allelopathy, certain effects on animals, and effects on the abiotic environment. A total of six stages that occur throughout succession are discussed individually within the grassland and deciduous forest biomes.

Consumer succession is described in Chapter V. Adaptations and requirements are briefly discussed, and the consumer influences of competition, predation and parasitism, effects on plants, and effects on the abiotic environment are reviewed. Animal succession is also examined in relation to plants.

Chapter VI discusses the sere as a system and suggests ideas for updating the study of succession by using a systems approach. Stress is laid on quantification of techniques and analysis in order to obtain predictive models to understand ecological phenomena better.

Abstract No. 563.

Haug, P. T., G. M. Van Dyne, and R. M. Hansen [ed.]. 1969. Dietary competition among herbivores--papers from a joint graduate seminar between wildlife biology and range science. Fall Quarter, 1968, Colorado State Univ., Fort Collins. 121 p.

This set of 18 papers from a joint graduate seminar between the Department of Fishery and Wildlife Biology and the Department of Range Science at Colorado State University explores various competitive dietary situations among certain herbivores. The following species are discussed: sage grouse/mule deer; white-tailed deer/cattle, sheep, goat; black-tailed jackrabbit/white-tailed jackrabbit; cattle/meadow mice; moose/caribou; elk/bighorn sheep; jackrabbit/cottontail; mule deer/ meadow mice; sage grouse/domestic sheep; moose/snowshoe hare; feral burrow/desert bighorn sheep; deer/elk; muskrat/nutria. Most of the papers are literature reviews.

Abstract No. 564.

Haupt, H. F. 1967. Infiltration, overland flow, and soil movement on frozen and snow-covered plots. Water Resources Res. 3(1):145-161.

This small plot study shows how ground cover, furrowing, and the presence of frost in soils of the Sierra Nevada affect infiltration from prolonged simulated winter rains. A rapidly melting snowpack over soil containing dense frost may accelerate on-site runoff. The presence of stalactite soil frost promotes rapid absorption of snowmelt and reduces overland flow. Conversely, porous concrete frost usually reduces infiltration capacity and increases overland flow on burned or sparsely vegetated sites but does not impair infiltration where plant and litter cover are appreciable. Snow cover, by cooling rain water, tends to preserve soil frost and keep it visibly intact. Snow absorbs raindrop energy much as dense vegetation does. Soil losses from snow-covered plots, regardless of vegetative cover, are practically nil. Generally, plants, litter, and snow cover dissipate raindrop energy and increase infiltration, but exposed rock usually accelerates overland flow and erosion. Shallow contour furrowing seemed to facilitate infiltration and controlled overland flow adequately.

Abstract No. 565.

Heady, H. F. 1950. Studies on bluebunch wheatgrass in Montana and height-weight relationships of certain range grasses. Ecol. Monogr. 20(1):55-81.

During 1946 and 1947, 1,110 plants in five species of grass from central Montana were processed to determine the nature of variations in height-weight. At the same time an attempt was made to determine the causes of the variations in bluebunch wheatgrass. The term height-weight is used to express the proportion of the total air-dry weight of a grass plant in successive 1-inch segments from the base to the top. When samples of 30 plants from one site and 1 year were compared with height class tables constructed from all plants processed, variations in percent of weight below stubble heights of 2 to 6 inches were less than 10%. The variations were not consistent with average height of plants, average weight, environmental conditions in the habitats, elevation, or comparability of species in the stand. However, clipping of bluebunch wheatgrass did result in considerable differences in the height-weight relationships. The height-weight method is used to determine utilization of grasses by livestock, and under the conditions of the experiment it was shown to be reasonably accurate for that purpose.

Abstract No. 566.

Heady, H. F. 1952. Reseeding, fertilizing, and renovating in an ungrazed mixed prairie. J. Range Manage. 5:144-149.

In the western states studies of relict areas have yielded much information necessary in the management of range vegetation. Such an area of approximately 20 acres is present on the North Montana Branch of the Montana Agricultural Experiment Station near Havre, Montana.

Annual rainfall averages 13.07 inches per year. The temperature range is extreme with a July average of 68.3°F and January average of 12.9°. The topography is rolling. The soil is a dark grayish brown sandy loam in the upper 10 to 15 inches, below which is glacial till of which the upper 8 to 13 inches has a high concentration of lime. The area was examined closely in the summer of 1947 to check three items: (1) the composition of vegetation after 32 years of protection; (2) a reseeding experiment started in 1936; and (3) a renovation and fertilization trial started in 1925.

Abstract No. 567.

Heady, H. F. 1970. Comprehensive Network Site description, HOPLAND. U.S. IBP Grassland Biome Tech. Rep. No. 42. Colorado State Univ., Fort Collins. 11 p.

The Hopland Site is located on the Hopland Field Station, a unit of the California Agricultural Experiment Station. The station is owned by the University of California and is operated by the experiment station for range research. The field station is in the Russian River drainage some 3 miles east of Hopland, California, which is on U.S. Highway 101 about 100 miles north of San Francisco. The station is approximately 4,750 acres in size and roughly rectangular in shape. It has been grazed by sheep for many decades, although some 400 acres have been livestock-free for more than 10 years. A wide variety of livestock grazing trials and rangeland manipulations (brush control, seeding, and fertilization, etc.) have been applied in various pastures. The nature of immediate results has been recorded for most practices.

Abstract No. 568.

Heady, H. F., and G. M. Van Dyne. 1965. Prediction of weight composition from point samples on clipped herbage. J. Range Manage. 18:144-148.

Percentage botanical composition by weight can be estimated from composition determined with the laboratory point method, if differences among species, seasons of growth, and botanical composition are taken into account.

Abstract No. 569.

Heerwagen, A. 1956. Mixed prairie in New Mexico, p. 284-300. *In* Grasslands of the Great Plains. Johnsen Publ. Co., Lincoln, Nebraska.

The mixed-prairie association occupies an estimated 35 to 40% of the total land area of New Mexico. It occurs principally on comparatively level to rolling dissected plains, plateaus, and broad river valleys at elevations ranging from approximately 4,500 to 7,000 ft.

The major portion of this extensive grassland is located in the eastern half of the state, lying generally to the east of the Sangre de Cristo Mountains in the lower Canadian River Valley and to the east of the Mescalero Escarpment of the Pecos River Valley. Another extensive portion of this grassland extends along the base of the foothills of the eastern front of the Sacramento Mountains, northward and westward across the plains and plateaus of the central portion of the state between the Pecos and Rio Grande River Valleys. This includes the Estancia Valley, lying immediately east of the Sandia and Manzano Mountains.

The major concentration of mixed-prairie in the western portion of the state is located in the northwestern corner of the San Juan drainage. However, there are interrupted areas of this plant association found on the high plains, mid-elevation plateaus, and river valleys in the west central portion of the state to the north of the Gila River drainage extending to the Arizona state line. The largest single area of mixed-prairie in this portion of the state occurs on the St. Augustine Plains which extend generally westward from Magdalena, New Mexico.

These grasslands provide year-long grazing principally for cattle and to a lesser degree for sheep. Portions of this area, particularly those adjacent to the major river valleys, have been subject to grazing use by domestic livestock since the time of the early Spanish settlements. Because of the prevailing semiarid climate, a comparatively small percentage of these grasslands has ever been subjected to cultivation.

At the present time dry farming operations are concentrated principally in the extreme eastern portion of the state and to a limited acreage in the Estancia Valley. Only a very small acreage of mixed-prairie has been developed for irrigated farming operations.

Abstract No. 570.

Heinrichs, D. H., and K. W. Clark. 1961. Clipping frequency and fertilizer effects on productivity and longevity of five grasses. Canadian J. Plant Sci. 41:97-108.

Agropyron cristatum, *Agropyron intermedium*, *Agropyron riparium*, *Elymus junceus*, and *Stipa viridula* were studied in relation to clipping effects on productivity and longevity. All species, except *Elymus junceus*, produced progressively less as the number of clippings increased. *Agropyron intermedium* yielded the most forage, especially when harvested only once per season, followed closely by *Agropyron cristatum*. Crude protein yield was less variable under various frequencies of clipping than forage yield, and differences between species were also smaller. *Elymus junceus* and *Agropyron cristatum* displayed the strongest competitive ability, especially under frequent clipping and *Stipa viridula* the lowest. The amount of root produced varied significantly between species. *Agropyron cristatum* and *Elymus junceus* produced the most root and *Stipa viridula* the least. Fertilizer applied in the fourth and fifth crop years increased the yield by 30 to 200%. It was concluded that *Agropyron cristatum* and *Elymus junceus* were about equally persistent under frequent clipping and should be more useful long-term pasture grasses than the other three in dry cold climates.

Abstract No. 571.

Heitschmidt, R. K., G. K. Hulett, and G. W. Tomanek. 1970. Vegetational map and community structure of community structure of a west central Kansas prairie. Southwestern Natur. 14(3):337-350.

The purpose of this study was to delineate vegetational communities cartographically within a 176 acre prairie in Trego County, Kansas. The communities were characterized as to vegetational structure, underlying soils, and topographic position. An attempt was also made to discern causal factors influencing species distribution.

Seven communities were recognized and mapped onto an aerial photograph. The communities identified were: *Buchloe-Bouteloua*, *Buchloe-Bouteloua-Agropyron*, *Bouteloua*, *Boutelŏua-Andropogon*, *Andropogon gerardi*, *Andropogon scoparius*, and *Kochia*.

The communities were found to be primarily the result of a moisture gradient established through the combined effects of topography and soils. Degrees of success varied for all species throughout the moisture gradient; thus, species with similar tolerance were aggregated into communities.

Abstract No. 572.

Helm, V., and T. W. Box. 1970. Vegetation and soils of two southern high plains range sites. J. Range Manage. 23(6):447-450.

Soil and vegetational properties associated with a high lime and a mixed plains site on the Texas High Plains were analyzed. Density of grass cover was similar on both sites, but the high lime site supported a higher percentage of climax grasses. Mesquite trees were dense on the mixed plains site, but virtually absent from the high lime site. The high lime site was characterized by a grayish, strongly alkaline soil high in clay content and low in bulk density; the mixed plains site had a brownish, moderately alkaline soil high in sand content and high in bulk density. Phosphorus, sodium, pH, and organic matter were higher in the high lime soils.

Abstract No. 573.

Hendricks, B. J. 1970. Style and format of technical reports. U.S. IBP Grassland Biome Tech. Rep. No. 56. Colorado State Univ., Fort Collins. 42 p.

This technical report covers the style and format desired for IBP technical reports. All technical reports submitted to the IBP Grassland Biome project should be in this form before being submitted for final typing. This will help provide cleaner copies and faster service.

Abstract No. 574.

Hendrickson, B. H. 1934. The choking of pore-space in the soil and its relation to runoff and erosion. Amer. Geophys. Union, Trans., 14(2):500-505.

The identification and evaluation of all factors influencing runoff and erosion on the erosive lands of the nation are manifestly studies of the most fundamental importance, especially insofar as they may be made to yield definite information upon methods of control over this insidious tendency upon cultivated lands.

Investigations in progress at our Soil Erosion Experiment Stations have rather clearly shown that we may divide the factors that are mainly responsible for preventing or provoking erosion into two broad categories, namely: (1) the protective effects of dense covers of vegetation of one kind or another, and (2) the almost certain destruction that follows the exposure of cultivated slopes to natural conditions of rainfall.

Since erosion is a natural consequence of runoff, the first logical question that might be asked is why runoff occurs under given conditions of slope and surface-exposure. The simplest answer is, of course, because the rate of rainfall exceeds the rate of infiltration or penetration of water into the soil. The capacity of a soil for taking up water and the rate at which it can do it thus become important factors for consideration along with the physical laws governing these tendencies.

When falling raindrops strike soil-surfaces which are unprotected by a littered forest-floor or by dense covers of vegetation, as grass, the water tends immediately to become muddied by fine material thrown forcibly into suspension. Such fine soil-material in suspension tends to clog the pores of the soil and thus appreciably increases runoff. In order to investigate this point some simple, preliminary experiments were carried out. These studies are referred to, and the results summarized briefly.

Abstract No. 575.

Henry, A. J. 1931. The calendar year as a time unit in drought statistics. Montana Weather Rev. 59: 150-154.

As almost everyone knows, the year is generally considered as being too long a unit for use in compiling drought statistics. While admitting the general soundness of that view, it is believed that the disadvantages of the calendar year have been somewhat exaggerated.

The reason why a shorter period than the year has not heretofore been used in compiling drought statistics is most likely because of the overlapping of drought periods from one month to the next and the fact that its ending rarely occurs at the end of a month; thus it would be necessary to make a special compilation in order to fix the definite limits of the duration of droughts. This has not been done, and to do it now for previous droughts is prohibitive on account of the labor involved.

The object of the present compilation was therefore to ascertain to what extent the calendar-year record of precipitation would serve to accurately fix the times and places of drought in the United States. In the beginning of the study the individual records of stations within a state using both the monthly and annual amounts were used. As the work progressed the difficulties of distinguishing the beginning and the ending of drought even from the monthly totals of precipitation led to its abandonment and the substitution of a shorter method based on the averages of precipitation for each year for each of the 42 districts organized into what were formerly known as state weather services, now known as climatological sections, of which as a rule there is one in operation for each state or combination of states.

The plan followed was to take out for each state the least annual precipitation that had been recorded during the forty-odd years during the life of the record, then the next lowest annual amount, and so on, on an ascending scale until the tenth year on that scale had been reached. Thus, it has been practicable to construct for each state a diagram beginning at the low point and increasing to, say, about 90% of the annual average precipitation. In like manner the year of greatest annual precipitation has been taken out and the nine subsequent years when the next greatest annual amount was received, and so on until the tenth year, on a decreasing scale, had been reached.

Abstract No. 576.

Hensel, R. L. 1923. Effect of burning on vegetation in Kansas pastures. J. Agr. Res. 23(8):631-643.

The data presented in this paper have been obtained in connection with pasture investigations conducted by the Kansas Agricultural Experiment Station. The experiments discussed were designed to study the effect of burning on the vegetation in pastures.

The conclusion is that studies so far conducted have failed to show that burning is injurious. More extensive experiments with different types of vegetation and for a longer period of time must be conducted before final conclusions regarding the effects of burning can be arrived at.

Abstract No. 577.

Herbel, C. H. 1954. The effects of date of burning on native Flint Hills range land. M.S. Thesis. Kansas State Coll., Manhattan. 40 p.

Burning has been practiced in the Flint Hills range land since the 1880's. Many of the southwestern cattle producers, who lease these ranges, demand that they be burned because burning permits earlier grazing.

This study is designed to evaluate effect of date of burning on native bluestem range lands under moderate grazing. Early, medium, and late spring burnings are compared on three 44-acre pastures. Burning started with the 1950 season. Since it is necessary to eliminate as much variation as possible between pastures to evaluate research data properly and to relate vegetation to its environment, the pastures have been mapped into site categories based on soil survey.

Abstract No. 578.

Herbel, C. H. 1971. A review of research related to development of grazing systems on native ranges of the western United States. U.S. Dep. Agr. Jornada Exp. Range Rep. No. 3. 28 p.

Research studies on grazing systems on native range in the 17 contiguous western states are reviewed. Yearlong-continuous grazing was superior to seasonal grazing on the California annual rangelands. There was only limited success with any grazing scheme other than continuous on rangelands grazed only for a part of the year (seasonal ranges). The deferred-rotation system at Sonora, Texas, has resulted in sufficient range improvement to permit a 33% increase in stocking as compared to continuous grazing.

Grazing research should include studies on the entire ecosystem, not just a few of the major species. Livestock performance per unit area may be more important in evaluating grazing studies than individual animal performance. Grazing studies should be flexible to permit consideration of fluctuation in plant attributes due to variations in weather conditions. Much additional study is needed to develop the most productive grazing scheme for each range operation.

Abstract No. 579.

Herbel, C. H., and A. B. Nelson. 1966. Activities of Hereford and Santa Gertrudis cattle on a southern New Mexico range. J. Range Manage. 19:173-176.

The Hereford cows spent more time grazing, less time walking, and traveled less distance than the Santa Gertrudis. When compared to results from other locations, there is no apparent relationship between grazing time and quantity of forage per unit area. There were generally four grazing periods: about midnight, from daybreak for the next 3 to 3½ hr, midday, and late afternoon for 3 to 3½ hr.

Abstract No. 580.

Herbel, C. H., and A. B. Nelson. 1966. Species preference of Hereford and Santa Gertrudis cattle on a southern New Mexico range. J. Range Manage. 19: 177-181.

The species preferences of Hereford and Santa Gertrudis cows were observed during a 3-year period. The cattle grazed a variety of species, undoubtedly an important factor affecting nutritional status. They ate, to some extent, all available species. There was no apparent difference between breeds in the quantity of coarse plants consumed.

Abstract No. 581.

Herbel, C. H., F. N. Ares, and A. B. Nelson. 1967. Grazing distribution patterns of Hereford and Santa Gertrudis cattle on a southern New Mexico range. J. Range Manage. 20:296-298.

Actual observations for 3 years and utilization surveys for 4 years were used to determine the grazing distribution patterns of Hereford and Santa Gertrudis cattle in southern New Mexico. The grazing patterns of the two breeds were similar in the pastures studied. There was good distribution throughout the pastures which extended 3.5 miles from water. In larger pastures, Santa Gertrudis cows may graze farther from water than Hereford cows because they walk farther. Earlier studies indicated a decreasing degree of utilization with an increasing distance from water. In this study, where a variety of species were available, cattle readily grazed a distance from water to obtain certain species. It is suggested that an important tool in obtaining better livestock distribution would be to encourage the growth of palatable species at a distance from water.

Abstract No. 582.

Herbel, C. H., and A. B. Nelson. 1969. Grazing management on semi-desert ranges in southern New Mexico. Jornada Exp. Range Rep. No. 1. New Mexico State Univ., Las Cruces. 13 p.

We will attempt to discuss some of the features of managing arid, southern New Mexico ranges, with some emphasis on benefits of various practices. Much of this research work was conducted at the Jornada Experimental Range, near Las Cruces, New Mexico. The Jornada Range was established in 1912. The major emphasis of the research program has been on grazing management and range ecology. It has only been in recent years that we have also given some attention to brush control and seeding.

The Best Pasture Grazing System and Flexible Herd Management have these advantages when compared to systems that include over-utilization of forage species as part of the scheme: (1) they maximize soil protection, (2) the primary forage plants maintain their vigor so they can take advantage of the erratic rainfall, (3) they permit full use of available forage, (4) they consider both plant and animal requirements, and (5) therefore, they are more profitable to operate.

Abstract No. 583.

Herbel, C. H., and R. E. Sosebee. 1969. Moisture and temperature effects on emergence and initial growth of two range grasses. Agron. J. 61:628-631.

This research, conducted in controlled light-temperature chambers, studied the effects of two temperature regimes and five moisture levels on early growth of black grama (*Bouteloua eriopoda* (Torr.) Torr.) and boer lovegrass (*Eragrostis chloromelas* Steud.). The maximum daily soil temperatures ranged from 38 to 67°C in the high temperature regime and from 38 to 51°C in the low temperature regime, depending on moisture level. The daily minimum temperatures were about 25°C in all treatments. The five soil moisture levels were determined as a portion of the volume required to maintain field capacity conditions. Level A was approximately field capacity; levels B and C were watered as level A on the planting day and then reduced to about one-half and one-third of level A for the remainder of the 21-day trial. Levels D and E were watered as level A for the first three days and then reduced to about one-half and one-third of level A for the remainder of the trial.

In the high temperature regime black grama did not emerge at moisture levels B and C; and boer lovegrass did not emerge at levels B, C, and E. In addition, boer lovegrass did not emerge in the low temperature regime at moisture level C. Survival of emerging seedlings ranged from 0 to 4.7% in the high temperature regime at all moisture levels except A. Reduced soil moisture, a day after planting, was more detrimental to survival than reducing soil moisture the third day after planting. Survival of black grama at moisture level A in the high temperature regime was not adversely affected by the high leaf temperatures (81°C). The shoot lengths and weights of surviving black grama seedlings were always greater than those of boer lovegrass. Survival and growth of seeded species in the southwest would be enhanced if soil temperatures and evaporation from the soil surface were reduced. Under the conditions of this 21-day trial it took about 70 mm of water for either species to survive in the low temperature regime and about 231 mm to survive in the high temperature regime.

Abstract No. 584.

Herbel, C. H., and R. D. Pieper. 1970. Comprehensive Network Site description, JORNADA. U.S. IBP Grassland Biome Tech. Rep. No. 43. Colorado State Univ., Fort Collins. 21 p.

The Jornada Site is located on the Jornada Experimental Range which was withdrawn from the public lands for research in 1912 by presidential proclamation. Since 1953, the Jornada has been operated by the arid pasture and range sections crops research division of the Agricultural Research Service. The entire Jornada Experimental Range contains 105,700 acres under direct control of the ARS and an additional 85,000 acres under lease to the White Sands Missile Range. The site selected for the IBP Grassland studies is located on the western side of the range about 6 miles west of the Jornada headquarters. The site is the area south and east of the west well range gauge. The site can be reached from Las Cruces, New Mexico, by traveling east on highway 70-82 and turning north on a gravel road marked by a sign designating the Jornada headquarters. The site is about 5 miles northwest of the south well.

The ungrazed area is a 10-acre exclosure, while the grazed area is the remainder of pasture 9. Livestock utilization on the area has been light, but on the grazed area the vegetation is at a stage below black grama climax because of grazing and drought. On the protected area, the vegetation is in the climax black grama stage.

Abstract No. 585.

Herrmann, S. J. 1970. A scheme for the quality of lentic habitats in Colorado. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

Data for temperature, total residue, total alkalinity, pH, total non-volatile solids, and total organic content were determined at each of 446 lentic sites throughout Colorado. Many were revisited and resampled two, three, and, in some instances, six times. From the data collected for the period 1964-1969 one can see tremendous diversity. A scheme for the classification of such diverse habitats is badly needed, especially since all voluminous data of this nature requires computer retrieval. Mean, range, and standard deviation values were presented for each parameter (except pH) in each lentic classification. Seven new lentic classes were presented and represent habitats not previously reported in the limnological literature for Colorado.

Abstract No. 586.

Herrmann, S. J. 1971. Physical and chemical limnology of Cottonwood Pond and Spring Pond (Sept. 1969--Dec.1970). U.S. IBP Grassland Biome Tech. Rep. No. 71. Colorado State Univ., Fort Collins. 27 p.

For the period September 1969 to December 1970 the following physical and chemical parameters were studied monthly in Cottonwood Pond and Spring Pond on the Pawnee Site: temperature, dissolved oxygen, hydrogen ion concentration, turbidity, total residue, conductance, hardness (total Ca, Mg), sodium, potassium, alkalinity (P and T), chloride, and sulfate. Several other variables were studied on an irregular basis: iron, phosphate, nitrate, and ammonia. In addition, a complete morphometric consideration of each pond was made.

Abstract No. 587.

Herrmann, S. J., J. W. LaVelle, and J. A. Seilheimer. 1970. Aquatic primary productivity and physical-chemical limnology on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 49. Colorado State Univ., Fort Collins. 19 p.

Monthly measurements of community primary productivity, planktonic primary productivity, and physical-chemical parameters have begun on the Pawnee Site. Preliminary data are reported and trends are beginning to appear, particularly in reference to physical-chemical changes of a seasonal nature.

Abstract No. 588.

Hesket, M. G., and E. D. Fleharty. 1965. Additional records of the least weasel (*Mustela nivalis*) in Kansas. Kansas Acad. Sci., Trans., 68(4):582-583.

Records on least weasels in Kansas are given. Location of each additional finding is given with a habitat description. Specimens were examined by external measurement, skin studies, and hair analysis.

Abstract No. 589.

Higgs, D. E. B., and D. B. James. 1969. Comparative studies on the biology of upland grasses. I. Rate of dry matter production and its control in four grass species. J. Ecol. 57:553-563.

The growth of four grass species, *Lolium perenne* S.24, *Agrostis tenuis*, *Sieglingia decumbens*, and *Nardus stricta* is described and compared. The species were grown as spaced plants under both fertile and infertile soil conditions. Their growth was studied using the technique of growth analysis.

The results showed that there were large differences in total dry matter production, relative growth rates, leaf area ratios, net assimilation rates and shoot:root ratios. The species fall into two groups with *Agrostis* and *Lolium* in one and *Nardus* and *Sieglingia* in the other. The species in the first group produce more dry matter and have higher relative growth rates than those in the second. The growth rates of *Lolium* and *Agrostis* are reduced on the infertile soil, but there is no such reduction in *Sieglingia* and *Nardus*. It is concluded that the differences found in the relative growth rates are brought about mainly in response to differences in leaf area ratios rather than net assimilation rates.

Of the four species studied, the ones which show the lowest rates of dry matter production are normally associated with the poorest soils. This evidence lends support to the view that slow growth rates may be of adaptive significance to plants indigenous to soils of low fertility.

Abstract No. 590.

Hildreth, R. J., and G. W. Thomas. 1956. Farming and ranching risk as influenced by rainfall. Part I. High and rolling plains. Texas Agr. Exp. Sta. Bull. Mp-154. 35 p.

Farmers and ranchmen on the high and rolling plains of Texas face many uncertainties in operating their businesses. One of the most important is the variation in crop and forage yields and in income to farmers and ranchmen due to fluctuations in rainfall.

Several important steps can be taken by farmers and ranchmen to help meet weather risks. By studying the occurrence and range of past weather variations, they can predict better the probability of future drouths and their severity, as well as the possibility of good years, and can adjust some farm or ranch operations to fit these constantly changing conditions.

This publication gives information and analyses of past rainfall records for 31 locations on the high and rolling plains which have relatively complete records. Annual and average monthly rainfall charts are presented to help appraise the risks associated with rainfall in the area. Some interpretations and predictions have been made to aid in understanding these charts. The individual can make a more complete analysis.

This publication is the first of a planned series presenting information and analyses of past rainfall records for several areas of the state, including the Edwards Plateau and Trans-Pecos and the Rio Grande Plain.

Abstract No. 591.

Hironaka, M. 1961. The relative rate of root development of cheatgrass and medusahead. J. Range Manage. 14:263-267.

The relative rate of root development of medusahead and cheatgrass was studied employing a new field technique. Individual plants were grown in nylon cloth tubes which were "planted" in the field. One row of tubes, consisting of four replicates of each species, was recovered monthly from mid-December through mid-June, and the depth of root penetration and aerial growth measurements were obtained.

Rate of vertical root penetration of the two annual grasses was about equal, but cheatgrass reached maximum branching a few weeks earlier than medusahead. Maximum root development coincided closely with time of full inflorescence for the two species. Because medusahead matures later, its root system remains functional for a longer period than those of cheatgrass. When the two species are growing together the water requirement for cheatgrass must be satisfied before medusahead is able to complete its life cycle.

Abstract No. 592.

Hitchcock, A. S., and A. Chase. 1950. Manual of the grasses of the United States. U.S. Dep. Agr., Misc. Pub. 200. 1051 p.

The manual includes descriptions of all grasses known to grow in the continental United States, excluding Alaska. There are 169 numbered genera and 1,398 numbered species. Of these, 46 genera and 156 species are introduced, mostly from the eastern hemisphere.

The manual is based mainly on the material in the United States National Herbarium, the grass collection of which is the largest in the world, numbering more than 320,000 sheets.

Nearly all the numbered species are illustrated. About half are accompanied by a map, giving the distribution of that species in the United States.

To aid the users of this work in pronouncing the Latin names the accented syllable is indicated. The accent mark is used to show the accented syllable without reference to the length of the vowel.

Abstract No. 593.

Hladek, K, L., G. K. Hulett, and G. W. Tomanek. 1972. The vegetation of remnant shale-limestone prairies in western Kansas. Southwestern Natur. (In press.)

Floristics, vegetation, indices, and soils were studied on 65 remnant stands within the shale-limestone region of western Kansas.

An environmental gradient, consisting of five moisture classes was established to study species distributions and community structure. Most species exhibited continuous distributional patterns in response to the moisture gradient. Mesic habitats were low in species numbers while drier sites exhibited a greater species diversity. The dominant grasses, *Andropogon gerardi*, *Andropogon scoparius*, and *Bouteloua gracilis* were too ubiquitous in their distribution to be used in community delineation; therefore, four communities based on indicator species were established within the study area.

Abstract No. 594.

Hoffman, R. S., J. K. Jones, Jr., and H. H. Genoways. 1971. Small mammal survey on the Bison, Bridger, Cottonwood, Dickinson, and Osage Sites. U.S. IBP Grassland Biome Tech. Rep. No. 109. Colorado State Univ., Fort Collins. 69 p.

Live- and snap-trapping of grids at five Network Sites on the northern Great Plains (Osage, Cottonwood, Dickinson, Bridger, and Bison) provide the basis for estimates of small mammal standing crop biomass density at one or two times during the growing season at these sites.

Osage had a high prairie vole (*Microtus ochrogaster*) population, comprising about 90% of the biomass total, in late May to early June. Biomass density was calculated as 1591.4 g/ha live weight (= 0.048 g/m^2 dry weight). Vole numbers declined somewhat over the summer, but still constituted 80 to 85% of the biomass total in late August; biomass density was estimated as 1121.7 g/ha live weight (= 0.034 g/m^2 dry weight).

Small mammal densities were extremely low in both mid-June and mid-August at Cottonwood, and no one species was dominant. Biomass density estimates were 114.8 g/ha live weight (= 0.003 g/m^2 dry weight) and 181.2 g/ha live weight (= 0.005 g/m^2 dry weight), respectively.

Densities also were fairly low at Dickinson, with no dominant species; biomass density in mid-June was estimated as 295.0 g/ha live weight (= 0.009 g/m^2 dry weight) and in early August as 369.3 g/ha live weight (= 0.011 g/m^2 dry weight). However, biomass density estimates based on live-trapping an irregular grid in a small exclosure were much higher because of the presence in the exlosure of a ground squirrel (*Spermophilus tridecemlineatus*) colony. Ground squirrels constituted 75 to 85% of the biomass total estimated as 2464.0 g/ha live weight (= 0.075 g/m^2 dry weight) and 976.0 g/ha live weight (= 0.029 g/m^2 dry weight) for the first and second periods, respectively.

Only single mid-season samples were taken at Bridger and Bison. At the former site, biomass density was moderate to high because of pocket gophers, which constituted 60 to 90% of the biomass total of 2375.8 g/ha live weight (= 0.071 g/m^2 dry weight) on the snap-trapped grid and 358.1 g/ha live weight (= 0.011 g/m^2 dry weight) on the live-trapped grid. At Bison the montane vole (*Microtus montanus*) constituted 90% of the biomass total of 397.4 g/ha live weight (= 0.012 g/m^2 dry weight).

Abstract No. 595.

Hoglund, C. R., and M. B. Johnson. 1947. Ranching in northwestern South Dakota. South Dakota Agr. Exp. Sta. Bull. 385. 31 p.

The ranch study made during 1945 in the four northwestern counties of the state revealed the following important facts:

Four major types of ranches were found in the area, namely, cattle, sheep, general and cash grain. The sheep ranches averaged the largest in both total acres operated and numbers of roughage consuming livestock. Considerable variation was found in the degree of mechanization on the 84 ranches visited. Tractors were owned by most general and cash grain operators but by only a small proportion of the cattle and sheep ranchers. The general and cash grain operators used combines and trucks extensively. Power mowers and buck rakes were important machines used by many ranchers.

Many desirable grazing and conservation practices have been developed in recent years. These include the separation of the range into a number of pastures used for seasonal grazing, the seeding of poor quality cropland or grassland to crested wheat grass for early hay and pasture, the building of stock water reservoirs, strip cropping, irrigation of hayland, firebreak construction, and shelter belt planting.

Most of the cattle are marketed through livestock auctions or shipped to terminal public markets. The sheepmen, on the other hand, sell practically all of their lambs direct to feeders and dealers.

Ranching, in general, was fairly profitable during 1944. High feed and labor costs and parasite problems resulted in lower incomes for sheep ranchers than for cattle ranchers.

The major adjustments suggested for the range are: (1) increasing the size (both acres and livestock numbers) of a large proportion of ranches, (2) adjusting ranching operation to fit environment, (3) seeding of a considerable acreage of cropland to crested wheatgrass and other permanent grasses, (4) emphasizing beef cattle and sheep production and less dependence on other livestock and grain as a stabilizing factor, and (5) adopting better livestock and range management practices.

Abstract No. 596.

Holscher, C. E. 1945. The effect of clipping bluestem wheatgrass and blue grama at different heights and frequencies. Ecology 26(2):148-156.

The effect of clipping on bluestem wheatgrass and blue grama was studied at the U.S. Range Livestock Experiment Station near Miles City, Montana. The clipping was done during five seasons, 1938-1942, in several enclosures which had been protected from grazing for several years prior to the time of study. The areas were typical of shortgrass ranges, but the densities of all vegetation were much below normal at the start of the study because of the severe drought which occurred in 1934 and 1936. During the years of this study, bluestem and grama on grazed quadrats on nearby experimental range increased by 170 and 575%, respectively, in recovering from the effects of the drought.

It seems evident that neither bluestem wheatgrass nor blue grama can withstand the degrees of clipping practiced in this study even with favorable weather, without a decline in vigor and gradual deterioration. Utilization by livestock must obviously be less severe if ranges are to be maintained at a level of maximum production. This suggests that under proper grazing a certain percentage of plants should remain unutilized each year so that the vigor may be rebuilt in those plants which were closely grazed in previous years.

Abstract No. 597.

Holscher, C. E., and E. J. Woolfolk. 1953. Forage utilization by cattle on northern Great Plains ranges. U.S. Dep. Agr. Circ. 918. 27 p.

The northern Great Plains, a semiarid region, is especially well-suited for the production of range livestock. In 1951, there were three million cattle and calves in this area. Precipitation fluctuates widely from year to year and long-time averages over the region vary from 10 to 16 inches. Three subtypes make up much of the range: the broad bottoms of heavy, poorly drained soils dominated by bluestem wheatgrass and buffalo grass; the uplands having sandy loam or sandy clay loam soils producing blue grama, needle-and-thread, bluestem wheatgrass, and threadleaf sedge; and the hills which produce a wide variety of forage plants on soils which may be heavy clay, rocky, and frequently alkaline.

Abstract No. 598.

Holt, D. A., and A. R. Hilst. 1969. Daily variation in carbohydrate content of selected forage crops. Agron. J. 61:239-242.

Daily variation in percentages of water-soluble carbohydrates, total nonstructural (0.2 N H_2SO_4 soluble) carbohydrates, and differences between these, representing nonstructural polysaccharides exclusive of fructosan, in alfalfa (*Medicago sativa*), Kentucky bluegrass (*Poa pratensis*), bromegrass (*Bromus inermis*), and tall fescue (*Festuca arundinacea*) were investigated.

Water soluble carbohydrate percentages in alfalfa followed a curvilinear diurnal trend from a low at 6:00 AM to maximum levels at 12:00 noon and decreased slightly by 6:00 PM. Nonstructural polysaccharide content followed a nonlinear daily trend with the most rapid increase occurring in the afternoon.

The grasses underwent linear increases in water soluble carbohydrate percentages from 6:00 AM to 6:00 PM. Likewise, the nonstructural polysaccharide content of the grasses followed an increasing linear trend in the daytime. Nonstructural polysaccharide content increased more rapidly in bromegrass and tall fescue than in bluegrass. Variation in water-soluble carbohydrate content accounted for almost all of the daily variation in total nonstructural carbohydrate content of bluegrass.

Alfalfa and bluegrass grown under low potassium nutrition had significantly higher water soluble carbohydrate percentages than those growing under high potassium nutrition.

Abstract No. 599.

Holtan, H. N. 1961. A concept for infiltration estimates in watershed engineering. U.S. Dep. Agr. Res. Service, ARS 41-51. 25 p.

The infiltration capacity of a soil as it changes with continuing rainfall is a most important estimate in computing the hydrologic performance of watersheds. Many of the designs developed in watershed engineering are based upon man's ability to modify the infiltration capacities of the various soils within the watershed. The hydrograph of runoff is greatly influenced by infiltration. A dependable system is needed for associating the infiltration curve with characteristics of the plant cover and the soil profile. The concepts presented in this paper offer some new avenues of approach.

Abstract No. 600.

Holtan, H. N., and M. H. Kirkpatrick, Jr. 1950. Rainfall, infiltration, and hydraulics of flow in runoff computation. Amer. Geophys. Union, Trans., 31(5):771-779.

This study considers three broad phases of hydrology (rainfall, infiltration, and hydraulics of flow) as they affect the occurrence of surface runoff. These three phases are not conglomerated into one single computation of runoff but are kept separate and considered consecutively which is the manner of their occurrence in nature. Rainfall expectancy is founded on the relatively longer and stronger rainfall records. The expectancies used are those derived by Yarnell.

Infiltration capacities of the soils in the watershed area are estimated from infiltrometer data for various soil and vegetative cover complexes. Rainfall must satisfy infiltration capacities before excesses can be produced for runoff. The rate at which excess rainfall runs off is a function of the characteristics of the watershed drainage system. Excess rainfall must supply the volumes of runoff simultaneously with the volumes of surface detention needed in order to produce given rates of flow. By the analysis of watershed data, it was learned that a definite relationship exists between the amount of detention and the rate of runoff from a given watershed. Although considerable refinement is needed it is evident that this relationship is affected by size of watershed area, vegetative cover, land-tillage practices, and presumably slopes or terrain of the watershed.

Through the isolation of the three phases, a new avenue of application is opened. With research designed to associate infiltration and hydraulics of flow with measurable characteristics of the watershed, the science of runoff prognostication should be appreciably advanced. The consecutive application of these phenomena permits and encourages comprehension and logic rather than acceptance of results on faith alone.

Abstract No. 601.

Holtan, H. N., C. B. England, and V. O. Shanholtz. 1967. Concepts in hydrologic soil grouping. Amer. Soc. Agr. Eng., Trans., 10(3):407-410.

The path from theoretical to applied research is generally tortuous, with frequent interruptions by missing bridges. This is particularly pertinent to research on the infiltration phenomenon as it applies in watershed hydrology. The rationale of simultaneous solutions of Darcy's law and the continuity equation would be highly desirable, but the required estimates of unsaturated hydraulic conductivities and diffusivities are difficult to obtain even in the laboratory. Valid estimates for field-scale applications are not available. Also, the sequential treatment of successive soil horizons is extremely precarious in the anisotropic conditions characteristic of our watersheds.

Work in the USDA hydrograph laboratory of the Agricultural Research Service has been toward the development of an empirical equation for estimating infiltration from information generally available or readily obtained for major soils of the nation. Equations [1, 2, 3] express infiltration as a function of the near constant rate of intake for a given soil in a fallow condition after prolonged wetting and exhaustion of available storage above the impeding strata:

$$f = a(S-F)^n + f_c \qquad [1]$$

wherein

f = rate of infiltration in inches/hr
S = storage potential of a soil above the impeding strata (total porosity minus antecedent soil moisture), in inches
F = accumulated infiltration, in inches
f_c = constant rate of infiltration after prolonged wetting, in inches/hr
a and n are the intercept and slope, respectively, of a logarithmic plotting of the quantity $(f-f_c)$ vs. (S-F).

The range of greatest hydrologic activity is estimated to lie between saturation (total porosity) and the wilting-point moisture content. The volume of moisture in this range is used as an upper limit on the value of S in computations of moisture depletions. Estimates of maximum storage above the impeding stratum can be derived from data in reports of tests by the soil survey laboratories of the Soil Conservation Service, state agricultural experiment stations and the Agricultural Research Service on many soils over the nation.

The SCS has grouped the major soils of the nation in accordance with their relative rates of infiltration after prolonged wetting. The concept of "S" suggests the possibility for a second hydrologic grouping of soils on the basis of their maximum storage potential above the impeding strata.

Abstract No. 602.

Hoover, J. P. 1971. Food habits of pronghorn antelope on Pawnee National Grasslands, 1970. M.S. Thesis. Colorado State Univ., Fort Collins. 285 p. (Advisor: Julius Nagy).

Hoover, J. P., and J. G. Nagy. 1971. International Biological Program: Food habits of pronghorn antelope on Pawnee National Grasslands. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

Pronghorn captured when a few days old, raised and trained, were used to obtain food habits data in field trials. The animals were released in the field and observers walked with the animals recording on tape the plant species and plant parts taken and estimated bite size. After an hour's observation the plants were collected in the same areas grazed by the animals. These daily samples were later composited for each animal and analyzed for chemical composition. Browse was predominant in the winter diet, grasses were important in the spring, and forbs were important in the summer. Fringed sage (*Artemisia frigida*) and scarlet globemallow (*Sphaeralcea coccinea*) are important forage species for pronghorn. In a seasonal comparison of the hand pluck samples collected for each animal, the cell wall constituents steadily decreased from winter to summer trials and crude protein increased from winter to spring and summer trials. The chemical constituents of the diet gained from hand pluck samples should best represent an average of the forage taken by the animals on trials. The bite count technique is uniquely applicable to pronghorn and may be the most precise in terms of descriptive data available on pronghorn food habits.

Abstract No. 603.

Hoover, M. M. 1939. Native and adapted grasses for the conservation of soil and moisture in the Great Plains and western states. Farmers Bull. 1812. 42 p.

The information given in this bulletin should enable farmers in the Great Plains and western states to select from the more common species of grasses some one or more suited to their needs. Common harvesting equipment and farm machinery can be adapted to the proper handling of native grasses. This brings the cost of such work within the means of most farmers.

The distribution maps and data presented in this bulletin are based on publications of the Department of Agriculture, particularly those of the Bureau of Plant Industry and the Forest Service, as well as on information gained in the field activities of the Soil Conservation Service. Federal and state agencies have cooperated at the several grass nurseries of the Soil Conservation Service and have assisted with this work.

Abstract No. 604.

Hoover, M. M., E. Smith, Jr., A. E. Ferber, and D. R. Cornelius. 1947. Seed for regrassing Great Plains areas. U.S. Dep. Agr. Farmers' Bull. 1985. 37 p.

Range and pasture grass seed, now needed on farms of the United States as never before, can be grown successfully as a farm crop. To produce the forage grass seed he needs and often cannot buy, the farmer needs skill and judgment. In addition, he needs special information as to what kinds of grass will best control erosion and produce forage on such soil as his and under the local conditions as to climate; how to tell whether a seed crop is worth harvesting and when it is ready for harvest; what machinery and methods should be used in harvesting the seed; and how the seed should be cleaned and processed. Helpful information on these points is offered here to farmers of the Great Plains and adjacent prairie areas.

Abstract No. 605.

Hoover, R. L., C. E. Till, and S. Ogilvie. 1959. The antelope of Colorado. Colorado Dep. Game Fish Tech. Bull. 4. 110 p.

The passage of the Federal Aid in Wildlife Restoration Act in 1937 made it financially possible for the Colorado Department of Game and Fish to initiate research and development projects which have resulted in a sound management program for antelope. Under the provisions of this act, an antelope project was begun in 1939 and continued through 1942, when the war interrupted the investigations. The project was resumed in 1947 and continued until 1956 when it was terminated. This publication is a report on these investigations.

The history of antelope in Colorado typifies the tragic story of so many of our game animals. It is a story that began with unlimited abundance in the early part of the last century, only to reach near-annihilation of the species by the end of that era. Relentless slaughter, lack of management, and the encroachment of civilization played their ruthless role throughout the 1800's. The 20th century, however, has witnessed quite different factors shaping the destiny of the Colorado pronghorn. Legal protection accompanied by strict enforcement, the establishment of refuges, and the application of management principles based upon intensive research has once again permitted the hunting of this magnificent game animal. The research work which this publication describes and summarizes has been the principal means for the laudable restoration and redistribution of antelope in Colorado.

Abstract No. 606.

Hopkins, H. H. 1941. Variations in the growth of side-oats grama grass at Hays, Kansas, from seed produced in the various parts of the Great Plains region. Kansas Acad. Sci. Trans., 44:86-95.

The experience of the people in the Great Plains region has shown that the permanent prosperity of the area will never come from an extensive program of wheat farming. More likely will it come from a program of diversified farming with major emphasis upon the raising of cattle. This means that thousands of acres of denuded land must be returned to its former state of grassland. This study is only a small part in the great drive taking place to find suitable methods and species for revegetating the former grazing lands.

Abstract No. 607.

Hopkins, H. H. 1951. Ecology of the native vegetation of the loess hills in central Nebraska. Ecol. Monogr. 21(2):125-147.

The native mixed-prairie consists of four principal communities. The shortgrass faciation, characteristic of the uplands, was dominated by *Bouteloua gracilis*, which comprised 90.9% of the vegetation. Basal area was 31%. Annual yield was about 2000 air-dry lb./acre, and the accumulation of mulch on the soil surface was 1743 lb. The typical expression of the association was the mixed-grass community characteristic of the hillsides. Dominants were *Bouteloua gracilis*, *B. curtipendula*, *Sporobolus cryptandrus*, *Agropyron smithii*, and *Andropogon furcatus*. Basal area was 19%. Clipped yield was about 2000 lb and mulch accumulation 993 lb./acre. The mid- and tallgrass associates occurred mostly on the lowlands and "catsteps." The dominant *Andropogon furcatus* occurred alone, associated with other tall grasses, or with *Poa pratensis* as an understory. Basal area was 9% and average production 3400 lb. Mulch varied from 15,000 lb. where unmowed to less than 1000 lb. where mowed annually. The western wheatgrass consociation, dominated by *Agropyron smithii*, was a product of the drought and not limited to any particular site. Most xeric conditions, as determined by soil water, soil and air temperature, relative humidity, evaporation, and wind movement, occurred on the upland in the shortgrass and western wheatgrass communities. Most abundant forbs were *Lygodesmia juncea*, *Amorpha canescens*, *Erigeron ramosus*, *Ratibida columnaris*, and *Psoralea tenuiflora*. The prairie had not yet recovered from the drought of 1933-40.

Abstract No. 608.

Hopkins, H. H. 1952. Native vegetation of the loess hills-sandhills ecotone in central Nebraska. Kansas Acad. Sci., Trans., 55:395-418.

This study was concerned with certain ecological aspects of the utilization of native vegetation. An attempt was made to correlate rainfall, soil water, growth, yield, moisture content, protein content, and utilization of vegetation, and yield of beef. The research was done in the college pasture near Hays, Kansas, from 1947 to 1950 inclusive.

Abstract No. 609.

Hopkins, H. H. 1953. Root development of grasses on revegetated land. J. Range Manage. 6(6):382-392.

A study was made in 1950 of root systems of several species of native and introduced grasses near Hays, Kansas. Root samples of each grass were removed from soil monoliths 3 inches thick, 12 inches wide, and 4 ft deep. Samples were cut into segments 6 inches long, air-dried, and weighed. Material from the surface to a depth of 1 inch (crowns) was separated from the rest of the first segment.

Abstract No. 610.

Hopkins, H. H. 1954. Effects of mulch upon certain factors of the grassland environment. J. Range Manage. 7(6):255-258.

Amounts of mulch on mixed prairie grassland ranged from 900 to 22,610 lb./acre due to variations in site, species, and condition of grazing. Tall grasses produced larger amounts of mulch than short grasses on ungrazed areas, but less mulch remained on grazed tallgrass sites.

Vegetation placed on the soil and allowed to decompose under natural conditions was mostly disintegrated after 3 years. Approximately half the initial weight was lost during the first year.

Mulch reduced soil temperatures and retarded evaporation. Its effectiveness in reducing evaporation was greatest when the surface soil was moist; evaporation losses were not in direct proportion to depth of mulch.

Rates of infiltration and soil water content were consistently greater on soils with mulch than without mulch. At the end of the growing season a mulched plot had available moisture to nearly 4 ft, an unmulched plot to only 2 ft.

Abstract No. 611.

Hopkins, H. H. 1955. Literature of the vegetation of Kansas. Kansas Acad. Sci., Trans., 58:171-195.

The portion of the science of plant ecology dealing with vegetation has advanced to the stage where there is a demand for information as to what has been published. This bibliography, arranged alphabetically by authors, also includes the most nearly related aspects of such other fields as taxonomy, geography, range management, and soil conservation. However, each reference is concerned to some extent with vegetation. It is hoped that this compilation will be of value to those interested in both descriptive ecology and its practical application.

There are included 339 references, some of which include more than one paper, and 170 authors to and including 1953. This seems quite commendable for a state as young as Kansas despite the fact there is no literature for many counties. In view of rapid destruction of native vegetation, concerted efforts should be made to record data on remaining natural communities.

The county index included refers to papers which provide specific information on the vegetation of the counties. This index should be helpful to those planning research or seeking data on certain areas. A chronological index has also been added which may be of value from a historical point of view.

Abstract No. 612.

Hopkins, H. H. 1956. Effects of mulch on yield and cover in mixed prairie. Kansas Acad. Sci., Trans., 59:71-75.

Various amounts of mulch were removed from or added to a series of square-meter quadrats to measure effects on yield and basal cover. Procedure was artificial in that all mulch was applied at once in April, 1950, thus subjecting vegetation to an abnormal situation. When an area is closed to grazing, mulch accumulates slowly permitting gradual adjustments to be made. As late as August 10, 1950, an estimated 10% of 1949 growth was still erect.

On upland, removal of all mulch or addition of 250 g/m^2 had little effect on cover, but addition of 500 and 750 g caused reduction from 91.2% in the control to 65.7 and 30.0%, respectively. Both removal and addition of mulch reduced yield though not proportional to changes in basal area. Some recovery occurred during the second year. On lowland, removal of mulch permitted an increase in both cover and yield.

It has been established that mulch can be an important factor in controlling soil water. Since moisture is usually the limiting factor in the growth of upland range grasses, results of a study of this sort would be expected to vary with season and habitat. Addition of large amounts of mulch on the upland reduced competition by decreasing cover. This resulted in a decrease in total yield but an increase in yield per unit of basal area. On the lowland, removal of mulch permitted cover to increase; and, since moisture was abundant, the additional vegetation provided a greater total yield.

Abstract No. 613.

Hopkins, H. H., F. W. Albertson, and A. G. Riegel. 1948. Some effects of burning upon a prairie in west-central Kansas. Kansas Acad. Sci., Trans., 51:131-141.

The purpose of this paper is to present data on the detrimental effects of pasture burning and the rate of recovery through two seasons of growth.

Abstract No. 614.

Hopkins, H. H., F. W. Albertson, and D. A. Riegel. 1952. Ecology of grassland utilization in a mixed prairie. Kansas Acad. Sci., Trans., 54(4): 395-418.

Correlations are presented for rainfall, soil water, growth, yield, moisture content, protein content, utilization of vegetation, and the yield of beef on pasture near Hays, Kansas, from 1947 through 1950. Soil water is paramount in a successful livestock program in this mixed prairie area.

Abstract No. 615.

Hopkins, H. H., and G. W. Tomanek. 1957. A study of the woody vegetation at Cedar Bluff Reservoir. Kansas Acad. Sci., Trans., 60:351-359.

Relatively little information is available on the establishment of plant communities around newly formed reservoirs. Because the plants have created problems in some areas and may in others, it is desirable that ecological data be accumulated.

Abstract No. 616.

Hornaday, W. T. 1889. Extermination of the American Bison: Report of the national museum (1886-1887), p. 367-548. *In* Government Printing Office, serials set 2582, Part 2.

It is hoped that the following historical account of the discovery, partial utilization, and almost complete extermination of the great American bison may serve to cause the public to fully realize the folly of allowing all our most valuable and interesting American mammals to be wantonly destroyed in the same manner. The wild buffalo is practically gone forever, and in a few more years, when the whitened bones of the last bleaching skeleton shall have been picked up and shipped East for commercial uses, nothing will remain of him save his old, well-worn trails along the water-courses, a few museum specimens, and regret for his fate. If his untimely end fails even to point a moral that shall benefit the surviving species of mammals *which are now being slaughtered in like manner*, it will be sad indeed.

Although *Bison americanus* is a true bison, according to scientific classification, and not a buffalo, the fact that more than 60 millions of people in this country unite in calling him a "buffalo," and know him by no other name, renders it quite unnecessary for me to apologize for following, in part, a harmless custom which has now become so universal that all the naturalists in the world could not change it if they would.

Abstract No. 617.

Horner, B. E. 1968. Gestation period and early development in *Onyshomys leucogaster brevicaudus*. J. Mammal. 49:513-515.

The literature on gestation in *Onyshomys leucogaster* cites a minimum period of 29 days for non-lactating *O. l. utahensis* and 32 days for *O. l. fuscogriseus*. This note records a gestation period of no more than 27 days for *O. l. brevicaudus*.

Abstract No. 618.

Horton, L. E., and R. H. Weissert. 1970. Relationship of utilization intensity to plant vigor in a crested wheatgrass seeding. J. Range Manage. 23(4):298-300.

Vigor characteristics of crested wheatgrass subjected to late fall grazing at three levels of intensity were studied over an 8-year period. The indicated level of utilization for maintenance of plant vigor under conditions of this study was about 60%.

Abstract No. 619.

Houston, W. R. 1960. Effects of water spreading on range vegetation in eastern Montana. J. Range Manage. 13:289-293.

A study of vegetational changes on a range water-spreading system near Miles City, Montana, was made between 1951 and 1959. On a western wheatgrass dominated area of clayey soils two durations of water spreading were studied. Only one duration was studied on a blue grama grass dominated area of sandy loam soil.

Abstract No. 620.

Houston, W. R. 1961. Some interrelations of sagebrush, soils, and grazing intensity in the northern Great Plains. Ecology 42:31-38.

A study was initiated in 1949 near Miles City, Montana, to observe the effects of heavy and light grazing and soil differences on the number and growth characteristics of big and silver sagebrush (*Artemisia tridentata* and *A. cana*).

Thirty plots each 10 × 12 m were established on three of the five major soil groups present and on both heavily and lightly stocked range areas. Plots were sampled in 1949, 1955, 1957, and 1959.

The areas were grazed from May 15 to late October. The climate, topography, soils, and vegetation of the study area are typical of a large portion of the northern Great Plains.

On the heavily grazed areas stocking rates averaged 1.85 acres AUM and on the lightly grazed ones 3.33 acres.

Both growing season and annual precipitation averaged only 86% of the long-time means.

Abstract No. 621.

Houston, W. R. 1963. Plains pricklypear, weather and grazing in the northern Great Plains. Ecology 44: 569-574.

The findings of this study largely bear out those of several previous investigators that weather has a far greater effect on abundance and vigor of plains pricklypear than any other influence investigated. The many high, although often nonsignificant, correlations of several measures of pricklypear abundance with precipitation indicate that this facet of weather is quite important, but not the only important one. The influences of weather are often delayed and probably tend to be accumulative, at least up to a certain point. Weather also may have opposing influences depending on the characteristic of plains pricklypear observed.

The influence of precipitation upon infestation of clumps of plains pricklypear by several insects is shown to be important. Since some of these insects are more abundant in years of high precipitation and others in years of low, insect infestation of pricklypear apparently is more or less continuous.

Biological control of plains pricklypear seems to have some potential. However, the strong effects of weather on the biological vectors must be considered. The rough topography and low-value land over a large portion of the area of distribution of plains pricklypear which limit the application of mechanical and chemical eradication measures would favor this type of control. The favorable aspects of pricklypear during periods of drought should be considered in any control program.

The strong influence of soils or soil habitat on abundance and vigor of plains pricklypear and on insect infestation has not been previously noted, although several investigators have suggested this possibility. Which soil properties are the decisive ones influencing these characteristics of pricklypear and insects are not known, but usually strong interaction with years suggests that soil water or soil texture are most important. Topography or microenvironmental differences, however, may also be important.

The almost nonexistent overall effect of stocking rate at least in the range of 1.8 to 3.2 acres/animal unit month on abundance and vigor of plains pricklypear found here is in contrast with the findings of several investigators. However, stocking rates were found to interact strongly with both weather and soils.

Abstract No. 622.

Houston, W. R., and R. R. Woodward. 1966. Effects of stocking rates on range vegetation and beef cattle production in the northern Great Plains. U.S. Dep. Agr. Tech. Bull. 1357:1-58.

In 1948 a study was initiated at the U.S. Range Livestock Experiment Station near Miles City, Montana, to determine long-term effects of different intensities of grazing on range vegetation and beef-cattle production.

The study was conducted in an area of mixed-grass prairie typical of the semiarid southwestern part of the northern Great Plains. The topography, vegetation, and soils are similar to those over a large part of this region.

Abstract No. 623.

Howell, J. C. 1951. The roadside census as a method of measuring bird populations. Auk 68(3):334-357.

Relative and absolute abundance differ because of the difference in conspicuousness of species. Percent conspicuousness, as measured against known absolute populations, ranged from 1 to 28 and varied with time of year, habitat, etc. Data from roadside censuses, adjusted by percent conspicuousness, applied to populations of the Mourning Dove, Flicker, Blue Jay, Bluebird, and Crow, show that these resident birds increase in number during fall and spring. Thirty matched censuses each in 1948 and 1949 show no difference in number of individuals; population changes under 30% were not statistically significant; fringillid populations were most stable; and data on flocking species are less reliable than on non-flocking species. The mornings were found to be better than afternoons for obtaining large samples of bird populations.

Abstract No. 624.

Hoyt, J. C. 1936. Droughts of 1930-1934. U.S. Geol. Surv. Water Supply Paper 680. 160 p.

During the 5-year period 1930-34 a serious drought occurred over some broad region of the United States in each year except 1932. The humid states were seriously affected in 1930 and to a lesser extent in 1931 and 1934. The semiarid states underwent minor droughts in 1931 and 1933, which added to the catastrophe of 1934. Drought conditions during these years are of more than academic interest. They stand out as a limiting basis in the availability of surface and ground waters in works involving many millions of capital outlay. If future water supplies are to be unfailing, sufficient storage must be provided to withstand the recurrence of similar shortages at any time.

This report summarizes, as an aid to the more detailed analyses that will arise in the consideration of specific projects, some of the more outstanding questions related to droughts, both physical and economic. It outlines the nature and extent of the droughts of 1930-34; compares them with past dry periods in terms of precipitation, runoff, ground water, evaporation, and transpiration; and sketches the effects of droughts on water supplies as related to a variety of human purposes, including agriculture, domestic and industrial uses, health, power, navigation, and recreation and wild life. It also touches upon the relief, political, and economic elements.

This report is based on information collected in the various states under the direction of the 36 district engineers of the United States Geological Survey, supplemented by data made available through the United States Weather Bureau, Bureau of Agricultural Economics, Bureau of Public Health Service, Office of the Chief of Engineers, Bureau of Reclamation, Emergency Relief Administration, American National Red Cross, and various state agencies.

Abstract No. 625.

Hubbard, W. A. 1950. The climate, soils and soil-plant relationships of an area in southwestern Saskatchewan. Sci. Agr. 30:327-342.

The approximate centre of the area studied is Swift Current, Saskatchewan. Of the total area, approximately 60% is under cultivation. Of the remainder, 2% is abandoned land, dominated by perennial and annual weeds, and 35 to 40% is native sod.

The climate is classified as semiarid with a precipitation-evaporation ratio of 0.45. The highest rainfall occurs during the month of June. Great extremes of temperature characterize the area, with a total variation of over 150 degrees and a frost-free period of approximately 120 days.

Composite soil samples were collected and analysed from all sites selected. Mechanical analysis, moisture equivalent, and wilting coefficient were obtained. Close correlation between the size of soil particles and the moisture factors is shown.

The vegetation of the region is described. This is comprised mainly of the grasses of the mid-grass formation, made up of several associations, namely, *Stipa-Bouteloua*, *Bouteloua-Stipa*, *Agropyron-Stipa*, and an *Agropyron* consociation. For the most part, the soils of the zone are characterized by light-brown coloured surface soils and a layer of lime ($CaCO_3$) accumulation relatively close to the surface.

The mineral elements of the soil do not appear to be limiting factors of plant growth on the area, although responses have been obtained by the use of manure. To date, however, there is little, if any, information on the mineral requirements of native plants in the Brown soil zone.

Climatic conditions throughout the area are assumed to be the same; however, soil texture which indirectly controls available moisture, is definitely correlated with the dominant grasses. A highly significant correlation was found between *Agropyron smithii* and percent clay content of the soil; and a significant negative correlation was observed between *Bouteloua gracilis* and the percent of clay. However, no correlation was found between *Koeleria cristata* or *Stipa comata* and the percent clay content of the soil.

Abstract No. 626.

Hubbard, W. A. 1951. Rotational grazing studies in western Canada. J. Range Manage. 4:25-29.

From 1932 to 1937, inclusive, a deferred-rotational experiment was carried out to determine the effects of this system of grazing in comparison with continuous grazing on vegetation and livestock. Two rates of grazing were used, 20 and 30 acres/head, or approximately 2.9 and 4.3 acres/cow month. The area selected represents the shortgrass prairie of Canada, a *Boutelous-Stipa* association.

Area-list quadrats and periodic weighings of the cattle were the principal methods used in the study. Under the heavier grazing, the vegetation on both the rotated and the continuously grazed fields suffered, but most pronouncedly on the latter. At this rate of grazing there was no significant difference in the gains made by the cows nor in the weaning weights of the calves. On the moderately grazed fields the stand of the primary forage species was maintained better under rotational use. At a grazing rate of 30 acres/head the average weaning weight of the calves in the rotated fields was significantly lower than that of the calves in the continuously grazed areas, while the average gain of the cows was identical.

It may be concluded that conservative continuous grazing in the region concerned is the most practical method of pasture use.

Abstract No. 627.

Hubbard, W. A., and S. Smoliak. 1953. Effect of control dykes and furrows on short-grass prairie. J. Range Manage. 6:55-62.

Most of the water available to the shortgrass prairie is from spring rain. As the snow melts great quantities of water are freed. Utilization of this water is very important to the stockman, hence dams and dugouts have been constructed to conserve some of the water for the late, dry summer. As an added aid to conservation and utilization of spring runoff, contour furrows and dykes and dams were constructed to test the types of structures and to increase forage production on limited areas by additional moisture. After 13 years, clippings were made and vegetation analyzed to evaluate the benefit of the work. It was found that contour dykes were of real benefit in increasing the volume of forage produced. The contour furrows became filled with ice and snow during the winter and were of no value in holding or spreading water. All dykes should be seeded down soon after construction to prevent washing and erosion.

Abstract No. 628.

Hubbell, D. S., and J. L. Gardner. 1944. Some edaphic and ecological effects of water spreading on range lands. Ecology 25:27-44.

The results of 8 years of study of the vegetation and soils in portions of three valleys in northwestern New Mexico as they are affected by water and sediment diverted from ephemeral streams are presented.

Abstract No. 629.

Hubbell, D. S., and J. L. Gardner. 1950. Effects of diverting sediment-ladened runoff from arroyos to range and crop lands. U.S. Dep. Agr. Tech. Bull. 1012. 83 p.

Water spreading is the practice of diverting flows from ephemeral streams and distributing the water over permeable soils of valley floors. Its effects were investigated at the Navajo Experiment Station in northwestern New Mexico during a 9-year period, 1935-43. Water was spread on 14 areas of native range land, otherwise untreated, by plugging the arroyos with earthen dams. The effect of water spreading was studied intensively on three of these sites and observed in less detail on the others. Additional studies were made on plots seeded with range grasses and field crops and on lysimeter plots seeded with the same grasses and watered with water-sediment mixtures carrying sediment of known quantity and quality.

Information was obtained on the responses of soil and vegetation to water spreading and on the quantity of sediment carried away by runoff from eroded uplands. The results of the study indicate, also, the extent to which sediment, if not controlled by some such means as water spreading, will obstruct normal stream flow and reduce the capacity of reservoirs.

Abstract No. 630.

Huddleston, E. W. 1970. Comprehensive Network Site description, PANTEX. U.S. IBP Grassland Biome Tech. Rep. No. 45. Colorado State Univ., Fort Collins. 12 p.

The Pantex Site is located on the Texas Tech University research farm. Texas Tech University research farm is located in the northern panhandle of Texas near Amarillo, Texas. The Pantex Site is located 15 miles east of Amarillo, Texas, on U.S. 60. The total land area is 16,076 acres, of which Texas Tech has 5,821.9 acres deeded and an agricultural use permit for an additional 8,000 acres of land now operated by the U.S. Atomic Energy Commission. The ungrazed study area is located in a 35-acre pasture bordered on all sides by pasture. Since 1966, no animals have been pastured on it; however, cattle have been held in the pasture for 1 to 3 days once or twice a year. The 158-acre pasture which will be used for the grazed treatment and the 1969/ungrazed 1970 treatment has been grazed moderately to lightly each year in a systematic grazing management procedure. Plant species composition of this pasture is similar to the ungrazed tract; however, a noticeable litter differential is present. This study area is located approximately 1 mile from the ungrazed site.

Abstract No. 631.

Huddleston, E. W., C. R. Ward, R. E. Howard, and L. G. Richardson. 1969. Some contributions to the study of grasslands insect populations. U.S. IBP Grassland Biome Tech. Rep. No. 48. Colorado State Univ., Fort Collins. 9 p.

Preliminary investigations were initiated in September 1969 to evaluate techniques for the study of grasslands insect populations. Three methods of population sampling--the Quick-Trap, the D-vac vacuum insect net, and the sweep net--were evaluated on two dates which spanned the first killing frost; this permitted the evaluation of the effect of the first freeze on range insect populations. The efficiency of Berlese-type extraction funnels was also evaluated.

Abstract No. 632.

Huddleston, E. W., H. N. Howell, W. J. Fournier, C. W. O'Brien, and C. R. Ward. 1970. Population trends of grassland insects on a mixed prairie. Entomol. Soc. Amer., Nat. Meeting, November 30-December 3, Miami, Florida.

Samples were taken using the Quick-Trap, D-vac method described in IBP Grassland Biome Technical Report No. 79. Beginning on April 10, 1970, samples were taken at 2-week intervals until October 23, 1970. After October 23, 1970, samples were taken at 1-month intervals. Insect populations showed a bimodal trend during the sampling period. The first peak occurred in May, and the second peak occurred during July and August.

Data indicates a significant correlation between rainfall and the size of insect populations. Data is presented comparing percentages of sucking insects to chewing insects and insect numbers vs. insect biomass per $\frac{1}{2}$ m^2.

Abstract No. 633.

Huddleston, E. W., W. J. Fournier, H. N. Howell, Jr., and C. R. Ward. 1971. Effect of first killing frost on rangeland insect populations. Entomol. Soc. Amer., Southwestern Branch Meeting, February 14-16, El Paso, Texas.

Insect samples were taken prior to, during, and after periods of below freezing weather. Data indicates that short periods of freezing weather do reduce the numbers of some insect groups, but other insect groups showed a definite increase in numbers. In fact, the overall number of all groups present increased during short periods of below freezing weather.

After sustained periods of freezing weather, the numbers of all groups of insects were reduced drastically. Data indicates that sampling should not be terminated with the first freeze, but does suggest an evaluation of the value of sampling after sustained periods of below freezing weather.

Abstract No. 634.

Huddleston, E. W., H. N. Howell, Jr., W. J. Fournier, and C. R. Ward. 1971. Insect populations on a southern mixed prairie. Entomol. Soc. Amer., Southwestern Branch Meeting, February 14-16, El Paso, Texas.

Insect herbivores fall into two major classes based on type of mouthparts, piercing-sucking and biting-chewing. A comparison of the numbers and biomass of each type was made to gain information on the manner in which energy is transferred in the insect compartment. Insect population components were monitored over a period of time and correlated with abiotic factors.

Abstract No. 635.

Huddleston, E. W., C. R. Ward, C. W. O'Brien, W. J. Fournier, and H. N. Howell, Jr. 1971. Insect population studies. U.S. IBP Grassland Biome Tech. Rep. No. 79. Colorado State Univ., Fort Collins. 41 p.

Insect populations on the Pantex Site, U.S. IBP, were quantitatively sampled by Quick-Trap, D-vac combination at 2-week intervals from April 10, 1970, to October 23, 1970, inclusive. Qualitative samples were taken by pitfall traps, light traps, sweep net, and observation. Three treatment effects were tested--ungrazed, moderately grazed, and grazed 1969/ungrazed 1970. Each treatment sample consisted of two replications of six randomly selected quadrats. A circular area of 0.5 m^2 was covered by the Quick-Trap in each quadrat. Plant litter and insects collected in the D-vac bags were placed in Berlese funnels and left for 48 hours under a 60-watt light bulb. The insects were collected in alcohol. Insects were sorted to easily recognized taxa--family level or below. A bimodal trend in insect numbers was detected during the season. The first maximum occurred in August and was caused by false chinch bug adults and nymphs of these and other Lygaeidae. The maximum number of insects collected per square meter was 5350. Insect biomass was at a maximum in August with 0.20 g/m^2. The percentages of piercing-sucking phytophagous insects tended to exceed the percentages of biting-chewing phytophagous insects in both numbers and biomass. Total insect biomass is expected to exceed 2.0 g/m^2. The lower figures this season were due to imperfection in sampling and extraction of the insects and less than normal rainfall during the season.

Abstract No. 636.

Hudson, H. J., and J. Webster. 1958. Succession of fungi on decaying stems of *Agropyron repens*. British Mycol. Soc., Trans. 41(2):165-177.

The succession of fungi on decaying stems of *Agropyron repens* has been followed during a 19-month period after flowering. The patterns of fungal distribution follow broadly that already outlined for *Dactylis glomerata*. The colonization of flowering and non-flowering tillers in *Agropyron* is very similar. Isolations from decaying stems are briefly described.

Abstract No. 637.

Hughes, J. H. 1969. An evaluation of the dry weight rank method of determining species composition of plant communities. M.S. Thesis. Colorado State Univ., Fort Collins. 111 p. (Advisor: George M. Van Dyne).

The dry weight rank method was applied to data from eight grassland and shrub communities. These varied from the complex, rapidly changing early stages of old field succession in Tennessee to the simple, climax vegetation of the salt desert shrub community of western Colorado. Through computer analysis of these data sets, the variation in the results due to plot size, observer variability, and analysis options was determined. It was found that there was no statistically significant difference in predictions due to plot size or observer variability. Effect of using each of the analysis options is presented. The results indicate that dry weight rank is a suitable method of determining the botanical composition of the variety of communities to which it was applied. Suggestions are given for field use of the method.

Abstract No. 638.

Hulbert, L. C. 1969. Fire and litter effects in undisturbed bluestem prairie in Kansas. Ecology 50:874-877.

Fire, like climate and soil, is a major factor affecting prairie ecosystems, yet we know little about why the effects occur. This study was initiated to help separate and assess heat, nutrient, and litter-removal effects of fire.

Abstract No. 639.

Hulett, G. K. 1962. A phytosociological study of dune sand vegetation in Saskatchewan. Bull. Ecol. Soc. Amer. 43:59.

Fifty-two stands located on various physiographic positions in two Saskatchewan dune sand areas were ordinated by use of similarity coefficients. Species behavior along the ordination illustrated the existence of a vegetational continuum in response to physiographically controlled moisture and stability gradients. Actively eroding and depositing areas had rhizomatous species, particularly *Agropyron* spp. and *Psoralea lanceolata*, as dominants. Stabilized blowouts were covered by radial mats of *Juniperus horizontalis* along with certain herbaceous species, while stabilized dunes supported grassland dominated by *Stipa comata*, *Carex eleocharis*, and *Koeleria cristata*. The most mesic sites, dune depressions, were occupied primarily by *Carex heliophila* and shrubs such as *Symphoricarpos occidentalis*, *Rosa woodsii*, and *Prunus virginiana*.

Abstract No. 640.

Hulett, G. K., R. T. Coupland, and R. L. Dix. 1966. The vegetation of dune sand areas within the grassland region of Saskatchewan. Canadian J. Bot. 44: 1307.

Quantitative data were collected in 101 vegetational stands in two regions considered to be representative of dune sand vegetation within the grassland zone of Saskatchewan. The purpose was to ascertain species distributional patterns and to attempt to relate these distributions to environmental factors. The data were used to establish two ordinations, one based on physiographic types and the other on compositional similarities between the stands. Areas of active erosion and deposition are dominated by rhizomatous species, particularly *Agropyron* spp. and *Psoralea lanceolata*. *Juniperus horizontalis* is prominent in stabilized blowouts, while stabilized dunes support grassland dominated by *Stipa comata*, *Carex eleocharis*, and *Koeleria cristata*. The most mesic sites, dune depressions and sand flats, are occupied by *Carex heliophila* and *Agropyron* spp. with a shrubby overstory of *Symphoricarpos occidentalis*, *Rosa woodsii*, and *Prunus virginiana*. Factorial gradients involved in the distributional patterns include a moisture gradient ranging from xeric to mesic and a stability gradient ranging from active complexes to stabilized areas. The existence of these gradients and the intergradation of the species behavioral patterns offer strong evidence of the continuous nature of dune sand vegetation in Saskatchewan.

Abstract No. 641.

Hulett, G. K., and G. W. Tomanek. 1967. Forage production on a clay upland range site in western Kansas. J. Range Manage. 22(4):270-276.

Forage production on clay upland range sites is related to seasonal precipitation, with May + June precipitation the most reliable predictor of total forage production. Annual carrying capacities, based on May + June precipitation for a clay upland site, range from 2 acres/AUM in wet years through 3 acres/AUM in average years to 4 acres/AUM in dry years.

Abstract No. 642.

Hulett, G. K., C. D. Sloan, and G. W. Tomanek. 1968. The vegetation of remnant grasslands in the loessial region of northwestern Kansas and southwestern Nebraska. Southwestern Natur. 13(4): 377-391.

The purpose of this study was to inventory and analyze the compositional structure of the vegetation and also to attempt to discern causal environmental factors influencing species distributions within the loessial region of northwestern Kansas and southwestern Nebraska. The study was limited to areas of native vegetation that had not been disturbed by burning, grazing of domestic livestock, periodical mowing, or by other activities of man for a period of not less than 15 or 20 years.

The family composition of the vascular plants in the loessial region indicated that 23.5% of the vegetation was in the family Gramineae, while Compositae, Fabraceae, and Euphorbiaceae were represented by 21%, 10.3%, and 5.6%, respectively.

The dominant grasses and forbs in the loessial area varied as a result of remnant stand exposure, slope, and position on slope. Blue grama (*Bouteloua gracilis*) and big bluestem (*Andropogon gerardi*) were dominant on dry level uplands while very dry, steep upper slopes afforded side-oats grama (*Bouteloua curtipendula*) and little bluestem (*Andropogon scoparius*) with greatest success. All four of these species were prominent on gentle upper slopes and gentle lower slopes, which were considered dry-mesic in moisture status. The mesic lowlands supported stands of big bluestem and western wheatgrass (*Andropogon smithii*).

Most species of forbs and grasses were distributed in response to a topographic gradient, which influenced site moisture conditions.

Abstract No. 643.

Hulett, G. K., and G. W. Tomanek. 1969. Remnant prairies on the shallow limy range site in north central Kansas. J. Range Manage. 22:19-23.

Eleven ungrazed shallow limy range sites were studied as to species composition, edaphic characteristics, and range condition. These stands were located in the shale-limestone region of north central Kansas. The sites were dominated by little bluestem and big bluestem. Edaphic conditions were marked by high surface rockiness, basic pH, low mulch, and low water-retaining capacity. Range condition as assessed by the Dyksterhuis method placed all stands in excellent range condition.

Abstract No. 644.

Hulett, G. K., G. L. Van Amberg, and G. W. Tomanek. 1969. Soil depth-vegetation relationships on a shallow limy range site in western Kansas. J. Range Manage. 22:196-199.

Soil depth heterogeneity within the shallow limy range site in western Kansas results in differences in range composition and production. Deep soils produce more forage than shallow (< 4 inches) soils. Such variations in production within an apparently uniform range site should be considered when evaluating range condition and establishing stocking rates.

Abstract No. 645.

Hulett, G. K., and G. W. Tomanek. 1971. Herbage dynamics on a mixed prairie grassland near Hays, Kansas. U.S. IBP Grassland Biome Tech. Rep. No. 108. Colorado State Univ., Fort Collins. 35 p.

Specific objectives of the project included: (i) to estimate the net primary production of shoot and roots, (ii) to estimate standing dead and mulch standing crops, and (iii) to estimate the caloric content of biomass components. Data were collected from an ungrazed and a grazed site on a typical *Andropogon-Bouteloua* community. Peak standing crop of green herbage varied from 222 g/m^2 on the ungrazed prairie (July 17) to 243 g/m^2 on the grazed area (July 2). Average productivity rate varied from 2.10 g/m^2 per day on the grazed area. Average standing dead for the ungrazed treatment was 123 g/m^2 while for the grazed treatment it was 84 g/m^2. Mulch estimates varied from a mean of 1,031 g/m^2 on the ungrazed to 375 g/m^2 on the grazed. Peak root standing crops of 1,500 to 1,600 g/m^2 occurred in summer and low root standing crops of 446 to 454 g/m^2 occurred during fall and early winter.

Abstract No. 646.

Hulett, G. K., J. H. Brock, and J. E. Lester. 1972. Community structure and function in a Kansas remnant prairie. Second Midwest Prairie Conf., Proc. (In press).

Eight communities in the prairie were dominated principally by *Andropogon gerardi*, *Andropogon scoparius*, *Buchloe dactyloides*, *Bouteloua gracilis*, *Bouteloua curtipendula*, *Agropyron smithii*, and *Sporobolus asper*. The distribution and abundance of these grasses were controlled by soil factors, topographic position, underlying parent material, and past history.

Net shoot production and biomass transfer rates were estimated in one community dominated by *Andropogon gerardi*, *Andropogon scoparius*, and *Bouteloua curtipendula*. Net shoot production was estimated at 296 g/m^2/day.

Biomass transfer rates were determined for these biomass categories: standing dead, fresh mulch, and humic mulch, whose average standing crops were 198, 260, and 500 g/m^2, respectively. Transfer rates ranged from 0.11 to 1.8 g/m^2/day for standing dead to fresh mulch, from 0.29 to 2.0 g/m^2/day for fresh mulch to humic mulch and from 0.71 to 2.1 g/m^2/day for losses from humic mulch. Net root-rhizome production (666 g/m^2/(year × 30 cm depth)) was estimated by multiplying the average root-rhizome standing crop (2635 g/m^2/30 cm depth) by a turnover coefficient (.25).

Abstract No. 647.

Hull, A. C., Jr., and W. M. Johnson. 1955. Range seeding in the ponderosa pine zone in Colorado. U.S. Dep. Agr. Circ. 953. 40 p.

Reseeding can restore the grass and help to prevent erosion on a half-million acres of depleted parks and openings in the ponderosa pine zone in Colorado. The ponderosa pine type extends along the Front Range in Colorado and across the southwestern part of the state, occupying about 4 million acres.

Twenty-eight studies were made at 20 locations to determine the species and methods for seeding these lands. In addition, records were obtained from 391 other seedings on lands in the ponderosa pine zone. Based on all studies and observations recommendations are made for seeding parks and openings in the ponderosa pine zone.

Abstract No. 648.

Humes, H. R. 1960. The ecological effects of fire on natural grasslands in western Montana. M.S. Thesis. Montana State Univ., Missoula, Montana. 85 p.

The ecological effects of accidental burning on grassland vegetation, native to the Palouse prairie region, were studied on seven mountain ranges near Missoula, Montana, in 1958 and 1959.

On one- and two-year-old burned ranges, plant growth, development, and production of the major grass and forb species, soil temperatures, and soil constituents were measured and compared with adjacent unburned stands.

Abstract No. 649.

Humphrey, R. R., and P. B. Lister. 1941. Native vegetation as a criterion for determining correct range management and run-off characteristics of grazing lands. J. Forest. 39:837-842.

Few range management programs can be fully effective unless based on a thorough knowledge of the vegetation of the range unit under consideration. This knowledge includes much more than present grazing capacities; it is intrinsically a knowledge of present vegetation considered in terms of the most desirable vegetation that might grow on the range unit involved. It is also a knowledge of the specific land-use practices that have resulted in the present vegetation and of remedial measures that will restore deteriorated areas. It is, in short, adequate knowledge to recognize range condition and to differentiate between top-condition and deteriorated ranges, to classify different degrees of deterioration, and to prescribe corrective measures.

Abstract No. 650.

Hunt, W. R. 1970. The influence of leaf death on the rate of accumulation of green herbage during pasture regrowth. J. Appl. Ecol. 7:41-50.

Spring and autumn measurements of growth and death in a perennial ryegrass-white clover sward were made. By integration of the growth and death data, an estimate was obtained of absolute levels of productivity throughout the successive stages of regrowth.

Initial reductions in the rate of accumulation of green herbage that mark the beginning of the phase of decreasing growth rate were accounted for by leaf death. When clover was dominant, there was an apparent reduction in the rate of overall synthesis as well. This reduction occurred with clover shortly after complete light interception was attained in both seasons. The lack of any similar effect with ryegrass until lodging occurred is attributed to species differences in growth habit and the subsequent effects of intense shading on the lower canopy.

Abstract No. 651.

Hunter, B., P. W. Cockerill, and H. B. Pingrey. 1939. Type of farming and ranching areas in New Mexico. Part I. New Mexico Agr. Exp. Sta. Bull. 261. 68 p.

A type of farming and ranching study has been conducted in New Mexico in order to acquire a comprehensive understanding of the agriculture of the state as a whole; to point out why the agriculture is as it is; to determine what types of farming and ranching are to be found in different parts thereof; to differentiate the state into areas and subareas in each of which the agriculture differs from that prevailing in adjoining areas; to describe each of these areas and the agriculture therein; to ascertain the nature and significance of the major problems which confront the farmers and ranchmen of the state; and, finally, to suggest along what lines major adjustments may be undertaken.

Abstract No. 652.

Hunter, R. F., and S. A. Grant. 1961. The estimation of "green dry matter" in a sample by methanol-soluble pigments. J. British Grassland Soc. 16(1):43-45.

To estimate what proportion of total DM of an herbage sample arises either from dead or green herbage, four methods have been compared. One of these, the pigmentation method, is described.

Abstract No. 653.

Hurley, N. A. 1968. Observations on the Pawnee Grasslands. Monthly Rep. of the Denver Field Ornithol. 4(2):1-2.

The article cites the different species of birds observed at the Pawnee grasslands. A total number of 41 different birds were watched, the most common ones being Mallard, Horned Lark, Robin, and Western Meadowlark.

Abstract No. 654.

Hurtt, L. C. 1939. Overgrazing increases production costs by reducing number and weight of range calves. Cattleman 26(5). 52 p.

Overgrazing increases feed costs of producing range calves by more than one-third when compared to production costs on adjacent range grazed more conservatively. This is the result from a range experiment at Miles City, Montana, conducted over a 5-year period by this station in cooperation with the Montana Agricultural Experiment Station and the Bureau of Animal Industry. This experiment was started in 1933 on typical shortgrass range pastures on which blue grama, bluestem wheatgrass, niggerwool, and buffalo grass predominated. The object was to find the best range utilization and management practices for such ranges. The experimental area was subdivided into three portions each grazed at a different degree or intensity of use--overgrazed 23.1, moderately grazed 30.5, and lightly grazed 38.8 acres per head, respectively, by three groups of 20 breeding cows and their calves. High grade Hereford cows of uniform age and breeding were selected for this test and grazed on the three adjacent sets of native range pastures. More supplemental feed in the form of hay was required for cows on the small pastures, otherwise the breeding, care, and other factors were the same for all lots.

Abstract No. 655.

Hurtt, L. C. 1948. For a better range management. U.S. Dep. Agr., Yearbook 1948:486-491.

Many factors point to the need for better range management. Good range management aims to regulate grazing, to safeguard resources and get sustained, maximum production of livestock, and the best forage species. The experience of the past half-century has clarified the benefits of such a program of better use. Tangled ownership patterns, public and private, caused excessive prices to be placed on poor rangeland. Extensive over-use of land, due to a long drought period, exhausted feed reserves. Other factors have contributed to this widespread range depletion. Reduced forage density, vigor, and production are some important indicators. Excessive trampling and grazing result in increased floods, siltation, and runoff, reduced soil water, and reduced forage growth. By 1944, this range had recovered to pre-drought production under moderate stocking. Unfortunately, however, many were restocked too quickly to allow full recovery.

Abstract No. 656.

Hurtt, L. C. 1948. The types of plains vegetation. U.S. Dep. Agr., Yearbook 1948:484-486.

The plains vegetation is of five types, based on the native vegetation on 231 million acres before a fourth of the total was plowed.

The northern shortgrass type covers about 228,000 square miles where average precipitation is from 11 to 17 inches a year. The dominant species are blue grama, bluestem wheatgrass or western wheatgrass, needle-and-thread and green needlegrass, buffalo grass, Sandberg bluegrass, and threadleaf sedge. Shrubby plants are widely distributed and provide some winter forage.

The tallgrass prairie type grows in a zone 50 to 100 miles wide where precipitation ranges from about 17 to nearly 30 inches, and much of the best land is cultivated. The main species are prairie beardgrass, bluejoint turkeyfoot, blue and side oats grama, bluestem wheatgrass, prairie dropseed, and bluegrass.

The sand-hills type occupies about 21,500 square miles. Precipitation there ranges from 15 to 22 inches. This is one of the best watered of all plains types. The principal species are prairie sandgrass, sand dropseed, sandhill muhly, and prairie beardgrass, bluejoint turkeyfood, and turkeyfoot.

The sagebrush-saltbrush grassland type includes a total of about 43,000 square miles where average yearly precipitation drops to 7 to 12 inches. Elevations reach upward to 7,500 feet. The principal species are bluestem wheatgrass, needle-and-thread, bluebunch wheatgrass, and sand dropseed. Black and big sagebrush, two or more saltbushes, and greasewood are important shrubs.

The open-forest type grows on mountain uplifts. Ponderosa pine, Douglas-fir, and spruce occur at the higher elevations. About 18,000 square miles is within this type, a large part of which produces usable forage. Still more important is the extra water for irrigating ranches from snow stored in the mountains. The grasses include bluebunch and bluestem wheatgrass, Idaho fescue, mountain bromegrass, pinegrass, and others.

Abstract No. 657.

Hurtt, L. C. 1951. Managing northern Great Plains cattle ranges to minimize effects of drought. U.S. Dep. Agr. Circ. 865. 24 p.

In the northern Great Plains severe drought is an ever-present threat to livestock operations. From 1878 to 1939, drought occurred on the average of once every 5 years. A major problem facing range livestock producers in this vast area is how to manage their range and livestock to minimize the effects of this recurring hazard.

From 1932 to 1936 the Forest Service, in cooperation with the United States Bureau of Animal Industry and the Montana Agricultural Experiment Station, conducted a cattle grazing study at the United States Range Livestock Experiment Station near Miles City, Montana. The study was to determine the rate of range stocking that would sustain high forage and livestock production and stabilize range operations, but severe drought occurred in 1934 and 1936 and disturbed the original plan. However, valuable information on the effects of drought was obtained.

Data from this experiment and experience gained over the years indicate some practical means of managing northern Great Plains ranges and the cattle grazing thereon to minimize the effects of the next drought. Basic management practices include (1) conservative stocking, (2) adequate supplemental feed supplies, (3) provision for adequate salt and stock water, (4) early breeding season, (5) seasonal use of the range, (6) uniform distribution of livestock over the range, and (7) inclusion of both steers and cows in the commercial herd.

Recommended adjustments during drought years include (1) close culling of dry cows, undesirably bred cows, and steers; (2) early marketing of culled animals; (3) changes in the plan of seasonal use to utilize early starting forage species; and (4) caution in restocking the range before good vigor has returned to the forage plants.

Abstract No. 658.

Hurtt, L. C., and E. J. Woolfolk. 1940. Range calf production as affected by grazing intensity. Northern Rocky Mountain Forest Range Exp. Sta. Res. Note No. 9. 5 p.

What are the relative effects of heavy and light grazing on yearlong shortgrass ranges as measured by the weights of calves weaned? Does heavy grazing result in a saving in the yearlong feed cost--range plus hay--in range calf production?

An answer to these questions is now provided by six years of data from a range experiment at the U.S. Range Livestock Experiment Station near Miles City, conducted by the Forest Service since 1933 in cooperation with the Bureau of Animal Industry and the Montana Agricultural Experiment Station. A total of 60 high quality Hereford cows were divided into three lots of 20 each and grazed at varying intensities on adjacent yearlong range pastures with an average of 23.1 acres for heavy use, 30.5 acres for moderate use, and 38.8 acres of range for light use for each of the 20 breeding cows and their calves. Typical shortgrass vegetation with a high degree of uniformity was the aim in fencing these pastures in which blue grama, bluestem wheatgrass, buffalo grass, niggerwool, and little bluegrass are the five most abundant and important grasses. The breeding, care, and other conditions were the same for the three lots in the experiment except that those with the smaller range acreage have required more hay on the average.

Abstract No. 659.

Hutcheson, H. L., and E. S. Olson. 1967. A comparison of soil algae in grazed and ungrazed grasslands in eastern South Dakota. South Dakota Acad. Sci., Proc., 46:257. (Abstr.).

Soil samples were collected from an overgrazed pasture and an adjacent, ungrazed grassland near White, South Dakota. These were examined to determine the kinds and numbers of algae present. A total of 13 genera were found. Blue-green algae were the most abundant type in both areas. There was a greater number of both green and blue-green algae in the grazed area than in the ungrazed. There was no difference in the number of diatoms. There was a correlation between the presence of blue-green algae and resistance of the soil to dispersion.

Abstract No. 660.

Hyder, D. H. 1969. The impact of domestic animals on the function and structure of grassland ecosystems, p. 243-260. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The grassland at the Central Plains Experimental Range (Pawnee Site) is described as shortgrass plains due to climatic conditions. This grassland is unique because grazing by livestock has only slight effects on species composition, even though excessive stocking rates reduce herbage and beef production. Herbage production is reported to amount to about 670 kg/ha annually. Blue grama, the dominant species, grows by spurts when soil water is available for growth in the warm season. The impact of grazing on herbage production is a function of the frequency and duration of the spurts of growth as well as of the stocking rate. At a moderate stocking rate of 1.05 ha/yearling-month in the warm season (May through October), the demand for forage amounts to about 1.1 kg/ha/day; whereas the herbage growth rate may exceed 20 kg/ha/day for short periods. Maximum daily intake of forage by yearlings is attained when the standing crop amounts to about 340 kg/ha of dry matter. Thus, the annual demand for forage (about 200 kg/ha) requires a production of at least 540 kg/ha of herbage. Forage intake by cattle probably accounts for less than one-fourth of primary production. The energy content of the forage consumed is returned to the soil (about 43%), dissipated to the air (about 48%), and retained in animal gain (about 9%). About 2 or 3% of the energy fixed in primary production of herbage, therefore, is retained in animal gain.

Abstract No. 661.

Hyder, D. N. 1970. The leaf replacement potential of forage grasses. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Leaf growth and leaf regrowth after defoliation are fundamental in grazing management. Some grasses have stemless (culmless) vegetative shoots and others have (culmed) vegetative shoots. In both cases some shoots become reproductive. In stemless vegetative shoots, the source of new leaves is protected from grazing because the growing points (shoot apices) remain at ground level. In stemmed vegetative shoots, leaves can be removed at an early stage of growth by cutting just above the growing points. Later, the lower part of the stems are leafless, but new leaves arise at the top. The growing points are elevated as the stems elongate. Elevated growing points can be removed. In this case, leaf replacement requires the initiation of new shoots (tillers). In reproductive shoots, leaves can be removed at an early stage of growth by cutting just above or through young (rudimentary) inflorescences. The stems remain committed to elongate, but can not produce new leaves. (Regrowth by different kinds of shoots after defoliation at an early stage of growth is illustrated below.) Leafless stems are undesirable. Harvest can be scheduled to stop stem elongation and promote growth of a new set of shoots. This is the principle involved in the development of two-crop and three-crop harvesting or grazing systems.

Differences among species make it necessary to understand the developmental morphology of each as a basis for better systems of grazing. Shoot growth by important species can be described unit (phytomer) by unit to define the leaf-replacement potential after defoliation at any stage of growth.

Abstract No. 662.

Hyder, D. N. 1969. Defoliation in relation to vegetative growth, Chapter 22. *In* V. B. Younger and C. M. McKell [ed.] The biology and utilization of grasses. Academic Press, New York.

If other elements are equal, plant growth is a function of the amount of leaf tissue exposed to sunlight. Nevertheless we tend to ignore the morphological details of leaf expansion and leaf replacement. Since better management can be attained by matching the harvest to the growth of plants, this chapter emphasizes the morphological aspects of vegetative growth as related to defoliation.

Organization of the subject matter of developmental morphology to emphasize the effects of defoliation is largely new to the literature. A new concept of leaf replacement potential is an important factor in the determination of resistance to grazing. When the rhythm of growth of a plant is understood, the same concept is a key to appropriate grazing management, especially on semiarid grasslands. Terminology is conventional, except for descriptive phrases such as "culmed vegetative shoots" and "culmless vegetative shoots."

Abstract No. 663.

Hyder, D. N., and R. E. Bement. 1964. Six weeks fescue as a deterrent to blue grama utilization. J. Range Manage. 17:261-264.

Six weeks fescue was found unacceptable to cattle at all seasons, and nitrogen fertilization did not increase its rooting strength or palatability. It contributed nothing to forage supply and interfered with cattle grazing of blue grama. Alternative practices for alleviating irregular grazing distribution include weed control or fertilization of infested areas to attract cattle.

Abstract No. 664.

Hyder, D. N., R. E. Bement, E. E. Remmenga, and C. Terwilliger, Jr. 1965. Frequency sampling of blue grama range. J. Range Manage. 18:90-94.

A quadrat 2 inches square satisfactorily sampled frequency distribution of blue grama, but a complementary quadrat 16 inches square was needed to sample associated species. A tallying technique was developed using beads and plastic tubes.

Abstract No. 665.

Hyder, D. N., R. E. Bement, J. J. Norris, and M. J. Morris. 1966. Evaluating herbage species by grazing cattle, part I, food intake. Int. Grassland Congr., Proc., 10:970-974.

Water-intake rates for European cattle were used to develop a water-intake method of estimating the amount of food eaten by cattle on range and pasture. The method requires the measurement of mean air temperature, moisture content of food, and water drunk.

Field data were used to evaluate the method. The mean adjusted food intake of yearling Hereford steers was 17.6 and 18.2 lb./day, as estimated by water-intake and herbage-clipping methods, respectively. Estimates by water intake were less variable than those obtained by herbage clipping.

Abstract No. 666.

Hyder, D. N., R. E. Bement, J. J. Norris, and R. R. Wheeler. 1966. Evaluating herbage species by grazing cattle, part II, food quality. Int. Grassland Congr., Proc., 10:974-977.

The net-energy equation for maintenance and production is adapted for estimating the apparent food quality of herbage eaten by grazing cattle. In the adaptation, gain and travel components are counted as net-energy requirements for production. Apparent food quality is calculated for maintenance.

The method requires the measurement of food intake, liveweight, liveweight gain, and distance traveled by the cattle.

Seasonal changes in food intake and apparent food quality were determined for a blue grama (*Bouteloua gracilis*) range pasture. Seasonal changes in the apparent food quality of blue grama herbage illustrate the value of the net-energy equation for evaluating herbage by grazing cattle.

Abstract No. 667.

Hyder, D. N., R. E. Bement, E. E. Remmenga, and C. Terwilliger, Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. J. Range Manage. 19:11-17.

An upland vegetational continuum and three bottomland associations are interpreted from frequency data, but intra-site heterogeneity masks vegetation-grazing relations. Summer-long grazing at different intensities for 23 years has not affected the frequency percentages of species to a great extent.

Abstract No. 668.

Hyder, D. N., K. L. Knox, and R. E. Bement. 1969. Metabolic components of cattle: Water-soluble tracers for determining water turnover and partitioning by cattle. U.S. IBP Grassland Biome Tech. Rep. No. 10. Colorado State Univ., Fort Collins. 32 p.

The objective of the project on water-soluble tracers for determining water turnover and partitioning by cattle is to determine the energy and nutrient components associated with the water components consumed and excreted by cattle. For example, if fecal water output can be determined, the dry matter and energy concentrations can be added to arrive at total daily amounts.

^{14}C labeled polyethylene glycol (PEG) was used to estimate fecal output, lithium (Li) was used to estimate urine output, and tritiated water ($^{3}H_2O$) was used to estimate total body water and total water turnover. Problems associated with sample collection and tracer extraction had high priority in the initial experiments.

Polyethylene glycol consumed in drinking water is excreted entirely in feces. However, adsorption to organic matter prevents complete recovery, and high concentrations are required for adequate sampling precision. A new extraction procedure that attains 100% recovery has been developed, and labeling with ^{14}C permits the use of very low concentrations. Since we prefer non-radioactive tracers for field studies, three non-radioactive compounds were tested as tracers of fecal output. These compounds were not satisfactory because of metabolic conversions and adsorption losses.

Lithium is excreted almost entirely in urine and can be used as a tracer of urine output. However, techniques for recovering Li from both urine and feces still require improvement.

Tritiated water is excreted in vapor as well as liquid phases of water and has been used widely to determine total body water and total water turnover. Since better sampling procedures are needed, we developed equipment for collecting respired water, which requires no purification and compared respired water with that obtained from saliva, blood, and urine. Tritium concentrations were the same in all water sources. Therefore, field sampling can be designed to accommodate the equipment available and the objectives of a study.

In future work, we will estimate urine and fecal outputs of cattle on pastures stocked heavily (23E) and lightly (23W), as well as to continue studies on the development of water-soluble tracers. For example, fecal output of fistulated steers was measured by total collection. Fecal output by the heifers used to apply the grazing routines was not measured. Urine output was not measured for any animal. Therefore, using water-soluble tracers to estimate urine and fecal outputs can make the work easier and the overall determination of bioenergetics more complete. The work in 1970 will determine sampling precision and accuracy, if the radioactive tracers are given safety clearance.

Abstract No. 669.

Hyder, D. N., and R. E. Bement. 1970. Soil physical conditions after plowing and packing of ridges. J. Range Manage. 23:289-293.

A system of seedbed preparation by moldboard plowing and packing small ridges appears to fulfill two requirements for successful seeding--control wind erosion and eliminate competing vegetation. The percentage by weight of soil aggregates larger than 0.833 mm increases greatly with an increase in the moisture content of soil at the time of packing. A sandy loam soil should contain 9 to 12% moisture when packed to obtain a surface condition greatly resistant to wind erosion.

Abstract No. 670.

Hyder, D. N., K. L. Knox, and C. L. Streeter. 1971. Metabolic components of cattle under light and heavy rates of stocking in 1970. U.S. IBP Grassland Biome Tech. Rep. No. 128. Colorado State Univ., Fort Collins. 42 p.

The work of metabolic components of cattle was conducted on pastures which were stocked lightly (23W) and heavily (23E) in 1970. Animal liveweights and animal days of grazing were monitored throughout the 6 months of warm-season grazing. After the completion of facilities, drinking water containing tritium, lithium, and chromium-EDTA was metered individually to fistulated animals and collectively to herd animals.

Samples of urine and feces were collected daily and composited by weeks for determinations of tracer concentrations and various chemical components. Forage intake was estimated in three different ways, and dry matter digestibility was estimated by a fecal-nitrogen index equation. Under light stocking there were 10.8 animal days of grazing per hectare, during which about 130 kg/ha of forage dry matter was harvested. Under heavy grazing there were 40.9 animal days of grazing per hectare, during which about 257 kg/ha of forage dry matter was harvested.

Abstract No. 671.

Hylton, L. O., Jr., and R. E. Bement. 1961. Effects of environment on germination and occurrence of six-weeks fescue. J. Range Manage. 14:257-261.

Germination data from laboratory experiments were obtained by subjecting seeds harvested at three different stages of ripeness to various temperatures and using tap water or a 0.2% KNO_3 solution as the moistening agent. Germination counts were taken at 7-day intervals through 42 days.

Phenological data were collected from two types of surface soils at various growth stages from March 19 through June 9, 1959. Density of six-weeks fescue was compiled from records at the Central Plains Experimental Range for each year from 1941 through 1960. Fall temperature and rainfall records for this period were investigated.

Results of this study are summarized as follows: (1) The constant temperature of 20°C allowed the best germination under laboratory conditions. Also, 15-25° was the best alternating temperature. (2) Average percent germination was significantly increased when a 0.2% KNO_3 solution was used as the moistening agent rather than tap water. (3) Phenological data indicated that during seedling growth the roots were much longer than the shoots. As the plant approached maturity, this relation gradually reversed. The rate of structural development of the plant appeared to be related to surface-soil texture. (4) Records of plant densities at the Central Plains Experimental Range from 1941 through 1960 revealed that six-weeks fescue density was the highest in 1941 and the second highest in 1958. Records of climatic data for the same period showed that the temperature and moisture conditions in late August and early September of 1940 and 1957 closely paralleled those found to be most favorable for the germination of six-weeks fescue in the laboratory.

Abstract No. 672.

Innis, G. 1972. ELM: A grassland ecosystem model. U.S. IBP Grassland Biome Preprint No. 35. Colorado State Univ., Fort Collins. 16 p.

The SIMCOMP compiler is used to develop a large-scale model of the grassland ecosystem. This model includes abiotic, producer, consumer, decomposer, and nutrient subsections. The flows within the system are both those represented by biological and physical data on the mechanisms associated with the flow and those represented by more tenuous hypotheses on the part of biologists as to the controlling mechanisms of these flows.

The results presented demonstrate the response of the model to perturbations such as grazing and moisture stress. The effects of these perturbations on the ecosystem are presented for a 2-year period. Some of the model results which are not easily observed in the real system, such as the effects of these perturbations on live and dead root biomass, are discussed. This effect is difficult to observe in the field because of problems with root sampling. The complex interactions occurring within this modelled system are discussed in terms of the modelling limitations and assumptions and of the biological implications.

Abstract No. 673.

Innis, G. S. 1972. The second derivative and population modeling: Another view. U.S. IBP Grassland Biome Preprint No. 24. Colorado State Univ., Fort Collins. 18 p.

A paper with a similar title by John Clark appeared in the summer 1971 issue of *Ecology* (52:606-613). This paper represents another view of the material that formed the basis for the previous paper, but with almost completely opposite conclusions.

Abstract No. 674.

Innis, G. 1972. Simulation of biological systems: Some problems and progress. U.S. IBP Grassland Biome Preprint No. 34. Colorado State Univ., Fort Collins. 7 p.

Over the past several years modelling of biological and other systems has certainly been on the upswing. In the biological sciences there has been considerable effort to apply systems analysis and modelling techniques to a wide variety of problems. These applications have often involved people who are not particularly trained in the use of the computers or mathematics and who may be somewhat skeptical of the potential benefits. The modellers, on the other hand, are often not particularly well-trained biologists. As a result of these mismatches, a number of different techniques have been used to establish a rapport between the experimenter and the modeller and to develop useful models of biological systems.

There are two distinct extremes to the scale problem. Small-scale models can be developed effectively with a single modeller and experimenter working together. Indeed, many times the small-scale model is developed by one individual serving in both the modeller and experimenter capacity. At the other extreme of the scale is the problem of developing large-scale models in which some of the problems associated with computing and mathematics become sufficiently important and involved that professionals in these areas are needed. In this situation teams involving modellers and experimenters are required in order to develop effective models. The establishment of rapport and working arrangements in these groups is a problem which often has not been solved to the satisfaction of either of the groups and has, on occasion, severely limited progress.

Abstract No. 675.

Innis, G. S., and L. D. Harris. 1972. An economic model for brush control. U.S. IBP Grassland Biome Preprint No. 29. Colorado State Univ., Fort Collins. 18 p.

An initial mathematical formulation and computer simulation of rangeland brush control is presented.

The utility of such a model takes various forms. First, it elucidates areas where data are inadequate; second, it provides a pedological tool for the evaluation of various parameter inputs; and thirdly, it provides an objective framework for the analysis of input/output relations by requiring (and supplying) explicit quantitative parameter values.

The model is still simple, and therefore we have yet to include some of the factors known to be of importance to brush control practices.

Abstract No. 676.

Inyamah, G. C. 1969. Population trends of insects on *Melilotus officinalis* (L) Lam. on the Pawnee Grassland. M.S. Thesis. Colorado State Univ., Fort Collins. 69 p. (Advisor: Ted Thatcher).

This thesis deals with an ecology study of the insects on *Melilotus officinalis* (L.) Lam. in a grassland ecosystem. Information was gathered on the insects present in order to develop population curves and their host phenology throughout the season. The data collected is intended for use in a computer so that, in the future, theoretical bases would be established for manipulations of ecological phenomena found in grassland ecosystems.

Studies were conducted twice weekly; and time of day, temperature, parts of plant fed upon, and type of damage were recorded. The specimens collected were counted according to species where possible, and representatives were pinned for further identification. The data showed that different insects were present in the field at different times depending on the availability of their food, prevailing weather, and life cycle.

Interaction between plants, insects, and their environment were quite normal, but specific instances were found showing succession and the close relationships of specific insects and plants.

Abstract No. 677.

Ives, R. L. 1950. Frequency and physical effects of chinook winds in the Colorado high plains region. Ann. Ass. Amer. Geogr. 40:293-327.

Chinook winds, by any common classification, are most frequent in the high plains area in winter and less frequent in summer. Both winter and summer portions of the chinook distribution curve are bipeaked, suggesting dual causative factors.

Classification of westerly winds in the high plains region is not possible from plains information alone but can be done for uncomplicated cases from plains information plus a precipitation and temperature report from a strategically-placed station.

Complicated chinooks, in which the precipitation takes place on the windward side of one mountain range and the descent of warm air occurs only after transit of a wide expanse of territory, cannot be so easily detected and are here classed merely as westerlies, because of lack of observational data.

Chinook winds, as defined by the meteorologist, are much less frequent than winds similarly classified by the plainsman, and the total number of chinook winds in a year averages only 39.26, of which a majority are detectable only after a careful study of the meteorological records.

Careful evaluation of the effects of chinook winds indicates that they have a negligible influence on annual climatic averages since their effects, spread over a year, are somewhat less than the probable error in individual instrument readings.

In contrast, their meteorological effects (one day) are considerable; and the impact of these meteorological effects on human activities may be considerable for a short time, such as one day.

In general, chinook winds produce a small increase in precipitation at windward stations on the west side of the Front Range, a decrease of perhaps 20% in effective precipitation on the plains as a result of loss of windward precipitation and sublimation of snow, and a very slight increase in annual mean temperatures at leeward (plains) stations.

Abstract No. 678.

Jackson, C. V. 1928. Seed germination in certain New Mexico range grasses. Bot. Gaz. 86:270-294.

1. The amount of rainfall during the year, especially during the growing season and at the time of harvesting, affects the vitality of the seed.

2. *Bouteloua eriopoda* and *B. gracilis* do not seed very often. Most of the florets are sterile and, because of their similarity to the fertile florets, are hard to distinguish from them.

3. *Aristida* seeds germinate just as well in the light as they do in the dark.

4. The seed coat is important in *Sporobolus* seeds, since it keeps out water and prevents germination. The seed coat must be punctured by some means before good germination results. Soaking affects the seed coats but little; shaking, even for 9 hr in sand, has little effect; but scratching or pricking hastens germination greatly.

5. The seeds of *Sporobolus airoides* do not need pricking to produce good germination results. The seed coat is more permeable to water than are the seed coats of the other species.

6. The *Sporobolus* seeds from 1925 retained their vitality very well.

Abstract No. 679.

Jackson, W. A., and R. J. Volk. 1970. Photorespiration. Annu. Rev. Plant Physiol. 21:385-432.

Estimates of respiratory activity of photosynthetic tissue during illumination are based on a variety of indirect methods, each of which includes at least one limiting assumption. Nevertheless, it is quite clear that substantial changes in respiratory processes occur upon illumination and that under certain conditions the light respiratory rate may be a significant fraction of the photosynthetic rate.

Higher plant species can now be separated into two general categories based on their respiratory responses to illumination. Those species which fix CO_2 primarily by the photosynthetic carbon reduction cycle apparently have very sizable respiratory rates in the light. Photorespiration is much more difficult to detect in the second group which fix CO_2 via the C_4-dicarboxylic acid pathway: these species generally are extremely efficient in photosynthesis. We shall refer to the second group as low compensation species because of their capacity to deplete the ambient atmosphere to very low CO_2 concentrations. The first group will be referred to as high compensation species.

Abstract No. 680.

Jameson, D. A. [Coordinator]. 1969. General description of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 1. Colorado State Univ., Fort Collins. 5 p.

The Pawnee Site, the intensive site location of the Grassland Biome, lies within the western division of the Pawnee National Grasslands which is administered by the U.S. Forest Service. At the western edge of the Pawnee National Grasslands lies the Central Plains Experimental Range operated by the Agricultural Research Service. Intensive studies requiring careful experimental control are conducted on the Central Plains Experimental Range; more extensive studies requiring a great deal of space but less control are conducted on the Pawnee National Grasslands.

Abstract No. 681.

Jameson, D. A. 1970. Land management policy and development of ecological concepts. J. Range Manage. 23:316-322.

As ecological concepts become incorporated into the training and background information of professional land managers, they also become incorporated into land management policies. Recent developments in ecology, such as nutrient cycling studies and computer simulation of complex processes, have a favorable climate for acceptance. Possible applications should be carefully studied by land managers.

Abstract No. 682.

Jameson, D. A. 1970. A mathematical model of a grassland ecosystem. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Systems can be extremely complex or quite simple. An ecosystem is, of course, such a complex system that it cannot be described mathematically in full detail. To be tractable, ecosystems must be reduced to mathematical models which are abstract simplifications of real systems. The degree of simplification, however, is more a function of the beholder than of the system itself. Mathematical models, therefore, have a narrower range of complexity than the real systems they represent. They tend to be large enough to be interesting, but small enough to be tractable. Thus, although abstraction and simplification are certainly attributes of mathematical models, the degree of abstraction and simplification is variable.

Mathematical models can take a great variety of forms. We will consider in this paper the usefulness of certain mathematical techniques to modelling of ecological systems. The simplest will be a straightforward "who-eats-whom" matrix; this in turn will be related to a deterministic, closed, point-space, linear coefficient compartment model. These simple models will then be expanded to more complex stochastic, open, distributed, nonlinear systems. Finally, we will consider heuristic modelling which begins, not with a given mathematical form, but with knowledge of the biology of the system and utilizes this knowledge to build a model of a functioning system which describes the function in quantitative mathematical terms.

Abstract No. 683.

Jameson, D. A. 1970. Modelling and systems analysis in range science. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Jameson, D. A. [Ed.]. 1970. Modelling and systems analysis in range science. Range Sci. Dep. Sci. Ser. No. 4. Colorado State Univ., Fort Collins. 134 p.

This volume began as a symposium of the same name chaired by the editor for the 23rd Annual Meeting of the American Society of Range Management, Denver, Colorado, February 9-12, 1970. Two additional and related papers from a related symposium entitled "The ecosystem approach to education, research, and management" chaired by James K. Lewis, South Dakota State University, are also included. The final paper in this volume was developed primarily for presentation at the latter symposium, but was not presented orally because of its rather technical nature.

The papers in this volume do not pretend to be a complete exposition on the subject of modelling and systems analysis. As symposium papers, they merely represent some examples of current thinking in the field at the time of presentation. In general, the papers presuppose no previous knowledge of the mathematical concepts involved; on the other hand, no effort is made toward mathematical explanation or development.

The symposia from which these papers were drawn were conceived to whet the interest of the practitioner of range science in the areas of modelling and systems analysis. If this volume can lead its readers into further investigation of such concepts, we will have met our goals.

Abstract No. 684.

Jameson, D. A. 1970. Value of broom snakeweed as a range condition indicator. J. Range Manage. 23(4):302-304.

Following an initial 13-year stabilization period, changes in broom snakeweed populations on southwestern pinyon-juniper ranges were investigated over a subsequent 13-year period. The changes which occurred appeared to be the result of oscillating populations rather than of range condition.

Abstract No. 685.

Jameson, D. A., R. K. Gierisch, S. Wallace, and R. Robinson. 1970. Range condition evalution by discriminant analysis. Range Sci. Dep. Sci. Ser. No. 8. Colorado State Univ., Fort Collins. 26 p.

To the experienced rangeland manager, range condition is not precisely forage production, nor the amount of soil covered by vegetation, nor soil erosion, nor stage of ecological succession, but rather it is a concept based upon a combination of many variables of the range. These variables and their associations with each other are so complex that no simple yet meaningful expression of range condition has been developed. Because of these difficulties, a common procedure in range condition classification is the development of scorecards which consider several measurements made on the range, and weighting factors are selected so that the product of the scorecard agrees with the range manager's interpretation of the range condition based on his training, experience, and judgement in the field. The range scorecards provide a tool that the less experienced range technician can use to arrive at an expression of range condition which is quite similar to that which the more experienced manager would have reached had he personally visited and examined the area. Generally, there is considerable difficulty in designing range condition classification guides which are entirely satisfactory; in spite of these difficulties, scorecards tend to be rigidly applied.

Abstract No. 686.

Jameson, D. A., and L. G. Nell. 1970. Memoranda of agreement and procedures for working on federal lands of the USDA. U.S. IBP Grassland Biome Tech. Rep. No. 8. Colorado State Univ., Fort Collins. 53 p.

This technical report contains examples of agreements, contracts and procedures, and the resulting official paperwork that outlines the cooperation between Colorado State University, the United States Department of Agriculture, and individual investigators, as part of the International Biological Program Grassland Biome studies.

Abstract No. 687.

Jardine, J. T., and M. Anderson. 1919. Range management on the national forests. U.S. Dep. Agr. Bull. 790. 98 p.

The object of this publication is to aid in bringing about uniformity in range management and a better understanding of grazing use in relation to the other uses of the national forests. The importance of adjusting grazing so as to secure the perpetuation of the range resources and so as not to interfere with the requirements of other resources is emphasized throughout. The phases of range management which must be given proper attention are pointed out; and, as far as practicable, rules of procedure are given. Exhaustive discussion of each of the subjects taken up is not attempted. The purpose is rather to bring together in handy form sufficient information on the essential points of grazing practice to enable the reader to make practical application of the best principles of regulated grazing.

Abstract No. 688.

Jenkins, M. B. 1937. Trees that conquered the prairie. Amer. Forest. 43:234-236, 251.

Experience has demonstrated that ponderosa pine, eastern red cedar, western red cedar, and hackberry will withstand rigorous conditions of the driest areas. The Austrian pine and Douglas fir are proving almost as dependable.

That tree survival depends largely upon choosing species adapted to the soil and climatic conditions, giving proper attention to seed source, and providing adequate protection and cultivation during the first few years is proved in the Lydick plantations. Fortunately, these are not the only instance of good farmstead and shelterbelt planting. Successful plantings of many other prairie farmers have resulted in increased crop production. The combined force of these results of pioneer vision and courage indicate that farm forestry is an important factor in the solution of the economic problems of this area. It deserves widespread consideration.

Abstract No. 689.

Jenkinson, D. 1971. Studies on the decomposition of C-14 labelled organic matter in soil. Soil Sci. 3:64-70.

Carbon-14, a weak (0.155 MeV) β-emitter of half life 5730 years, was first used for work on soil organic matter in 1953. Since then it has been featured in almost 100 papers on soil organic matter, and two congresses have been held at which this work was a major interest. Carbon-14 is now used in so many aspects of soil research that it is pointless to collect and discuss papers in which the only common factor is the use of this isotope. Instead, five topics have been selected, in all of which the use of C^{14} has played an integral part. The first three are concerned with the overall losses of carbon when labelled organic matter decomposes in soil, the others with the transformations undergone by that part of the added organic material remaining in the soil.

Abstract No. 690.

Jenner, C. F. 1970. Relationship between levels of soluble carbohydrate and starch synthesis in detached ears of wheat. Australian J. Biol. Sci. 23(5):991-1003.

Detached ears of wheat were cultured on solutions of sugars. A highly significant correlation was observed between the concentration of sucrose in the endosperm and the rate of starch synthesis. Fluctuations in the level of sucrose in the endosperm were accompanied by parallel changes in the rate of starch synthesis. It is suggested that the concentration of sucrose in the endosperm regulates the rate of starch synthesis.

A linear relationship held over a wide range in concentration between the external level of sucrose and the amounts of sucrose in the foral organs and rachis. However, in the endosperm the relationship was curvilinear, and the maximum level of sucrose recorded at high external concentrations was very much lower than the concentration in the rachis.

These findings are discussed in relation to the regulation of starch synthesis in cereal grain.

Abstract No. 691.

Jensen, H. L. 1931. The fungus flora of the soil. Soil Sci. 31:123-158.

A number of Danish soils were examined by the usual methods to determine the relative numbers of microorganisms present, the composition of the flora, and its importance for decomposition processes in these soils. Results correspond closely with those obtained by American workers, the numbers of fungi varying from 24,300 to 460,000/g of soil as determined by plate counts. The physical character and humus content showed no definite relation to fungal counts; but soil reactions below pH 6, although not markedly correlated with the actual number of fungi, showed a distinct correlation with the ratio of fungi to bacteria plus actinomycetes. This ratio apparently depended almost entirely on pH. Dextrose and cellulose added to soil samples stimulated fungal growth in acid soils, but bacteria were affected reversely. Casein and alfalfa seed meal also stimulated the activities of fungi under acid and, to a much less extent, under alkaline conditions. Cellulose gave the same result in neutral and alkaline soils, but then the flora was found to differ in type. The fungi, most active when such nitrogenous substances were added, were not those exhibiting the strongest proteolytic powers in pure culture.

Abstract No. 692.

Johnson, E. H. 1931. The natural regions of Texas. Texas Univ. Bull. 3113. 148 p.

The particular purpose of this publication is to delineate Texas regions as units which are necessary not only in making an analysis of the commercial aspects of the natural resources of the state, but also in establishing bases for the analysis of the economic development of the various sections of Texas as well as of the state as a whole.

The method employed in this publication may be described as *geographic correlation*, that is, the interpretation of the areal extent and characteristics of regions in terms of relationships between the elements of the regional environment insofar as these elements have an areal expression.

Abstract No. 693.

Johnson, L. E., L. R. Albee, R. O. Smith, and A. L. Moxon. 1951. Cows, calves and grass: Effects of grazing intensities on beef cows and calf production and on mixed prairie vegetation on western South Dakota ranges. South Dakota Exp. Sta. Bull. 412. 39 p.

For nine years, 1942-1950 inclusive, the South Dakota Agricultural Experiment Station, in cooperation with the Soil Conservation Service, conducted a summer grazing experiment to measure the effects of heavy, moderate, and light rates of grazing on beef cow and calf production and on mixed prairie vegetation at the Range Field Station near Cottonwood, South Dakota.

Abstract No. 694.

Johnson, M. B. 1930. Cattle ranch organization and management in western South Dakota. South Dakota Exp. Sta. Bull. 255. 54 p.

The South Dakota range area has been divided into six districts based on the land classification made by the United States Department of the Interior.

Ranch operations in South Dakota were generally profitable during 1927 and 1928 due largely to the increase in market prices of cattle above the 1926 prices.

The land area operated per ranch as shown by the average of 15 South Dakota ranches was 5,446 acres, of which 1,731 acres, or approximately 32%, were owned and the remainder leased. In addition to these acreages, a majority of the ranches had access to varying amounts of free range.

The sources of income of the 15 ranches were as follows: range cattle, 83%; hogs, 4%; cash crops, 5%; feed crops, 5%; miscellaneous, 3%.

The cost of winter feed was the highest single item in range cattle production. The average cost of feed per head of cattle wintered varied between districts, depending largely on the relative amounts of range and winter feed available.

Probably the outstanding handicap in ranch operation is the difficulty of obtaining long-time control of sufficiently large areas of grazing land. Ranchmen generally should have uninterrupted control of large units of grazing land for long periods of time.

Generally speaking, an increase in the numbers of cattle handled with a corresponding increase in the grazing area per ranch seems necessary to insure the permanence and profitableness of the industry.

By the use of breeding pastures and the conditioning of bulls, the calf crop may be increased.

Production of winter feed may be increased by the adoption of good cultural methods and crop rotation systems adapted to the region.

On some ranches, cash crops are desirable supplements to the cattle business, particularly where a surplus of suitable land is available.

Hogs may be an important source of income under certain specific conditions.

Crop yields are expected to increase with the adoption of improved cultural practices and improved varieties of field crops.

The federal land purchase project has been an important factor in stabilizing range cattle production.

The period since 1940 has been the most prosperous period in the range country since open range days.

Some of the important characteristics of ranch organizations best able to maintain financial solvency through good and bad years are listed.

Abstract No. 695.

Johnson, M. B. 1947. Range cattle production in western North Dakota. North Dakota Agr. Exp. Sta. Bull. 347. 47 p.

Severe droughts are the greatest menace to stable range cattle production in western North Dakota. But ranches in the area are better prepared to "weather" periods of drought than at any time in history.

Some 64% of the area studied--7% more than has been classed as best suited for grazing or grazing forage production--is being used for grazing or the production of wild hay.

Operating units have decreased in numbers and increased in size. The average size is now the largest on record.

Land ownership has increased materially during recent favorable years.

More attention is given to feed production and winter feeding than in former years.

Abstract No. 696.

Johnson, W. C. 1965. Wind in the southwestern Great Plains. U.S. Dep. Agr. Conserv. Res. Rep. 6. 65 p.

The purpose of this report is to assemble information about wind in the southwestern Great Plains for use by specialists in advising farmers and ranchers. In this report the southwestern Great Plains is considered to be that part of the Great Plains west of the 100th meridian or west of the eastern edge of the Texas Panhandle, extending from southern New Mexico to the Nebraska Panhandle.

This report, written to compile information about wind in the southwestern Great Plains for use by specialists in advising farmers and ranchers, consists of a description of the sources of information used, a comparison of the climate during two 5-year periods, a presentation of the basic wind data, and a comparison of wind conditions throughout the area.

Abstract No. 697.

Johnson, W. D. 1900. The high plains and their utilization. Part 4. Annu. Rep., U.S. Geol. Surv. 21: 601-768.

The Arid Region, as its limits are now determined, comprises a smaller and much more irregular area than the featureless, "unexplored" region of the early maps known as the Great American Desert. This contraction of boundaries by the recognition of relatively humid tracts has, in fact, gone so far that the name, Arid Lands, designating, rather, a grouping of detached parts is coming into use instead.

Originally the desert was assumed to have its beginning in the treeless expanse of the Great Plains, including the whole. We now witness the spectacle of the highest type of agricultural development extended over a belt of states wholly within that early boundary. So much of the Plains had been mistakenly regarded as arid.. Yet the development was slow and uncertain. Gradually also, beginning at a somewhat later date, reclamation by irrigation was undertaken on a small scale in the unmistakably arid region at the western limit of the Plains, under the spur of the mining development nearby in the mountains. And here, too, natural fertility was demonstrated.

Altogether, however, no great inroad, comparatively, had thus far been made upon this immense body of open land, nor any deliberate effort toward its fullest utilization. The public lands elsewhere had not yet become exhausted. It remained undetermined how far encroachment might profitably be carried without artificial aid. Finally, realizing that exhaustion of public land in the recognized humid areas was close at hand, immigrants rapidly invaded and in a short time covered with settlement the entire intervening space westward to the zone of irrigation. It was at the worst a drought belt, and the experiment was tried on a scale and with a reckless elaborateness that promised heavy disaster in case of failure.

Failure in fact followed, and disaster with almost complete depopulation has resulted. Especially was this the case with the High Plains, which presented the maximum inducement of fertile soil and unbroken smoothness of surface.

Abstract No. 698.

Johnson, W. M. 1945. Natural revegetation of abandoned crop land in the ponderosa pine zone of the Pike's Peak region in Colorado. Ecology 26(4): 363-374.

Secondary succession on abandoned fields in the ponderosa pine zone in the vicinity of Pike's Peak, Colorado, progresses through the following stages:

1. An annual weed stage characterized by a few species occurring in great abundance, such as *Chenopodium album*, *Solanum nigrum*, *Amaranthus retroflexus*, *Verbesina encelioides*, and *Setaria viridis*. Occasionally, almost pure stands of either one or two species may develop. The annual forb stage is of short duration, usually only one or two years.

2. A perennial forb stage characterized by an increased number of perennial grasses and forbs but having lower total densities of plant cover. *Agropyron smithii* and *Muhlenbergia montana*, as well as some of the permanent forb species, *Cirsium ochrocentrum*, *Erigeron flagellaris*, and *Astragalus goniatus*, make their appearance in this stage and become permanent members of the subclimax. This stage may last from 7 to 10 years.

3. A mixed grass and forb stage which, in the early period of development, is characterized by an abundance of *Stipa robusta* and *Agropyron pauciflorum*. *Bouteloua gracilis* gradually replaces the *Agropyron* in the later phase. Perennial forbs increase both in numbers and abundance. The stage may last from 10 to 25 years.

4. The subclimax bunchgrass stage in which *Muhlenbergia montana* and *Festuca arizonica* are the dominant species.

5. The climax *Pinus ponderosa-Pseudotsuga taxifolia* association.

Abstract No. 699.

Johnson, W. M. 1953. Effect of grazing intensity upon vegetation and cattle gains on ponderosa pine-bunchgrass ranges of the front range of Colorado. U.S. Dep. Agr. Circ. 929. 36 p.

Grazing western ranges on a basis that will maintain forage and watershed values and at the same time make efficient use of the forage for beef production is especially important to the stockmen, ranchers, and larger livestock operators of the Front Range of Colorado. In 1941 a study of the effect of grazing intensity on ponderosa pine-bunchgrass ranges was begun at the Manitou Experimental Forest. This study, ending in 1947, included the measurement of herbage utilization, herbage production, and cattle gains on six experimental pastures located in the open ponderosa pine zone of the Front Range in central Colorado.

Abstract No. 700.

Johnston, A. 1961. Comparison of lightly grazed and ungrazed range in the fescue grassland of southwestern Alberta. Canadian J. Plant Sci. 41: 615-622.

The influence of grazing on the vegetative cover of fescue grassland in southwestern Alberta was assessed by studying two adjoining sites, one lightly grazed, the other ungrazed. Percentage basal area, yield, water-intake rate, soil temperature, soil water, and amount of root material were compared on a paired plot basis.

The data showed that light grazing resulted in the development of a richer flora dominated by *Danthonia parryi*. Protection from grazing appeared to simplify the flora with a trend toward a cover consisting largely of *Festuca scabrella*. There was little evidence of difference in productivity between the two sites. Cooler and moister conditions prevailed in the upper 12 inches of the soil profile of the ungrazed site as a result of heavy accumulation of mulch. Considerably more root material to a depth of 54 inches was present on the lightly grazed site. The harmful effects of herbage removal, shown by clipping studies, were not apparent in the field study under a light rate of grazing.

Abstract No. 701.

Johnston, A. 1961. Some factors affecting germination, emergence, and early growth of three range grasses. Canadian J. Plant Sci. 41:59-70.

Factors affecting germination, emergence, and early growth of *Festuca scabrella*, *Danthonia parryi*, and *Bromus pumpellianus* were studied in the germinator or greenhouse. Germination of *D. paaryi* was not affected differentially at temperatures ranging from 55°F to 85°F. *F. scabrella* germinated best at 65°F and *B. pumpellianus* at 75° to 85°F. Percentage germination of *F. scabrella* was inhibited by a wet-cold treatment and by a solution prepared from partially decomposed litter. Shallow seeding was found to offer the best opportunity for seedling establishment. Fewest seedlings survived where competition was greatest, i.e., when seeds were broadcast on the surface of a rapidly-growing, established sod. This treatment produced the least vigorous seedlings as measured by tiller or rhizome numbers, dry matter yields, and root and leaf lengths.

In a depth-of-litter study involving *F. scabrella*, as the depth of litter increased, the percentage emergence of seedlings decreased. Seedlings continued to emerge for an 85-day period from all except shallow (½-inch) litter depths of seeding.

Six square-foot sods obtained in mid-June, 1958, from *Festuca* prairie in excellent condition were dissected in the laboratory. Numbers and locations of seedlings were recorded and showed that the same trends existed on the prairie as were detected in the greenhouse experiments. The cumulative results of the studies suggested that seed and seedling mortality in the grasses studied was of considerable magnitude.

Abstract No. 702.

Johnston, A. 1962. Effects of grazing intensity and cover on the water-intake rate of fescue grassland. J. Range Manage. 15:79-82.

A study was conducted to determine the effects of grazing intensity and cover on the water-intake characteristics of soils of the fescue grassland. A mobile infiltrometer was used to apply artificial rainfall at measured rates to selected study sites. The results showed that, even after 10 years of very heavy grazing, soil erosion by water was not a critical factor in management. The water-intake rate increased with increasing amounts of standing vegetation and natural mulch. Soil loss from artificially bared plots was approximately 2½ tons per acre at a rainfall intensity of 3.23 inches per hour.

Abstract No. 703.

Johnston, A., S. Smoliak, L. M. Forbes, and J. A. Campbell. 1965. Alberta guide to range condition and recommended stocking rates. Alberta Dep. Agr. Pub. No. 134/14-1. 12 p.

The principles of range management are: (1) Balance the number of animals with the available forage supply. (2) Use the kinds of livestock most suited to the forage supply and the objectives of management. (3) Alternate periods of grazing and rest to manage and maintain the vegetation. (4) Obtain a uniform distribution of animals over the range.

The principles of range management are based, in turn, upon two fundamental ecological principles: (1) Physical factors, plants, and animals function as a unit; and any change in one factor, such as that caused by fire or grazing, changes the whole complex. (2) Vegetational changes are natural phenomena which follow certain patterns.

This publication is concerned primarily with the second ecological principle, namely, that vegetational changes are natural phenomena which follow certain patterns.

Abstract No. 704.

Jones, J. K., Jr., E. D. Fleharty, and P. B. Dunnigan. 1963. The distributional status of bats in Kansas. Mus. Natur. Hist., Univ. Kansas Misc. Pub. No. 46. 33 p.

In the accounts that follow we have attempted to summarize the distributional status of each of 15 species known from Kansas. A key to bats occurring in the state and a list of other species that one day may be found are appended. On distribution maps, the shaded area is our estimate of the probable distribution in Kansas of the species concerned; if no shading is used anywhere on the map, the species is to be expected (in suitable habitats) in any part of the state. In preparing maps we took account of specimens reported from adjacent states. In lists of specimens examined and records cited from other sources, localities in italic type are not plotted on the maps because symbols would have been unduly crowded. For the same reason, some localities that are plotted are slightly offset on the maps.

In checking distributional records, we found that some localities have been incorrectly located in earlier published reports. Several of these are discussed in text; others can be recognized in the sections entitled "specimens examined" or "other records" because the name of an earlier-reported locality is followed in brackets by our best estimate of its exact location.

Abstract No. 705.

Jones, R. 1968. Estimating productivity and apparent photosynthesis from differences in consecutive measurements of total living plant parts of an Australian heathland. Australian J. Bot. 16:589-602.

Estimates of productivity and apparent photosynthesis in a typical Australian heathland were obtained by harvesting monthly over a period of 2 years. Net productivity was small (400 g/m^2/year or less), while the rate of apparent photosynthesis was considerable (about 6000 g/m^2/year), representing a photosynthetic efficiency around 5%.

Belowground production exceeded production above ground 6 to 10 times. Root biomass was of the order of 6500 g/m^2. Death and consumption of roots was large, and most of the products of community photosynthesis were diverted below ground to replace an annual root loss of some 5500 g/m^2.

Community growth was a reflection of the behaviour of the dominant, *Leptospermum myrsinoides*. Standing biomass above ground was sensitive to the activity of this species, which produces new shoots from spring to autumn in relation to available soil water. The annual occurrence of extensive leaf abscission and high mortality of roots is correlated with high temperatures, low humidity, and depleted soil water.

Abstract No. 706.

Jones, R. E. 1962. The quantitative phenology of two plant communities on Osage County, Oklahoma. Oklahoma Acad. Sci., Proc., 42:31-38.

During different seasons of the year animal species frequently use different components of their habitats. Many times the reason for this is not readily apparent. In a study of the greater prairie chicken (*Tympanuchus cupido pinnatus*) this phenomenon was recognized, and it was wondered whether the availability of green plants as food might not be a determining factor in their daily movements, at least during the winter months. Consequently this study was begun as an attempt to find plant phenological features influencing movements of animal species.

This study was carried out on the K. S. Adams Ranch in Osage County, Oklahoma, in two pastures approximately one mile apart. The plots were set out in pairs as the shortgrass sites are usually small interdigitations within the larger areas of the tall-grass site.

Time did not permit the taking of quadrat counts on the fields studied, but the vegetation of each field was checked, listing the species encountered and an attempt made to give the relative frequency of each species.

Abstract No. 707.

Judd, B. I. 1940. Natural succession of vegetation on abandoned farm lands in Teton County, Montana. J. Amer. Soc. Agron. 32:330-336.

Much interest has been manifest during the past few years in the process of natural succession of vegetation on abandoned farm lands. In view of this, various investigators have made this process the object of careful study. This paper presents further information on natural revegetation of previously cultivated land representing a portion of the Great Plains heretofore unreported.

Abstract No. 708.

Judd, B. I., and M. D. Weldon. 1939. Some changes in the soil during natural succession of vegetation after abandonment in western Nebraska. Agron. J. 31:217-228.

A study was undertaken on cultivated land, native grassland, and land abandoned for various periods of time in Kimball County, Nebraska, for the purpose of discovering the changes that occur in the soil during the process of revegetation. Determinations were made of the rate of infiltration of water in the field and of percolation in the laboratory, the volume-weight, the state of aggregation, and the quantity of plant roots, organic matter, and nitrogen in the soil.

Abstract No. 709.

Kamstra, L. D., J. K. Lewis, D. Schentzel, and L. B. Embry. 1963. The *in vitro* digestibility and carbohydrate composition of western wheatgrass. J. Anim. Sci. 22. 851 p.

Samples of western wheatgrass were taken May 11, June 9, and July 11, 1961, from exclosures within lightly and heavily grazed pastures. The plants were cut individually at ground level, separated as to leaf number, and dried. Leaves, sheaths, and internodes were separated from each plant according to leaf number, ground to 40 mesh, and stored under refrigeration. Samples were taken in a similar manner in 1962 from high-good pastures; however, the individual leaves were not removed. The comparative cellulose digestibility was determined in vitro with the 1961 samples on each leaf separation by sampling date, grazing rate, and number of leaves on the plant. Holocellulose, hemicellulose, cellulose, and lignin analyses were completed on all collections where sample size permitted. The in vitro digestions indicated that the first leaf emerging was the least digestible with the last leaf being the most digestible. Leaves taken from plants having the same number of leaves from heavily grazed pastures were more digestible than from a comparable plant from lightly grazed pastures. The leaves were more digestible than the sheath from which it emerged. At the same cutting date, leaves of plants with fewer leaves were more digestible than comparable leaves of plants with higher leaf numbers. The holocellulose, hemicellulose, and cellulose values were similar between plants of different leaf numbers within a sampling period. Lignin increased, however, as the number of leaves increased and with a later cutting date.

Abstract No. 710.

Kamstra, L. D., J. K. Lewis, D. Schentzel, and R. Elderkin. 1966. Neutral sugars and other chemical components of western wheatgrass. South Dakota Agr. Exp. Sta., A. S. Ser. 66-3. 4 p.

Kamstra, L. D., J. K. Lewis, D. Schentzel, and R. Elderkin. 1966. Neutral sugars and other chemical components of western wheatgrass. Prepared for the 10th Beef Cattle Field Day, April 20.

A detailed investigation of forage carbohydrates and associated plant components is one of the objectives of a 13-state regional effort to obtain a better understanding of forage utilization by ruminants. Western wheatgrass was selected as the first of a series of prairie grasses to be studied under the local contributing project. Introduced forages and rumen metabolism of fibrous materials are being investigated by other states in the region. The neglected area of hemicellulose sugars was given special attention in this study.

Abstract No. 711.

Kamstra, L. D., J. K. Lewis, and M. Wurster. 1968. Characterization of range grasses at Cottonwood Range Field Station. South Dakota Agr. Exp. Sta., A. S. Ser. 68-2:7-18.

A previous report considered only the fibrous fractions of cool and warm season prairie grasses as related to subtropical grasses. As a continuation, a limited number of prairie grasses were subjected to more intensive laboratory evaluations to define criteria which might be used to characterize grass types and determine their potential as nutrients for ruminants.

Laboratory digestibility in addition to analysis for chemical components suggests that it is quite possible to use laboratory methods to characterize types of grass such as cool and warm season. An estimate of the relative nutritive value during the growing season may also be obtained, especially if digestibility studies are included. Digestibility determinations would be the least laborious for routine studies in which large numbers of plant samples are to be processed. Relative levels of hemicellulose sugar components vary with grass types as well as with time of the growing season. These differences may be responsible for differences in palatability or energy value between grasses.

Abstract No. 712.

Kamstra, L. D., D. L. Schentzel, J. K. Lewis, and R. L. Elderkin. 1968. Maturity studies with western wheatgrass. J. Range Manage. 21:235-239.

Leaf class (number of leaves per plant) and cutting date were considered as indices of maturity of western wheatgrass. Although some early-season effects of leaf class could be demonstrated, cutting date was a better measure of stage of maturity. Cutting date but not leaf class was shown to affect plant fractions and chemical components. The upper portion of the plant was more digestible than the basal portion. No digestibility effect was demonstrated for topographic location or leaf class. Leaf blades removed from plants under heavy grazing were more digestible in vitro than those from lightly-grazed pastures, probably because of later emergence or shorter height.

Abstract No. 713.

Karn, J. F., D. C. Clanton, and L. R. Rittenhouse. 1971. In vitro digestibility of native grass hay. J. Range Manage. 24(2):134-136.

Method of storage had a greater effect on the in vitro dry matter digestibility (DMD) of native grass hay than either storage time or date of cutting. The nutritive value of native hay was maintained better by storing it in round bales than by storing it in windrows, bunches, or letting it remain standing. The first 60 days in storage was the period when native hay had the greatest loss of nutritive value regardless of storage method. There was an interaction of cutting date and year on DMD. The early cut hay in 1962 had a higher DMD (42.7%) than the late cut hay (40.3%). There was no difference in 1963 (40.6 vs. 40.1%).

Abstract No. 714.

Karper, R. E. 1933. Rate of water evaporation in Texas. Texas Agr. Exp. Sta. Bull. 484. 27 p.

Losses of water through evaporation from reservoirs is an important consideration in the planning for an adequate supply for domestic, municipal, or irrigation purposes; and the rate of such losses from the soil has a marked influence upon crop adaptation and farming practices in a particular region. Measurements of the evaporation from a free water surface have, for a number of years, been collected by the Texas Agricultural Experiment Station at substations in the various regions of the state; and these, together with similar records from U.S. field stations located in Texas and from U.S. Weather Bureau records at Austin and Dilley, are reported in this bulletin. In all, the monthly and annual evaporation, in inches, is given for 21 points within the state, fairly well distributed from the upper Panhandle to the Rio Grande Valley and from the more humid regions of the Gulf Coast to the drier Trans-Pecos Region in the west.

Abstract No. 715.

Katznelson, H. 1965. Nature and importance of the rhizosphere, p. 187-206. *In* K. F. Baker and W. C. Snyder [ed.] Ecology of soil-borne plant pathogens. Univ. California Press, Berkeley. 571 p.

An understanding of the extent and nature of the microbial population in the root zone is essential for a critical evaluation of "Factors Determining the Behavior of Plant Pathogens in Soil" and a discussion of methods of control. Also important is a consideration of the antagonistic and associative biotic events occurring in the rhizosphere and how they may be influenced to create an environment that is unfavorable for a pathogen. It is intended here to reexamine the various features of the rhizosphere with emphasis on current observations. As demonstrated by the methods to be described, the rhizosphere effect is the resultant of two major forces--the plant root and the microorganisms that grow on and around it. This discussion will be confined to microbiological aspects, since the major contributions of the plant have been considered in the preceding paper. Furthermore, the review will be limited to the saprophytic rhizosphere populations of intact roots; the invasion of roots by symbiotic or plant-parasitic organisms will be dealt with elsewhere in this volume.

Abstract No. 716.

Keith, J. O., R. M. Hansen, and A. L. Ward. 1959. Effect of 2,4-D on abundance and foods of pocket gophers. J. Wildlife Manage. 23(2):137-145.

Aerial spraying of weedy, mountain rangeland in western Colorado with 2,4-D resulted in the following changes 1 year after treatment: (1) Pocket gopher populations were reduced 87%. (2) Production of perennial forbs was reduced 83% and grass production increased 37%. (3) The diet of pocket gophers changed from 82% forbs to 50% forbs and from 18% grass to 50% grass.

Untreated control areas showed no significant change in gopher numbers or herbage production from one year to the next. Gopher food habits did not change on untreated areas. About two-thirds of the gophers' diet during summer months consisted of aboveground plant material. The most common food items identified in pocket gopher stomachs were dandelion, western yarrow, and Rydberg penstemon. Although the reasons for the decline in gopher numbers on sprayed areas are not known, depletion of essential food items and nitrate poisoning are the most likely explanations.

Abstract No. 717.

Kelly, M. J., P. Opstrup, J. S. Olson, S. I. Auerbach, and G. M. Van Dyne. 1969. Models of seasonal primary productivity in eastern Tennessee *Festuca* and *Andropogon* ecosystems. Oak Ridge Nat. Lab. (Oak Ridge, Tennessee) TM-4310. 296 p.

Three purposes of study were: (1) to test various sampling and mathematical techniques in the analysis of grasslands typical of eastern Tennessee, (2) to explore the feasibility of increasing efficiency in future investigation, and (3) to use computer models for theoretical estimation of gross and net production and for mathematical description of transfer coefficients or functions in grasslands. Widely planted Kentucky-31 tall fescue (*Festuca elatior* var. *arundinacea* Schreb.) and the normal native old-field (or pasture) invader called "broomsedge" or "sagegrass" (*Andropogon virginicus* L.) dominated the areas studied on Clinch River terrace soils in Oak Ridge. Both communities had nearly equal annual net primary production (root plus top), but phenological cycles of dominant and minor species were quite different. Productivity estimates would have been biased on the low side without careful repeated sampling by species and/or allowance for losses of live material that occur simultaneously with growth. Present agreement between empirically and theoretically derived estimates suggests that results of both are nearly valid and complementary, but some improvements for future work are suggested.

Abstract No. 718.

Kelso, L. H. 1938. Food of the burrowing owl in Colorado. Oölogist 55:116-118.

The habitat of the Burrowing Owl (*Speotyto cunicularia hypugaea*) in Colorado is comparatively level ground covered by low and sparse vegetation. This facilitates comparison of food chosen by the owl to food available. To make such a comparison 230 pellets were collected from two territories near Aurora, Colorado. The material was collected from late September to October 25, 1938. Insect life was still abundant. The four owls present were full grown. There is no doubt as to identity of the pellets examined.

Abstract No. 719.

Kelting, R. W. 1951. Vegetation and soil conditions of prairie and pasture plots in Central Oklahoma. Ph.D. Thesis. Univ. Oklahoma, Norman. 57 p.

This investigation deals with an analysis of the vegetation and soils of four plots: a virgin prairie, a protected pasture, a grazed pasture, and a revegetating abandoned field in McClain County in central Oklahoma.

Abstract No. 720.

Kelting, R. W. 1952. A comparison of organic carbon, hydrogen-ion concentration, and volume weight of some central Oklahoma soils. Oklahoma Acad. Sci., Proc., 33:151-156.

Organic carbon, pH, and volume weight measurements were made at two levels (0-6 and 12-18 inches) of the soil of four grassland plots (a virgin prairie, a pasture protected from grazing, a grazed pasture, and a revegetating, abandoned field) near Norman, Oklahoma, in the autumn of 1949 and during the growing season of 1950.

The percentages of organic carbon (Walkley and Black method) were lowest in the abandoned field and progressively greater in the virgin prairie, protected pasture, and grazed pasture.

Few differences were noted in the pH values of the various soils. The values were relatively high in the fall of 1949, low in the spring of 1950, and high again in the fall of 1950. The greatest fluctuation of pH was encountered in the abandoned field soil.

The volume weight measurements were significantly lower in the virgin prairie than in the other three plots. Consistent differences were not found between the volume weights of the other plots.

Abstract No. 721.

Kelting, R. W. 1954. Effects of moderate grazing on the composition and plant production of a native tall-grass prairie in central Oklahoma. Ecology 35:200-207.

This investigation deals with an analysis of the vegetation of two grassland plots: a small virgin prairie and a grazed pasture in McClain County in central Oklahoma.

The dominant grasses in the virgin prairie were *Andropogon scoparius*, *Panicum virgatum*, and *Sorghastrum nutans*. *Andropogon gerardi* probably should be included in the dominants of this plot. *Andropogon scoparius* and *Sorghastrum nutans* were the dominants in grazed pasture. The data indicate that *A. scoparius* appears to be favored by moderate grazing of the pasture.

A smaller number of species and a lower average living areal cover was found in the virgin prairie than in the grazed pasture. Total weight of living plant material was higher in the grazed pasture than in the virgin prairie. However, total weight of dead plant material was lower in the grazed pasture than in the virgin prairie. No consistent correlations were found between the total living cover and the weight of the living material in either of the plots.

Soil moisture did not become a limiting factor during the 1950 growing season. Certain trends suggest that the soil in the grazed pasture dries out much more readily than in the virgin prairie.

Minor fluctuations were found in the pH determinations in the two plots. No correlation could be found between pH and any other soil factor studied.

The percentage of organic carbon in the soil was lower in the virgin prairie than in the grazed pasture. The amount of organic carbon seems to be related to the quantity of living plants and not to the mass of dead plant material.

Volume-weight values were markedly lower in the virgin prairie than in the grazed pasture.

Abstract No. 722.

Kendeigh, S. C. 1941. Birds of a prairie community. Condor 43(4):165-174.

The bird population of a 50-acre sample of true prairie association in the *Stipa-Antilocapra* biome on the west side of Lake Okoboiji in northwestern Iowa in the summer of 1940 consisted of four species that both nested and fed in the prairie, six species that nested elsewhere but fed in the prairie, six species that were confined to the forest-edge, and two species that were confined to seral communities. Strictly prairie species were *Dolichonyx oryzivorus*, *Ammodramus savannarum*, *Phasianus colchicus*, and *Sturnella neglecta* and averaged one bird per acre. The total population that used the prairie to some extent averaged 2.2 birds per acre. *S. neglecta* and *A. savannarum* had well-defined territories averaging 2.2 and 3.4 acres, respectively. *D. oryzivorus* and *P. colchicus* appeared not to possess territories after nesting was well begun, and there was evidence that both were polygynous. The territorial requirements of a forest-edge species, *Dendroica aestiva*, included suitable nest-sites, concealing cover, tall singing posts, feeding areas in trees, and space; and when certain of these factors were lacking territorial relations became confused, and the behavior of the birds became modified.

Abstract No. 723.

Kendeigh, S. C. 1944. Measurement of bird populations. Ecol. Monogr. 14(1):67-106.

Abundance of birds may be measured in relative terms or as actual populations. Although determination of relative abundance is sufficient for some purposes, it is more limited in its use and application than determination of actual populations; and the use and improvement of true census methods is encouraged.

Relative abundance has been commonly measured as percentage of days or trips on which the species was recorded, number of individuals observed per trip or per unit of time (hour) or per unit of distance (mile), or by a combination of these methods. All these methods have serious imperfections unless corrections are made for difference in conspicuousness of the various species and for the relative amount of observations made in different communities (habitats).

The use of several of these methods is illustrated with data from northern Ohio. Differences in the conspicuousness of various species were measured by the average distance at which their presence was first observed. The relative abundance of 22 species in northern Ohio during the winter months is presented, after correcting for their differences in conspicuousness and community occurrence. These methods were found more applicable during the wintering than during the breeding season.

Data on the number of bob-white in Ohio in early winter for the period 1908 to 1942, inclusive, suggest yearly fluctuations of a rhythmical nature with high populations having been attained in 1911 or 1912, 1923 or 1924, and 1935 and low populations in 1909 (?), 1915, 1928 or 1929, and 1940.

An analysis is made of the species composition and average number of individuals of each species making up the avian population in mature, relatively undisturbed, climax forests of the deciduous forest biome. The total population of forest-interior species amounts to 220 pairs per 100 acres (40 ha).

Abstract No. 724.

Kendeigh, S. C., and S. P. Baldwin. 1937. Factors affecting yearly abundance of passerine birds. Ecol. Monogr. 7(1):92-123.

A study was made of the factors affecting yearly fluctuations in abundance of a typical passerine bird (*Troglodytes aedon* Vieillot). The study was made by the statistical method involving the use of coefficients of correlation.

Abstract No. 725.

Kendrew, W. G., and B. W. Currie. 1955. The climate of central Canada. Meteorol. Div., Dep. Transport. Toronto, Ontario. 194 p.

This climatological report is one of a series covering the greater part of Canada.

The book is divided into 6 chapters. Chapter 1 is concerned with the general climatic features of central Canada as a whole, and emphasis is laid on the physical controls which determine some important elements. The later chapters, 2 to 6, describe the several regional divisions in more detail; they contain available data of many climatic elements, arranged by elements, temperature, winds, etc., and also collected in comprehensive climatological tables at the end of each chapter. These chapters provide much material for the examination of the influence of the climate on life, plant, animal, and human.

Abstract No. 726.

Kennedy, R. K. 1972. The sickledrat: A circular quadrat modification useful in grassland studies. U.S. IBP Grassland Biome Preprint No. 28. Colorado State Univ., Fort Collins. 5 p.

A sickle-shaped modification of a circular quadrat has been used advantageously in tallgrass rangeland production studies in northeast Oklahoma. The main advantages of this quadrat are the reduction of the area concept bias in quadrat placement, ease of quadrat placement, reduction of perimeter decisions, and facilitation of precision clipping at various heights above the soil surface.

Abstract No. 727.

Khan, A. A. 1971. Cytokinins: Permissive role in seed germination. Science 171(3974):853-859.

A working hypothesis for the hormonal control of dormancy and germination presents eight different sets of hormonal or physiological situations likely to be encountered in seeds. The presence or absence of any one of three classes of hormones (gibberellins, cykokinins, and inhibitors) at physiologically active concentrations might dictate whether the seed will remain dormant or germinate. A seed will remain dormant if gibberellin is absent whether cytokinin or inhibitor is present or not, or in its presence when inhibitor is also present but cytokinin is lacking. Germination will occur in the presence of gibberellin and absence of inhibitor whether cytokinin is present or not, or in the presence of inhibitor with cytokinin to oppose its effect.

Abstract No. 728.

Kilcher, M. R., and D. H. Heinrichs. 1958. The performance of three grasses when grown alone, in mixture with alfalfa, and in alternate rows with alfalfa. Canadian J. Plant Sci. 38:252-259.

Crested wheatgrass, intermediate wheatgrass, and streambank wheatgrass, chosen for diversity of root type, were compared for yield and competitive ability when growing alone, in mixture with alfalfa, and in alternate rows with alfalfa. For each seeding method the order of the grass species yield performance was the same, but the magnitude of the yield difference varied by seeding methods. In pure stands the yield difference between the low and high producing grass was 50%, in mixture with alfalfa 170%, and in alternate rows with alfalfa 220%. The total yield was greatest in alternate rows and smallest in pure grass stands (fertilized). In 1954 grass and alfalfa growing in alternate rows outyielded grass and alfalfa in mixed rows by 4%; in 1955, by 10%; in 1956, a dry year, by 33%; and in 1957, an extremely dry year, by 137%. The relative stand of alfalfa to grass was greater when growing in alternate rows as compared to mixed rows. This relationship held for all grass species but was less pronounced for streambank wheatgrass, the least competitive species of the three grasses.

Abstract No. 729.

Kilcher, M. R., and D. H. Heinrichs. 1960. The use of cereal grains as companion crops in dryland forage crop establishment. Canadian J. Plant Sci. 40:81-93.

The effect of wheat, oats, barley, and spring rye as companion crops on the establishment of a perennial forage crop mixture consisting of crested wheatgrass, brome, and alfalfa under arid conditions compared to no companion crop was studied at Swift Current, Saskatchewan. Cereal companion crops reduced the vigour, stand, and subsequent early forage yields of the grass-alfalfa mixtures, but less so if the cereal crop and the forage crop were seeded separately at right-angles to one another. The method of harvesting the cereal companion crop also influenced the performance of the subsequent forage crop. Cutting the cereal crops at a height of 8 inches or more for grain resulted in better grass-alfalfa stands and yields than was obtained when the cereal crops were mowed at a 2-inch height for hay. The effect of kind of cereal grain on performance of the perennial forage differed little. Wider row spacings for the cross-seeded companion crops also resulted in a better stand and yield of the grass-alfalfa crop.

Abstract No. 730.

Kincer, J. B. 1923. The climate of the Great Plains as a factor in their utilization. Ann. Ass. Amer. Geogr. 13:67-80.

A number of geographic factors, principally climate, topography, and soil fertility, operating either separately or in varied combinations, influence agricultural conditions. Of these, climate is the most fundamental, unalterable, and important, not only in influencing the distribution of particular crops, but also in determining the suitability of land for agricultural purposes. The land surface of the earth may be classified broadly as potentially agricultural and non-agricultural. The potentially agricultural land may be designated as productive and non-productive, and the former subdivided according to suitability for crops, pastures, or forest, based largely on climatic conditions.

Agriculturally, the United States is one of the most favored countries of the world. Large areas of its land surface are potentially agricultural, with climatic conditions favorable for crop growth, particularly in the eastern half of the country. In the west, however, much of the land is semi-productive, since the climatic elements do not occur in the best combination to favor intensive cultivation. Precipitation is usually the limiting factor. The most important single area to be classed as semi-productive is the region of the Great Plains lying just east of the Rocky Mountains.

Abstract No. 731.

Kincer, J. B. 1941. Climate and weather data for the United States. U.S. Dep. Agr. Yearbook 1941:685-747.

The following pages of the Yearbook contain data on climate and weather in the United States of interest in connection with agriculture. Practically every county in every state is included, so that farmers everywhere may find facts that are of value in their own locality. This article discusses the material included in the tables and maps. Before taking up this discussion, the author gives some general background on the collection of climatic and weather data in the United States so the reader may know the sources of the material used.

Abstract No. 732.

Kinsinger, F. E., and H. H. Hopkins. 1961. Carbohydrate content of underground parts of grasses as affected by clipping. J. Range Manage. 14:9-12.

A field and laboratory study was made in 1951 and 1952 to determine the effects of moderate and heavy clipping upon the carbohydrate root reserves of several grasses. Treatments also consisted of control (unclipped) plots. Evidence is presented that a system of moderate utilization will allow removal of considerable forage without any apparent decrease in root reserves. Heavy utilization two successive years depleted the food reserves 26.1, 23.6, and 21.2% in big bluestem, western wheatgrass, and the short grasses, respectively, compared to unclipped plots.

Carbohydrates accumulated after seed formation and when the plants approached dormancy. For the warm-season grasses a peak of stored carbohydrates occurred in the early winter. Stored carbohydrates in the roots of western wheatgrass, a cool-season grass, coincided with summer and early winter dormancy of this species. Decreased amounts of carbohydrates were present in the roots during periods of rapid growth in the early spring or fall.

Amount of carbohydrates in the roots of moderately-clipped plants exceeded those of unclipped plants during several sampling periods. However, roots of heavily clipped plants consistently had less stored food than unclipped or moderately clipped plants.

Although the role of hemicellulose in plant metabolism is unknown, data presented show an inverse proportion between hemicellulose and total readily available carbohydrates suggesting conversions may be made to soluble carbohydrates.

Abstract No. 733.

Kirk, L. E. 1941. The utilization of virgin grasslands in western Canada. Canadian Conserv. Ass., Trans., 1:51-59.

The conception which one frequently encounters of western Canada as an almost continuous grain field is very far from the reality. The idea would be reasonably correct for certain districts; but in the province of Saskatchewan, for example, as far north as latitude 48 no less than 45% of the land is non-arable. Of the 60 million acres that have been surveyed the proportion of the land which is submarginal for wheat is approximately 27 million acres. Nearly all of this is virgin grassland; and if to this is added the land which is still unbroken on arable farms it will be found that grassland in Saskatchewan, together with a limited amount of wooded country, comprises about 50% of the total area of the prairie section, or 30 million acres.

The corresponding estimate for Manitoba is 47.4% of the land listed as farms, and for Alberta the percentage of non-arable land probably differs but little from that in Saskatchewan and Manitoba.

Thus in the three prairie provinces, which originally had a grassland area of approximately 106 million acres, there remain about 50 million acres of unimproved land. To this must be added some 16½ million acres of available ranchland in British Columbia, about 10 million acres of which are located in the Kamloops-Nicola and Cariboo-Chilcotin ranching zones. The total area of grassland in western Canada is therefore in the neighbourhood of 66 million acres.

The vast area of virgin grassland of the western provinces, if properly conserved can be counted on as a permanent national asset of first importance. Most of this land is submarginal for wheat and other cereal crops but for the most part well suited for grazing purposes. In order to realize the maximum value from these grasslands, however, it is necessary that the methods of utilization shall be in harmony with the climatic, biotic, and other natural characteristics of the environment and consistent with the economic factors which make for successful agricultural development.

Abstract No. 734.

Klein, D. A. 1971. Microbial decomposer activities at the Pawnee Site: Integration of experimental approaches with program modelling requirements. U.S. IBP Grassland Biome Tech. Rep. No. 110. Colorado State Univ., Fort Collins. 29 p.

Experimental procedures which will allow modelling of Pawnee soil decomposer responses have been tested during this research period, and results are discussed in relation to general soil biochemical considerations and specific characteristics of the grassland ecosystem. Procedures for measurement of respiration and mineralization which are recommended include macrorespirometry and an *in situ* spatially-oriented dehydrogenase assay. Combined with measurement of evolved carbon dioxide, these procedures give baseline responses for test soils. Plating enumerations for total bacteria, actinomycetes, and fungi have been tested together with Most Probable Number (MPN) nitrifier and amoebal protozoan assays. Soils have been perturbed by variations in temperature and by moisture, glucose, control hay, and extracted hay additions. Results are discussed in relation to parameters of nitrogen and phosphorus additions planned for future experiments. Progress to date in modelling of decomposer functions is presented.

Results from this research period indicate that sensitive, inexpensive procedures are now available for characterization and modelling of grassland decomposer functions.

Abstract No. 735.

Kline, J. R. 1969. Soil chemistry as a factor in the function of grassland ecosystems, p. 71-88. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

This review is confined to the subject of the role of mineral nutrition in the functions of grassland ecosystems. Results from the literature are chosen selectively rather than exhaustively to permit a qualitative overview of the subject which is not overburdened with excessive detail. The subject matter is further restricted by considering only dominant processes in their main effects and ignoring complex interactions as far as possible. A plan is followed which attempts to bring together some of what is known about soil chemistry and some of what is known about plant responses and functions in order to make at least an approach to understanding what role mineral nutrients and soil chemical properties have in determining properties of plant communities.

The soil is the ultimate reservoir of plant nutrients, while plants through the expenditure of metabolic energy are a driving force for nutrient release and uptake from soils. How this affects plant community structure and function is obscured by several factors. First, since all plants require the same group of nutrients it is not immediately clear how they influence differentiation in plant communities. Second, plant communities are affected in their structure and function by a host of other variables which, except in extreme conditions, may dominate the community response and obscure the role of nutrients. Such variables are well known and include grazing, moisture regime, insects, and others.

Although plants require qualitatively the same group of nutrient elements for survival, evidence is presented that they are themselves differentiated with regard to their ability to extract and utilize nutrients even from the same substrate. Several examples of this differentiation are discussed along with examples of how this is manifest both in productivity and species composition of vegetation. It is often possible to correlate the properties of a plant system with those which are easily observable in soils such as profile characteristics while it is just as often found that quantitative measurements of soils are not well correlated with plant community properties. This may be due in part to the presence of unmeasured influences such as those previously mentioned which have important effects on plant communities. Evidence is presented which indicates that the influence of nutrients in plant communities may be assessed better through experimental application of nutrients to the soil than through the correlative approach because of the presence of these variables.

Abstract No. 736.

Klipple, G. E. 1964. Early-and late-season grazing versus season-long grazing of short-grass vegetation on the Central Great Plains. U.S. Forest Service Res. Paper RM11. 16 p.

A grazing experiment was conducted on the Central Plains Experimental Range near Nunn, Colorado, from 1943 through 1952 to compare (1) increased stocking during a 3-month early grazing period (May 10-August 10, approximately) followed by a second 3 months on other pastures that had been deferred during the early period with (2) average stocking during a 6-month season-long grazing period (May 10-November 10, approximately).

Three groups of three pastures were used in the experiment to allow for three randomized replications of each grazing period. Each of the nine pastures was grazed for 10 years during the period assigned to it.

Abstract No. 737.

Klipple, G. E., and J. L. Retzer. 1959. Response of native vegetation of the Central Great Plains to applications of corral manure and commercial fertilizer. J. Range Manage. 12:239-243.

Manure and several commercial fertilizer treatments were applied to a good stand of native shortgrass vegetation on the Central Plains Experimental Range in northeastern Colorado during 1951, 1952, and 1953. The long-time average annual rainfall for the study area is about 12 inches. The rainfall during the study period was comparable to the long-time average, except for an acute drought in 1954. General observations were made each year from 1952 to 1956, and plot records of density and herbage production were taken in 1952, 1953, and 1956. Fodder analyses of the mature blue grama herbage from plots that had received four of the fertility treatments and from the untreated plots were made in 1956.

Manuring was the most effective treatment. It increased herbage yields 15 to 50%. Yields from plots treated with commercial fertilizers seldom exceeded those from the untreated native range. Commercial nitrogen applied in 1953 had little, if any, effect upon the protein content of blue grama herbage produced in 1956. Manure and phosphorus treatments improved the protein content of blue grama herbage. Manure and nitrogen reduced the phosphorus content, but phosphorus fertilization gave little increase in the phosphorus content of the herbage.

Abstract No. 738.

Klipple, G. E., and D. F. Costello. 1960. Vegetation and cattle responses to different intensities of grazing on short-grass ranges on the Central Great Plains. U.S. Dep. Agr. Tech. Bull. 1216:1-82.

A study to determine the effects of grazing intensity on shortgrass vegetation was made at the Central Plains Experimental Range in northeastern Colorado. Three intensities of grazing were applied from May 10 to November 10 each year from 1940 to 1953. Each intensity was replicated on four half-section pastures. Grazing that removed approximately 60, 40, and 20% by weight of the current growth of herbage by the dominant forage grasses at the end of the grazing season were, respectively, designated as heavy, moderate, and light grazing treatments. These treatments were applied by grazing commercial grade, yearling Hereford heifers.

The vegetation was typical of several million acres of shortgrass range on the high plains of eastern Colorado and Wyoming, western Kansas and Nebraska, and southwestern North Dakota. Blue grama and buffalo grass were the dominant grasses. Common secondary grasses and sedges were western wheatgrass, needle-and-thread, alkali sacaton, sand dropseed, inland saltgrass, and threadleaf and needle-leaf sedges. Three-awns were common on all areas where the native sod had been disturbed by plowing, anthills, etc. Scarlet globemallow, scurfpeas, and slenderbush eriogonum were the more common perennial forbs. Annual forbs were numerous in wet years. Fourwing saltbush and winterfat were the leading browse species. Shrubs of little forage value were rubber rabbitbrush, broom snakeweed, and fringed sagebrush.

The Central Plains Experimental Range is in the 10- to 15-inch average annual rainfall belt. The 15-year (1939-53) average annual precipitation was 11.96 inches. Approximately 72% of the annual rainfall was received, usually from thunderstorms, during a 5-month growing season (May-September). Wind movement and moisture evaporation were high.

Responses of the range vegetation and cattle to the grazing treatments were studied. Vegetation response was measured by change in the vegetation cover, herbage production, and range-condition classification. Animal responses were judged by weight gain produced, death losses incurred, thrift condition of the cattle, and monetary return.

Abstract No. 739.

Klipple, G. E., and R. E. Bement. 1961. Light grazing--is it economically feasible as a range improvement practice. J. Range Manage. 14:57-62.

Light grazing has been used only infrequently by range-improvement practice. Their reasons for not doing so arise from doubt on their part as to its economic feasibility and its effectiveness. Results from a number of controlled grazing-intensity studies reported over the past 20 years are analyzed in relation to the validity of these doubts.

Light grazing for a few years does increase the herbage-yielding ability of deteriorated native ranges. The cost of applying light grazing is low in comparison with costs of other methods often used for range improvement. The logical time to use light grazing for range improvement is before the range has become depleted. Light grazing cannot do the job alone when competing undesirable vegetation dominates the site. Results of grazing-intensity studies demonstrate that light grazing is economically feasible when results are expressed in dollars received for the forage per acre of rangeland.

Abstract No. 740.

Kneebone, W. R. 1957. Blue grama seed production studies. J. Range Manage. 10:17-21.

Seed production studies were made in 1953, 1954, and 1955 on an established stand of blue grama drilled in 12-inch rows at the United States Southern Great Plains Field Station, Woodward, Oklahoma.

Excellent heading and seed set were obtained in 1954 and 1955 by applying water and ammonium nitrate fertilizer to summer dormant grass in mid-August, with continued irrigation until seed was in the soft dough stage.

In 1954, plots to which 50 pounds of nitrogen per acre were applied, produced 326 pounds of rough seed per acre while checks yielded 81 pounds. Fertilized plots had more heads and higher caryopsis percentages.

In 1955, rates of 50, 100, 200, and 400 pounds of nitrogen per acre were used with no check other than observation of adjacent untreated areas. There were no significant differences in seed yield, caryopsis percentage, or forage yield among the four rates and no residual effects on these characters from the 50 pound application in 1954. Average rough seed yield was 405 pounds per acre.

Significant increases in caryopsis percentage were obtained in 1953 and 1954 from dieldrin applied at 0.25 pound per acre, with total applications .25 pound in 1953 and .50 pound in 1954. Insect infestation in 1955 was apparently low, and the increase in seed set from two dieldrin sprayings at .25 pound per acre each was not statistically significant. In these studies, spraying with systox, parathion, and DDT had little effect upon caryopsis percentage. Increases in caryopsis percentages were probably primarily due to control of thrips.

A considerable amount of valuable forage was produced each year in addition to the seed. Total air-dry yields of seed and forage on fertilized plots averaged

3,648 pounds per acre in 1954 and 4,127 pounds in 1955. Air-dry forage available for grazing after seed harvest in 1955 averaged 2,432 pounds per acre.

Abstract No. 741.

Kneebone, W. R. 1959. An evaluation of legumes for western Oklahoma rangelands. U.S. Dep. Agr. B-539. 13 p.

Much of the information obtained in these studies dealt with difficulty or ease of propagation. Most of the native species and many of the introductions can be eliminated from consideration because of poor seed habits and difficulties in establishment. One rather large group of species, the scurfpeas (*Psoralea* spp.), were not even included in trials because of their poor seed habits and apparent limited value for seeding purposes. They are present on many native ranges in Oklahoma and Kansas.

With presently available information there seems little justification for attempts to use native legumes for reseeding purposes. A breeding program aimed at developing an alfalfa for pasture and range use in western Oklahoma has good chances for success, and its product can be an important contribution to the agricultural economy of the area.

Abstract No. 742.

Knievel, D. P. 1971. Temperature response of buffalograss, blue grama, and western wheatgrass growth in a controlled environment, p. 35. *In* General index to agronomy abstracts. Amer. Soc. Agron., Madison, Wisconsin.

Buffalograss (*Buchloe dactyloides* (Nutt.) Engelm), blue grama (*Bouteloua gracilis* (H.K.B.) Lag. ex Steud.), and western wheatgrass (*Agropyron smithii* Rydb.) were grown with day/night temperature regimes of 37.8/32.2C, 32.2/26.7C, 26.7/21.1C, and 21.1/15.6C while western wheatgrass was grown at 32.2/26.7C, 26.7/21.1C, 21.1/15.6C, 15.6/10.0C, and 10.0/4.4C. Buffalograss (BF) and blue grama (BG) had optimum growth rates in the 32.2/26.7C temperature regime (.609 g/day and .427g/day, respectively) while western wheatgrass (WW) grew best at 15.6/10.0C and 10.0/4.4C temperature regimes (.210 g/day). Tillering rate was highest at 32.2/26.7C in BF and WW, while in BG it was highest in the 21.1/15.6C regime. Root growth rate was highest at optimum growth temperature for BG and WW, but was highest at 37.8/32.2C for BF. BG had more green leaf-blade weight (and probably leaf-blade area) at its temperature optimum (7.86 g/pot) than either BF (5.44 g/pot) or WW (4.50 g/pot). Leaf-blade weight to sheath weight ratio of WW increased significantly with temperatures to 26.7/21.1C and then decreased, while similar ratios in BF and BG were not affected by temperature.

Abstract No. 743.

Knievel, D. P., and D. A. Schmer. 1971. Preliminary results of growth characteristics of buffalograss, blue grama, and western wheatgrass, and methodology for translocation studies using ^{14}C as a tracer. U.S. IBP Grassland Biome Tech. Rep. No. 86. Colorado State Univ., Fort Collins. 28 p.

The temperature response of various growth characteristics of buffalograss (*Buchloe dactyloides* (Nutt.) Engelm), blue grama (*Bouteloua gracilis* (H.K.B.) Lag. ex Steud.), and western wheatgrass (*Agropyron smithii* Rydb.) was determined under controlled conditions. Buffalograss and blue grama had highest growth rates in the 32.2/26.7°C day/night temperature regime, while western wheatgrass grew best in the 15.6/10.0°C and 10.0/4.4°C temperature regimes.

Methodology for studying carbohydrate translocation to belowground parts of buffalograss, blue grama, and western wheatgrass was developed using ^{14}C as a tracer. Methods for administering $^{14}CO_2$ and sampling the plant material, including sample preparation for radioactive analysis, was developed. These procedures and experimental data are discussed.

Abstract No. 744.

Knight, D. H. 1969. Some influences of vegetation structure on energy flux, water flux, and nutrient flux in grassland ecosystems, p. 197-120. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

This paper synthesizes the information now available on how vegetation structure may influence energy flux, water flux, and nutrient flux in grassland ecosystems. The discussion is focused on the influence of leaf area, leaf angle, vegetative cover, growth-form composition, and diversity. Such features have been shown to be modifiers of light penetration, evaporation from soil, infiltration, runoff, wind velocity, raindrop impact, and other aspects of energy flow. Data are presented that suggest the magnitude of flux modification by some features. The influence of vegetation structure on nutrient flux and the influence of diversity do not appear to be well understood, but some ideas are included which may be pertinent. Brief consideration is given to the measurement of vegetation structure and to the influence of structure on animal populations and diversity.

Abstract No. 745.

Knight, D. H. 1971. Leaf area dynamics on a shortgrass prairie. Colorado-Wyoming Acad. Sci., Proc., April 30, Pueblo, Colorado.

Leaf area indices were measured periodically on the Pawnee Grassland in northern Colorado during the 1970 growing season, using the point quadrat method. A motorized point frame was constructed to facilitate the field work. The maximum total green LAI, 0.55, was reached about June 15 and declined steadily after that date. Brown leaf area and litter cover were measured in addition to green leaf area, and a comparison of the three measurements suggests that the point quadrat method can be used for measuring leaf mortality and the transfer rate of standing plant material to litter. Data were gathered from exclosures, as well as grasslands subjected to different grazing pressures. *Bouteloua gracilis* (H.B.K.) Lag. comprised 61% of the total green LAI in the exclosure, 77% in the lightly and moderately grazed units, and 86% in the heavily grazed unit.

Abstract No. 746.

Knight, D. H. 1971. Some measurements of vegetation structure on the Pawnee Grassland, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 72. Colorado State Univ., Fort Collins. 43 p.

This report contains the results of measurements on the vegetation structure of the Pawnee Grassland in 1970. The measurements were made primarily at micro-watersheds 2, 3, 5, and 7--one each in management units subject to heavy, moderate, light, and zero grazing pressure by cattle. Estimates are presented for total green leaf area index (LAI), total green and brown LAI, *Bouteloua gracilis* green LAI, and *Bouteloua* brown LAI. Also summarized in this report are data on percent cover by the succulent, bunch grass, and shrub growth forms; percent bare ground; percent vegetation cover from various solar angles; percent mulch cover; and average vegetation height. These measurements will be used for ecosystem simulation, for intra- and interbiome comparisons, and for evaluating the magnitude of energy and water flux modification by vegetation structure.

Abstract No. 747.

Knight, J. L., E. D. Fleharty, and J. D. Johnson. 1972. Noteworthy records of distribution and habits of some Kansas herptiles. J. Herpetology. (In press).

A collection of herptiles amassed by the senior author in southwestern Kansas in spring and summer of 1971 provided noteworthy information on distribution and habits of six species. Specimens mentioned are housed in the Museum of the High Plains at Fort Hays Kansas State College.

Abstract No. 748.

Knipe, O. D. 1971. Light delays germination of alkali sacaton. J. Range Manage. 24(2):152-154.

Exposure of alkali sacaton seeds to light for a few seconds after imbibition delayed germination 24 hr; exposure for 9 to 13 hr delayed germination 28 hr; exposure for more than 13 hr delayed germination 72 hr, and continuous exposure reduced germination 40%.

Abstract No. 749.

Knipe, D., and C. H. Herbel. 1960. The effects of limited moisture on germination and initial growth of six grass species. J. Range Manage. 13:297-302.

Two hundred caryopses each of black grama, bush muhly, tobosa, mesa dropseed, lehmann lovegrass, and boer lovegrass were germinated in petri dishes on blotter paper moistened with water-mannitol solutions of 0.3, 3.0, 7.0, 11.0, 15.0, and 20.0 atm osmotic concentration (degrees of moisture stress). The object of the study was to determine differences within and among species in time required to germinate, total germination, and initial growth of seedlings under various conditions of moisture stress.

Abstract No. 750.

Knoll, G., and H. H. Hopkins. 1959. The effects of grazing and trampling upon certain soil properties. Kansas Acad. Sci., Trans., 62:221-231.

This study was initiated in 1954 to obtain basic information about the effects of grassland utilization on certain soil properties. The studies were conducted in the moderately-grazed college pasture and a nearby heavily-grazed pasture on a similar site, both near Hays, Kansas. All sites were on gently sloping uplands with deep, well-developed loessial soils. Blue grama and buffalo grass were the dominant species. Growing conditions were highly unfavorable.

Abstract No. 751.

Knox, J. H., J. W. Benner, and W. E. Watkins. 1941. Seasonal calcium and phosphorus requirements of range cattle, as shown by blood analysis. Agr. Exp. Sta. Bull. 282. New Mexico State Univ., Las Cruces. 28 p.

The results obtained in this experiment may be summarized as follows: The amount of calcium in the forage consumed by the cattle used in this experiment is believed to have been adequate. Phosphorus, however, for the greater part of the year, was below that required for range breeding cows. The amounts of both calcium and phosphorus in the forage eaten were higher in the spring and summer months than in winter. Blood calcium did not prove to be of value as a measure of calcium intake. The inorganic phosphorus in the blood plasma appeared to be closely related to the phosphorus intake. The consumption by range cows of phosphorus in the supplement increased during the course of the experiment from about 2 g to about 3 g a day. The low initial consumption and the low blood phosphorus levels indicate that the mixture of 60% salt and 40% dicalcium phosphate may not have been palatable. The excellent health and superior production of the mineral-fed cows, which were on this plan of feeding from May 1937 to October 1940, seem to indicate that such levels of intake and such blood pictures may not be inconsistent with optimum health and production for mature range cows in this region. The records on yearling steers are inconclusive, but point to the observation that from July to November, steers which have formerly received ample phosphorus in the form of bone meal or cottonseed cake will gain as much without as with a phosphorus supplement. When placed in the experiment as early as March or April, the gains for the steers receiving dicalcium phosphate were considerably greater. Breeding cows which received the phosphorus supplement produced more living calves and heavier calves than the cows which had no supplement.

Abstract No. 752.

Knox, J. H., and W. E. Watkins. 1942. The use of phosphorus and calcium supplements for range livestock in New Mexico. Agr. Exp. Sta. Bull. 287. New Mexico State Univ., Las Cruces. 18 p.

There is general lack of phosphorus in the range forage of New Mexico. Calcium is present in larger amounts and there appears to be no serious deficiency in this mineral, unless it is in the southwestern part of the state, where the samples of grass analyzed contained less calcium than in other areas.

The lack of these minerals is seasonal to a large extent. Range experiments with the use of phosphorus- and calcium-bearing mineral substances such as bone meal have resulted in: (1) smaller death loss in newborn calves, (2) larger number of calves weaned, (3) greater weight of calves and lambs at weaning, (4) greater gain in weight by yearling and 2-year-old cattle, and (5) higher wool production from range ewes.

Cows which calve from March to June are dry during the season when the calcium and phosphorus contents of the forage are lowest, and the breeding season comes at a time when the range feed is usually of good quality.

Minerals have been successfully and conveniently fed mixed with salt. Salt mixtures which contain 6.5% of phosphorus have been satisfactory for breeding animals and young growing cattle.

Mixtures containing 50% of special steamed bone meal or bone black contain at least 6.5% of phosphorus and have given good results for the Experiment Station and for ranchmen. These mixtures are palatable, and their use results in an adequate consumption of both salt and phosphorus.

Mineral substances such as limestone and oystershell should not be used on the range for they provide only calcium and are entirely lacking in phosphorus, for which there is a much greater need. Neither is it advisable to mix these substances with the high-phosphorus minerals such as bone meal, bone black, and dicalcium phosphate, for these products themselves furnish ample calcium.

Abstract No. 753.

Knox, J. H., J. W. Benner, and W. E. Watkins. 1946. Seasonal feeding of mineral supplements. Agr. Exp. Sta. Bull. 331. New Mexico State Univ., Las Cruces. 12 p.

Results of this experiment verify the opinion that breeding cattle on ranges which produce forage lacking in phosphorus or calcium should be fed a supplement supplying the deficient elements at all seasons. It is now known that such deficiencies may occur in all parts of New Mexico. In fact, some parts of the state produce grass more lacking in these elements than the range on which this experiment was conducted, where no disease such as "creeps" caused by insufficient minerals has been noted.

Facts learned from this experiment support a policy of continuous feeding of mineral supplement.

Abstract No. 754.

Koford, C. B. 1958. Prairie dogs, whitefaces and blue grama. Wildlife Monogr. 3:1-78.

This is the report of an exploratory investigation of the ecology of one common range rodent. During 12 months in the field, from December 1954 to December 1955, my principal method was to observe and compare the features of many dog towns. I noted especially the composition and density of plant cover, evidences of feeding and digging, and the numbers and distribution of prairie dogs and their burrows. Censuses were taken by counting the rodents an hour or two after sunrise or before sunset. I made sketch maps of the large towns, marked on them the numbers of prairie dogs seen at various locations and compared these data with subsequent counts.

On dog towns I took about 300 photographs of the effects of animals on soil and vegetation, collected plants, and shot or trapped 200 prairie dogs. The carcasses were examined for size, age, reproductive status, stomach contents, parasites, and other conditions. Additional information was obtained from unpublished notes and manuscripts, aerial photographs, and interviews with ranchers, wildlife workers, and government officials.

Abstract No. 755.

Kok, B. 1965. Photosynthesis: The path of energy, p. 904-960. *In* J. Bonner and J. E. Varner [ed.] Plant biochemistry. Academic Press, New York.

The bulk of energy conversion on earth is carried out by green and brown oxygen-evolving plants. The main functional pigment is chlorophyll a, which absorbs about half of the solar spectrum (wavelengths shorter than 700 mμ). For various reasons, even this half is not used very efficiently under natural conditions, although in an optimal environment photosynthesis can convert up to 30% of absorbed radiant energy into chemical potential energy. Roughly 1% of the solar energy is routed through the plant kingdom and supports life; the other sunlight is wasted as heat. Despite this low overall yield, the total energy conversion by photosynthesis exceeds by orders of magnitude the total industrial output of man.

Photosynthesis is a very complicated process, and its ramifications cover many areas of science. The following sections are not intended as a complete survey, but rather cover a number of selected topics relevant to the scope of this textbook.

Abstract No. 756.

Kothmann, M. M., G. W. Mathis, and W. J. Waldrip. 1971. Cow-calf response to stocking rates and grazing systems on native range. J. Range Manage. 24(2):100-105.

Studies of grazing management for cow-calf operations on native range have been conducted on the Texas Experimental Ranch since 1960. Three stocking rates and three grazing systems were evaluated. Calf production was greater from the deferred-rotation grazing systems than from continuous grazing at the same stocking rate. Heavier stocking rates reduced calf production per animal unit slightly, but production per acre increased significantly. The net returns per animal unit were greatest from the Merrill system, stocked at a moderate rate, and the net returns per acre were greatest from heavy continuous stocking. The optimum stocking rate for this range appeared to be between 40 and 50 animal units per section and it was profitable to use the Merrill grazing system.

Abstract No. 757.

Kucera, C. L., R. C. Dahlman, and M. R. Koelling. 1967. Total net productivity and turnover on an energy basis for tallgrass prairie. Ecology 48: 536-541.

The energy equivalent of total net productivity including foliage and roots on unburned prairie in 1962 was 4.351×10^6 cal/m^2, representing 992 g of biomass. The root system provided slightly over 50% of the annual increment. For 1963 the total growth was 1,133 g/m^2. The average energy for these years was equivalent to 1.21% of the incident radiation received during the growing season for the 400-700 mμ portion of the light spectrum. The maximum energy budget including current increment, roots of previous years, and litter was equal to 2.6 turnovers. In years with favorable rainfall, fire approximately doubled the aboveground yield. During drought, productivity increases of fire plots over control plots were curtailed sharply. On a dry matter basis, the total aboveground biomass at the end of the growing season was approximately twice that of the standing crop. During the April-September period for 3 years of observation, the loss in dry weight of the aboveground material ranged from 57% to 65%. For the remainder of the year the decrease was 31 to 39%. These values indicate a fluctuating but generally balanced annual system of growth and decay. For aboveground biomass, the turnover estimate was 2 years and for root biomass, 4 years. The decay time of a standing crop or root increment as determined from isolated litter samples and carbon-14-labeled roots in the field indicated that the annual turnover was comprised of a series of increments of different ages, decreasing in caloric content with time on a dry weight basis (uncorrected for ash). On an ash-free basis, litter 4 years old showed some increase in caloric content, suggesting changing composition of the residual fraction. The tallgrass prairie is seen as a relatively efficient ecosystem when compared to the worldwide terrestrial average. The stimulus of fire to dry matter production in the humid prairie indicates a more efficient use of solar energy; however, the long-term effects of sustained burning require observation.

Abstract No. 758.

Kulcher, A. W. 1964. Potential natural vegetation of the conterminous U.S. Amer. Geog. Soc. Spec. Pub. 36. 116 p.

Vegetation may be defined as the mosaic of phytocenoses in the landscape. A phytocenose is the same as a plant community. It consists of a given combination of life forms and a given combination of competing taxa with relatively uniform ecological requirements.

According to its title, the new vegetation map shows the potential natural vegetation. This title results from the work of the International Colloquium on Vegetation Mapping in Toulouse, France, during the spring of 1960, where it was decided that the titles of vegetation maps should always be as explicit as possible. The potential natural vegetation is always described as of a given date. The new map reveals the geographical distribution of the types of vegetation in their setting on the continent and in their relation to one another.

The vegetation types on the new map are all characterized by life forms and taxa, and nothing else. The types, therefore, are not units of some classification in a hierarchic sense.

The classless approach is not affected by the grouping of vegetation types into physiognomic and floristic units. These broad categories may perhaps serve as nuclei for a classification. But as used here they are a device to assist the reader in establishing and locating a type more readily. The conclusion is that the relationship among the types ranges from very close to absent.

On the map legend the size of the names of the vegetation types has been reduced to a minimum. The reader who desires more information on the vegetation than the legend offers is invited to consult the manual. This manual is designed to supplement the map legend. This is organized uniformly throughout, thus facilitating comparisons of different vegetation types. Also, the reader quickly appreciates just what kind of information he may hope to find and where to find it. There are five points for every vegetation type, as follows: title; physiognomy; dominants; other components; occurrence.

The unsystematic use of colors on the new vegetation map emphasizes the fact that vegetation is portrayed exclusively. No environmental features have been allowed to alter the original purpose of the map content. The selection of color is subjective. It has been found practical to use the same color more than once, even with the same pattern. A number of patterns of dots and lines have been used to lend a greater variety to a given color. The one exception to this rule is that all vegetation types shown in the legend to be mosaics or transitions have been given the same coarse multicolored pattern of vertical bars throughout the area of the map.

A small map scale implies generalized and heterogeneous types of vegetation covering extensive areas. A photograph shows what might be expected in that type, but it cannot illustrate all aspects and variations of type.

Abstract No. 759.

Lacey, M. L. 1942. The effect of climate and different grazing and dusting intensities upon the yield of the short-grass prairies in western Kansas. Kansas Acad. Sci., Trans. 45:111-123.

The non-grazed quadrats produced a good yield of short grass, but less than that of the lightly grazed plots. This indicates that a well managed grazing program is beneficial to the short grasses.

The forage yield and percent ground cover of short grass were greatest on lightly grazed quadrats.

Moderate grazing maintained a constant forage yield and short grass cover, except under extremely adverse conditions, when a considerable decrease in short grass yield and cover was noted.

Careful grazing practices following heavy grazing caused an increase in forage yield, but not on the basal cover of short grass.

Overgrazing caused an enormous reduction of short grass forage production and a corresponding loss in ground cover: conversely an increase in weedy annuals was generally the result.

Dusting caused an enormous loss in production of short grass forage and percent ground cover. Weedy animals, however, made a great increase.

Heavy infestation of grasshoppers reduced short grass yield.

Abstract No. 760.

Lackey, E. E. 1937. Annual-variability rainfall maps of the Great Plains. Geogr. Rev. 27:665-670.

The present study is undertaken in the belief that the theory of probabilities applied in a new way to weather data may offer an approach to more rational agricultural operations. The region selected is the Great Plains, an area admirably adaptable to a demonstration of the principle involved and, correlatively, an area where the need of applied climatological studies is acute.

Abstract No. 761.

Lake, J. V. 1967. Respiration of leaves during photosynthesis. I. Estimates from an electrical analogue. Australian J. Biol. Sci. 20:487-493.

A new analogue for the gas exchange of leaves takes account of respiratory CO_2. During light-saturated photosynthesis, the rate of respiratory CO_2 production by some dicotyledons was at least double that occurring in darkness. That this was apparently not so for three grasses, two tropical and one temperate, may be explained morphologically as well as biochemically.

Abstract No. 762.

Lane, R. D., and A. L. McComb. 1948. Wilting and soil moisture depletion by tree seedlings and grass. J. Forest. 46:344-349.

As a result of summer drought conditions common throughout the prairie areas and the Ozarks, plantations made on grassy sites may fail during the initial growing season. The authors found that brome grass absorbed soil moisture more rapidly than some tree seedlings and that the permanent wilting percentage was lower with grass than with trees. The results of their investigation emphasize the need for moisture-conserving treatments when tree seedlings are planted in heavily sodded sites.

Abstract No. 763.

Lang, R. L. 1945. Density changes in native vegetation in relation to precipitation. Wyoming Agr. Exp. Sta. Bull. 272. 31 p.

An eight-year study to determine the relationship between precipitation and density of native vegetation was conducted in parts of Converse, Campbell, and Weston counties, Wyoming.

There was a striking relationship between the precipitation during any 12-month period beginning September 15 and the density of the vegetation in the following growing season.

The relationship between the three vegetative groups: (1) grass and grass-like plants, (2) forbs, and (3) shrubs and semishrubs, did not remain constant. On the shortgrass vegetative type the density of perennial grasses had decreased, while the forbs and shrubs had increased. On the cactus-grass type the perennial grasses and shrubs had increased, while the forbs had decreased in density. On the sagebrush-grass type the density of all three groups had fluctuated in about the same proportion in accordance with fluctuations in precipitation. On the mixed grass vegetative type there has been a tendency for a decreased density of forbs, while the shrubs remained relatively constant. On the abandoned farm land there has been a sharp decrease in forb density and a moderate increase in density of perennial grasses.

Since the period of study covered some extremely dry years as well as some relatively wet years, it has shown that density decreases of 50% or more may be expected from wet to dry years.

Abandoned farm land was found to revegetate to perennial grasses very slowly by natural processes. The dominant perennial grass nearly 10 years after abandonment was found to be needle grass. Blue grama, which is the dominant grass on unbroken land, was found on only 2% of the plots studied.

Three years of complete protection from grazing did not materially change the total density of vegetation as compared to grazed areas. However, there was a slight increase in grass and shrub density and a decrease in forb density on the protected areas, which showed that although the total density had not been materially affected by protection, the composition was being slowly changed.

Abstract No. 764.

Lang, R. L., and O. K. Barnes. 1942. Range forage production in relation to time and frequency of harvesting. Wyoming Agr. Exp. Sta. Bull. 253. 32 p.

Clipping experiments carried on at the Archer Field Station in southeastern Wyoming show that the short grasses yield more when harvested frequently at ground or crown level than they do when protected during the growing season and harvested after growth has ceased. This was true even on plots which had been harvested in this manner for two years with no apparent decrease in the density of perennial grasses.

Midgrasses were found to yield significantly higher under protection and harvesting at the end of the growing season than under frequent clipping, just the opposite reaction to that exhibited by the short grasses.

Annual forbs made the same response as the midgrasses, that is, lower yields under frequent clipping. Perennial forbs reacted in the same manner as the short grasses in giving a higher yield under frequent clipping.

Abstract No. 765.

Lang, R. L., O. K. Barnes, and F. Rauzi. 1956. Shortgrass range-grazing effects on vegetation and on sheep gains. Wyoming Agr. Exp. Sta. Bull. 343. 32 p.

A grazing study of 10 years' duration (1945-54) was conducted on native shortgrass rangeland in southeastern Wyoming.

The principal objectives were to determine the effect of three degrees of forage utilization on the botanical composition of the vegetation and the pounds of gain per head and per acre on the sheep used in the experiment.

Abstract No. 766.

Lang, R. L., and L. Landers. 1960. Beef production and grazing capacity from a combination of seeded pastures versus native range. Wyoming Agr. Exp. Sta. Bull. 370. 12 p.

A study to compare grazing capacity and beef production from a combination of seeded pastures grazed at their optimum period of growth with native range was initiated at the Gillette Substation in 1954.

The seeded pastures consisted of standard crested wheatgrass for spring grazing, intermediate wheatgrass for summer grazing, and Russian wildrye for fall grazing. Each of these species was seeded with alfalfa and yellow-blossom sweetclover. The native range was a mixture of shortgrasses, midgrasses, and forbs with some big sagebrush present in the composition.

Yearling Hereford steers were used as experimental animals, and weight records were taken periodically, so that gains could be calculated by either specific dates or for specific pastures.

Animal gains per day were similar for both seeded and native pastures. Gains per acre and grazing capacity were two to three times as great from the combination of seeded pastures as from native range.

Clipped plots showed that in 1955, 1956, and 1957 a considerable amount of forage remained on all pastures after grazing.

When costs were calculated on a local custom-rate basis, and no credit allowance was made for A.S.C. payments, the cost of establishing the seeded pastures plus some profit was realized during the first four years of grazing. As these seeded pastures may well be expected to be productive for an additional six years, with little or no additional costs, it could be assumed that this combination of seeded pastures would show considerable economic advantage over an equal acreage of native range.

Abstract No. 767.

Lang'at, R. K. 1968. Developmental morphology of the shoots of *Bouteloua gracilis* and *Andropogon hallii* in relation to grazing. M.S. Thesis. Colorado State Univ., Fort Collins. 57 p.

The study was conducted at the Eastern Colorado Range Station from April to October 1967. Its objectives were to determine (1) the developmental morphology of the grass shoot and (2) the morphological changes resulting from simulated grazing.

Abstract No. 768.

Langdon, R. M. 1933. The Lark Bunting. Bird Lore 35(3):139-142.

According to data in the files of the Bureau of Biological Survey, United States Department of Agriculture, the Lark Bunting is predominantly an insect eater. An examination of 36 stomachs, mostly collected in July and August, revealed 79.08% animal matter and 20.92% vegetable matter in the bird's total diet. Field observations seem to confirm these percentages. The verdict is, "In summer, therefore, under normal conditions in most localities of its range, the Lark Bunting should be regarded as a highly beneficial bird."

Abstract No. 769.

Langer, R. H. M. 1963. Tillering in herbage grasses. Herbage Abstr. 33:141-148.

The author gives a detailed review of the Gramineae seedling and the formation of its axillary shoot, the tiller. The account goes into the life history of tillers; factors affecting tillering (including genotype, temperature, light intensity, water supply, mineral nutrition, flowering, growth regulators and cutting); and tillering under field conditions.

Abstract No. 770.

Lantow, J. L. 1933. The assimilations of calcium and phosphorus from different mineral compounds and their effect on range cattle. Agr. Exp. Sta. Bull. 214. New Mexico State Univ., Las Cruces. 30 p.

Calcium and phosphorus were beneficial as supplements and were profitable to feed. A compound that contained both calcium and phosphorus was more beneficial than one in which the calcium was lacking.

Calcium and phosphorus deficiency retards growth, maturity, and milk production.

Mineral experiments should probably extend over the entire life period of the range animals to determine not only the immediate effects of the added supplements but secondary results and effects, such as increased production.

Abstract No. 771.

Lantow, J. L., and E. L. Flory. 1940. Fluctuating forage production: Its significance in proper range and livestock management on southwestern ranges. U.S. Dep. Agr. Soil Conserv. 6(6):1-8.

Data on rainfall and forage production are presented with comments about the injurious effects of overgrazing in dry years. Practical suggestions are outlined for properly adjusting livestock numbers to available feed.

Abstract No. 772.

Larson, F. 1940. The role of bison in maintaining the short grass plains. Ecology 21:113-121.

The term "disclimax" gives the wrong concept of ecological development of the short grass plains; these plains are a true climax (in Clements' sense). Weaver and Clements justify their classification of the short grass plains as a disclimax by citing the reappearance of taller grasses under protection from grazing; reestablishment of the taller grasses in wet years, and the photographic evidence of the Hayden Expedition of 1870. These sources of evidence meet the following objections: protected plots are atypical of biome conditions because the plains formerly received heavy grazing from buffalo and other wild grazing animals. Minimal, not maximal, quantities are more important in plant ecesis; therefore, the plus phase of the climatic cycle should not be the criterion. The narrative section of Hayden's Report on the expedition of 1870 lists short grass as being dominant in the plains. Many of the photographs were taken along streams and in valleys where taller grass was more common and at a time of undergrazing when the buffalo population had been greatly reduced and the livestock population was not yet large. Three kinds of evidence indicate that the short grass plains represent the true climax of the pristine biome: Numerous and reliable quotations in the historical record show that the former population of wild grazing animals stocked the plains to carrying capacity; direct statements from journals and reports of early explorers and pioneers make specific reference to the existence of the shortgrass plains prior to the period of settlement; and the marked ability of the short grass dominants to withstand overgrazing indicates that this environmental factor is not strange or new.

Abstract No. 773.

Larson, F., and W. Whitman. 1942. A comparison of used and unused grassland mesas in the badlands of South Dakota. Ecology 23(4):438-445.

During the summer of 1939 a sampling study was made of the grassland vegetation on three adjacent mesas in the badlands of South Dakota. A relict area of grassland which apparently had never been grazed was compared with a nearby area which had been subjected to moderate intermittent use, and with a similar area subjected to mowing and light grazing for the past 40 years.

The results showed that total protection had maintained a mixed-grass type dominated by western wheatgrass and dry-land sedges, while combined mowing and grazing produced a short-grass type dominated by blue grama grass. Although the short-grass type produced the greatest density of vegetative cover, the yield of forage was greatest from the mixed-grass type.

Needle-and-thread, usually abundant on protected areas, was not a major dominant on the completely protected mesa. It was most abundant on the intermittently-used mesa. Mowing and grazing apparently had reduced greatly the amount of this species and of the sedges, *Carex eleocharis* and *C. pennsylvanica*, on the mowed mesa as compared with the other mesas. Forbs and woody plants were negligible on the protected mesa but made up an appreciable portion of the cover on the intermittently-used and the mowed mesas. There was no evidence of accelerated soil erosion on any of the areas, but the plant mulch was much thicker on the protected and the intermittently-used mesas.

Abstract No. 774.

Larson, M. M., and G. H. Schubert. 1969. Root competition between ponderosa pine seedlings and grass. U.S. Dep. Agr. Forest Service Res. Paper RM-54: 1-12.

Soil water was the main factor in competition between grass and ponderosa pine seedlings. Pine seedlings survived and grew best on completely cleared plots. New grass roots started growth earlier and grew faster than pine roots. Arizona fescue and mountain muhly depleted soil water faster and to lower levels than ponderosa pine. In early June, pine seedlings with a needle moisture content (NMC) under 146% and water saturation deficit (WSD) above 25% had less than a 50-50 chance of surviving the ensuing drought period.

Abstract No. 775.

Lauenroth, W. K., and W. C. Whitman. 1971. A rapid method for washing roots. J. Range Manage. 24: 308-309.

The use of a system consisting of two sieves and pail with a spout on it greatly facilitates washing soil material from roots. Washing into the first sieve can be continued until all visible soil material is removed. The capacity of the system was 150 to 180 samples per eight-hour day. The major soil type on the sampling area was a Flasher loamy fine sand.

Abstract No. 776.

Launchbaugh, J. L. 1948. Studies of increment, height-weight, and moisture content of important western Kansas grasses. M.S. Thesis. Fort Hays Kansas State College, Hays. Unpublished.

Includes description of vegetation of areas sampled near Hays.

Abstract No. 777.

Launchbaugh, J. L. 1955. Vegetational changes in the San Antonio Prairie associated with grazing, retirement from grazing, and abandonment from cultivation. Ecol. Monogr. 25(3):39-57.

The San Antonio Prairie was mapped from a vegetational survey and studies were conducted during 1950 and 1951 to determine the following: (1) the course of plant retrogression from climax on grazed native pastures; (2) trends of secondary plant succession on pastures retired from grazing; and (3) stages of secondary plant succession on abandoned cultivated land. Fields representing different stages of plant succession and retrogression were selected for vegetation analysis. Line-interception and belt transect measurements were made to determine percentage composition and basal density of the vegetation in each field.

Abstract No. 778.

Launchbaugh, J. L. 1957. The effect of stocking rate on cattle gains and on native shortgrass vegetation in west central Kansas. Kansas Agr. Exp. Sta. Bull. 394:1-29.

The purpose of this report is to present the results of grazing trials on native shortgrass pastures near Hays, Kansas, for 1946-56, inclusive. Information regarding (a) the effects of different rates of stocking on beef production; (b) the effects of supplementing shortgrass pasture with protein concentrates during the latter part of the grazing season; and (c) the effects of different intensities of grazing on native shortgrass vegetation are presented and discussed.

Abstract No. 779.

Launchbaugh, J. L. 1964. Effects of early spring burning on yields of native vegetation. J. Range Manage. 17(1):5-6.

Production of *Buchloe dactyloides* (Nutt.) Engelm., *Bouteloua gracilis* (H.B.K.) Lag. ex Steud., and *Agropyron smithii* Rhydb. was reduced 48 to 82% the first year and 19 to 73% the second year following a wildfire in March 1959. Third-year yields were not significantly different. Yield reductions were attributed to partial killing of the plants and lower soil water intake in the burned areas.

Abstract No. 780.

Launchbaugh, J. L. 1967. Vegetation relationship associated with intensity of summer grazing on a clay upland range site in Kansas 20- to 24-inch precipitation zone. Kansas Agr. Exp. Sta. Tech. Bull. 154:1-24.

Shortgrass pastures on a clay upland range site were summer grazed at three intensities by yearling cattle during a 20-year period. Forage disappearance averaged 66.0, 47.5, and 38.8% under heavy, moderate, and light grazing, respectively, during the last 10 years of the experiment.

Buffalo grass was the major dominant in terms of basal cover at the start of the trials, but diminished in all pastures during the first 10 years. Coverage of blue grama decreased following an initial increase during the same period and western wheatgrass cover adjusted to grazing intensity by decreasing under heavy grazing and by increasing then decreasing slightly with moderate and light grazing. During the remaining 10 years, basal cover of buffalo grass was highest under heavy grazing and lowest under light grazing; western wheatgrass basal cover was lowest under heavy grazing and highest under light grazing; and blue grama basal cover was approximately the same regardless of stocking rate. The frequency of most miscellaneous grasses and broadleaved plants, composed chiefly of annual bromegrasses and western ragweed, was greatest under light grazing except for little barley and upright prairie coneflower, which were most frequent under heavy grazing.

Abstract No. 781.

Launchbaugh, J. L., and K. L. Anderson. 1963. Grass reseeding investigations at Hays and Manhattan, Kansas. Kansas Agr. Exp. Sta. Tech. Bull. 128. 22 p.

These studies indicated that planting grasses at the proper time had a more profound effect on initial and surviving seedling numbers than did type or amount of seedbed cover. Under conditions of these studies, it appeared that high amounts of preparatory crop residue were more essential for April grass plantings than for seedlings made during late fall and midwinter.

Abstract No. 782.

Launchbaugh, J. L., and H. L. Hackerott. 1969. Early-spring blue grama inflorescences from fall-initiated spikes. Crop Sci. 9:631-633.

Blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) was discovered flowering less than 1 month following severe winter weather and 2 months before the normal onset of heading in native range near Hays, Kansas. Variable spike damage was an indication of freezing or drought injury to the inflorescences during early development. The short interval between start of growth and spike exertion under field and experimental conditions suggests the early spikes were initiated the previous fall, started to develop, went into winter dormancy, and completed development during the earliest favorable growth period in the spring.

Abstract No. 783.

Launchbaugh, J. L., and C. E. Owenby. 1970. Seeding rate and first-year stand relationships for six native grasses. J. Range Manage. 23(6):414-417.

Average first-year plants per foot of row were .37, .64, 1.34, and 2.80 from pure live seed rates of 4, 12, 36, and 108, respectively. Average percent establishment in relation to seeding rate was 9.3, 5.3, 3.7, and 2.6 in the same order. Planting two-species mixtures in various proportions and at increasing rates did not significantly influence plant numbers compared with pure species plantings at similar rates.

Abstract No. 784.

LaVelle, J. W., J. A. Seilheimer, N. L. Osborn, and S. J. Herrmann. 1969. A preliminary study of three lentic communities on the Pawnee National Grasslands, p. 308-315. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Literature was reviewed on primary productivity of grassland lentic communities. Studies of this nature are very limited in number and apparently lacking for the Colorado, Wyoming, and Nebraska area. Instrumentation was developed to measure and record diurnal oxygen changes in grassland ponds. Three shallow water bodies on the Pawnee grasslands were surveyed: Cottonwood Pond, Spring Pond, and Lake George. The surface areas were 0.4, 0.3, and 20.2 ha, respectively. All three ponds had a mean depth of approximately .5 m. Biological and chemical sampling was done at monthly intervals on each pond beginning in September 1968. This preliminary survey showed each pond to be highly unique in its chemical and biological characteristics. The three ponds, however, represent types which occur commonly in the grassland biome.

Abstract No. 785.

Lavigne, R. 1972. Ethology of *Ablautus rufotibialis* on the Pawnee Grasslands IBP site (Diptera: Asilidae). U.S. IBP Preprint No. 30. Colorado State Univ., Fort Collins. 6 p.

A population of *Ablautus rufotibialis* Back was encountered atop a sandy bank overlooking Owl Creek, an intermittent stream passing through the International Biological Program Grassland Biome Intensive Study Site, 11.2 km north of Nunn, Colorado. This population was studied intermittently between April 19 to May 12, 1969 and March 30 to May 13, 1971. The dominant vegetation is *Bouteloua gracilis* (H.B.K.) Lag. (blue grama) with a scattered overstory of *Atriplex canescens* (Pursh.) Nutt. (4 wing saltbush), *Opuntia polyacantha* Haw. (prickley pear cactus), *Oryzopsis hymenoides* (Roem, & Schult.) Ricker (Indian rice grass), *Gutierrezia sarothrae* (Pursh.) Britt. & Rusby (broom snakeweed), and *Eurotia lanata* (Pursh.) MOQ. (winterfat).

Despite the fact that the genus was erected by Loew in 1866 and 12 new species have been added to it since that time, no biological or behavioral information concerning it has appeared in the literature. Dr. Joseph Wilcox, who identified these specimens, notes that (1966) "members of the genus *Ablautus* are usually found in sandy areas early in the season, from February to May; however, one species has been collected only in the summer and another one in the fall." On the IBP site, the population of very small asilids (6 to 8 mm in length) reaches its peak size in early April, becoming gradually smaller as the season progresses.

Abstract No. 786.

Lavigne, R. J., and L. E. Rogers. 1970. Effect of insect predators and parasites on grass feeding insects, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 20. Colorado State Univ., Fort Collins. 38 p.

The predators included in this study are the robber flies (Asilidae), tiger beetles (Cicindelidae), wolf spiders (Lycosidae), jumping spiders (Salticidae), Mantids (Mantidae), sphecid wasps (Sphecidae), and western harvester ants (*Pogonomyrmex occidentalis*). Data presented here are related to the population densities of these predators. An effort also was made to determine type of prey selected, amount consumed and general predatory behavior in relation to the environmental factors present at the study site. A food web is included with this report, showing some of the predator-prey relationships.

Abstract No. 787.

Lavigne, R. J., L. E. Rogers, and J. Chu. 1971. Data collected on the Pawnee Site relating to western harvester ant and insect predators and parasites, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 107. Colorado State Univ., Fort Collins. 96 p.

This technical report presents data concerning the role of the western harvester ants (*Pogonomyrmex occidentalis* Cresson) and the robber flies (Asilidae) in the grassland ecosystem. Other general data are presented concerning the parasitism rate of grasshoppers and the population fluctuations of other insect predators.

Abstract No. 788.

Lavin, F. 1953. Photoperiodic responses of geographic strains of blue grama. Ph.D. Diss. Univ. Chicago, Illinois.

Eight strains of blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.), originating over a latitudinal range of 18°2' from southern Alberta, Canada, to Nogales, Arizona, were grown in greenhouse experiments at the University of Chicago during 1942 and 1943 on constant photoperiods of 9, 13, 16, and 20 hr and on Chicago natural daylength.

Both floral and vegetative growth and development were found to be sensitive to length of photoperiod.

Time elapsed before onset of internodal elongation was least on the short photoperiods for all but the two most northern strains.

Leaf numbers four weeks after germination were very uniform among both treatments and strains, but by seven weeks differences had appeared. The largest numbers of tillers for all strains were formed on the shorter photoperiods.

Average maximum heights were greatest on the 16-hr photoperiod and least in the 9-hr series. Heights were also greatest for the southern strains in all treatments and tended to vary inversely with latitude.

The inter- and intrastrain diversity reported above must have a genetic basis. Reproductively, these strains can be arranged in a graded series; at one end are the more or less indeterminate northern strains and at the other the definitely short-day southern strains.

Additional evidence is provided that it is unwise to attempt photoperiodic classification at a species level until strains from a wide latitudinal range have been investigated. The results also substantiate the hypothesis that blue grama originated at higher elevations in the subtropics and then spread to the higher latitudes of North and South America. Results show that the habit of a plant population in one environment is not predictable from its mode of growth in another. The large amount of interstrain and individual variation in blue grama makes it possible for much improvement and uniformity to be obtained by selection. It may also be possible to breed new and superior strains for certain localities.

Abstract No. 789.

Lawrence, T. 1960. Quality of Russian wild ryegrass seed as influenced by time and method of harvesting. Canadian J. Plant Sci. 40:474-481.

A study was conducted with Russian wild ryegrass, *Elymus junceus* Fisch., to relate seed quality to stage of maturity of the seed at time of harvest and method of harvesting. Removal of the seed from the seed culms at an immature stage (straight combining), and drying the seed immediately after, had a detrimental effect on the germinability of the seed. This effect decreased as maturity advanced until there was no appreciable germination loss 2 to 3 days before complete maturity. On the other hand, if the seed was left attached to the seed culms until dry and then threshed (swather method), the loss of seed quality attributable to reduced germination was considerably less. However, seed harvested more than 6 days before maturity by both methods had a rather low 100-kernel weight which might be reflected in lower seed yields.

Abstract No. 790.

Lawrence, T., and J. E. Troelsen. 1964. An evaluation of 15 grass species as forage crops for southwestern Saskatchewan. Canadian J. Plant Sci. 44(4):301-310.

Fifteen grass species were evaluated for dry-matter yield, protein content, in vitro digestibility of cellulose, and winter hardiness. Of these species only *Agropyron cristatum* and *Elymus junceus* are used extensively as cultivated forage crops in the prairie area. *Elymus excelsus*, *E. giganteus*, *E. sibiricus*, and *E. striatus* appeared to possess fairly high forage-yielding potential as they produced nearly as much as *A. cristatum* in the first crop year. *Elymus sabulosus* and *Stipa tenacissima* lacked drought tolerance but may give satisfactory yields in moist areas. The other species yielded less forage, generally in the range of production typified by *E. junceus*. The cellulose digestibility of *E. angustus* was similar to that of *E. akmolinensis* and *E. junceus*. However, *E. angustus* contained less crude protein than these two species. *S. viridula* exhibited qualities between those of *A. cristatum* and *E. junceus*, and since its yielding capacity and drought resistance were quite good, this species should be reasonably useful for forage production. Of the 12 *Elymus* species, *E. Angustus* showed the best possibilities of becoming a useful forage crop on dry land for late fall and winter grazing. After the severe drought of 1961, *E. arenarius*, *E. excelsus*, *E. giganteus*, *E. sibiricus*, *E. striatus*, and *E. virginicus* killed out completely and should therefore be considered of doubtful usefulness as cultivated forage crops in a semi-arid, cold climate despite other attributes they may possess.

Abstract No. 791.

Lechleitner, R. R. 1957. Reingestion in the black-tailed jack rabbit. J. Mammal. 38(4):481-485.

Reingestion of soft feces is a normal part of the feeding biology of the black-tailed jack rabbit on the Gray Lodge Waterfowl Management Area, Butte County, California. The soft feces are formed in the caecum and swallowed during the daylight hours, which are the main periods of inactivity of the hares. No seasonal trends in the process of reingestion could be detected.

Abstract No. 792.

Lechleitner, R. R. 1958. Certain aspects of behavior of the black-tailed jackrabbit. Amer. Midland Natur. 60(1):145-155.

Observations of behavior were made on a population of jack rabbits in which 100 of the hares were marked and released. No social organization or family structure could be detected among the adult hares. Open areas were most often used for feeding, and feeding activity occurred mainly in the evening. Reaction to alarm consisted of freezing, creeping away or fleeing rapidly, depending on the type and suddenness of the alarm and on the situation. Alarm effects appear to spread from animal to animal. Sexual activities can be classified into: the hunt, the approach, the chase, the "boxing match," and copulation. Any one of these activities can end quickly and be replaced by some other behavior. Pregnant jack rabbits avoid approach by others, reacting antagonistically. This antagonism may function as a type of territorial behavior. Almost all of the sexual and aggressive behavior seems to be intimately related to the breeding season.

Abstract No. 793.

Lechleitner, R. R. 1958. Movement, density, and mortality in a black-tailed jackrabbit population. J. Wildlife Manage. 22(4):371-384.

A population of the black-tailed jack rabbit was studied on the Gray Lodge Waterfowl Management Area, Butte County, California, from October 1954 to March 1956. Two methods were used: one of these consisted of the necropsy of a number of hares killed in each month of the study period; the other consisted of capturing, tagging, releasing, and then observing a sample of the hares.

Numerous observations on the tagged jack rabbits indicate that these hares have rather well-defined home ranges of less than 50 acres. There is considerable overlap of individual home ranges at the observed density of about one jack rabbit per acre. The size of the home range seems to be determined by the pattern of food, water, and cover in the environment. Shifting, expansion, and contraction of the home ranges allow for the quick population of fields that were formerly not suitable habitat. Jack rabbits driven from their home ranges may return to them.

Automobiles and fires may kill considerable numbers of jack rabbits. Predators, except dogs, appear to have little influence on the adult population. The greatest losses of marked jack rabbits occurred in the winter. During and after the winter flood of 1955-56, 150 carcasses were found. About 20% of these deaths were probably due to an intestinal coccidiosis, but the remainder appeared to have died of a condition resembling shock disease.

Abstract No. 794.

LeClerg, E. L., and F. G. Smith. 1928. Fungi in some Colorado soils. Soil Sci. 25:433-441.

The dominant type of fungi in Colorado soils seems to be species of Penicillia, whereas species of Aspergilli occur only occasionally. The three dominant groups of fungi in order of total numbers and in variety of species are Penicillia, Trichodermae, and Aspergilli. The rarer forms are species of *Cephalosporium*, *Verticillium*, *Spicaria*, *Hormodendrum*, *Macrosporium*, and *Stachybotrys*.

From the 27 soils studied it appears that soils low in moisture apparently favor the growth of *Rhizopus nigricans* and *Trichoderma lignorum*. Moisture did not seem to limit the presence of *Penicillium expansum*. Moisture content, which varied in the samples taken from 1.9% to 5.5%, apparently had no specific effect on the prevalence of other species.

The number of species of fungi isolated was considerably less in soils containing high quantities of soluble salts than in those of low salt content. Greater numbers of Penicillia were found in soils of high salt content than of any other fungus. *Penicillium expansum* and *P. lilacinum* were abundant under these conditions. Species of *Macrosporium* and *Cephalosporium* were also found in soils high in salts. *Trichoderma lignorum* and *Rhizopus nigricans* were abundant only in soils of low salt content. *Penicillium expansum*, *P. roseum*, *P. lilacinum*, *P.* No. 55, and *Fusarium* sp., were found in small numbers under low salt conditions.

Rhizopus nigricans and *Penicillium expansum* were common to both productive and unproductive soils, but were more abundant in the latter. *Trichoderma lignorum* was present only in the surface of these two soils. Greater numbers of species of Fusaria were isolated from the productive than from the unproductive soils. *Penicillium glaucum*, *P. roseum*, and *Cephalosporium* sp. were found only in productive soils, whereas *Macrosporium* sp. was isolated only in the unproductive soils. *Penicillium expansum* was isolated from 5 of the 8 samples of productive soils and also from 6 of the 9 samples of unproductive soils.

The number of species found decreased with depth. Only two species were isolated at 42 inches. *Trichoderma lignorum* and *Penicillium expansum* were present at all depths examined. *Aspergillus niger* was abundant only in the surface when present. *Fusarium* sp. was present in both the surface and subsurface of the soils examined. *Spicaria simplicissima* and *Hormodendrum pallidum* No. 50 were found in the surface, whereas *P. duclauxi*, *P.* No. 67, *P. lilacinum*, and *P.* No. 55 were present only in the subsurface.

Abstract No. 795.

Lester, J. E., and H. G. Fisser. 1970. *Opuntia* clump size variation on the shortgrass plains, Pawnee Site, Nunn, Colorado. J. Colorado-Wyoming Acad. Sci. 7(1):37-38.

Opuntia polyacantha was examined on upland sites, subjected to three grazing treatments (light, medium, and heavy), for over 30 years, for variations in mean area of clump size. A quantitative determination of non-randomness was established on each site by comparing the observed number of individuals per quadrat to the expected number per quadrat derived from a Poisson series. Frequency data were obtained from transects of 256 contiguous decimeter square quadrats in 30m × 30m study plots within each grazing treatment. The analysis of variance technique applied to the frequency data gave an estimate of clump sizes for each transect. Mean area of *Opuntia* clump size in each grazing treatment was determined from the consistent appearance of peaks in a set of replicate transects. Clump sizes for the light, medium, and heavy grazed treatments were found at scales of: 4, 16, and 128; 4 and 128; and 8, 32, and 128 dm, respectively.

Abstract No. 796.

Lettau, H. 1969. Evapotranspiration climatonomy: I. A new approach to numerical prediction of monthly evapotranspiration, runoff, and soil moisture storage. Monthly Weather Rev. 97(10):691-699.

The background and development of a theoretical method to solve the water balance equation for land areas is discussed. A forcing function is considered that is essentially determined by the product of absorbed solar energy multiplied by monthly precipitation; the response function is soil water in its month-to-month variations. A very simple parameterization is provided by one nondimensional surface characteristic named the "evaporivity" (which measures the fraction of absorbed insolation utilized during the month in the vaporization of concurrent precipitation) and a characteristic lag-time interval of the order of 2 to 3 months to express "delayed" evapotranspiration and runoff. The solution is obtained by a closed integration of the water balance equation (rather than employment of regression or correlation methods) and yields a coherent set of data on monthly evapotranspiration, runoff, levels of exchangeable soil water, and storage changes. For verification, area averages for the central plains and eastern region of North America are calculated and compared with several years of actual data analyzed and evaluated by Rasmusson. In spite of simplifying tentative assumptions used in the model calculation, the agreement between predicted and observed data is improved in comparison with results of the earlier prediction methods discussed by Rasmusson.

Abstract No. 797.

Levitt, J. 1951. Frost, Drought, and heat resistance. Annu. Rev. Plant Physiol. 2:245-268.

The main reason for dealing with all three kinds of resistance in one review is the large mass of evidence pointing to a relation between them, i.e., the development of resistance to one factor usually involves an increase of resistance to one or both of the others. This point will be discussed in greater detail. Such a relationship can be expected to apply only when resistance is used in the sense of withstanding or tolerating the frost, drought, and heat in the very tissues of the plant, but not in the sense of opposing these factors or preventing their penetration into the plant. Thus, it does not apply to the "drought resistance" of succulents, nor to the "frost resistance" of plants that supercool instead of freezing, nor to "heat resistance" due to an ability to maintain a lower temperature than that of the environment. This review will therefore be confined to resistance of the first kind mentioned above, with greatest emphasis on those papers that are concerned with the mechanism of resistance.

Abstract No. 798.

Lewis, F. J., E. S. Dowding, and E. H. Moss. 1928. The vegetation of Alberta. J. Ecol. 16(1):19-70.

The types of swamp, moor, and bog forest vegetation in three of the phytogeographical regions of Central Alberta have been described. The areas lie in morainic basins of varying size, and the blue glacial clay under the peat deposits contains numerous mosses and the seeds of water plants inhabiting the lakes before the formation of the low-moors and high-moors which now occupy these basins.

The pH of the low-moors varies from 5.0 to 6.5 and the high-moors 4.0 to 5.5. Analyses of the clays and the free water in types of swamps, low-moors, and high-moors are given.

The vegetation is described from a regional point of view under the three climatic climax formations characteristic of Central and Northern Alberta, viz., the Cordilleran Forest, Northern Forest, and Poplar Parkland.

Abstract No. 799.

Lewis, J. K. 1970. Comprehensive Network Site description, COTTONWOOD. U.S. IBP Grassland Biome Tech. Rep. No. 39. Colorado State Univ., Fort Collins. 26 p.

Cottonwood Site is located on the Cottonwood Field Station which is owned and controlled by South Dakota Agricultural Experiment Station. The Cottonwood Range Field Station is located in west central South Dakota on highway 14 about 75 miles east of Rapid City, 2 miles east of Cottonwood, and 11 miles west of Philip. The area of the Cottonwood Range Field Station is 2,640 acres. A summer intensity of grazing study has been conducted since 1942. Pastures 1 and 4 have been grazed heavily, pastures 2 and 5 moderately, and pastures 3 and 6 lightly since the beginning of the study. Since the intensity of grazing has been a summer treatment, there are six pastures which have been grazed in the winter only. The pasture south of the beef sheds west of the road, the section on which the farmstead is located, and the reserve pasture on the east have received varying use for the management of a breeding herd and for animals which were not on experiment. Four small (2-acre) watersheds were installed on north facing slopes on pastures 4, 5, and 6 in 1962, and runoff data have been collected on these by personnel of the Agricultural Research Service from 1963 to the present. Various range improvement plots are located in the north portion of the winter pastures.

Abstract No. 800.

Lewis, J. K. 1970. Primary producers in grassland ecosystems, p. 241-1 to 241-84. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. *A supplement*. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The grassland vegetation of today is the result of the controlling factors of the elements of climate, geological materials (including parent material, relief, and ground water), and available organisms (both macro-and microflora and fauna) interacting through time. The vegetation, as we see it today, is the result of autogenic progression, allogenic succession (probably both regression and progression), succession induced by the activities of man, change due to fluctuation in the controlling factors of the ecosystem or to dynamic adjustments among the dependent factors (vegetation, microclimate, reducers, and decomposers, consumer organisms and soil). Cyclical changes may also be involved.

These kinds of ecosystem changes result in vegetation structure which can be observed and measured. The structure can be categorized by (1) life form; (2) the species composition and infraspecific variation; (3) the morphology of the plant community, including leaf area index and characteristics of the plant biomass; (4) the microclimate within the vegetation; (5) the organisms which are closely associated with or attached to the vegetation; (6) the vegetation pattern (morphological, sociological, and environmental); (7) periodicity; (8) stratification; and (9) species diversity. Vegetation structure is determined by the interaction of competing plant taxa with the environmental complex.

Ecosystem function includes energy flow, nutrient cycling and ecosystem regulation. Vegetation is involved in each of these functions, and their parameters are influenced by the vegetation structure. Net primary production, which is the contribution of the vegetation to energy flow, is the result of vegetation structure and the constellation of factors that affect the light, temperature, moisture, mineral nutrition, and other chemical activities of the competing plant taxa. Net primary production is thus strongly conditioned, not only by the climate and soil, but also by the extensive interlocking activities of the great variety of organisms involved in the grazing and the detritus food web. The management activities and mismanagement activities of man may be overriding in their effects. Methods of measuring net primary production and expressing its efficiency are discussed.

Vegetation structure also influences biogeochemical cycles of water and various essential nutrients which in turn affect the rate of net primary production. Vegetation structure through its influence on energy flow and nutrient cycling is extremely important in ecosystem regulation and the maintenance of a natural or a managed steady state.

The human uses of the grassland ecosystem include food derived from grazing animals, human and wildlife habitat, good quality water, germ plasm for domestication and breeding, and the scientific study of the operation of natural and semi-natural ecosystems. In less favorable environments optimum management for all of these uses involves management to maintain the vegetation in a condition somewhat similar to that of the natural steady state, characterized by relatively high net primary production coupled with sufficient diversity to insure stability. In more favorable environments the development of several cultivated ecosystems may be desirable. However, some uses are not served as well by intensively managed monocultures as by native grassland ecosystems in high range condition.

Abstract No. 801.

Lewis, J. K. 1971. The Grassland Biome: A synthesis of structure and function, 1970, p. 317-387. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

The structures of the ecosystems of the Comprehensive Network Sites of the Grassland Biome study have been compared with reference to site constants, treatment variables, and 1970 state variables. The primary producer state variables studied included seasonal trends and time-weighted means of aboveground standing crop of primary producers by category and functional group, mulch, and belowground standing crop. Consumer variables studied included seasonal trends and time-weighted means of invertebrate density and standing crop by families and trophic levels and small mammal and bird standing crops by species and ecological groups. In addition, typical standing crops of domestic livestock were compared.

Relationships of the time-weighted means of primary producer state variables to site constants, driving forces, and calculated soil water were studied using stepwise multiple regression. Likewise, relationships of time-weighted means of standing crops of invertebrate trophic levels and selected families to primary producer variables as well as abiotic variables were studied using stepwise multiple regression.

The function of some ecosystems was compared with reference to the rate processes of net primary production and herbivory as affected by site constants and treatment variables.

Abstract No. 802.

Lewis, J. K., G. M. Van Dyne, L. R. Albee, and F. W. Whetzal. 1956. Intensity of grazing: Its effect on livestock and forage production. South Dakota Agr. Exp. Sta. Bull. 459:1-44.

An intensity of grazing study with beef cows and calves on western South Dakota ranges has been conducted since 1942. This publication is a progress report presenting data collected from 1952 through 1955. Heavy, moderate, and light grazing have resulted in the following average stocking rates for the 7-month summer grazing season: 1.82, 2.85, and 3.78 acres per animal unit month. These stocking rates resulted in an average forage utilization of 69, 51, and 26% for heavy, moderate, and light grazing, respectively.

Under the conditions of this study since 1942, it appears that a utilization of the annual forage production of between 30 and 45% from May 1 to December 1 would result in maximum sustained livestock production consistent with maintaining the soil and vegetative resources. This utilization is affected largely by yearly differences in precipitation but may be obtained by an average stocking rate of from 2.50 to 3.00 acres per animal unit month during a 7-month summer grazing season on ranges similar to the Cottonwood Range Field Station.

Abstract No. 803.

Lewis, J. K., F. R. Gartner, and J. Nesvold. 1964. The effect of winter supplementation and intensity of grazing on steer gains on native range. Western Sect., Amer. Soc. Anim. Sci., Proc., 15:59. 7 p.

Two experiments with steer calves wintered on the range with various supplements from late fall to green-up and then grazed on summer range at 3 intensities at the Cottonwood Range Field Station are reported. In experiment 1, the calves were fed 2-1/2 lb. per head daily of a supplement containing added phosphorus and vitamin A and supplying 1/3, 2/3, or 1 lb. total protein. In experiment 2, the calves were fed 1-1/2, 2-1/2, or 3-1/2 lb. per head daily of a supplement containing 2/3 lb. total protein, added phosphorus, and vitamin A.

Winter × summer interactions were not significant. Two-thirds lb. total protein contained in 2-1/2 lb. concentrate feed (soybean meal, corn, and dicalcium phosphate) was adequate to support about 2/3 lb. daily gain on calves grazed on native range in the winter. Increasing the amount of total protein without increasing the total amount of supplement did not result in significantly increased gains. Increasing the total feed from 1-1/2 to 3-1/2 lb. without increasing the total protein above 2/3 lb. resulted in a small but significant increase in gain. Steer calves wintered to gain 1/3 lb. per head daily did not differ significantly in yearlong gain from calves fed to gain 2/3 to 3/4 lb., regardless of whether the terminal date had been the September, October, or November weigh date.

Abstract No. 804.

Lewis, J. K., J. Nesvold, and B. Beer. 1966. The effect of level of winter supplementation and intensity of summer grazing on steer gains on native range. Prepared for the 10th Beef Cattle Field Day, April 20.

Lewis, J. K., J. Nesvold, and B. Beer. 1966. The effect of level of winter supplementation and intensity of summer grazing on steer gains on native range. South Dakota Agr. Exp. Sta., A. S. Ser. 66-9. 3 p.

The amount of energy and total protein needed in supplements for wintering steer calves on the range has been studied at the Cottonwood Range Field Station, 12 miles west of Philip, for several years. During the summer as yearlings, these cattle are grazed on range pastures that have been grazed heavily, moderately, or lightly since 1942. This experiment is a continuation of this series of studies. Results from 1959 through 1963 are reported in the Beef Cattle Field Day Report for 1964.

Abstract No. 805.

Lewis, J. K., and B. Beer. 1968. Effect of level of winter supplementation of steer calves grazing winter range. South Dakota Agr. Exp. Sta., A. S. Ser. 68-18:90-92.

Previous supplementation studies at the Cottonwood Range Field Station with steer calves grazing winter range have shown the importance of both protein and energy. In 1960-61 and 1961-62 calves were fed 2-1/2 lb. of a supplement containing 1/3, 2/3, or 1 lb. of total protein, added phosphorus, and vitamin A from mid-November to green-up in mid-April and gained 0.32, 0.67, and 0.71 lb. per head daily, respectively. While gain was doubled by increasing the amount of protein fed by 1/3 lb. at the low level, increasing the protein by a further 1/3 lb. produced essentially no increased gain. If higher gains are to be achieved, more energy as well as more protein will be required.

In 1962-63 and 1964-65, calves were fed 2/3 lb. of total protein contained in 1-1/2, 2-1/2, or 3-1/2 lb. of total feed and from fall to green-up gained 0.52, 0.68, and 0.77 lb. per head daily, respectively. Thus, gains were increased about 0.1 lb. per head daily for each one pound increase in the supplement, showing that if greater gains are desired with efficiency more protein as well as more energy will be required.

These two studies suggested that 1-1/2 lb. of supplement daily containing 2/3 lb. of total protein would be about the minimum to support daily gains of approximately 1/2 lb. from steer calves grazing winter range. The studies also suggested that if protein and energy were fed in the proper ratio then gains would be generally proportional to the amount of supplement fed, at least at low levels. Since protein-rich concentrates are good sources of energy as well as protein, a study was designed to compare the results of feeding different amounts of a protein-rich concentrate in which the ratio of energy to protein is constant.

Abstract No. 806.

Lewis, J. K., J. Nesvold, and B. Beer. 1968. The effect of intensity of summer grazing on steer gains on native ranges. South Dakota Agr. Exp. Sta., A. S. Ser. 68-26:130-131.

Six native pastures at the Cottonwood Range Field Station have been summer grazed heavily, moderately, or lightly since 1942 by cattle. For the four years 1964 through 1967, average daily gains of yearling steers were in general inversely proportional to stocking rate while gains per acre were directly proportional. However, in wet years differences in gain per head were small and heavily grazed pastures produced the highest gains per acre. In dry years average daily gains were much greater at the lighter stocking rates and gain per acre was lowest in the heavily grazed pastures.

The range is still deteriorating under heavy grazing. The range may also deteriorate under moderate and light stocking rates during drought or during years with unfavorable distribution of precipitation. Economical range recovery requires cool season deferment, and when depletion is severe mechanical treatments and/or seeding may be required for rapid improvement.

Abstract No. 807.

Lewis, J. K., J. L. Dodd, H. L. Hutcheson, and C. L. Hanson. 1971. Abiotic and herbage dynamics studies on the Cottonwood Site, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 111. Colorado State Univ., Fort Collins. 147 p.

Above- and belowground herbage biomass, mulch, and abiotic factors were studied in a permanent exclosure in high range condition and in a temporary exclosure in low range condition at the Cottonwood Range Field Station, 75 miles east of Rapid City. The permanent exclosure was fenced from a pasture with a history of light grazing in 1963. This area appears to be approaching stability. The temporary exclosure was fenced from a pasture with a history of heavy grazing in the spring of 1970. Both exclosures are located on gentle, northeasterly slopes with silty clay soils. Mean annual precipitation is 15.1 inches of which about 75% is received from April through September.

Precipitation, evaporation, evaporation pan wind movement, and soil temperatures at 10, 20, 50, 100, and 150 cm were measured daily in exclosures near to and very similar to the study areas. Total solar radiation, wind movement and wind direction at 2 m, air temperature, and relative humidity in a standard weather bureau instrument shelter were measured daily near the study areas. Soil water was determined gravimetrically on the clip plots at each sample date by 10 cm increments to 60 cm. Heavy snow in April resulted in total soil water to 60 cm of about 21 cm in both exclosures in early May, decreasing steadily to about 11 cm on September 2 with brief recharge in early July and early August with a significant increase in the fall. Precipitation for the year was 2.92 inches below normal.

Abstract No. 808.

Lieth, H. 1968. The determination of plant dry matter production with special emphasis on the underground parts, p. 179-168. *In* F. E. Eckardt [ed.] Functioning of terrestrial ecosystems at the primary production level. UNESCO, Paris.

Different techniques are necessary for the study of biomass production above or below the surface of the soil. In this article all the most difficult problems involved in measuring the productivity are discussed, the basic techniques are assumed to be already known. In those concerned with the aboveground organs, none have explained in detail methods which determine production during the last period of growth of ligneous plants. In this paper, therefore, emphasis is placed on the advantages presented by the study of tree rings, or the measure of wood density growth.

To establish a program for future research, it is important to consider the fact that we were never able to obtain by this method of harvesting, the total production at the end of the growth period. Some parts of the plant were always lost in the course of this period. Studies of the productivity imply, therefore, growth analysis.

The eventual role of absorbent root hairs and young lateral roots is briefly discussed.

The bibliographic list contains, other than the references mentioned in the text, the references of important work on this subject.

Abstract No. 809.

Linnell, L. D. 1961. Soil-vegetation relationships on a chalk-flat range site in Gove County, Kansas. Kansas Acad. Sci., Trans. 64:293-303.

Little research pertaining to soil-vegetation relationships has been done on a chalk flat range site. The purpose of the study reported herein was to determine soil properties and vegetation structure on such a site in Gove County, Kansas. Data concerning soils and vegetation were collected from a line transect extending eight-tenths of a mile across the site.

Abstract No. 810.

Lippert, R. F., and H. H. Hopkins. 1950. Study of viable seeds in various habitats in mixed prairie. Kansas Acad. Sci., Trans. 53:355-364.

Denuded areas are often repopulated by seeds present at the time of the disturbance. The purpose of this study was to find what viable seeds were present in the surface soil of various plant communities.

Three soil samples, each 0.5 inch in depth and with an area of 1 square foot, were taken from each of 22 habitats. A total of 18,539 seedlings emerged from these samples. Excluding sand dropseed, there were 18 times as many seedlings of weedy species as of non-weedy species. Most abundant weeds were downy brome, little barley, pigweed, mat spurge, and sticktight.

Sand dropseed furnished 42% of the total seedlings. A comparatively small number of seedlings of other perennial grasses emerged; perennial forbs were also few in number. Maximum emergence of weedy plants occurred during the first week, but that of non-weedy plants was not reached until the sixth week.

There was some correlation between species of seedlings and composition of the community from which the samples were taken. In samples from the moderately grazed shortgrass community, little barley and six-weeks fescue furnished 92 of the 105 grass seedlings. More weedy plants emerged from samples from the overgrazed shortgrass type than from any other type. Blue grama seedlings were also comparatively abundant.

Samples from the mid-grass community, which is typical of rocky hillsides, produced no weeds but a large number of perennial forbs. Perennial grasses were most abundant from the lowland mixed-grass community. Despite the absence of vegetation in the denuded pasture corner, seedlings of several weedy species emerged in large numbers from the samples.

A total of 959 seedlings of sand dropseed emerged from soil taken in the natural revegetation habitat. Where burning had occurred, this number was increased to 5,793. Samples of soil from the weedy meadow produced considerable numbers of both weeds and perennial grasses.

Abstract No. 811.

Livingston, B. E., and F. Shreve. 1921. The distribution of vegetation in the United States as related to climatic conditions. Carnegie Inst. Washington, Pub. 284. 585 p.

The work presented in this publication has fallen under three heads: (1) giving the facts as to the distribution of certain types of vegetation and certain species of plants of the United States; (2) giving the data to show the intensities of the leading climatic conditions in the United States; (3) correlating these two bodies of facts in such a manner as to learn the exact range of conditions under which each plant or vegetation lives with respect to each of the climatic elements.

Abstract No. 812.

Livingston, R. B. 1952. Relict true prairie communities in central Colorado. Ecology 33(1):72-86.

The climax vegetation characteristic of lower altitudes to the Platte-Arkansas divide is the mixed prairie association; that characteristic of much of the upper portion of the divide is an extension of the montane forest onto the plains. Within both of these communities occur many relict grassland communities dominated by species typical of the true prairie. The relicts within and immediately adjacent to the forest include among their important dominants *Sporobolus heterolepis*, *Stipa spartea*, and *Poa pratensis*. Dominants of the relicts occurring at lower altitudes within the mixed prairie include *Sporobolus heterolepis*, *Andropogon scoparius*, and *Sorghastrum nutans*. Associated with these dominants are numerous subordinate species which are characteristic of the true prairie.

Neither precipitation, temperature, nor evaporation appears to be the causal factor influencing or limiting the presence of these communities.

These relict true prairie communities have been able to survive in this semi-arid region only in sites where soil water conditions are unusually favorable. Increased soil water at sites of the relicts is largely influenced by the topographic position of the communities in the forest (at margins of open meadows), and by an unusually high water table at the sites within the mixed prairie.

It is possible that these relict communities may have resulted from man's activities, having been recently established from seed introduced from the eastern true prairie region. There is, however, little evidence to support this view. Secondly, they may have originated from a westward migration from the true prairie, following the same migration path that led the Rocky Mountain forest communities eastward into the true prairie region of Nebraska. A third and more probable explanation of the origin of these relict communities, is that they are relicts of a former climax.

Abstract No. 813.

Lloyd, J. E., and R. R. Grow. 1971. Soil macro-arthropods of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 104. Colorado State Univ., Fort Collins. 18 p.

The summer of 1970 was devoted to collection on a biweekly basis and identification of soil insects from the four differentially grazed pasture types. All organisms that were retained on a one millimeter sieve were considered macro-arthropods. Major insect groups collected and identified, in order of decreasing abundance were: Formicidae, Scarabaeidae, Staphylinidae, Rhinotermitidae, Tenebrionidae, Carabidae, Margarodidae, Curculionidae, Annelida, Asilidae, Elateridae, Lepidoptera, Lygaeidae, and Cerambycidae. Biomass and caloric values of the abundant groups will be determined.

Abstract No. 814.

Lockwood, J. L. 1968. The fungal environment of soil bacteria, p. 44-65. *In* T. R. G. Gray and D. Parkinson [ed.] The ecology of soil bacteria: An international symposium. Univ. Toronto Press, Toronto.

Since the bacterial environment we are considering is the fungus, we should first try to place in perspective the occurrence of fungi in soil and the kinds of fungus structures which are available as micro-sites for bacterial development. According to current ecological concepts the soil is an impoverished medium in which microbial development is restricted to available nutrient substrates rather than occurring actively at all times throughout the soil mass. Prominent among potential substrates for fungi are dead plant or animal material, rhizospheres or root tissues of plants. A temporary fungal development may occur more generally when soluble nutrients become released or redistributed by such processes as alternate drying and wetting or evaporation from a surface. As nutrients become exhausted, hyphae of many fungi are rapidly lysed in soil. Fungi must then survive as resting spores sclerotia or resting mycelium or be extinguished. Thus, vegetative development of fungi is dispersed in time and space according to the availability of nutrients.

Unfortunately, knowledge of the fungal biomass in soil is only fragmentary. The general impression gained from direct microscopic examination of soils is that hyphal development therein is scant.

It is generally accepted that colony counts of fungi on dilution plates reflect numbers of fungus spores, and values obtained with this method range from a few thousand to over a million per gram of soil. Such estimates are no doubt low due to the well-known deficiencies of plating methods.

Besides the indigenous soil fungi, vast amounts of air-borne fungus spores come to rest on soil and these may also provide a significant substrate. Prominent among such spores might be basidiospores of hymenomycetes, uredospores of cereal rusts, teliospores of cereal smuts, and conidia of common saprophytes such as *Cladosporium*.

In this context, this paper will attempt to describe the types of interactions which bacteria and actinomycetes enter into with fungi in soil, and to interpret the significance of such interactions to both partners.

Abstract No. 815.

Lodge, R. W. 1970. Complementary grazing systems for the northern Great Plains. J. Range Manage. 23(4):268-271.

Grazing systems for the northern Great Plains based on the exclusive use of natural grassland are no better than continuous grazing. Since the quality of the majority of the ecosystems within the region makes seeded grass pastures feasible, seeded pastures containing highly adapted cultivars such as crested wheatgrass, Russian wildrye, and alfalfa can be used in various grazing systems to balance and extend the grazing season. The growth habits and nutrient characteristics of the herbage of the native grasses are of maximum value for a relatively short period during the year. Grazing systems detailed include one in which the requirement per animal unit is reduced from 24.8 to 11.4 acres.

Abstract No. 816.

Logan, O. L. 1961. A comparison of bird populations inhabiting three areas of encephalitis study in Weld County, Colorado. M.S. Thesis. Colorado State Univ., Fort Collins. 158 p.

Three areas of study in Weld County, Colorado, were censused, and the avifaunas of the grassland, riparian woodland, and marsh habitats were compared in terms of numbers of individuals per 100 acres, standing crop biomass per 100 acres, and consuming biomass per 100 acres. The dominant species in numbers and biomass for each habitat was determined. Each species was placed in an arbitrary feeding category according to whether the species fed primarily on animal or vegetable material. From this classification, the primary and secondary consumers for each habitat were established, and the avifaunas of each habitat were compared as to whether primary consumers or secondary consumers were dominant according to numbers, standing crop biomass, and consuming biomass.

By raising the mean body weight of each species to the 0.7 exponent, a figure relating to the food consumption ability of each species was determined. This value is useful as a basis for comparing the energy utilization by avifaunas in the same macroclimate.

The value of the consuming biomass--standing crop biomass ratio (CB/SCB) gives a basis from which the efficiency of an avifauna in utilization of energy can be estimated. The efficiencies of avifaunas of different habitats in the same area or similar habitats in different areas can be compared by this method.

The data obtained from this study were compared with those given by other workers.

Abstract No. 817.

Lommasson, T. 1947. Developments in range management: The influence of rainfall on the prosperity of eastern Montana, 1878-1946. Montana Stockgrower 19(2):18-19.

Above-average rainfall years were 1878-1879 and 1880. Grass crops were excellent. The period 1881 to 1904 included 15 dry years and 9 above average or average. The state was still a frontier, but weather controlled human use and prosperity. In 1880 central Montana was practically uninhabited. In 1888 all the land north of the Missouri and much south of the Yellowstone was Indian reservation. The early 80's were bonanza cattle days. Hard winters began in 1880-1881. The year 1886 was the end of the big profit cattle raising days. Following the winter of 1886-1887 stockmen began to raise hay.

The period 1905 to 1916 was a period of growth and prosperity built upon a period of years when rainfall during the growing season was above average. Enough rain fell so that good crops were produced. Ranges became progressively better. The year 1916 was the peak of dry farming. The period 1917 to 1939 was the most severe drouth period in the history of the state. Montana lost percentages of its banks, farms, manufacturing establishments, retail business, population, tand some towns. Taxes on farmland rose and valuation of the land itself dropped. The period of 1940 to 1946 has been a period of high level production and prosperity. This prosperity has been built upon an above average period of rainfall, which is the greatest in the history of the state. Production is at the highest levels of record, prices have been the highest ever received. The amount of money in circulation is the greatest ever known. If the pattern of past weather repeats itself, the present above average years will revert to drier years. Stockmen would re-establish average levels of stocking, retain a supply of grass for dry years, and keep ranges in top condition.

Abstract No. 818.

Lomnicki, A., E. Bandola, and K. Jankowska. 1968. Modification of the Wiegert-Evans method for estimation of net primary production. Ecology 49:147-149.

The assumptions on which the Wiegert-Evans (1964) "paired plots" estimation method of net primary production are based are discussed. An approach is proposed which does not involve the estimation of the disappearance rate of dead plant material and the standing crop of dead vegetation and which uses only measurements of growth of green plant material and of dead plant material. The Wiegert-Evans method and the modification were compared on a grassland community in Poland. There were no significant differences in the results, but the modified method proved simpler to use.

Abstract No. 819.

Looman, J. 1963. Preliminary classification of grasslands in Saskatchewan. Ecology 44(1):15-28.

A classification of the vegetation types in the Saskatchewan grasslands is proposed. As a unit of classification the association *sensu* Braun-Blanquet was adopted. This association, characterized by a combination of kensorts, is easily recognized in the field and may be considered a good ecological indicator.

The classification presented is based on more than 700 species-presence lists from which the associations and kensorts were isolated by means of statistical comparisons. The prearrangement of the species lists in a vegetational continuum, divided into intervals, can serve as an objective basis for the comparisons and results in a considerable saving of labor.

Correlation of occurrence of species, when used to construct vegetation models, shows clustering of species which are considered kensorts of associations or higher units.

Quantitative samples taken in different associations and ordinated statistically show an arrangement in accordance with the quantities of species represented in the samples. The arrangement obtained conforms to the units already established. Ordination of quantitative samples from stands in a single association gives valuable information on the ecology of the stands, especially the influence of soil, and utilization.

The associations form several vegetational continua, spatial as well as temporal, in which only the initial associations (on sharply contrasting habitats) are mutually discontinuous. In theory, the successional continua may be considered to converge towards one climactic vegetation type.

The classification proposed is not in conflict with either dynamic ecology or the concept of the individualistic association. The associations are considered to be equivalent developmental phases and are therefore not static. The stands, comprising the synthetic associations, are "individuals" of which no two are identical, but which are united in an association on the basis of floristic similarity.

The validity of the association as a vegetational unit in the strictest sense is of little importance to the practical value of the association as a regional classification unit.

Abstract No. 820.

Loomis, C. P. 1937. The human ecology of the Great Plains area. Oklahoma Acad. Sci., Proc., 17:14-28.

Because of a combination of factors, including destructive farm practices resulting from faulty settlement methods on the part of the government and lack of knowledge of how to adjust in an arid region on the part of the farmers, the over-extension of tilled crops with the destructive practices attending this expansion, the over-grazing of rangelands, and the immediate condition of insufficient precipitation, the following conditions have resulted: (1) Billions of dollars of federal funds have been poured into the area in the form of grants, allotments, payments, and loans. (2) Much land which would have been useful for either grazing or dry-land farming purposes has been utterly "wrecked." Thousands of acres of land (it is estimated as being 65% of the soil in the Great Plains states) have been damaged by wind erosion. (3) Mobility of the farm population has been extreme and would be even greater if federal aid had not been made available during distress periods. (4) The size of holdings has not been adjusted to the natural soil and climatic conditions which prevail in the area. (5) Land speculation has been extreme and has resulted in excessive indebtedness. (6) The proportion of farms operated by tenants has more than doubled in the last 55 years.

In order to establish a stable, well-adjusted agricultural society in this area many adjustments must be made. Soil conservation on the scale required by the prevailing conditions and adaptation of the farm practices and general culture of the area cannot be accomplished by private initiative. Much must be accomplished through present governmental institutions and agencies which have been established to cope with the problem.

Abstract No. 821.

Lotspeich, F. B., and M. E. Everhart. 1962. Climate and vegetation as soil forming factors on the Llano Estacado. J. Range Manage. 15:134-141.

The climate of the Llano Estacado is characterized by low rainfall with a summer maximum, high wind velocities, moderately high summer temperatures, and moderate to low relative humidities. Winters may have frequent short periods of near zero temperature, but total snowfall is small and winters are open. An important feature of winter is the rapid change in temperature with the passage of cold fronts; variations of 50° from one day to another are not unusual. Precipitation effectiveness is low because of the high evapotranspiration stress and the convectional type rainfall. The soil seldom is wetted below 3 ft during years of normal rainfall.

Under pristine conditions, the area was covered by grassland communities of simple floristic composition. Evidence suggests the possibility of a coniferous forest during pluvial intervals which, in the past, have alternated with periods of aridity. Local conditions caused by soil texture and topographic control of precipitation effectiveness result in several variations of the climax vegetation. Roots penetrate to a shallower depth on the Pullman soil but to a greater depth on the sandier soils of the Amarillo series, reaching a maximum on the dune sands of the Tivoli series.

Although the aerial portions of the climax grass species seldom exceed 1½ ft in height, the roots are extensive and extract moisture from large volumes of soil. The extensive ramification of the root system tends to dry the soil to permanent wilting percentage rapidly after a rain and to improve the structure and permeability of the soil. Moreover, this thorough permeation by grass roots contributes to the deeper distribution of organic matter of the soil without actual movement of the organic matter after mineralization. Since water is lacking, the intensity of soil forming processes is reduced because of the low precipitation which falls during the time of year when climax vegetation is removing moisture at a maximum rate.

Abstract No. 822.

Lowdermilk, W. C. 1930. Influence of forest litter on runoff, percolation, and erosion. J. Forest. 28:474-491.

The object of the studies described in this paper was to determine: (1) The factors which influence the division of rainfall into surficial run-off and percolated water. (2) The effects of surficial run-off on soil erosion under certain conditions.

Abstract No. 823.

Lutz, J. F. 1947. Apparatus for collecting undisturbed soil samples. Soil Sci. 64(5):399-401.

Two devices for collecting undisturbed soil samples are described. One collects the sample in a can; the other collects it in a stainless steel cylinder. The can or cylinder is held by a larger cylinder, fitted with a piston for facilitating removal. For can samples, the can edge does the cutting; for cylinder samples the apparatus is fitted with a removable cutting edge which can be replaced separately. All samples can be used for porosity and volume weight determinations; and, in addition, the cylinder samples can be used for percolation studies.

Abstract No. 824.

Lyford, F. P. 1968. Soil infiltration rates as affected by desert vegetation. M.S. Thesis. Univ. Arizona, Tucson. 51 p.

Soil infiltration rates on two soils measured at radial distances from the stems of palo verde (*Cercidium microphyllum*) and creosote bush (*Larrea tridentata*) were found to average nearly three times greater near the base of plants than in the inter-plant areas. Bulk density was lower and organic carbon content was higher for soil at the surface under plants than in inter-plant areas. Soil under plants often had higher percentages in either the 1- to 2-mm particle size range or the .1- to .25-mm particle size range than soil in inter-plant areas.

Differences in soil infiltration and soil properties can be attributed, for the most part, to increased biotic activity and deposition by wind under the plants and protection from raindrop action and animal trampling.

Abstract No. 825.

Lyon, T. L., and H. O. Buckman. 1946. The nature and properties of soils. MacMillan, New York. 499 p.

This volume is designed for the student who is interested in the nature and properties of soils and their relationships to higher plants. A working knowledge of inorganic chemistry and elementary physics is presupposed as well as some understanding of the colloidal state of matter. A background of general geology and biology will be exceedingly helpful.

Abstract No. 826.

Mace, A. C., Jr. 1968. Effects of soil freezing on water yields. Rocky Mountain Forest and Range Exp. Sta., Research Note No. 121. Fort Collins, Colorado. 4 p.

Concrete and granular types of soil freezing in the White Mountains of Arizona influence the disposition of snowmelt water. Concrete frost occurs in the open grassland areas and appears to increase surface runoff. Only granular frost occurs in the timber types and appears to decrease surface runoff and increase soil water recharge. Concrete freezing causes increased soil water and reduced bulk densities in the zone of freezing, whereas granular freezing has no effect on these properties.

Abstract No. 827.

MacFadyen, A. 1970. Soil metabolism in relation to ecosystem energy flow, p. 167-172. *In* J. Phillipson [ed.] Method of study in soil ecology. IBP/UNESCO Symp., Paris.

A complete and simultaneous compilation of metabolic expenditure for all the organisms in a type of soil of a known region and a measured period of time is an exercise which will not be accomplished in the near future. All that we wish to do at this stage is work with the representative organisms under a series of realistic conditions and to try to appreciate their relative importance in comparison with the total of the soil ecosystem. The activities of the soil decomposers must be integrated with the studies of the ecosystems considered as a whole. The author describes a simple method for measuring the total metabolism of the soil which one is easily able to apply and which embodies the most precise criteria applicable for such a procedure.

Abstract No. 828.

Makarov, B. N. 1970. Methods for determining the intensity of CO_2 liberation from soil. Soviet Soil Sci. 2(3):346-350.

A critical evaluation of the methods recommended by Karpachevskiy and Kiseleva [2] for determining the intensity of soil respiration is presented. It is shown that the amount of CO_2 in the air of the isolating vessel and its surface area must be taken into account when determining the intensity of CO_2 liberation from soil.

Abstract No. 829.

Malecheck, J. C. 1966. Cattle diets on native and seeded ranges in the Ponderosa Pine Zone of Colorado. U.S. Forest Service Res. Note RM-77. 12 p.

Forage samples collected by freely grazing ruminal fistulated steers were analyzed chemically and botanically to ascertain the quality of the diets selected by two herds of Hereford range cows managed under separate grazing systems. Crude protein in the diet of the herd grazing both native and seeded ranges on an integrated basis was adequate to excessive for 10 months of the 1-year study period, whereas crude protein in the diet of the herd grazing native ranges only was adequate for only 8 months. The seeded ranges provided a 2-month advantage of adequate dietary protein because they started growth earlier in the spring and became dormant later in the fall.

Seasonal trends in both dietary crude protein and dietary phosphorus indicated that the stage of forage maturity at time of consumption was of major importance in determining the general nutritive quality of the diets of both herds.

Botanical compositions of the diets were highly variable, particularly on native ranges. The variability was believed to reflect the heterogeneity of the ranges sampled rather than changes in animal preference.

Abstract No. 830.

Malin, J. C. 1946. Dust storms, 1850-1900. Fred Voiland, Jr., State Printer. Topeka, Kansas. 71 p.

In three papers dealing with dust blowing between 1850 and 1900, the three sections of the state of Kansas and of the western grassland have been reviewed: the tallgrass, the mixed-grass, and the shortgrass regions. During the period under consideration, meteorology was just emerging as a science, attaining for the first time a new level of competence. On the administrative side, a nation-wide system for collecting data and analyzing it was first achieved. This provided a standardized methodology, instruments, and definitions for a more exact quantitative measurement of weather data. Theoretical analysis of weather phenomena was possible on a new level of probability, and this is illustrated conspicuously during the last years of the nineteenth century in the papers published on the dust storm and other problems.

What is important is that a large quantity of more or less systematically collected data was being recorded and that a beginning was made in subjecting it to analysis. In time the outcome of such work would meet more exacting scientific standards.

It was more than a coincidence that the period of agricultural discontent associated with the Granger movement occurred during the drought and soil blowing of the decade of the 1870's, and that the dust crisis of the 1890's was also the period of the Populist movement. In either case, the grievances exploited by those movements fell far short of explaining adequately the condition of the farmer during these discouraging years. The worst manifestations of soil blowing as related to agricultural operations occurred during the pioneering process. The country was new, the population was not settled-in on a firm and stabilized foundation in harmony with the new environment. The people were short of capital, of machinery, of motive power, as well as experience. The older and better established communities usually kept their soil fairly well under control. In recent times, because of the technological revolution in agriculture and as the result of the initial exploitative stage of power farming, the period of the late 1920's was analogous in a sense to pioneering.

Abstract No. 831.

Malin, J. C. 1947. The grassland of North America; prolegomena to its history. Lithoprint, Lawrence, Kansas. 398 p.

The area of the earth's surface chosen for this study is that part of the United States designated usually as the Trans-Mississippi West. In its natural state, the feature that gave character to most of the landscape, in contrast with the area east of the Mississippi River, was the vegetational cover of grass rather than forest. Incidentally, the term natural state, as used here, means the condition in which it was found by the European at the opening of the sixteenth century. This rules out of direct consideration the condition of the continent at different periods of geological time, or of anthropological time.

The method employed in the study of this chosen area recognizes the ecological, agronomical, pedological, and geographical factors that provide the areal setting for its history. The sciences bring to the aid of the historian new tools and new methods whose possibilities have been little explored. One purpose of this book is to bring together summaries of the literature in the several borderland fields that seem significant to history, and to give them some application to this specific problem. There is no attempt here to present a formal history of the grassland of North America. There are many works in which aspects of that history are well treated, and, for present purposes, there is no point in mere restatement of such material. The things put into this book are those that seem most pertinent to the main purpose: new methodology, different points of view or emphasis, syntheses of materials not hitherto brought to bear upon this field of history, and some illustrative products of original research. From one point of view, the book may be considered as a series of essays on historiography, materials, and methods, together with sample case studies.

Abstract No. 832.

Malin, J. C. 1952. Man, the state of nature, and climax: As illustrated by some problems of the North American grassland. Sci. Monthly 74(1): 29-37.

The state of nature as it is commonly accepted is nonexistent. When man appeared upon the scene he destroyed such a state, because he possessed the unique capacity to act with a purpose. No matter how primitive, he introduced the factor of planning and the element of choice. The length of time man has occupied the North American continent has been variously estimated.

The contention of this paper is that the botanist, zoologist, and the soil scientist cannot expect any real success in many aspects of their own disciplines, in an ecological sense, until some tangible achievement is made in dealing with the problem of man's influence. Such a necessary recognition of the role of man affords a common ground between them and the geographer and the historian. First, the nature of the problem of man as an ecological factor must be discussed and defined, in order to appreciate the full range of the ramifications involved. Once the significance of the problem is fully recognized, then, possibly, methodology can be formulated and techniques and tools devised that may achieve some exactitude of measurement, and thereby place the study upon a quantitative basis. If success attends such efforts, then the accumulation of necessary data will follow. All that can be attempted here is to undertake the first step of definition and discussion of the nature and scope of the problem as applied to a particular area of its implications to all the disciplines concerned.

Abstract No. 833.

Malin, J. C. 1953. Soil, animal and plant relations of the grassland, historically reconsidered. Sci. Monthly 76(4):207-220.

The central purpose of this paper is to point out the role of history in a research program. Sound and comprehensive studies are more likely to require a commitment to many years of systematic collection and analysis of data in full context. Furthermore, data must be tied explicitly to time and place. Each spot is unique in an absolute sense. In a perfectionist sense a historical project can never be finished. But, within the realm of the possible, historical work, as intellectual enterprise, can be so comprehensive and complete as to render difficult, without danger of immediate exposure, any flagrant misuse of evidence by propagandists. A temporary tendency toward establishment of a "steady state" is certain of interruption by the intervention of unpredictable events, and, for emphasis, man must be specified explicitly because of his characteristic of worrying about the future and of devising ways and means for trying to manipulate nature. What is said about the state of the ecosystem at any particular moment is the product of the factors of the past that have shaped it; and the state existing at that specified moment is the parent material upon which, or through which, succeeding states are formed--an indeterminate system.

The present paper is focused upon the past, which is peculiarly in the jurisdiction of history.

The ideal of intellectual enterprise, whether history or science, is to attain at one and the same time, both depth and perspective. To attempt either without the other can lead only to futility. In many respects, twentieth-century specialization has reached that barrier, and in some areas more seriously than in others. The development of ecology, or the ecological point of view, is a healthy recognition of that fact and an earnest of a determination to do something about it.

Abstract No. 834.

Malone, C. R. 1967. A rapid method for enumeration of viable seeds in soil. Weeds 15:381-382.

Soil dispersion in an aqueous solution of sodium hexametaphosphate and sodium bicarbonate facilitates extraction of seeds by flotation with magnesium sulphate. The percentage viability of seeds collected in this manner subsequently can be determined with 2,3,5-triphenyl-tetrazolium chloride. Extraction of seeds usually is 100% efficient, and enumeration of viable seeds via the tetrazolium test is accomplished much more rapidly than with conventional methods.

Abstract No. 835.

Malone, C. R. 1968. Determination of peak standing crop biomass of herbaceous shoots by the harvest method. Amer. Midland Natur. 79:429-435.

The peak standing crop biomass of herbaceous shoots, a measure of net primary shoot production, was determined in three first-year old fields by two methods: (1) sampling the peak community standing crop at one moment and (2) summing the peaks of the individual species over the entire growing season. The methods gave similar estimates of peak standing crop in the two old fields where the major producers reached peaks at comparable times. In the third old field, a large discrepancy existed between the two estimates as a result of the diverse times at which the major producers reached peak standing crops. It was valid to use an estimate of net primary shoot production based on the community peak standing crop only when the dominant species had similar phenologies. Whenever this occurred, such an estimate had a smaller statistical error associated with its mean than an estimate derived from the sum of individual species peaks.

Abstract No. 836.

Malone, C. R. 1970. Short-term effects of chemical and mechanical cover management on decomposition processes in a grassland soil. J. Appl. Ecol. 7: 591-601.

The effects of chemical and mechanical cover control on processes of organic matter decomposition in grassland (*Festuca arundinacea*) soil were studied in a randomized plot experiment during the 1968 growing season. Treatments consisted of plots mowed and raked bi-weekly, plots mowed and sprayed with dalapon to kill shoots and roots, and unmowed plots sprayed with dalapon.

Saprophytic mites were unaffected by cover manipulations, but densities of soil Apterygota and predatory-parasitic mites appeared suppressed by high and low extremes of soil temperature and moisture, respectively, which occurred in denuded plots.

In plots upon which fescue had been killed, regardless of whether the dead cover was removed, densities of soil bacteria increased, corresponding to enhanced rates of organic matter decomposition. Evidence was found that living fescue produces toxic substances, explaining in part the proliferation of bacteria whenever the vegetation was killed. This suggests that a factor of primary importance in the responses of soil organic matter decomposition to cover management is the presence or absence of vegetation types which produce bacterial-inhibiting compounds. If such plants are eliminated by management techniques, decay of organic matter might be greatly accelerated, possibly hastening mineralization of soil.

Abstract No. 837.

Marbut, C. F. 1923. Soils of the Great Plains. Ass. Amer. Geogr. Ann. 13(2):41-66.

The Great Plains, as defined in this paper, is a region in which certain soil characteristics prevail. No attempt whatever is made, in this definition of the region, to conform to any of the other definitions that have been proposed or used. The paper is written for the purpose of describing the soils of the region, and for that reason soil character will be given the predominant attention not only in the details of descriptions but in the definition and delimitation of the region.

Abstract No. 838.

March, H., K. F. Swingle, R. R. Woodward, G. F. Payne, E. E. Frahm, L. H. Johnson, and J. C. Hide. 1959. Nutrition of cattle on an eastern Montana range as related to weather, soil, and forage. Montana Agr. Exp. Sta. Bull. 549. 91 p.

This report records the results of a 5-year study of the correlation of soil nutrients, forage nutrients, and nutrition of Hereford range cows on grazing land at the U.S. Range Livestock Experiment Station near Miles City, Montana. The data on which the findings are based include weather records; soil analyses for nitrogen and phosphorus; forage plant analyses for protein, phosphorus, and carotene; analyses of blood plasma of cows for phosphorus, calcium, magnesium, carotene and vitamin A; and the performance of the cows, as measured by weight, general condition and health, and reproductive efficiency. The experimental cattle were grazed on pastures established on native range at three grazing intensities--heavy, moderate, and light.

Abstract No. 839.

Marion, W. R. 1970. Diurnal raptors of Pawnee Site in northeastern Colorado. M.S. Thesis. Colorado State Univ., Fort Collins. 39 p. (Advisor: Ron Ryder).

The diurnal raptors of the Pawnee Site in northeastern Colorado were censused 13 times at regular intervals between 4 October 1969 and 8 March 1970 by the area count method. This method was an attempt to obtain a total count of the diurnal raptors frequenting the 56-square mile study area. A total of 6 species was recorded on the area during this period of time by this census method. The Golden Eagle (*Aquila chrysaetos*) was the most abundant of the species I observed. It comprised 44% of all observations. Rough-legged Hawks (*Buteo lagopus*) were the next most abundant diurnal raptor, comprising 19.1% of all observations on the study area. Smaller numbers of Marsh Hawks (*Circus cyaneus*), Ferruginous Hawks (*Buteo regalis*), Prairie Falcons (*Falco mexicanus*), and Red-tailed Hawks (*Buteo jamaicensis*) were also observed. The distribution and behavior of these diurnal raptors was reported. The results of this study were then compared with other similar studies.

Abstract No. 840.

Marshall, J. T., Jr. 1957. Birds of the pine-oak woodland in southern Arizona and adjacent Mexico. Cooper Ornithol. Soc., Pacific Coast Avifauna 32: 1-25.

Woodland of mixed pines and oaks is familiar mountain scenery in Mexico, whence it extends into southeastern Arizona along with many kinds of Mexican birds. This woodland occupies a belt from about 5500 to 6500 ft in elevation between encinal (oak woodland) below and ponderosa pine forest above. It combines tree forms of both these zones so as to make a smooth transition between them. The present report compares the numbers of each species of breeding bird in a series of stations, within pine-oak woodland, which were visited in the summers of 1951, 1952, and 1953. The stations differed in the following ways which affected the local occurrence of birds: steepness, whether on a ridge or in a canyon, amount of water and riparian vegetation, stature and spacing of trees, amount of grass, and proximity to coniferous forest.

My censuses were linear. I recorded each pair, flock, or singing male either on a map sketched to scale and showing vegetation and topography, on a tabulation over a paced off mile, or on a tabulation of a cross-country hike for which I estimated the distance. For localities visited two or more summers, the census on maps showed which species used the same territories in successive years. I also took notes in the field on behavior, especially feeding behavior, and collected specimens here and there, generally off the census places, to learn about breeding status and food taken as well as to authenticate critical records of occurrence. In addition to the census, I sought to learn how each kind of bird uses pine-oak vegetation in its hunting and what it chooses for its place of activity. From these considerations an attempt is made to explain its abundance and distribution within the study area.

Abstract No. 841.

Marshall, T. J., and G. B. Stirk. 1950. The effect of lateral movement of water in soil on infiltration measurements. Australian J. Agr. Res. 1(3): 253-265.

The effect of lateral movement on minimum infiltration capacity was examined using small flooded plots of various sizes without buffer zones and using small sprayed and flooded plots surrounded by wetted buffer zones.

When no buffer zones were used, the minimum infiltration capacity of a given soil decreased with increasing size of plot, and there was a corresponding increase in the fraction of applied water remaining beneath the plot at the conclusion of the trial. An expression for the relation between plot size and lateral movement is discussed.

Although buffer zones around flooded plots effected some reduction in lateral movement, the measurements were subject to considerable error and the method was considered unduly cumbersome for routine work. In a spray infiltrometer procedure, a sprayed buffer zone surrounding a small test plot was found to be effective on the soils examined.

When all data from flooded plots with and without buffer zones were examined, it was found that the minimum infiltration capacity of a soil varied inversely with the fraction of applied water remaining beneath the plot at the conclusion of a trial. When the minimum infiltration capacity was multiplied by the corresponding value of this fraction, the effect of lateral movement was reduced considerably. It is shown that results from small plots then approximate more closely to those to be expected from large ones, and there is also a reduction in variability due to causes other than variation in size of plot. Limitations in the use of this correction factor are discussed fully and the general limitations of infiltration data derived from small plots are briefly considered.

Abstract No. 842.

Marti, C. D. 1969. Renesting by Barn Owls and Great Horned Owls. Wilson Bull. 81:467-468.

Renesting, at least in the same nest site, following an interruption of the nesting cycle apparently is unusual in owls. The Barn Owl, however, displays a very adaptable reproductive pattern, and this may explain its ability to renest. A pair of Barn Owls may retain its breeding capability longer than most large raptors, and this facilitates production on second broods. It would facilitate renesting even more. The Great Horned Owl seems to be less versatile in its reproduction. In a case of renesting caused by loss of the male early in incubation, the female's hormonal control may have had time to recycle, allowing her to find a new mate and start a second brood.

Abstract No. 843.

Marti, C. D. 1969. Some comparisons of the feeding ecology of four owls in north-central Colorado. Southwestern Natur. 14(2):163-170.

Marti, C. D. 1969. Some comparisons of feeding ecology of four species of owls in north-central Colorado. U.S. IBP Tech. Rep. No. 27. Colorado State Univ., Fort Collins. 21 p.

Four species of owls, Great Horned (*Bubo virginianus*), Long-eared (*Asio otus*), Burrowing (*Speotyto cunicularia*), and Barn (*Tyto alba*) were selected for a study of feeding ecology. These species were chosen because it was believed data adequate to determine feeding ecology could be collected for each of them in north-central Colorado. These species occupy the secondary consumer level in the food chain, consuming a wide variety of vertebrate and invertebrate prey.

In order to determine differences and similarities which might contribute to competition for food or reduce this competition, a number of aspects will be examined. These aspects will be in the areas of physiology, morphology, and behavior. The basis for many of these comparisons will be food habits data derived from pellet analysis.

Abstract No. 844.

Marti, C. D. 1970. Feeding ecology of four sympatric owls in Colorado. Ph.D. Diss. Colorado State Univ., Fort Collins. 106 p. (Advisor: Ron Ryder).

Great Horned (*Bubo virginianus*), Long-eared (*Asio otus*), Burrowing (*Speotyto cunicularia*), and Barn Owls (*Tyto alba*) of north-central Colorado were studied from 1966 to 1970 to determine niche segregation in feeding ecology. Mechanisms which contribute to niche segregation are described and discussed.

Food habits were studied for each owl by pellet analysis. Great Horned Owl prey totaled 2,288 individuals; Long-eared Owl prey, 2,673; Barn Owl prey, 4,366; and Burrowing Owl prey, 4,936. Great Horned Owls preyed on the widest variety of species with *Sylvilagus* being most important in biomass consumed. Long-eared Owls fed on a much smaller array of prey, almost entirely mammalian, with *Peromyscus* and *Microtus* the most important. Prey of Burrowing Owls included insects as most numerous, but mammals contributed more biomass.

The four species of owls selected significantly different frequencies of prey ($P < 0.005$). Mean prey size selected by each owl was also found to be significantly different ($P < 0.05$). Comparisons were made among prey composition from 3 years for each owl species. Significant differences were found for the Great Horned Owl ($P < 0.005$) and Barn Owl (P between 0.01 and 0.005). No difference was indicated for the Long-eared Owl (P between 0.75 and 0.50) and Burrowing Owl prey in this respect ($P > 0.995$).

Prey collected from three different habitat types were compared for the Great Horned and Barn Owls and found to differ significantly in both owls ($P < 0.005$). Prey of Long-eared and Burrowing Owls were compared between two habitat types. No difference was indicated for the Long-eared (P between 0.25 and 0.10) or Burrowing Owls ($P > 0.995$) in this comparison either. Seasonal prey variation is also listed for each owl species.

Captive owls of the four species were tested for daily food intake. The Great Horned Owl consumed 4.7% of its body weight each day; the Long-eared Owl 12.7%; the Burrowing Owl 15.9%, and the Barn Owl ate 10.1% of its body weight in food per day.

Barn and Long-eared Owls were found to be strictly nocturnal in their hunting. Much of the Great Horned Owl's hunting was crepuscular. Burrowing Owl foraging was both diurnal and crepuscular.

Great Horned Owls hunted primarily by flights from observation perches. Wing loading in Great Horned Owls was 1.94 cm^2 of wing surface area/g of body weight. Long-eared and Barn Owls both had lower wing loading ratios--4.61 and 3.62, respectively--apparently being adapted for hunting on the wing. A variety of hunting methods were utilized by Burrowing Owls. Wing loading ratio was 3.67 for this species.

The Great Horned Owl tested was able to find dead mice by sight under an illumination of 13E-6 foot-candles. The Barn Owl also found mice at 13E-6 foot-candles. Only 70E-8 foot-candles were required by the Long-eared Owl to find dead mice, but the Burrowing Owl was unable to locate dead mice by sight at light levels less than 50E-6 foot-candles.

All four species successfully captured live mice by hearing in complete darkness.

Abstract No. 845.

Martin, A. E., and G. W. Skyring. 1962. Losses of nitrogen from the plant soil-plant system, p. 1934. *In* A review of nitrogen in the tropics with particular reference to pastures. (A symp.) Commonwealth Bur. Pastures Field Crops, Bull. 46. Hurley, Berkshire, England. 185 p.

Recoveries of fertilizer N from growing crops seldom exceed 50%; and succeeding crops, grown in the same soil, do not generally utilize more than a further 10%. Many attempts have, therefore, been made to account for this apparently low availability, and it is now known that a variable portion of the residual N may be immobilized (either biologically or following chemical fixation of the ammonium ion), or lost by leaching, erosion, or fire damage. Many estimates have been made of the amounts of N lost through these causes, and some of the published data are summarized briefly in this review.

However, N (like carbon) is also subject to gaseous losses, and it is generally assumed that this is suffered mainly by the soil component. Estimates of the amounts so lost vary widely, as do also the reliability of the results, since many are strictly "unaccounted" losses and are assumed to have occurred through volatilization. Indeed, in some cases (22) a drop in soil-nitrate content has been identified with denitrification, using soils in which no attempt has been made to account for all other forms of soil N. Only in laboratory studies have these gaseous products been identified and a satisfactory N balance struck. A good deal of fairly reliable information can be found from a study of lysimeter results, but close inspection of some published work suggests that a portion of the observed N losses may be more apparent than real and need not necessarily be ascribed to volatilization. It is the main purpose of this review to summarize some of the evidence concerning this more subtle source of loss and to examine critically the methods that have been used to detect it.

Abstract No. 846.

Martin, E. P. 1960. Distribution of native mammals among the communities of the mixed prairie. Fort Hays Stud. Sci. Ser. 1., Hays, Kansas. 26 p.

From October, 1952, until August, 1958, the small mammals on a relict area near Hays, Kansas, were studied. The observations were undertaken to establish a standard to which the mammals of variously disturbed areas could be compared; also, information concerning the relations of the species of mammals to the communities of the mixed prairie was sought.

After six years of study, information has accumulated which may be of interest to ecologists. Some conclusions can be drawn concerning the distribution and ecology of several species of mammals of the mixed prairie. Until March, 1957, the period of study was one of severe drought; from that month to the end of the study period rainfall was above average. This situation permitted study of the responses of populations to drought and to wet years.

Detailed descriptions of various habitats used by native mammals may help to reveal ecological relationships not obvious when distributions are plotted on a larger scale. These relationships should increase the ability of biologists to explain many of the fluctuations of populations as well as the vagaries of distribution.

Population densities estimated from sampling heterogenous areas, without consideration of the type of distribution among communities described in this paper, may lead to erroneous conclusions in both applied and theoretical ecology. The effects of native mammals on range condition and the ecological role of a mammalian species would both be misunderstood without relating density and distribution to plant communities.

Abstract No. 847.

Martin, E. P., and G. F. Sternberg. 1955. A swift fox, *Vulpes velox velox* (Say), from western Kansas. Kansas Acad. Sci., Trans., 58:345-346.

The swift (or kit) fox, *Vulpes velox velox* (Say), has been reported extinct in Kansas.

In January, 1955, the museum at Fort Hays Kansas State College received an adult male swift fox. It had been shot by Howard Laverne Maxwell in Gove County, Kansas, three and one-half miles northeast of Quinter. The specimen was frozen immediately, and accurate measurements were obtained.

The swift fox is buffy-yellow in color and slimmer than the red fox (*Vulpes fulva*). Its black-tipped bushy tail and a pair of black spots on its snout are identifying marks of the species.

The specimen was mounted and is on display in the museum of Fort Hays Kansas State College. The skull of the fox is in the collection of the Department of Zoology of the college.

Abstract No. 848.

Martin, E. P., G. W. Tomanek, and F. W. Albertson. 1955. Use of regression line to estimate basal cover of sod-forming grasses. Kansas Acad. Sci., Trans., 58:526-527.

To measure basal cover, especially in permanent quadrats, many ecologists have employed a pantograph method. Two men operate a pantograph; one guides a pointer around plants and bunches of grass while the other operates a pencil which reproduces the outlines of the plants, greatly reduced, on a chart. A planimeter then is used to measure the area occupied by each species. The results obtained by this method have been satisfactory, but the enormous amount of time and labor involved detracts from its usefulness, especially when much of the cover consists of sod-forming grasses such as big bluestem (*Andropogon gerardi*), switch grass (*Panicum virgatum*) and western wheatgrass (*Agropyron smithii*). The relationship between the number of stems of western wheatgrass in a quadrat and the percentage of the quadrat covered by western wheatgrass was analyzed to determine whether a simple count of stems would yield useful information of basal cover.

Pantograph charts of western wheatgrass were made of 705 quadrats, each a meter square, and the number of stems of western wheatgrass in each quadrat was counted. The correlation coefficient between the number of stems and the percentage of basal cover was 0.88, and the standard error of estimate was 0.14. The regression coefficient of the percentage of basal cover on number of stems was 0.34 ± 0.001, and the equation of the regression line was $Y = 0.034X$.

We concluded that the basal cover of western wheatgrass can be estimated satisfactorily from the number of stems present. There is no apparent reason why a similar relationship could not be established for other species of sod-forming grasses. The economy in man-hours will be ample reward for the effort of collecting the data necessary to calculate the regression lines.

Abstract No. 849.

Mason, E. 1952. Food habits and measurements of Hart Mountain antelope. J. Wildlife Manage. 16(3):387-389.

In January, 1950, representatives attending the Four-State Antelope Meeting at Lakeview expressed interest in conducting a comprehensive food habits study. The available literature revealed that stomach analyses had been largely confined to samples collected during the hunting season, and information at other periods of the year was inadequate or lacking.

The Oregon Game Commission agreed to collect two to three antelope per month. Analyses of stomach contents were to be made by the Food Habits Laboratory of the California Division of Fish and Game.

The Hart Mountain Herd was selected for study since it contained the largest number of animals found in any single herd in the state and resides in habitat representative of typical antelope range.

Collections were commenced on May 4, 1950, and terminated on April 19, 1951. A total of 26 stomach samples was analyzed. As far as practical, collections were made at monthly intervals unless weather or other factors interfered. With the exception of two females taken in December, 1950, all collections were limited to bucks.

The Hart Mountain herd summers on or adjacent to the Hart Mountain Antelope Refuge and winters in the vicinity of Sagehen Flat and Big Spring Table southeast of the refuge along the Oregon-Nevada state line.

In addition to food habits analyses, field measurements of all specimens were taken.

Abstract No. 850.

Mathis, G. W., M. M. Kothman, and W. J. Waldrip. 1971. Influence of rootplowing and seeding on composition and forage production of native grasses. J. Range Manage 24(1):43-47.

Effects of rootplowing, with or without seeding, on forage production and composition of native grasses were determined on a deep upland range site. Percent composition of stoloniferous species, particularly buffalograss, was reduced initially and after 6 growing seasons by the rootplowing treatments. Frequency counts indicated a reduction of Texas wintergrass on rootplowed plots (seeded and nonseeded) compared to an undisturbed, native check area. This reduction the first growing season was attributed to the competitive effect of sorghum almum introduced in the seeding mixture. Unsuccessful establishment of other seeded grasses (sideoats grama and switchgrass) appeared to be related to poor seedbed preparation, competition from sorghum almum plants, and below normal rainfall immediately after seeding. Rootplowing decreased grass production. After 6 growing seasons, significantly less forage per acre was produced on rootplowed-seeded plots than on nonrootplowed plots. Differences in forage production were related to plant composition and density.

Abstract No. 851.

Mathisen, J. E., and A. Mathisen. 1968. Species and abundance of diurnal raptors in the panhandle of Nebraska. Wilson Bull. 80(4):479-486.

Diurnal raptors were recorded from 1957 through 1959 while traveling by automobile in the panhandle of Nebraska. A total of 2,564 raptors of 17 species were observed while traveling 54,347 miles. The number of raptors per 100 miles was 3.5 in 1957, 5.1 in 1958, 5.9 in 1959 and averaged 4.8 for the three years.

Annual patterns of raptor abundance were, with but few deviations, similar among years. But the magnitude of abundance for certain months varied among years. April and September were months of major migrations.

Major winter raptors were the Rough-legged Hawk, Marsh Hawk, and Golden Eagle. Abundant species in summer included the Sparrow Hawk, Marsh Hawk, and Swainson's Hawk. In spring and fall the raptor population was dominated by the Sparrow Hawk, Marsh Hawk, and Rough-legged Hawk.

Abstract No. 852.

May, L. H. 1960. The utilization of carbohydrate reserves in pasture plants after defoliation. Herbage Abstr. 30(4):239-245.

It is widely recognized that too heavy, too early, or too frequent removal of pasture foliage leads in general to declining yields, and that the consequences of overgrazing occur first in the roots, and only at a later stage become visible in the tops. Many physiological and agronomic experiments have been conducted to explore in more detail the behavior of pasture associations in response to defoliation (by seasonal changes, cutting or grazing). In the past, attention has been directed mainly towards the effects of stored reserves. The emphasis in this review returns to the role of carbohydrate reserves, and reference to these other factors is only made when a direct relationship with carbohydrate reserves is evident.

Abstract No. 853.

May, P. F., A. R. Till, and A. M. Downes. 1967. Nutrient cycling in grazed pastures--a preliminary investigation of the use of [^{35}S] Gypsum. Australian J. Agr. Res. 19:531-543.

[^{35}S] Gypsum was applied to six strips covering a total of approximately 1/32 of the area of a pasture grazed by sheep. The specific activity of samples of soil, plants, ingesta, faeces, and wool was measured. The results were as would be expected from uniform labelling of the whole paddock, and enabled translocation to untreated areas to be measured. They indicate that doses of the order of 1 to 10 mc should be detectable on paddocks up to 4 ha in area for periods of up to 1 year.

When animals were put onto or removed from the treated pastures, changes in the specific activity of wool indicated that 100 to 150 days were required for the sulphur in the sheep and pasture to reach equilibrium. Animals continuously maintained on the pasture were still producing wool at 60% of the maximal specific activity after 600 days, which indicated a continuing recycling of the applied sulphur.

From calculation of the isotope dilution it appears that only a small fraction of the total soil sulphur was available for plant uptake, and the continuing cycling of this over a period exceeding 600 days indicates a high residual value of the initial application.

Abstract No. 854.

Mayeux, J. V., and E. A. Jones. 1969. Bacterial ecology of grassland soils, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 22. Colorado State Univ., Fort Collins. 13 p.

This report describes the work that has been conducted in the study of the bacterial population in the soil of the Pawnee National Grassland IBP research station. The primary objectives were to obtain estimates of the bacterial population with depth in the soil profile and to determine if there was any indication of variation in the population of the different treatments the grazing plots had been subjected to in the past years. These treatments were ungrazed exclosures, lightly grazed areas, moderately grazed areas, and heavily grazed areas. The preliminary work involved the use of soil samples to determine which methods would be best suited for determining the viable bacterial biomass of the soils. A comparison was made of bacterial culture media in order to determine which medium would be best suited for determining the bacterial population of the soils. A comparison was made of bacterial culture media in order to determine which medium would be best suited for the bacterial enumerations. Treatment of the soil by different methods, that is, sonication, blending, or other means of mechanical agitation, were examined in order to determine which procedure would yield the best and most consistent results.

Abstract No. 855.

Maze, R. L. 1965. Bird populations of a desert scrub area in southern New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces. 40 p.

Composition, habitat preference, and population densities of the avifauna in a desert scrub area in southern New Mexico were studied. Censusing was done by cruising and mapping on a grid covering one square mile.

Nine different species nested on the area during the study. Composition of the avifauna appears to be mainly dependent on the diversity of vegetation. Absence of trees and lack of dense vegetation have influenced the composition such that other species which nest in southern New Mexico do not nest on the uplands.

Black-throated Sparrows maintained the highest densities, followed by Mourning Doves, Verdins, and Black-tailed Gnatcatchers. Major factors influencing densities appear to be availability of plants suitable for nesting, primary productivity of the general area, and size and efficiency of territories.

Most birds nested in the more mesic arroyos. Sparse vegetation on upland areas apparently discouraged utilization by species other than Mourning Doves. Distribution of species appears respons ve to distribution of nest-site plants and to abundance and profile of vegetation in the vicinity of nest sites.

In species composition the avifauna is similar to those of other areas, arid and nonarid. Differences are correlated with vegetation differences. Desert regions support lower densities than more mesic environments.

Abstract No. 856.

Mazurak, A. P., and E. C. Conard. 1959. Rates of water entry in the three great soil groups after seven years in grasses and small grains. Agron. J. 51(5):264-267.

Rates of water entry into soil after 2 or more hours of irrigation were lower in the grain rotation plots of Chestnut and Chernozem soils than in grass plots. In general, cool-season grasses, as a group, had more favorable effect on soil structure, with respect to water entry into soil than did the group of warm-season grasses. For the same grass, the effect on soil structure was more pronounced in the Chernozem than in the Brunizem soil. The cool-season grasses in the Chernozem soil influenced the soil structure to a greater extent than in either the Chestnut or Brunizem soil. *Agropyron desertorum*, a cool-season grass, maintained a high rate of water entry into soil in all three great soil groups. Application of ammonium nitrate did not significantly alter the rates of water entry into the soils.

Abstract No. 857.

McBee, R. H. 1971. Significance of intestinal microflora in herbivory. *In* R. F. Johnston [ed.] Annu. Rev. Ecol. Syst. 2:165-176.

In nearly all herbivorous animals one or more parts of the alimentary tract are expanded to form an organ which accommodates a microbial population valuable in the digestion of foods for which the animals do not have the necessary complement of enzymes. The animals usually utilize the vitamins and proteins synthesized there and may enhance the protein synthesis by secretion of urea into the organ contents. Microbial fermentation products are absorbed from the organ and metabolized by the herbivores.

Generally the most successful large herbivores, those over 5 kg body weight, have a rumen or some similarly modified forestomach in which fermentation occurs. Fermentative forestomachs are found not only in ruminants, in which their presence is well known, but also in kangaroos, whales, dugongs, hippopotamus, sloths, and colobid monkeys. Smaller herbivores such as rodents are usually endowed with a large cecum, although they may also have a number of stomach modifications accommodating microbial fermentations. Other fermentations may occur in the small intestine, and cecal fermentations may continue into the large intestine or colon.

The cecum is a blind pouch occurring at the juncture of the small and large intestines and is the organ from which the appendix arises, if there is one. Mammals generally have a single cecum, gallinaceous birds two, and fish may have several.

Below the cecum there may be further modifications of the intestinal tract to facilitate either continued fermentation or absorption. The horse has a cecum containing 25 to 30 liters which empties into an even larger great colon with a capacity of 55 to 70 liters. The hyrax has a second cecal-like structure larger than the cecum. This large two-horned organ is part of the large intestine.

Abstract No. 858.

McCalla, T. M., and F. L. Duley. 1946. Effect of crop residue on soil temperature. Agron. J. 38: 75-89.

Soil temperatures were determined under the quantities of residues used in the system of subsurface tillage, or stubble mulching, as compared with soil temperatures when using heavy mulches or the conventional system of plowing. Heavy mulches, such as an 8-ton per acre application of straw, have lowered soil temperatures as much as 17.7°C at the 1-inch depth. For a period of 3 or 4 months after the application of a straw mulch at the rate of 2 or 3 tons per acre, soil temperatures may be reduced from 3° to 6°C at the 1-inch depth and 2° to 4°C at the 4-inch depth. However, with the stubble mulch system of farming, soil temperatures were not reduced appreciably below that of plowed land after 6 to 9 months. In such farming, only amounts of residues equal to those grown on the land were returned to the surface of the soil, while decay and fragmentation of the residue continued.

Soil temperature of the mulched plots lagged behind air temperature and this difference reached a peak on clear days around 1 to 2 o'clock. Soil temperature reached the lowest point for the day along with the air temperature at about 5 AM. At this time mulched and bare plots usually had almost the same temperature. It was during the day that the temperature of the bare soil exceeded the mulched soil. The temperature, after considerable decay had taken place, at the time of widest differences was only a few degrees lower on the mulched soil.

Generally, soil temperature under mulches did not appear to be unfavorable to plant growth where an amount of residues equal to that grown on the field was used.

Due mainly to shading, a growing crop on the land decreased the temperature differences between the mulched and unmulched soil.

Abstract No. 859.

McCarley, H. 1966. Annual cycle, population dynamics and adaptive behavior of *Citellus tridecemlineatus*. J. Mammal. 47(2):294-316.

A marked population of *Citellus tridecemlineatus*, averaging 131 individuals per year, was studied for 3 years on a 113-acre tract in northern Texas. Emergence from hibernation was from 12 March to 5 April. Adults began hibernating in July and juveniles in August and September. Adults averaged 135 days of dormancy and 238 days of aboveground activity. Mating occurred aboveground in April, May, and June. Litters were born in May, June, and July. Some females older than one year produced two litters per reproductive season. Size of litters emerging from the nest burrow ranged from an average of 4.9 for young females to 7.0 for old females. The sex ratio of juveniles was 1:1. The resident adult population varied from 24 individuals in 1965 to 34 individuals in 1964 with a sex ratio of 1 male:2.8 females. Mature females tended to survive longer than mature males. Home ranges averaged 11.7 acres for males and 3.5 acres for females. Population size was mostly regulated by dispersal of the juvenile part of the population in late summer and early fall. Additional adjustment of population size and sex ratio through dispersal and mortality occurred in the spring. Colonies of thirteen-lined ground squirrels in northern Texas probably result from attraction to a particular habitat rather than attraction of one squirrel to another. Because the species does tend to occur in colonies, both social and individual behavior have evolved. The adaptive significance of vocal signals, defense and care of young, burrow construction, and escape behavior are discussed.

Abstract No. 860.

McCulloch, C. Y., and J. M. Inglis. 1961. Breeding periods of the Ord kangaroo rat. J. Mammal. 42: 337-344.

During eight intermittent years for which records were available, *Dipodomys ordi richardsoni* seldom bred from April to July. Breeding usually began in August or September and ended in March. Rate of reproduction was associated with precipitation, food supply, and population densities of kangaroo rats and other rodents.

Following the 1956 drought, few females became receptive, few young were born, and the population declined. After the favorable growing season of 1957, most females in the sparse population became pregnant within the first two months of the breeding season. Most bred at least twice during that season, and young females born early produced litters before the season ended. In 1958, another year of abundant rainfall and plant growth, the population was dense and few females appeared gravid prior to mid-November. Following a moderately productive 1955 growing season, the population was sparse and reproductive activity was intensive from August to at least the following February. Young born early reproduced later the same season, but there was little indication of second litters produced by old females.

Abstract No. 861.

McDaniel, B. 1971. The role of invertebrates in the Grassland Biome, p. 267-315. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Intraseasonal dynamics of the density of important invertebrate taxa are discussed for areas which are grazed and ungrazed by large herbivores at five sites in the U.S. IBP Grassland Biome. Ecological characteristics of the important families are discussed in relation to the 1970 intraseasonal dynamics.

Principal component analyses for density and standing crop of invertebrate families are presented. Analyses of variance of density and standing crop of invertebrate taxa and standing crops of important families and trophic levels using time-weighted means for the potential growing season are presented and discussed. From these studies 15 invertebrate taxa emerged as requiring more intensive study. These are Acarina, Araneida, Coccinellidae (Coleoptera), Scarabaeidae (Coleoptera), Tenebrionidae (Coleoptera), Entomobryidae (Collembola), Lygaeidae (Hemiptera), Miridae (Hemiptera), Tingidae (Hemiptera), Cicadellidae (Homoptera), Pseudococcidea (Homoptera), Formicidae (Hymenoptera), Acrididae (Orthoptera), Gryllidae (Orthoptera), and Thysanoptera.

Abstract No. 862.

McDaniel, B. 1971. Studies of populations of adults and immature insects and mites from two treatments at Cottonwood, South Dakota. U.S. IBP Grassland Biome Tech. Rep. No. 112. Colorado State Univ., Fort Collins. 79 p.

Arthropod samples collected periodically during the months of May through August 1970 yielded information on the population trends of various groups of invertebrates. Six orders of insects make up the greater density of the invertebrates in both treatments studied. The large number of Hymenoptera is due to the presence of ants. During the month of May, a total of 32,995 individuals were collected and distributed among 13 orders of the class Insecta, the Acarina, Araneae, Diplopoda, and Chiliopoda. A total of 12,297 of these were collected from the grazed treatment and 20,698 from the ungrazed treatment. In June only 7,963 individuals were obtained among 14 orders of Insecta, the Arachnida, and Diplopoda. The grazed treatment contained 4,514 individuals, while 3,449 specimens were obtained from the ungrazed treatment. The month of July is evaluated on the basis of one sample date with a total of 9,185 specimens collected. The grazed treatment contributed 5,914 individuals and the ungrazed treatment only 3,271 specimens. These were distributed in 12 orders of the Insecta, the Arachnida, Diplopoda, and the Chilopoda. The month of August contributed a total of 21,028 individuals in 10 orders of the Insecta, and the Arachnida. The grazed treatment had 13,183 individuals while the ungrazed treatment contained 7,845 specimens.

Abstract No. 863.

McDonald, I. W. 1962. The nitrogen intake and excretion of grazing ruminants, p. 43-55. *In* A review of nitrogen in the tropics with particular reference to pastures. (A symp.) Commonwealth Bur. Pastures Field Crops Bull. 46. Hurley, Berkshire, England.

Productivity of grazing ruminants means, in essence, the conversion of plant nitrogenous compounds into animal proteins. The only major exception to this generalization is the production of butter fat, and even here there can be no doubt that, for human nutrition, the milk proteins far outweigh the fats in biological importance. All the non-nitrogenous components of the ruminant's ration may be considered as accessories required for the operation of the animal's body in making these nitrogenous conversions. However, it must not be concluded from this statement that the nitrogenous components of the fodder are the primary determinants of pasture quality--this attitude has unfortunately been a common one, with an unconscious tendency to equate high quality with high protein content. This point will be discussed at a later stage, but here it may be stated as a general principle that efficient animal production may be expected from fodders of relatively low protein contents and that no increase in efficiency will occur with protein contents beyond a certain optimum range.

Technical difficulties have gravely impaired progress in the study of the grazing animal. For this reason special attention will be given to a discussion of available techniques. Studies on the nutrition of grazing animals have been few, and it has therefore been necessary to make extrapolations from experiments with pen-fed animals. These technical difficulties have forced most workers to confine their observations to the final productive phase, e.g., body weight, milk production or wool growth, so that present-day knowledge of the mechanisms involved, or the intermediary phases, is sketchy indeed.

The economic importance of production by grazing animals in Australia is so obvious that no special plea is required for intensification of research on the biological principles which determine the extent and efficiency of animal productivity.

The ruminants, like other homothermic mammals, maintain a relatively constant internal "environment" and are therefore far less sensitive to the external environment than are plants. *Per contra*, unlike most plants, the animals have no resting or resistant phase, and hence cannot survive more than a few months under conditions in which they cannot maintain themselves in N balance. These considerations lead one to suggest that most of the problems concerning ruminants in the tropics will be common to the temperate regions, the differences being solely in magnitude. It may therefore be confidently anticipated that most of the information accruing from studies of cattle and sheep in temperate regions can be extrapolated to animals in the tropics.

Abstract No. 864.

McDonald, J. E. 1956. Variability of precipitation in an arid region: A survey of characteristics for Arizona. Univ. Arizona Inst. Atmos. Phys. Tech. Rep. 1:1-88.

A number of statistical and meteorological aspects of the temporal and spatial variability of precipitation in Arizona have been examined in terms of their bearing on the water resources of the arid southwestern United States. Most of the work summarized has been of the nature of initial exploratory investigations made in order to lay the foundation for the much more extensive studies that will shortly be begun as part of the University of Arizona-U.S. Weather Bureau Cooperative Punchcard Climatological program.

A selected sample of long-record Weather Bureau precipitation stations in Arizona were analyzed for their historic variability properties, a number of statistical and calculational techniques were tested, and a general plan has been developed for the next phases of the Institute's variability program.

It is believed that these findings will be of interest not only to investigators in arid regions themselves but also to investigators chiefly concerned with more humid areas; for, in many respects, the statistical characteristics of arid-lands precipitation pose the most stringent of all requirements on statistical methodology. In that sense, the quantitative results of the present report may serve as useful indicators of upper bounds on the effects of non-normality, skewness, and heteroscedasticity of precipitation frequency distributions for North America in general.

Abstract No. 865.

McDougall W. B. 1967. Botany of the Museum and Colton Ranch area. IV. Vegetation changes in field five. Plateau 39:134-142.

Observations during a 10-year period on an abandoned field in northern Arizona showed marked vegetational changes each year, but no successional trend was detected. The great majority of the plants, 24 years after cultivation of the field ceased, were still annual weeds. It is suggested that it may require a series of "population explosions" among native perennial plants to start a trend toward a stable biotic community and that it may take hundreds of years for the community to mature and become well organized.

Abstract No. 866.

McGinnies, W. G., and J. F. Arnold. 1939. Relative water requirement of Arizona range plants. Arizona Agr. Exp. Sta. Tech. Bull. 80:167-246.

The water requirement of 28 species of Arizona range plants and five crop plants was determined under varying climatic conditions during the period 1931 to 1936.

The experimental work was done at the Desert Grassland Station on the Santa Rita Experimental Range, located about 30 miles south of Tucson, Arizona.

The water requirement results obtained for the crop plants were used as a basis of comparison of climatic conditions at the Desert Grassland Station with those at Akron, Colorado, and elsewhere in the Great Plains area.

The native species included six groups of plants--namely, (1) perennial grasses of the desert grassland, (2) perennial grasses of plains grassland, (3) southern tall grasses, (4) winter annuals, (5) summer annuals, (6) xerophytic trees and shrubs.

Abstract No. 867.

McGinnies, W. J. 1960. Effects of moisture stress and temperature on germination of six range grasses. Agron. J. 52:159-162.

Increased moisture stress delayed germination, reduced rate and 28-day total of germination. Highest average germination was at 20°C. Under high moisture stress all species germinated better at 20 than at 10 or 30°C. Seed size showed positive correlation with germination at a stress of 15 atmospheres.

Abstract No. 868.

McGinnies, W. J. 1962. Effects of seedbed firming on the establishment of crested wheatgrass seedlings. J. Range Manage. 15:230-234.

The effects of cultipacking, pre-packing (wheel-track planting), and post-packing (press-wheel drilling) on the establishment of crested wheatgrass seedlings were evaluated at the Foothills Range near Fort Collins, Colorado, and at Central Plains Experimental Range (CPER) near Nunn, Colorado. Nordan crested wheatgrass was planted on areas not cultipacked, cultipacked once, and cultipacked three times. Significant increases in numbers of seedlings resulted from cultipacking at the Foothills and slight improvement at CPER.

Pre-packing improved seedling stands, but light and heavy wheel pressures caused little difference. Pre-packing was most effective on uncultipacked plots and least effective on heavily cultipacked plots.

Press-wheels of 2- and 4-inch width and dead weight pressures of 70 to 300 pounds were used for post-packing after seed placement. Post-packing generally improved seedling stands but less than pre-packing. When heavy pressures were applied to the 2-inch press-wheel, the wheel cut into the uncultipacked soil too deeply, placed the seed too deeply, and thus reduced seedling numbers.

Cultipacking and pre-packing provide a firm seedbed and permit the depth bands on disc openers to work effectively. On loose seedbeds, depth bands frequently were not effective in accurately controlling planting depth and the seed was planted too deeply.

Abstract No. 869.

McGinnies, W. J., D. F. Hervey, J. A. Downs, and A. C. Everson. 1963. A summary of range grass seeding trials in Colorado. Colorado State Univ. Agr. Exp. Sta. Tech. Bull. 73. 81 p.

The purpose of this publication is to make available the results of the many tests. At each test location, all species are listed irrespective of degree of success or failure. It is hoped that by showing the results for all species, anyone interested in range seeding will have a better basis for selection of grasses and strains for further testing.

The primary purpose of the tests reported in this publication was to determine the ability of various species to become established and to persist on the particular site. Small plot plantings serve as screening tests and are the first step in the overall field testing program. The large number of species and strains which have become available made necessary the determination of those promising for further testing. The most promising species may then receive more intensive testing involving productivity, persistence under grazing, palatability, adaptability for erosion control, and response to grazing management.

Abstract No. 870.

McIlroy, R. J. 1967. Carbohydrates of grassland herbage. Herbage Abstr. 37(2):79-87.

Carbohydrates can be classified into two groups: (a) those involved in the structural framework of the plant, and (b) the non-structural components such as free monosaccharides, oligosaccharides and "reserve" polysaccharides. The nonstructural carbohydrates are more commonly described as water-soluble carbohydrates.

Abstract No. 871.

McIlvain, E. H., A. L. Baker, W. R. Kneebone, and D. H. Gates. 1955. Nineteen-year summary of range improvement studies at the U.S. Southern Great Plains Field Station, Woodward, Oklahoma. Woodward Program Rep. 5506. 41 p. [Mimeo.]

Range improvement studies have been conducted at the U.S. Southern Great Plains Field Station, Woodward, Oklahoma, since 1937. Grazing investigations with **beef cattle were begun in 1941 and have been in progress for 14 years on the Southern Plains Experimental** Range, a 4300-acre research unit located near Fort Supply, Oklahoma. The soil and vegetation of the Experimental Range is characteristic of about 15 million acres of sand sagebrush rangeland in the Southern Great Plains.

Objectives of the studies have been to determine the most practical and profitable means of (1) seeding grasses, (2) controlling brush and weeds, (3) managing native and seeded grasslands, (4) supplementing range forage with protein, other feeds and minerals, and (5) controlling parasites of beef cattle. This 19-year summary deals with major results.

As a special feature of this report, a check list of many range management and livestock husbandry practices for increasing ranching profits in the Southern Great Plains has been added as an appendix.

Abstract No. 872.

McLaren, A. D., and G. H. Peterson [Ed.]. 1967. Soil biochemistry. Vol. 1. Dekker, Inc., New York. 509 p.

Soil Biochemistry, written by leading international experts, presents the first analysis in English of recent research in soil biochemistry. It is a monograph in three parts: Isolation and Characterization of Soil Biochemicals, Metabolism of Soil Biochemicals, Soil Microbe Relationships, all combined in this one volume. The book outlines the approach to investigation of planetary soils and includes biochemistry and biodegradation of herbicides and detergents, and microflora of the rhizosphere. Suitable as either a text or a reference, this work is valuable for researchers in soil science, soil microbiology and biochemistry, agricultural chemistry, plant nutrition, plant pathology, and microbial physiology, as well as all microbiologists.

Abstract No. 873.

McLaren, A. D., and J. Skujins. 1971. Soil biochemistry. Vol. 2. Dekker, Inc., New York. 527 p.

Soil Biochemistry, Volume 2, expands the comprehensive coverage of Volume 1. It describes modern methods of organic matter research and the biochemistry of minor elements in soil. Pesticides, which were included in the first volume, are given further consideration in this volume. Also included are interactions between soil particles and microorganisms. Finally, some kinetic aspects of microbial transformations in soil are explored.

Teachers and researchers in soil science, soil microbiology and biochemistry, agricultural chemistry, plant nutrition, plant pathology, microbial physiology will find this book valuable as a text or reference work.

Abstract No. 874.

McMillan, C. 1956. Nature of the plant community. I. Uniform garden and light period studies of five grass taxa in Nebraska. Ecology 37(2):330-340.

The grassland type of vegetation approaches the ideal for an experimental analysis of the nature of the plant community. The growth form of most members of the grassland community, in contrast with those of communities in which woody members predominate, allows liberal use of transplant techniques. Readily available clones of most members at any time during the year afford ample material for an experimental study.

For an understanding of the nature of a plant community which has been geographically oriented and whose composition has been determined with respect to plant identification, the individual plant behavior within the community needs to be observed and evaluated. The present study was designed to observe individual behavior and then to compare the behavior of individuals of a number of species from one community site with individuals representing the same series of species from a different community site.

Abstract No. 875.

McMillan, C. 1959. The role of ecotypic variation in the distribution of the central grassland of North America. Ecol. Monogr. 29:285-307.

Investigations of the behavior of grasses in a transplant garden at Lincoln, Nebraska, and in the greenhouse under various light periods, coupled with observations of behavior within the natural habitats, provided an evaluation of the role of ecoyptic variation in grassland distribution. Clonal material was studied from a longitudinal and latitudinal grid extending from Manitoba and Saskatchewan to northern Texas and New Mexico. Three general flowering patterns were displayed in the transplant garden. The first showed early flowering for clones from the northern and western communities and later flowering toward the south and east. This type was shown by *Koeleria cristata*, *Bouteloua gracilis*, *B. curtipendula*, *Panicum virgatum*, *Schizachyrium scoparium*, the *Andropogon gerardi* complex, *Sorghastrum nutans*, and *Sporobolus heterolepis*. The second flowering pattern presented earliest flowering of clones from southern communities, followed by somewhat later flowering from western and northern communities, and latest flowering from easternmost communities. Only *Elymus canadensis* displayed this flowering trend. The third pattern of flowering was shown by *Stipa spartea*, *S. comata*, and *Oryzopsis hymenoides*. Here, flowering was simultaneous from all communities represented. The communities in a latitudinal transect from Devils Lake, North Dakota, to Ponca City, Oklahoma, indicated selection for self-maintenance under the progressively longer growing season toward the south. Clones representing 6 species-populations at Devils Lake reached initial anthesis in the transplant garden over a 40-day span, those from Ponca City over a 125-day span. Communities along a latitudinal transect from Montana to Colorado displayed a similarity of response in the transplant garden. The mechanism of grassland distribution involves the intimate relationship of genetic gradients within vegetation coupled with habitat gradients, of which the selective influence of climate is paramount.

Abstract No. 876.

McMillan, C. 1965. Ecotypic differentiation within four North American prairie grasses. II. Behavioral variation within transplanted community fractions. Amer. J. Bot. 52(1):55-65.

Ecotypic differentiation in transplanted clones of *Andropogon scoparius* Michx., *A. gerardi* Vitman, *Panicum virgatum* L., and *Sorghastrum nutans* (L.) Nash showed north-south correlations. In Austin, Texas, during 1959-1962, southern populations had earliest spring activity, latest flowering and latest dormancy. Northern community fractions from Massachusetts to North Dakota showed early flowering and a short span separating initial anthesis among the species-populations. Community fractions from Virginia to Nebraska had initial anthesis over a longer period than in more northern or more southern samples. Community fractions from South Carolina to eastern Texas had late flowering over a short period. Western community fractions, latitudinally and altitudinally diverse, were behaviorally uniform. The length of the growing period and its recurrent selection have sorted out ecological variants in harmony with the habitat gradients. Whether they are of the predominant physiognomic types, as in the true prairie region, or understory plants in the pine forests, the four grass taxa are in the climax matrix.

Abstract No. 877.

McMillan, C. 1969. Ecotypes and ecosystem function. BioScience 19(2):131-134.

The role of the ecotype in ecosystem function is one of insuring community adaptation to its habitat by maintaining environmental relations conducive to efficient usage of energy input. The unique site-ecosystems that result from the concomitant selection of ecotypic variants within different kinds of organisms have been demonstrated most completely in the temperate grassland ecosystem-type. Examination of the deciduous forest-cloud forest ecosystem-type and the marsh ecosystem-type has provided further examples of ecotype-ecosystem interplay in temperate to tropical regions. Since the plant ecotype plays a major role in determining the primary productivity of a point ecosystem, projected ecosystem analyses need to include a consideration of ecotypic status of component populations and an assessment of the contribution of the ecotype to ecosystem function.

Abstract No. 878.

McMillan, C. 1969. Survival patterns in four prairie grasses transplanted to central Texas. Amer. J. Bot. 56(1):108-115.

Transplanted clones of four widespread prairie grasses, *Andropogon scoparius*, *A. gerardii*, *Panicum virgatum*, and *Sorghastrum nutans*, that had survived in cultivation 1958-1962 in central Texas were studied without cultivation 1963-1967 to determine survival patterns. In all four species, clones from northern and eastern sites in the United States were eliminated. Survival of *A. scoparius* was restricted to plants originating in central and southern Texas and in northern Mexico. Surviving clones of *A. gerardii*, *P. virgatum*, and *S. nutans* were chiefly of Texas origin but included other clones mostly from the south central United States. Population samples of the four species from a central Texas grassland community showed greatest survival in a multi-ramet comparison of clones originating from North Dakota to Mexico City and in a multi-clone comparison from six sites in Texas and one in New Mexico. While the superior adaptation to the local habitat by the local populations might have been expected, this study documented the survival potential of organisms in the local ecosystem.

Abstract No. 879.

McWilliams, J. L. 1955. Effects of some cultural practices on grass production at Mandan, North Dakota. U.S. Dep. Agr. Bull. 1097. 28 p.

The practices studied were widths of row spacings for the production of grass seed; dates, depths and rates of seeding, and seedings of grass and grass-legume mixtures.

Abstract No. 880.

McWilliams, J. L., and P. E. Van Cleave. 1960. A comparison of crested wheatgrass and native grass mixtures seeded on rangeland in eastern Montana. J. Range Manage. 13:91-94.

In 1940 plantings of crested wheatgrass and mixtures of native species were made on formerly cultivated land in Prairie County, Montana. Green needlegrass and western wheatgrass were the dominant native species used in the mixtures. These plantings have been grazed since 1942. A study of the plantings 17 years after seeding brought out these points: (1) Herbage yield by the native mixture was 58% greater than for crested wheatgrass in a pasture grazed April 15 to December 15 annually for 16 years. (2) Herbage yield of the native mixture was 36% greater than for crested wheatgrass in the pasture used for spring and winter grazing. (3) The native mixture controlled erosion considerably better than the crested wheatgrass. (4) Continuous use April to December permitted an increase of needle-and-thread grass in the mixture seeded area and a reduction in the vigor and yield of the crested wheatgrass. (5) With spring and winter grazing, green needlegrass increased and encroached on the adjoining crested wheatgrass strips. (6) For long-time production and erosion control under the conditions studied, mixtures of native species are better for range reseeding than crested wheatgrass alone.

Abstract No. 881.

Melendez, A. S. 1963. Studies on the density and vegetation ecology of *Pogonomyrmex occidentalis* (Cresson) (Hymenoptera Formicidae). M.S. Thesis. New Mexico State Univ., Las Cruces. 37 p.

A study on the density and vegetation ecology of *Pogonomyrmex occidentalis* (Cresson) was initiated during the summer of 1962 near Datil, New Mexico. Eight one-section plots were selected for study, four in a pinyon-juniper type and four on open grassland. Ant populations and vegetation within these areas were analyzed and comparisons between these areas made.

A modified random pairs method was used for measurements of *P. occidentalis* population densities. These densities were found to be significantly greater in pinyon-juniper than in grassland. Tree population densities were also obtained by the random pairs method.

Grass cover was measured by the use of sample plots covering two square feet. A considerably greater grass cover was found in the open grassland areas in association with a lower ant density.

A plant list of the species found in the study area is included in the appendix.

Abstract No. 882.

Mercer, R. D. 1938. Crested wheatgrass in Montana. Montana Agr. Exp. Sta. Circ. No. 92. 12 p.

Crested wheatgrass is taking a very prominent place in the readjustment of farm and range patterns in Montana. It is a hardy perennial bunch grass, well adapted for pasture and hay use, and, while its feeding value is somewhat less than alfalfa, it is the most drouth, insect, and disease resistant feed crop grown in the state of Montana.

Crested wheatgrass increases the efficiency of any system where legumes and grasses are grown at the present time. It is a cool-weather plant and makes an early spring and late fall growth which provides good pasture before legumes and other grasses are ready for use.

Crested wheatgrass has a fibrous root system. It is twice as heavy as the ordinary bunch grass, and will penetrate the soil to a depth of 8 to 10 ft for moisture. The roots reach out in every direction for moisture and make such good use of it that when a field is once established a maximum growth is made on limited rainfall.

The only weakness with crested wheatgrass is that it is delicate in the seedling stage. This period lasts for about six weeks after sprouting. Then the plant starts to tiller and form a crown. After this it becomes so well established in the soil that it is not likely to be seriously damaged by drouth or insects and will stand more abuse with less injury to plant and stand than any other grass. The stems of crested wheatgrass are erect and obtain a height of from one to four feet depending on soil and moisture condition. The leafiness depends on the strain planted. Both stems and leaves retain their green color long after the seed spikes have ripened. In the spring new growth comes from the base of the old stalks and, to a lesser degree, from new buds on the underground stems.

The head of a crested wheatgrass plant is fan-like and will vary from one to three inches in length. In the same field the size and shape of the heads will vary greatly. The seed is small and will vary from 200,000 to 300,000 per pound, with an average weight of about 22 pounds to the measured bushel. When properly stored, crested wheatgrass retains a satisfactory germination for several years.

Abstract No. 883.

Metcalfe, C. R. 1960. Anatomy of the Monocotyledons. I. Gramineae. Oxford Univ. Press, Amen House, London. 731 p.

The enormous and highly specialized family of Gramineae, noted for its wide diversity and complexity, has posed many problems to the taxonomist using traditional methods based on grass morphology; histological data are of great significance. Collaborating botanists in various parts of the world have collected and fixed grasses specially for this work. The aim throughout has been to examine grasses of as many different affinities as possible, and in this way to give as complete an account as possible of the anatomy of the Gramineae. In addition to the examination of plant material this book includes summaries of many articles on grass anatomy, but this survey of the literature cannot claim to be complete.

Abstract No. 884.

Miller, D. E., and W. H. Gardner. 1962. Water infiltration into stratified soil. Soil Sci. Soc. Amer., Proc. 26(2):115-119.

A laboratory investigation was made of the effects of textural and structural stratification within the profile on rate of water infiltration into soil. A recording infiltrometer was devised and a method developed for obtaining uniformly packed tubes of soil. Infiltration data were obtained for soil-conditioner treated Palouse silt loam. These data were used to test several infiltration equations found in the literature. It was observed that none of the equations tested adequately describe the experimental data.

Effects of strata within soil were related to the pore characteristic differences between the layering material and the surrounding soil. When most of the pores in a layer were larger than those in the surrounding soil, infiltration was temporarily inhibited after the wetting front reached the layer. The degree of inhibition was increased when the pore sizes in the layer were increased. Water must accumulate at a layer-soil interface until it is at a tension low enough to allow it to move into pores in the layer. Water movement into the surface is reduced while the accumulation takes place.

Abstract No. 885.

Miller, L. D. 1970. Automatic interpretation of remotely produced data for vegetation inventories. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Remote sensing systems collect vast amounts of quantitative information on the vegetation of the earth's surface. Visual interpretation of the images of these systems is important in determining their application to vegetative mapping. Complementary developments in automatic image interpretation are also necessary so that as applications and principles are defined, the vast quantity of data collected may be reduced and applied in a timely, economical, and synoptic fashion.

The simultaneous multispectral scanner illustrates the growing number of remote sensors whose outputs are suitable for automatic image analysis. It is used to map the ground from aircraft altitudes simultaneously in up to 12 different spectral bands. New systems will handle 24 simultaneous spectral bands in the ultraviolet, visible, reflective infrared, and thermal infrared portions of the electromagnetic spectrum. The outputs of the multiple output channels of these instruments are individually and synchronously recorded on magnetic tape in a form suitable for interpretation on analog or digital computers. The variation in the intensity of the radiation measured in the various wavelength intervals at any instant is the product of the reflectance of the ground element observed and the spectral quality of the solar illumination. The illuminating light quality in the various wavelength intervals is recorded as a function of time at the aircraft. It is used to normalize the multiple readings at any instant into the reflectance spectra of the ground area scanner. The reflectance of the vegetation and soil observed by this system is indicative of the types of vegetation and soils present in the area mapped. The aerially mapped reflectance spectra can be exploited to identify the vegetative and soil elements of the scene and their biophysical condition using computational techniques such as spectrum matching.

Initial research into the use of this system for vegetational mapping has been in the automatic identification and mapping of the type and condition of agricultural crops. Using the technique, crops such as wheat, corn, soybeans, and alfalfa have been automatically differentiated, recognized, and their acreages measured with respectable accuracy. The physiological stresses of such monocultures are also often manifested in changes in their reflectivity and can be mapped.

Application of automatic image collection-reduction schemes to mapping natural vegetation is just beginning. The available techniques lend themselves to repeated and synoptic collection of the following basic characteristics of the grasslands ecosystem on a spatial basis: (1) Percent cover of green, functioning vegetation which, in turn, can be related to biomass within a community; (2) Indication of the moisture status of the soil; (3) Community mapping to be used for pattern and distribution analysis and in connection with biomass estimates in #1; (4) Animal population counts.

Abstract No. 886.

Miller, L. D., and R. Pearson. 1971. The remote sensing activity in the IBP Grassland Biome. 7th Int. Symp. on Remote Sensing of the Environment, May 18, Ann Arbor, Michigan.

This technical report contains the progress report from January 1970 to January 1971 and the planning report for January 1971 through January 1972 for the Field Light Quality Laboratory of the Grassland Biome of the International Biological Program. Included in the report are descriptions of the laboratory design as well as the experimentation completed during 1970 which determined how well the lab responds to changes in percent cover of functioning green vegetation and the spectro-reflectances of some common grassland constituents in early October.

Abstract No. 887.

Miller, L. D., and R. L. Pearson. 1971. Areal mapping program of the IBP Grassland Biome: Remote sensing of the productivity of the shortgrass prairie as input into biosystem models. 7th Int. Symp. on Remote Sensing of the Environment, May 18, Ann Arbor. 42 p.

The IBP Grassland Biome program is a major ecosystem analysis involving 88 principal investigators systematically describing the functioning of natural grasslands. A comprehensive remote sensing research program has been undertaken in the context of this overall experiment to determine the utility of various sensor devices in supplying input data into this biosystem model. The initial objective of this effort has been to design and test a multifaceted approach to measure and map percent cover of areas ranging from small sample grassland plots to much larger landscapes. These maps provide the basic data from which to interpret standing crop or aboveground biomass and, in turn, the primary productivity of a grassland.

The amount of vegetation on a prairie can be measured by its characteristic spectroradiance or spectroreflectance. A variety of approaches to exploiting this relationship are covered in the report, including the use of airborne and satellite multispectral scanner imagery, aerial and ground photography, and ground spectrometry. Each of these approaches is explained in detail and preliminary results are presented. A description of the design, construction, and testing of the trailer-mounted, field spectrophotometer is also included. A landscape model is described which has been designed to interface the data taken by mapping remote sensors to the biosystem or hydrologic models which statistically describe the functioning of a natural grassland.

Abstract No. 888.

Milner, C., and R. E. Hughes. 1968. Primary production of grassland. IBP Handbook No. 6. F. A. Davis, Philadelphia. 70 p.

Grassland may be defined floristically as a plant community in which the Graminiae are dominants and trees absent. However, it is often more useful to consider it physiognomically or structurally as a plant community with a low-growing plant cover of non-woody species. This definition includes therefore such communities as the early successional stages following the abandonment of arable land (old field) which contain a high proportion of dicotyledonous species and communities dominated by Cyperacae or Juncaceae, including those of arctic and alpine regions. It also includes grassland dominated by annual and ephemeral plant species occurring in arid regions, the main characteristics of which are dealt with in Part III of this handbook. Despite some structural affinities with grasslands, the dwarf shrub communities present unique problems and require methods specifically developed for use in such communities. One of this type of community, common in Britain and Scandinavia, is discussed in Part II of the handbook.

In view of the large area of the world occupied by grassland and its high potential for food production, the study of its primary production and the factors limiting this are of particular importance. A considerable volume of literature exists on the measurement of production in sown grasslands and rather less on the extensively grazed natural or subclimax grasslands. This section of the handbook deals mainly with natural or semi-natural grasslands grazed by large herbivores (domestic or wild) or by smaller vertebrates such as rodents. Methods are also discussed for study of the much smaller acreage of grasslands which are not apparently utilized by vertebrates. Although many of the methods discussed are applicable to and derived from studies of intensively managed grasslands, in general the handbook is not principally concerned with this type of highly artificial plant community.

Abstract No. 889.

Milthorpe, F. L., and J. L. Davidson. 1966. Physiological aspects of regrowth following defoliation, p. 241-255. *In* F. L. Milthorpe and J. D. Ivins [ed.] The growth of cereals and grasses. Butterworths, London. 359 p.

A primary object in grassland management is the maximum production of digestible material and protein per acre per growing season from plants which are periodically defoliated by grazing or cutting. In this system the effect of the removal of part of the plant tissue on the subsequent rate of growth is a central issue. An assessment of its significance involves an appreciation of the contribution to new growth of those components which remain and the various interrelationships between these components.

During the development of a grass sward, tillers are continually emerging, growing and dying at rates which differ appreciably, depending on environmental conditions and stage of development. At any one time, therefore, there is a population of tillers ranging in size from dormant buds to perhaps elongating flowering stems. The rate of growth of the sward, being the integral of the growth rates of the component tillers, is influenced by the rate of tiller production as well as the growth rates of individual tillers. The latter, however, is often the dominant feature and is a positive function of growth already made at least until anthesis. That is, the most rapid rates of production of digestible matter are found when a high proportion of tillers are elongating.

It is convenient to consider the influence of cutting and grazing in relation to individual tillers. The two operations differ, of course, cutting normally resulting in the removal of all growth above a given height whereas grazing is more selective, some species being defoliated more intensely than others and usually younger tissues being preferred to older stems and leaves, especially if herbage is abundant and grazing pressure is low. We will discuss the phenomena concerned mainly in relation to cutting, which allows more precise specification of the tissues which remain.

Abstract No. 890.

Minderman, G. 1968. Addition, decomposition and accumulation of organic matter in forests. J. Ecol. 56:355-362.

Organic matter annually added to the soil will be submitted to a process of decomposition. The added quantity and the rate of decomposition will in the end lead to a smaller or larger accumulation of humoid compounds. It is difficult to give a quantitative gravimetric picture of this phenomenon, because of the simultaneous processes of mineralization and of accumulation. However, the following details can be more or less accurately measured: (1) The annual addition of organic matter to the soil. (2) The period during which this addition takes place. (3) The loss in weight of the litter *sensu lato* after one or several years. (4) The accumulation of organic matter after a certain number of years, provided that the history of the forest plantation and the original condition of the soil are well known. (5) The maximum accumulation in a system that has come to an "equilibrium" with the environment.

On the bases of the few analytic data, various authors have tried to construct mathematical models that describe the phenomenon of decomposition and accumulation. As a result of this, it is more or less common opinion in papers on this subject that the process of decomposition and accumulation can be represented by exponential functions of the type e^{-x}.

This implies that the process of decomposition can be represented logarithmically, so that a fixed multiplication factor, the decomposition factor, determines the loss.

On the basis of the hypothetical exponential functions, various quantities can easily be calculated, e.g., the time it takes for one year's crop of litter to be reduced to half its weight; or the maximum accumulation from addition and decomposition; or the rate of decomposition from the annual addition and from the accumulated organic matter.

Abstract No. 891.

Mitchell, G. C. 1971. Spatial distribution and successional state of grassland vegetation related to grazing intensity treatments. U.S. IBP Grassland Biome Tech. Rep. No. 101. Colorado State Univ., Fort Collins. 70 p.

A study was conducted on the International Biological program's (Grassland Biome) Pawnee Site to measure the pattern of several plant species in relation to grazing intensity. Five study sites were selected: a light grazed, a medium grazed, a heavy grazed, a 10-year exclosure, and a 30-year exclosure. An analysis of variance procedure was used to determine the pattern scale and intensity of *Bouteloua gracilis*, *Carex eleocharis*, *Opuntia polyacantha*, and *Sphaeralcea coccinea*.

The five areas sampled were each determined to be in differing stages of secondary succession due to grazing pressure or lack of it. The four species selected for the pattern analysis were determined to be nonrandomly distributed. Small scale-patterns which could be attributed to morphology and seed dispersal characteristics were exhibited by *O. polyacantha* and *S. coccinea*. At the medium scales the reciprocal pattern forced upon neighboring species by *O. polyacantha* seems to be dominant. Larger scale-pattern was found but could not be attributed to grazing influences. The pattern intensity of all rhizomatous species decreased as the site approached a climax condition.

Abstract No. 892.

Mitchell, J., and H. C. Moss. 1948. The soils of the Canadian section of the Great Plains. Soil Sci. Soc. Amer., Proc. 13:431-437.

For the purpose of this paper, the Great Plains region in Canada is considered to include the glaciated, elevated plain lying mostly on Cretaceous bedrock and bounded on the east by the Manitoba Escarpment, on the northeast by the Pre-Cambrian Sheild, and in the north by the Cretaceous Escarpment. The west boundary lies along the foothills of the Rocky Mountains. The northerly part of the region so defined is largely forest land which could be regarded as a separate section of the Great Plains. However, the above defined area appears to make a fairly satisfactory physiographic unit. The area delineated is roughly triangular in shape with the broad base of the triangle on the 49th parallel stretching from the Red River Valley in Manitoba to the foothills of the Rocky Mountains in Alberta, and with the apex in the vicinity of Fort Nelson, British Columbia (60° N Lat 124° W Long). The area is roughly 440,000 square miles in extent. The soils discussed below include major profiles of the semiarid-subhumid grasslands and of the southern fringe of the northern forest, representing the main areas so far covered by soil surveys in Alberta and Saskatchewan and the westerly section of Manitoba.

Abstract No. 893.

Mitchell, J. E. 1971. An analysis of the beta-attenuation technique for estimating standing crop of prairie range. J. Range Manage. 25(4):300-304.

The standing crop of aboveground shortgrass prairie vegetation may be quickly and accurately estimated by the beta-attenuation technique. This technique is based upon the principle that herbage absorbs or attenuates beta particles emitted by certain radioactive nuclides as a predictable function of the herbage biomass intersecting the attenuation field between emitter and detector. Two methods of measurement are correlated with standing vegetation. These tests indicate that the method can account for approximately 90% of the variation measured in the field, with the exception of quadrats dominated by plains pricklypear. In addition to being accurate, precise, and relatively inexpensive, the beta-attenuation technique is non-destructive in nature, allowing repetitive sampling of the same location.

Abstract No. 894.

Mitchell, J. E. 1971. Consumption and metabolic rates of some leaf-eating, chewing arthropods: A summarized literature review. U.S. IBP Grassland Biome Tech. Rep. No. 118. Colorado State Univ., Fort Collins. 4 p.

The study of insects and other arthropods in a quantitative manner is an area of man's knowledge which has seen little study at best. Entomologists and zooecologists have only recently begun to investigate the impacts which arthropods are having on various terrestrial and aquatic ecosystems. In general, however, such concepts as energy flow, assimilation, productivity, and respiration are yet unknown to most entomologists. This is especially true for those interested in insects other than the orthopterans. To emphasize this point, it may be noted that no articles containing information concerning respiration or metabolic rates could be located which had been published prior to 1960. Also, it could be considered significant that there are no published data relating to insect consumption or metabolic rates available from any of the U.S. IBP biome projects.

Abstract No. 895.

Moinat, A. D. 1956. Comparative yields of herbage from oak scrub and interspersed grassland in Colorado. Ecology 37:852-854.

This study of a foothills scrub oak community shows that the yields of herbage average twice as great from the open grass-weed parks between the oak clumps as from the clumps themselves.

The forage under the oaks is of fairly high quality, being composed almost entirely of blue grass, while in the parks there are more forbs and drought and sun-tolerant grasses. With moderate to heavy grazing, there is a definite trend to the less palatable species while the Arizona fescue and mountain muhly decrease in number and vigor.

The results of this study suggest the desirability of further work with records of forage yields from land cleared of oak scrub and seeded to suitable range species.

Abstract No. 896.

Moir, W. H. 1968. Prairie rebirth. Science 162:1312.

The North American tallgrass prairie never really had a chance. Before a botanist could say *Baptisia*, the white man had checked the wildfires that maintained the prairie, plowed it and planted corn, or allowed pastures or forest to lay claim to its fertile soils. This may all be changed now. In a symposium on prairie and prairie restoration at Knox College, Illinois, 14-15 September 1968, a group of scientists and prairie enthusiasts gathered to compare notes on how to recreate prairie communities before their otherwise inevitable extinction.

Twelve of the papers given at the symposium were concerned with the nature of prairie environments and causative factors. Ten papers were concerned with techniques of restoration.

Abstract No. 897.

Moir, W. H. 1969. Energy fixation and the role of primary producers in energy flux of grassland ecosystems, p. 125-147. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

This paper reviews how herb-dominated communities, grasslands in particular, bring about energy transformations. In a nonbiological, purely physical land system solar energy incident to a land surface is subject to transformations of sensible and latent heat flux and thermal radiation emission. In a grassland ecosystem upward of 2 to 3%, more or less, of incident solar energy is channeled into chemical energy as a consequence of metabolic activities of plants. Photon trapping by chlorophyll is the first step in energy fixation, and numerous subsequent chains of enzyme reactions lead to chemical energy stored as plant biomass. During these processes of chemical transformation, a grassland community brings about modifications in other energy flux components of the land surface.

The central thesis of this review is that the energy transformations within the grassland ecosystem must be very closely regulated by abiotic and synecological environmental factors. Photosynthesis of leaf mesophyll is sensitive to ambient changes in the leaf microclimate. Plant growth depends upon a supply of photosynthate and upon seasonal changes in the whole plant environment, which in turn affect metabolic systems regulating plant ontogeny. Despite the seeming remoteness between solar energy and the energy of chemical storage in plant tissue, the integration of instantaneous physiological and microenvironmental events over an entire growing season is a very real plant function that can be expressed by changes in community biomass over the growing season.

Abstract No. 898.

Moir, W. H. 1969. Photosynthesis of shortgrasses under field conditions. U.S. IBP Grassland Biome Tech. Rep. No. 31. Colorado State Univ., Fort Collins. 17 p.

Progress to September 1969 consisted mainly in developing and improving an instrumentation system for measuring carbon dioxide gas exchange in plants growing under field conditions. The observation system now includes a rigorous gas flow and temperature control.

By August 1969 major components of the photosynthesis measurement system had been tested and found satisfactory, although further improvements and modifications of some subsystem components are envisioned. The response of shortgrasses to diurnal ambient changes was measured during two weekends near the end of the growing season. Additional responses in gas exchange were measured during short periods of the active growing season, and the results are discussed.

Plans for the 1970 season include replication of photosynthesis measurements at up to six field sites, continuous diurnal observations correlated with major phenological events, measurements of soil respiration under field conditions, and measurements of the influence of plant moisture stress to carbon dioxide exchange rates.

Abstract No. 899.

Moir, W. H. 1971. Seasonal variations of plants and stand dehydrature in contrasting forest habitats, Colorado Front Range, 1970. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

Pre-dawn pressure bomb measurements were made on plants in the understory of stands from five forest habitats. Measurements during wet periods with soils near field capacity established minimum pressures (MIN) for each species. Such pressures were assumed to represent plant twig hydrature near full turgidity. On some species maximum daytime pressures (MAX) on hot, clear days departed very little from the following pre-dawn pressure. These maximum pressures established upper limits for pressure bomb measurements during the period from 22 July to 29 September. Dehydratures for *Juniperus communis*, *Arctostaphylos uva-ursi*, *Shepherdia canadensis*, *Abies lasiocarpa*, and *Pseudotsuga menziesii* were computed as

$$D = (100\ (R - MIN))/(MAX - MIN)$$

where R was the pre-dawn pressure. Values of D (as percentages) might be related to needed quantities of root zone water for returning the plant to fully turgid twig hydrature by pre-dawn. Stand dehydrature was averaged from dehydratures of understory species. Consecutive measurements in a stand from the *Pseudotsuga menziesii/Arctostaphylos uva-ursi* habitat revealed the extent of variations in D during the late summer: 16, 17, 36, 49, 14, 19, 19, 18, 19, 45, 12%. Two stands in *Pinus contorta* habitat ranged from 8 to 36% and 7 to 55% dehydrature. Maximum dehydratures between 60 to 70% occurred 12 September in *Pseudotsuga menziesii* and *Picea-Abies/Vaccinium myrtillus* habitats. I found no consistent ordering of stands from dry to wet habitats according to D values over the late summer. It is possible, however, that consistent dehydrature relationships between stands of diverse forest habitats could be observed in dry summer years.

Abstract No. 900.

Moldenhauer, W. C. 1959. Establishment of grasses on sandy soil of the southern High Plains of Texas using a mulch and simulated moisture levels. Agron. J. 51:39-49.

Emergence of seven grasses occurred at a much lower moisture level when a mulch covered the seeded area. The mulch was much less beneficial with cool temperatures during the period of germination. Weather records show that a mulch would have been helpful in 31% of the years at Big Spring, Texas, and 36% of the years at Seminole, Texas.

Abstract No. 901.

Molz, F. J., and I. Remson. 1971. Application of an extraction-term model to the study of moisture flow to plant roots. Agron. J. 63:72-77.

A one-dimensional extraction-term model is used to simulate the moisture flow and removal process in the vicinity of plant roots. The dependence of model results on root depth and soil type are investigated. Moisture contents, root moisture absorption rates and soil-moisture fluxes are computed and discussed for several hypothetical root systems in a sandy soil and in a clay soil.

The model is solved numerically with a procedure based on the Douglas-Jones predictor-corrector method. Results indicate that moisture extraction by the roots from soil in their immediate vicinity is the dominant process, with Darcian flow in the root zone playing a smaller but often significant role.

Extraction-term models are versatile and seem able to describe many of the phenomena associated with moisture removal by the roots of transpiring plants.

Abstract No. 902.

Monson, O. W., and J. R. Quesenberry. 1958. Putting flood waters to work on rangelands. Montana Agr. Exp. Sta. Bull. 543. 39 p.

Soil erosion has been a prominent agricultural problem during recent years. The solution to this problem in the midwest where the rainfall is abundant but poorly distributed has been first, to check the velocity of flow of runoff water, thereby reducing the erosive action and saving the soil; and second, to make the soil more receptive to moisture penetration through better cropping and cultural practices, thereby increasing the conservation and use of water and reducing the loss and waste from runoff. In the arid west the conservation of moisture is still more important.

The methods of control, therefore, change from the construction of check dams which merely check or retard the flow of water, to the use of diversion dams which force the water back onto the land. Instead of dikes and ditches which collect surplus water and convey it at a slow velocity from the fields and discharge it into a coulee or stream channel, dikes and ditches are constructed with proper grades to convey flood waters from the coulee out onto the land and spread it out so it can be absorbed by the soil. The emphasis changes from soil conservation to the conservation of water; yet both are accomplished in the same operation.

Prolonged ponding or excessive flooding is not recommended because of its bad effect on some of the highly desirable species of grasses such as grama and buffalo grass. All grasses do not require heavy irrigation. A given amount of water spread over a large area will produce more grass than the application of a heavy irrigation to a smaller area.

The water which collects and drains from the rough, broken lands of the range country carries with it tons and tons of silt. When the muddy water is permitted to flow into the rivers it contributes to clogging the channels. This causes overflow and flood damage to the flood plains and lowlands bordering the rivers all the way to the Gulf of Mexico. Through the recovery of the flood water, its by-product, the silt, is also recovered and helps to fertilize the land and produce crops of grass or hay.

Abstract No. 903.

Moon, E. L. 1940. Notes on hawk and owl pellet formation and identification. Kansas Acad. Sci., Trans., 43:457-466.

This paper records the progress to date (March 15, 1940) of attempts made to establish a basis for the identification of the pellets of certain raptorial birds found in western Kansas. The fundamental purpose of this study is to show that the accurate identification and interpretation of pellets, which have been formed under natural conditions in the field, may increase their value as food habits data when carefully studied.

Abstract No. 904.

Moore, R. A. 1970. Symposium on pasture methods for maximum production in beef cattle: Pasture systems for cow-calf operation. J. Anim. Sci. 30: 133-137.

Three pasture systems were compared in a South Dakota study. They include a native grass mixture, an introduced pasture, and a series of tame pastures. The net returns per ha in 1967 varied from $6.42 for the native to $23.03 for the introduced pasture and $33.84 for the series. The latter was slightly better than the best cash crop which was spring wheat with a net return of $30.87 per ha.

It is suggested that many alternatives exist in supplementing a basic grassland type in order to achieve maximum sustained production.

Abstract No. 905.

Moore, R. E. 1940. The relation of soil temperature to soil moisture: Pressure potential, retention, and infiltration rate. Soil Sci. Soc. Amer., Proc., 5:61-64.

Experiments have demonstrated that temperature has considerable influence on such soil-moisture properties as pressure potential, retention, and infiltration rate, and that the nature of this influence could not be predicted a priori from the known effect of temperature on viscosity, surface tension, and expansion of liquids and gases. The inability to predict the influence of temperature is not due to deficiencies in the tools of mechanics and thermodynamics, but inheres in the nature of the parameters of the moist soil system to which these tools must be applied. These parameters, such as size and shape of soil pores, are still incapable of adequate definition. They are dynamic, and are altered by temperature.

The writer found that changes in temperature in the absence of thermal gradients along the vertical axis of soil columns, changed pressure potential gradients, caused changes in the height of water tables and induced a redistribution of water in columns which were originally at steady state. This paper reports further investigations on the effect of temperature on the pressure potential, retention, and infiltration rate of soil moisture.

Abstract No. 906.

Moore, R. M., and E. F. Biddiscombe. 1964. The effects of grazing on grasslands, p. 221-235. *In* D. Barnard [ed.] Grasses and grasslands. St. Martin's Press, New York.

Grazing involves not only reduction in leaf area of plants with concomitant effects on their storage of carbohydrate, tiller development, leaf and root growth but, in addition, alters their microenvironment, introduces such factors as trampling and return to soil of dung and urine, and modifies the dispersal of seeds and fruits. Further, the effects of grazing animals on grassland communities are not simple summations of their effects on individual species. Since species in such communities differ in germination, sprouting and flowering times, growth rhythms, and palatabilities, their inter-relationships may be profoundly altered by grazing.

For these and other reasons, grazing cannot be simulated in totality by cutting, particularly in greenhouse experiments, though such studies may be useful in elucidating the physiological effects of defoliation *per se* in individual species.

Abstract No. 907.

Moorefield, J. G., and H. H. Hopkins. 1951. Grazing habits of cattle in a mixed-prairie pasture. J. Range Manage. 4:151-157.

Activities of cattle on the range have certain relationships with proper range management. The purpose of this study was to find when and how much time cattle spend at various activities in a mixed-prairie pasture.

Abstract No. 908.

Moreshet, S. 1970. Effect of environmental factors on cuticular transpiration resistance. Plant Physiol. 46:815-818.

Measurements of the various diffusive resistances to water vapor transport within the leaves of sunflower plants (*Helianthus annuus*) growing in a controlled environment chamber were used to calculate values of cuticular resistance under a range of environmental conditions. Cuticular resistance to water loss was found to be inversely related to the relative humidity of the surrounding air, and it is suggested that such a mechanism would form a useful adaptation to arid conditions, enabling plants to maintain a more favorable internal water balance.

Abstract No. 909.

Morris, M. S. 1970. Comprehensive Network Site description, Bison. U.S. IBP Grassland Biome Tech. Rep. No. 37. Colorado State Univ., Fort Collins. 23 p.

Bison Site is located on the National Bison Range which is operated by the Branch of Wildlife Refuges, Bureau of Sport Fisheries and Wildlife, U.S. Department of Interior. The entrance to the area is located approximately 45 miles northwest of Missoula, Montana, near Moiese, Montana, in the western portion of the state. The National Bison Range comprises an 18,500-acre area. It is bounded approximately by the Jocko River on the south and Mission Creek on the north. The Flathead River is near the western bôundary. The area is fenced to prevent movement of large mammals as well as to provide administrative control for protection and management.

Abstract No. 910.

Morris, M. S., and J. D. Brunner. 1971. Primary productivity of the fescue grassland in western Montana. U.S. IBP Grassland Biome Tech. Rep. No. 113. 74 p.

A study of primary productivity in the fescue grassland in western Montana was conducted on the National Bison Range northwest of Missoula, Montana, in 1970. A comparison of two vegetation conditions was made. They are: a stand dominated by a rough fescue (*Festuca scabrella* Torr.) with a grazing history of light to no use in most years and a mixed stand of Idaho fescue (*F. idahoensis* Elmer) and bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scrib. and Smith) with a grazing history of moderately close use and both stands on comparable sites. Air and soil temperatures, relative humidity, precipitation, wind velocity, and soil moisture characteristics of the environment were monitored. Height growth, plant moisture content, and phenology were recorded. Biweekly harvesting of .5 m^2-plots was initiated in April and continued to October. Separation of aboveground plant biomass components was made, including 1970 standing green, 1970 standing dead, and 1969 standing dead and litter. Moss and belowground plant biomass were single date determinations. Total plant biomass was 3170 and 1728 g/m^2 for the light and moderately close grazed treatments, respectively. Net primary production was 531 and 298 g/m^2, respectively. While growth is initiated in the fall of the previous year, significant spring growth requires daily mean temperatures of over 5°C. Soil moisture stress at -15 bars terminated growth by 3 July under both treatments. Efficiency in utilization of precipitation is a more realistic measure of the use of the environmental resources than use of radiant energy.

Abstract No. 911.

Moss, E. H. 1932. The vegetation of Alberta. IV. The poplar association and related vegetation of central Alberta. J. Ecol. 20:380-415.

The poplar association covers a large portion of central Alberta, consisting of two consociations of *Populus balsamifera* and *P. tremuloides*, respectively. The former species rarely exceeds 135 years, the latter 120 years in age. Stands of these trees are almost always even-aged due to reestablishment by suckers after burning. These fires seem to be more frequent at 20-year intervals during dry years, indicating 20-year climatic cycles. Gray soils of a forest type prevail in the northern and western parts of the region, black grassland soils in the center, and brown grassland soils in the south. The aspen vegetation tends to invade the grassland to the south and east. As a consequence there is a broad transition belt, the parkland, consisting of groves of trees in depressions and on north-facing slopes scattered through the grassland. The poplar forest passes to a climax forest of *Picea albertiana* to the north and west, but the aspen seems to be the climax of the southern part of the forest and of the parkland. Thickets of *Salix* spp., *Symphoricarpos* and *Eleagnus* occur in the parkland and the adjacent grassland. The parkland seems to have invaded the prairie during the past few centuries. The species of the various communities are listed with their constancy and frequency.

Abstract No. 912.

Moss, E. H. 1944. The prairie and associated vegetation of southwestern Alberta. Canadian J. Res., Part C. 22:11-31.

This is a contribution to an understanding of the floristic composition and ecology of the chief plant communities in the region. Three major grassland types are recognized and correlated with climatic factors, topography, and soil colour zones--the *Bouteloua-Stipa* association in the dark brown soil zone, the *Festuca-Danthonia* association in the black soil zone, and the *Agropyron-Stipa-Carex* associes in the intermediate shallow black soil zone. Of some 250 species and varieties of vascular plants found in these grassland communities, approximately 125 are regarded as either common or characteristic. Poplar and coniferous vegetation is considered in relation to climate, physical features, and the associated grassland. The limber pine and Douglas fir communities of rocky ridges in the "parkland" are described. Prairie and poplar associations are compared with corresponding vegetational types described for other regions. Brief consideration is given to probable migration routes of certain species and to current fluctuations and trends in the flora of the region.

Abstract No. 913.

Moss, E. H. 1952. Grassland of the Peace River region, western Canada. Canadian J. Bot. 30:98-124.

Natural grassland is associated with poplar and willow groves to form parkland areas on dark soils in the generally forested Peace River region of western Canada. The grassland is described as an *Agropyron-Stipa-Carex* community. Comprising this community are three subtypes or faciations, viz, *Agropyron-Carex* on low areas, *Stipa* on dry slopes, and *Agropyron-Stipa* on mesic sites. For the entire community 154 vascular species are recorded and for the *Agropyron-Stipa* faciation, which is the most common native grassland of the region, 139 vascular species, consisting of 36 graminoids, 84 forbs, and 19 woody species. The leading grasses are *Agropyron trachycaulum*, *Stipa spartea* var. *curtiseta*, and *Koeleria cristata*. The *Agropyron-Stipa* faciation is the "climax" grassland of the region and therefore may be classified as an "association." The occurrence of native grassland areas in the boreal forest region is explained in terms of special physiographic and edaphic features of these areas, notably poorly drained and inadequately aerated soils. Therefore, the *Agropyron-Stipa* grassland may be interpreted as an edaphic climax. Compared with the fescue grassland of south-central Alberta, the Peace River grassland lacks *Festuca scabrella* but has many of the other plants of the fescue association, certain of these assuming the role of leading species. Reliable indicators of early stages in grassland retrogression brought about by heavy grazing are the small sedges, *Carex obtusata* and *C. heliophila*.

Abstract No. 914.

Moss, E. H. 1956. The vegetation of Alberta. Bot. Rev. 21:493-567.

The province of Alberta, Canada, holds more than ordinary interest for botanists, especially for specialists in phytogeography, taxonomy, and ecology. This is mainly because it is a region of vegetational transition zones. Here, two great plant formations, steppe and forest, come together, having east-west and north-south ecotones, as well as outliers, one within the other. Here also, is the meeting ground of east (Atlantic) and west (Pacific) floras or, more precisely, of boreal and Cordilleran elements. Moreover, in the north of the Province, transition from boreal to arctic begins.

Vast areas of the region are still unknown botanically, and many of the published reports are to be regarded as preliminary and tentative. Nevertheless, the literature is now of sufficient coverage and extent to warrant a review and general appraisal. Moreover, a synthesis of present knowledge would seem to serve a useful purpose in focussing attention on some of the main issues and unsolved problems. Not all aspects of our subject can be covered, of course, even within the compass of a fairly long review. The main emphasis is on synecological aspects of our vegetation, with particular reference to the prairie and forest associations of southern and central Alberta, the northern portion of the Province having been dealt with in recent comprehensive papers. The presentation is generally in terms of communities, succession, and monoclimax; however, for certain mountain forests, the "continuum" concept and the climax as a "variable pattern" find favor. It is hoped that the review may interest those who are concerned with these concepts. Our discussion of prairie parkland includes a few excerpts from writings of early explorers. These and various later publications serve to show how our present understanding of the vegetation has been reached.

Abstract No. 915.

Moss, E. H., and J. A. Campbell. 1947. The fescue grassland of Alberta. Canadian J. Res., Part C. 25:209-227.

A distinction is drawn between the virgin fescue prairie described as the *Festuca scabrella* association and the fescue grassland produced by mowing for hay or by grazing. The virgin or climax association, dominated by *Festuca scabrella*, is characterized by some 150 species of higher plants. Various of the associated species, notably a few of the grasses, increase greatly in frequency and coverage when the prairie is used as hay meadow or as pasture, while the fescue shows a corresponding decline. Where grazing has been heavy the fescue has virtually disappeared. The fescue association is considered in relation to *Stipa*, poplar, and other contiguous plant communities. The name "submontane" for the fescue prairie of Alberta and Saskatchewan is inappropriate. The fescue association is believed to have been associated with the formation of the black soils of Alberta, including the soils of those black and gray-black zones occupied in recent times by wooded vegetation. The bulk of the organic matter in the black soils has apparently derived from a single species of grass, viz, *Festuca scabrella*. An understanding of climax communities and successional relationships is basic to a proper classification of range land for lease purposes and to sound long-term administrative policy for this land.

Abstract No. 916.

Moyer, F. J. 1953. Ecology of native prairie in Iowa. Ph.D. Thesis. Iowa State Coll. Libr., Ames. 110 p.

A vegetational analysis of two native prairies in Iowa was attempted.

The following characteristics were determined: A flora of the prairies, stability of the prairies, frequency percentages of the species, percentage composition by species, dominant species, quantity of plant materials above and below ground, and soil structure in terms of volume weight, aeration porosity, and aggregation.

Abstract No. 917.

Mueller, I. M. 1941. An experimental study of rhizomes of certain prairie plants. Ecol. Monogr. 11:165-188.

An experimental study of the rhizomes of 24 species of prairie plants was made to secure exact information on habits of growth, on rates of spread in natural habitats and in two types of tilled fields, and on responses of certain species to desiccation and to deposition of soil.

Abstract No. 918.

Mueller, I. M., and J. E. Weaver. 1942. Relative drought resistance of seedlings of dominant prairie grasses. Ecology 23(4):387-398.

Mixed plantings of seedlings of 14 species of dominant prairie grasses were tested for resistance to drought at ordinary summer temperatures. Only a few plants, all of which were short grasses, survived where drought was most critical. Of these blue grama (*Bouteloua gracilis*) showed the greatest drought resistance, three times as many plants surviving as those of hairy grama (*B. hirsuta*) and buffalo grass (*Buchloe dactyloides*) which were next in order. Western wheatgrass (*Agropyron smithii*) was least able to resist drought.

There was no mortality and only slight damage to seedlings subjected to hot winds of 135°F when soil moisture was available. Leaves of the shortgrass seedlings, listed above, were scarcely injured by temperatures as high as 145°F. Neither differences of a few weeks in age nor previous exposure to drought had any significant effect on the survival of seedlings which were exposed to hot winds.

When the results of exposure to soil drought and to atmospheric drought were both taken into account, *Bouteloua gracilis* was the most drought resistant. In order of decreasing drought resistance the species were *Buchloe dactyloides*, *Bouteloua hirsuta*, *Sporobolus asper*, *Bouteloua curtipendula*, *Stipa comata*, *Andropogon scoparius*, *A. furcatus*, *Panicum virgatum*, *Sorghastrum nutans*, *Stipa spartea*, *Koeleria cristata*, *Elymus canadensis*, and *Agropyron smithii*. In general, species characteristic of uplands or which normally occur westward in mixed-prairie were more resistant, and those in the lowlands or in the true prairie less resistant to drought.

Abstract No. 919.

Mulkern, G. B., and J. F. Anderson. 1959. A technique for studying the food habits and preferences of grasshoppers. J. Econ. Entomol. 52(2):342.

Previous investigations of the food preferences and feeding habits of grasshoppers have included a considerable amount of rearing of grasshoppers and plants under artificial conditions. This work has been valuable, but has many drawbacks associated with the artificial conditions.

In the study reported on herein a technique was developed by means of which the composition of the diet of grasshoppers can be analyzed by examination of the contents of their crops. The first step was to determine if different species of plants exhibited characteristics which permitted their identification in a masticated condition. Grasshoppers were confined on various plants for two days and then killed. Crops were removed and their contents examined. The results from these first experiments indicated that plants could be recognized in the crops, and a broader program was initiated in which grasshoppers were individually caged on a larger number of species of plants in the field. Permanent slides were made of the contents of the crops of these grasshoppers and were used as "type" reference slides. Another method of obtaining type reference slides was developed using a Waring Blendor with a semi-micro container assembly. Plant samples were collected and preserved in 70% alcohol and then chopped in the blender to a particle size approximating that found in the grasshopper crop. Slides made from this material proved to be equal or superior to those of the contents of the grasshopper crop for reference purposes.

This method allows for much experimentation. By selecting fields in which the relative abundance of different plants varies, a comparison of the preferences of the grasshoppers for the various plants may be obtained. If all plants are eaten at random, they should appear in the crops in proportion to their abundance. If the grasshoppers are selective, the plants in the crops should reflect this by their disproportionate abundance.

Abstract No. 920.

Muller, C. H. 1939. Relation of the vegetation and climatic types in Nuevo León, Mexico. Amer. Midland Natur. 21(3):687-729.

Classification of climatic types in Nuevo León are exceedingly inaccurate because of the scarcity of observatories in the mountains. Existing vegetation types at high elevations indicate several cooler and more moist climatic types than those credited to the lowland observatories. Vegetation types and corresponding climatic types are described under the following designations: (1) central plateau desert scrub with warm and arid climate, (2) eastern coastal plain scrub with warm and semi-arid climate, (3) piedmont scrub and montane low forest with mild and semi-arid climate, (4) montane mesic forest with cool and subhumid climate, (5) western montane chaparral with cool and semi-arid climate, (6) subalpine humid forest with cold and humid climate, and (7) alpine meadow and timberline with alpine climate. Mean annual temperatures range from 25°C on the plains to 3°C in the alpine zone; rainfall from 360 mm to about 2,250 mm. The vegetation types range from the most scant of desert scrub to luxuriant forests and lush meadows. The altitudes range from about 300 m to 3,800 m, the mountains occupying over one-fourth of the area of the state. Landscape photographs illustrate the vegetation types; maps include relief and distribution of vegetation and climatic types.

Abstract No. 921.

Muller, C. H. 1947. Vegetation and climate of Coahuila, Mexico. Madroño 9(2):33-57.

The several vegetation types of Coahuila are described, mapped, and correlated with those of adjacent Nuevo León and some of those of Texas and Chihuahua. The types recognized are (1) Chihuahuan Desert Shrub occupying the Central Plateau region, (2) Tamaulipan Thorn Shrub on the Coastal Plain, and a series of types confined to the several mountain ranges, including (3) Piedmont Shrub on the windward piedmont, (4) Grassland on the foothills generally, (5) Montane low forest above the windward piedmont, (6) Montane Chaparral at higher elevations particularly to the west, and (7) Montane Mesic Forest at the higher elevations of the major mountain masses. The Chihuahuan Desert Shrub and Tamaulipan Thorn Shrub are approximately co-extensive with the climate types of Sanchez named, respectively, "Clima Desertico" and "Clima de Estepas." The several piedmont and montane vegetation types occupy approximately 10% of the total area of the state. On the basis of the vegetation and soils of these areas, it is concluded that they are characterized by climate types more moist and cool than the desert and steppe climates ascribed to the entire state by conventional climatological classifications.

Abstract No. 922.

Munroe, E. 1956. Canada as an environment for insect life. Canadian Entomol. 88:372-476.

Two things make it difficult to write an account of Canada in relation to insect life: the vast size and varied nature of the country and the relatively small amount of work that has been done on its insects. Those familiar with the intensely worked biota of Western Europe or even of many parts of the United States will find this description meagre indeed. In general, Canadian environments are known better than the insects that inhabit them. In only a few orders of insects is our knowledge even of species taxonomy reasonably adequate; for all orders our knowledge of geographical distribution in Canada is sketchy or fragmentary and our knowledge of ecological relations almost non-existent. Serious collecting and study of insects has been carried out in only a few centres. The National Collection itself has been developed actively only since 1919 and on a large scale only in the last few years. There is no close network of amateur and professional workers such as exists in better-studied countries. What I have tried to do, therefore, is to give a brief geographic account of the main environmental factors as seen by an entomologist, to give a short outline of the possible history of the fauna, to give examples of the main distributional types, and to provide a tentative classification of entomological regions, with notes on some characteristic insects of each. The main feature that will undoubtedly be impressed on the reader, as it has been impressed on me, is our ignorance and the need for further investigation of the insect fauna.

Abstract No. 923.

Murray, R. B., Jr. 1961. A study of range condition in a fescue grassland in western Montana. M.S. Thesis. Montana State Univ., Missoula. 88 p.

The response of the vegetation and soil to the varying effect of grazing was studied on an upland site in the fescue grasslands near the town of Philipsburg in western Montana during 1960 and 1961. Three adjacent areas with similar soil, slope, and aspect were preclassified into excellent, fair, and poor range conditions on the basis of standards set by the Soil Conservation Service. These condition areas were investigated in detail to determine the nature of vegetation deterioration and accompanying soil changes resulting from different degrees of livestock grazing. Ecological and economic information was obtained which can be used as guides for the proper management of these ranges.

Abstract No. 924.

Musgrave, G. W., and G. R. Free. 1936. Some factors which modify the rate and total amount of infiltration of field soils. J. Amer. Soc. Agron. 28(9): 727-739.

Of the various factors which may modify the rate of infiltration of water into field soils, the percentage of porosity is one of the most dominant. Increasing the average percentage of pore space of cores of field structure through surface cultivation has markedly increased the rate of infiltration. While there are many possible ways of increasing porosity, only one was included in the study reported herein, namely, various depths of cultivation. On Marshall silt loam the average rates over a 3½-hour period were as follows: without cultivation, 0.78 inch per hour, with 4-inch cultivation, 0.99 inch per hour; and with 6-inch cultivation, 1.23 inches per hour.

In this study little evidence is found that close vegetation such as bluegrass and alfalfa increases the rate of infiltration enough to account for the marked control of surface runoff that is characteristic of such cover. The reduction in runoff may be accounted for at least in part by a lower velocity of runoff which gives in effect a greater time for infiltration. The effect of lower velocity becomes particularly marked when studied for areas of appreciable size. There are undoubtedly other factors which are not touched upon in this study which also have a definite bearing upon the marked control of runoff which is affected by various types of close vegetation.

The study as a whole would indicate that, although the infiltration rate may be greatly modified by changes in porosity induced by one or another means, and relatively by soil moisture content or vegetative cover, yet the dominant factor may well be the soil type, at least insofar as comparison between the permeable Marshall and the relatively impermeable Shelby are concerned.

Abstract No. 925.

Musgrave, G. W., and G. R. Free. 1937. Preliminary report on a determination of comparative infiltration-rates of some major soil-types. Amer. Geophys. Union, Trans., 18(2):345-349.

The data indicating the relative infiltration for eight of the outstanding soil-profiles in the state of Georgia presented in this preliminary report indicate clearly that for a given intensity and duration of rainfall marked differences in runoff may be expected. It seems probable that treatments for the control of runoff must be much more rigorous upon the soils of low infiltration-rates, all other conditions being the same.

The data for three profiles of the Cecil series which have been previously subjected to various degrees of erosion differ widely and show the need of more extensive study of the factors which are involved.

Although several of these soils have such high infiltration-rates that one might question their susceptibility to erosion, the tests with turbid water indicate at least one of the reasons for the excessive erosion so commonly found.

A continuation of the project will deal further with the turbidity-factor and will include also further studies in the laboratory upon samples which have already been collected for the purpose.

Abstract No. 926.

Myers, G. T., and T. A. Vaughan. 1964. Food habits of the plains pocket gopher in eastern Colorado. J. Mammal. 45:588-598.

The contents of the stomachs of 298 *Geomys bursarius* taken in the sandhills of eastern Colorado were examined microscopically. As a basis for judging food preferences, floral composition estimates were made at each capture site. Approximately 64% of the yearly diet was grass, although forbs were preferred when they were succulent in spring and summer. The plants most commonly eaten by pocket gophers and the percentages of the yearly diet they comprised were: *Stipa comata*, 22%; *Agropyron smithii*, 14%; *Bouteloua gracilis*, 12%; and *Opuntia humifusa*, 9%. The four most highly preferred plants and their preference indices were: *Opuntia humifusa* (25.0), *Astragalus* spp. (10.0), *Stipa comata* (5.5), and *Sphaeralcea coccinea* (5.0). Aboveground parts of plants (leaves and stems) were most important in the diet in July and least important in February and made up 26% of the yearly diet. The food habits of the different sex and age-classes differed slightly. Young animals ate significantly more aboveground vegetation than did adults, and young and adults had different preferences for certain plants.

Abstract No. 927

Nagel, H. G. 1967. A comparison of point contact methods and clip quadrats in analysis of ungrazed mixed prairie. Trans. Kansas Acad. 70(4):497-504.

Three methods of analysis were compared for efficiency and accuracy of sampling ungrazed prairie vegetation.

Percentage composition and coefficients of variability by clip quadrat and all-contact points compare favorably. Basal-contact points overestimated forbs and produced a high coefficient of variability.

Each of the two point contact methods required less than one-third the sampling time as clip quadrats.

Abstract No. 928

Nagy, J. G., T. A. Barber, and A. E. McChesney. 1969. *Clostridium perifringens enterotoxemia* in hand-reared antelope. J. Wildlife Manage. 33: 1032-1033.

Enterotoxemia caused by *Clostridium perfringens* was responsible for the death of a 2-month-old hand-reared antelope (*Antilocapra americana*). This case of enterotoxemia and other digestive upsets occurred as a group of antelope fawns began to consume solid food along with their milk diet. Symptoms of the disease and preventive treatment given to the animals is discussed.

Abstract No. 929

Nagy, J. G., K. L. Knox, and D. E. Wesley. 1969. Progress report IBP antelope project, Pawnee Site. U.S. IBP Tech. Rep. No. 13. 18 p.

This report covers activities mainly during the period between January 1969 and September 1969. Some activities and data collections, however, occurred before the above period. It was felt that, while building up an experimental herd of antelope and gaining experience with handling the animals, certain trials such as energy flux and water turnover rate studies should be initiated. It is important to know the basic energy requirements of the pronghorn under laboratory-controlled conditions before field trials can be conducted on available energy and nutrients in antelope food. Antelope, having evolved in an arid environment, may have special adaptations to regulate water metabolism. The investigation of this physiological phenomenon was another part of our study.

Abstract No. 930

Nagy, J. G. and J. P. Hoover. 1971. Pronghorn antelope field food consumption studies. U.S. IBP Tech. Rep. No. 87. 63 p.

This investigation started in December 1969 and will continue during 1971. Methodology was emphasized in the first year of the study. The major objectives are to determine the botanical and chemical composition of the pronghorn diet.

Abstract No. 931

Nagy, J. G., K. L. Knox, and D. E. Wesley. 1971. Metabolic studies of pronghorn antelope. U.S. IBP Tech. Rep. No. 88. 11 p.

Six young female antelope were trained to accept metabolic chambers which were constructed to permit temperature regulation. Metabolic response of fasting antelope to age followed a pattern similar to that of other ruminants. Metabolic rate dropped rapidly prior to seven months of age and became relatively stable after this age. The mean fasting metabolic rate of mature pronghorn is approximately 70 kcal/kg$^{3/4}$/day. The thermoneutral area for fasting antelope ranged from approximately 32°C to a point just above 0°C. Digestible energy for pronghorn on a mixed concentrate and leafy alfalfa diet was not different from domestic ruminants. Pronghorn, however, metabolized a greater percentage of its digested energy than reported for some domestic ruminants.

Abstract No. 932

Nauman, E. D. 1926. An Iowa bird census. Wilson Bull. 38(2):83-91.

The destruction of our native birds and their nesting places is mainly to blame for the increasing difficulties farmers and horticulturists have with insect pests in the production of food for humanity. Bug poisoning contrivances are numerous, their use is expensive and requires much time and labor. The birds would be glad to do most of this work if they were encouraged and protected. Birds make their homes where they find shelter and protection. Their food being mainly insects, they can find it most anywhere.

Every farm should have a timber lot occupying at least one-tenth of its size. In it underbrush and bushes should be permitted to grow. This will not injure the trees and the larger trees can be used for wood and lumber at proper times, if replanting is attended to, without detracting from the value of the lot as a bird harbor. Ponds maintained at suitable places will not only serve to attract some most valuable birds but can be used as water reservoirs for live stock as well. A few bushes and trees along fences will help to attract the birds.

Abstract No. 933

Neal, J. H. 1938. The effect of the degree of slope and rainfall characteristics on runoff and soil erosion. Univ. Missouri Agr. Exp. Sta. Res. Bull. No. 280. 47 p.

A Putnam silt loam surface soil from a timothy meadow was placed in a wooden soil tank 12 feet long, 3.63 feet wide (area = 1/1000 acre) and 2 feet deep. The set-up was in a greenhouse. Artificial rain was applied by an overhead sprinkling system.

The runoff and soil losses were determined at 10-minute intervals under cultivated conditions for (1) slopes ranging from 0 to 16 percent, (2) rainfall intensities ranging from 0.90 to 4.00 inches per hour, (3) rain duration ranging up to 6 hours and (4) different initial moisture contents and surface conditions of the soil.

The infiltration was not affected by either the slope or the rainfall intensity, but varied inversely as the initial soil moisture content.

The percentage of slope had no apparent effect on the percentage of runoff for slopes above one percent.

The percentage of runoff increased as the rain intensity increased but at a decreasing rate.

The amount of erosion from a soil which was in a dry condition at the beginning of the rain was affected by the initial soil moisture content and the condition of the soil surface, in addition to the degree of slope, the rainfall intensity and the duration of the rain.

Abstract No. 934

Neiland, B. M. and J. T. Curtis. 1956. Different responses to clipping six prairie grasses in Wisconsin. Ecology 37:355-365.

Among the native grasses of the Tall Grass Prairie, *Andropogon gerardi*, *Panicum virgatum*, *Elymus canadensis*, *Sorghastrum nutans*, and *Andropogon scoparius* have been found to decrease in density in direct relation to increases in the intensity of grazing or clipping, in that relative order, while *Bouteloua curtipendula* at first increases, and then decreases as defoliation becomes severe. In the attempt to ascertain the autecological factors related to these differential responses, studies were made on these species in established plots at the University of Wisconsin during 1953 and 1954. Data were obtained on the life history and general morphology of each species and each was subjected to clipping treatments removing varying amount of photosynthetic tissue.

Abstract No. 935

Nellis, Carl H. 1968. Productivity of mule deer on the National Bison Range, Montana. J. Wildlife Manage. 32:344-349.

The mule deer (*Odocoileus hemionus hemionus*) on the National Bison Range, western Montana, are controlled by selective removal of a third of the herd annually and suffer limited natural mortality. Fawn production, at 143:100 does, is only 5 percent lower than the fetal rate of 150:100 does and indicates very low postnatal fawn mortality. The corpora lutea rate of 168:100 does suggests that about 10 percent of the ova are lost due to fertilization and implantation failures and intrauterine fetal mortality. Yearling:adult ratios are 61:100 for males and 55:100 for females, for an annual adult mortality of 58 percent. This heavy *adult* mortality is counterbalanced by a low fawn loss and results in about a third of the herd being removed annually.

Abstract No. 936

Nelson, A. B., C. H. Herbel, and H. M. Jackson. 1969. Chemical composition of the diet of cows grazing an arid land range. Western Sect., Amer. Soc. Anim. Sci., Proc. 20:355-360.

Chemical composition of range plants offers an indication of their nutritive value. The protein content of forages usually decreases as plants mature. The levels of fiber and lignin are generally reflections of the availability of energy from the plant, because as plants grow and mature the level of fiber and degree of lignification increase and the digestibility of these fibrous portions decreases. Several New Mexico studies have reported the chemical composition of range plants collected throughout the state. These reports concern forage species found in a pasture without emphasis on proportions or quantities of each species grazed by livestock. Also, sampling has not included many forbs, which may constitute a major portion of the diet of grazing cows.

The objective of this study was to determine the chemical composition of the plant species grazed by cattle on an arid range in southern New Mexico.

Abstract No. 937

Nelson, A. G., and G. E. Korzan. 1941. Profits and losses in ranching, western South Dakota, 1931-1940. South Dakota Exp. Sta. Bull. 352. 31 p.

Many ranchers have succeeded quite well in western South Dakota while others have failed. This study was made in an attempt to find out how the successful operators have made money; that is, how their ranches are organized and how the operators manage their business so as to make it successful.

Abstract No. 938

Nelson, E. W. 1934. The effect of precipitation and grazing on black grama grass range. U.S. Dep. Agr. Tech. Bull. 409. 32 p.

Black grama, the subject of this 13-year study on the Jornada Experimental Range in southern New Mexico, owes its great value in this region of low, uneven rainfall, high temperatures, high evaporation, and relatively severe winds, to its characteristically drought-resistant quality and its high palatability and forage value both in summer and winter. The main growth of black grama is made during the summer rainy season, ordinarily July, August, and September. Only under the most favorable precipitation is growth made in the spring. Black grama seldom reproduces from seed but, after drought or overgrazing, revegetates rapidly from residual plants by tillering and by stolons.

The period of study included two droughts, one of which continued through 1916, 1917, and 1918, and a second which began in the late summer of 1921 and continued almost 5 years until the spring of 1926. In addition to observation of the effects of variations in seasonal and annual precipitation, the areas studied were submitted to several intensities of grazing use.

The results of all tests made bring out especially the amazing ability of black grama to survive drought, to recover after a drought period, to compete successfully with associated species, and to remain as the dominant plant on conservatively grazed range in spite of encroachment of sand dropseed and three-awn grasses and other species following depletion of stand by drought. The ability of black grama to withstand conservative utilization by livestock, without a reduction in stand except the variations due to vicissitudes of climate suggests conservative grazing as the most stable and productive system of grazing. Heavier grazing use, in the degree of its intensity, results in gradual or extreme deterioration, a subordinate stand of black grama, reduced grazing capacity, and unsatisfactory conditions for permanent livestock production.

Abstract No. 939

Nelson, E. W. and W. O. Sheperd. 1940. Restoring Colorado's range and abandoned croplands. Colorado Exp. Sta. Bull. 459. 31 p.

Artificial reseeding should be attempted only under favorable soil and climatic conditions.

The use of improved range management methods on many depleted range lands is the more practical solution to increase the yield of the native forage grasses.

Most range forage plants demand good soils for establishment and optimum growth. Therefore it is desirable to use considerable judgment in the selection of sites for reseeding. Many abandoned cropland areas, especially in the Great Plains, are potential seeding areas if it is possible to control soil blowing. In the foothill and higher mountain range regions, areas where existing vegetation may prevent the successful establishment of new seedling stands should be avoided.

Early spring sowing of forage species is recommended for the Great Plains region except for blue grama, which should be sown from the middle of April to early May. Late fall sowing is preferable to spring sowing in the foothills and higher mountains. However, spring sowings in the foothills are also recommended.

A well-prepared seedbed enhances the probabily of success in reseeding. Eradication of weedy growth is extremely desirable except on wind-blown areas, where it is a good practice to leave strips of weeds to control blowing of soil. In the Great Plains it is recommended that sorghums and sudan grass be planted prior to grass seeding. In harvesting the forage of these two crops, a high stubble should be left to minimize soil blowing.

The best results are obtained when it is practicable to plant with a grain drill or any other similar drill. This method is better than broadcasting seed by hand. Where seed is broadcast, it should be covered by using a spike-toothed harrow or brush drag. Successful stands have been obtained where the seed has been trampled in by sheep. The proper depth to sow most grasses varies from three-fourths inch to 1½ inches. Grass seed should always be covered with soil for best results.

Every consideration should be given new grass stands. Where practicable, weed growth should be mowed at least once or twice the first year. As a general rule, livestock should not be allowed on newly seeded areas during the first year. However, the more rapid-growing species, slender wheatgrass and crested wheatgrass, may be lightly grazed late the first year if the new plants are well established.

The use of legumes, especially yellow sweet clover, is desirable in mixtures with grasses because it increases the yield and nutritive value of the forage. Where conditions justify, a mixture of smooth brome and alfalfa is desirable.

Various mixtures of grasses are recommended for different sites and climates because forage plants vary in their rate of establishment.

Abstract No. 940

Nelson, J. R. 1961. Woody plant communities in the Badlands of western North Dakota. North Dakota Acad. Sci., Proc. 15:42-44.

The climax vegetation in the North Dakota Badlands is considered to be mixed-grass prairie. However, the broken nature of this region encourages the development of woody plant communities. The woody plant types are of small extent compared to the grassland, but they are of considerable importance as a source of food and cover for the big game population of the region. The vegetation composition and structure of the four principal woody plant community types in this area were studied during the summers of 1959 and 1960. These types include the green ash, the juniper-slope, the cottonwood, and the silver sagebrush community types. Each of these types is characterized by a single dominant species in their superior stratum.

Ten stands of each of the four principal woody vegetation types were studied in detail. The mature tree stratum and the shrub and sapling stratum were sampled separately in each stand using a modification of the line-strip method. Density, cover, basal area frequency, height, and crown diameter estimates were obtained from 10 line-strips in each stand. One hundred 1-sq. meter and 100 1-sq ft. quadrat samples were employed in each stand to obtain additional herb and shrub information.

Abstract No. 941

Neubauer, T. A. 1963. The grasslands of the West. J. Range Manage. 16:327-332.

Of the 728 million acres of grazing land in the 17 Western States, about 407 million acres are privately owned pasture and range which comprises about five acres out of every six in the U.S. mainland. This acreage varies widely by states and regions.

About 70 percent of this pasture and range is in land capability classes VI and VII. However, more than 72 million acres are in classes I II, and III, land suitable for the production of crops.

Erosion is the dominant problem on more than 217 million acres of pasture and range which is more than half of the total. Unfavorable soil as a problem is on 129 million acres.

About 307 million acres of the Western States' grassland needs conservation treatment which is about 75 percent of the 417 million acres. Establishment of the plant cover is needed on nearly 46 million acres, improvement of cover on about 84 million and protection of the grass cover on nearly 178 million acres.

About 90 percent of the pasture and range or more than 157 million acres that need protection only is in an overgrazed condition. Nearly 69 million acres need protection from fire hazards. About 53 million acres of grassland need protection from woody and noxious plants as well as considerable acreage from erosion.

Abstract No. 942

Neuberger, J. W., A. L. Sharp, and A. R. Kuhlman. 1964. **Precipitation-runoff relationship on western South Dakota watersheds. South Dakota Farm** Home Res. 15(1):6-9.

One of the more serious problems facing people in the semiarid parts of the Northern Great Plains is developing means for utilizing watershed runoff more effectively. Of particular importance is the need for hydrological data for designing dependable livestock and domestic water supplies where ground water is poor in quality, inadequate or non-existant. Because of limited and variable precipitation, water is at a premium throughout the area much of the time.

In order to properly utilize range vegetation, numerous stockwater dams or dugouts have been constructed to collect and store large quantities of runoff water during wet years for use during low runoff years. Providing livestock water in rangeland this way is often ineffective during long drought periods.

Another means of water conservation which has received considerable interest in this area is water spreading or supplemental irrigation. The topography of the land in many cases lends itself to this practice.

When hydrologic research was initiated in western South Dakota, the pond method of measuring runoff water seemed well adapted because a large number of stations can be maintained with a minimum of cost and man-power, the volume of runoff is measured, the sediment yields are obtained, and evaporation and seepage losses from the ponds are measured. The main disadvantage to the system is that the actual flood hydrograph is difficult to obtain.

One of the criteria used in selecting watersheds was that the ponds should have large storage capacities in relation to the drainage areas so that runoff could be measured as actual volumes in the ponds. One or more recording rain and snow guages were installed in the watersheds and all were equipped with stage recorders.

Data presented was obtained from observations and measurements from 12 of the range watersheds and their respective stockponds for 1958 through 1962, inclusive. The watersheds have drainage areas of 35 to 280 acres, and the dams were built primarily to supply water to livestock. Six watersheds are located in areas of medium-textured soils, and six are in the area of fine-textured soils as determined by the Soil Conservation Service. Annual precipitation and runoff data from the stockpond watersheds show the average annual precipitation and runoff in inches from six watersheds on each of the soil-textural groups.

Abstract No. 943

Newbould, P. J. 1968. Methods of estimating root production, p. 187-190. *In* F. E. Eckardt [ed.] Functioning in terrestrial ecosystems at the primary production level. UNESCO, Paris. 516 p.

Roots are neglected in many studies dealing with productivity because evaluation of their growth is difficult. Evaluating the quantity of root system biomass at a given moment in a group of vegetation is still extremely difficult. In particular, it is quite a complex procedure to estimate the development and the disappearance of small roots during the growth period.

The methods used to evaluate root system production are:

1. Taking regular monthly samples of the rhizosphere, in order to determine the percentage of new "white" roots. In this way one is able to estimate the rootsystem mass represented by groups of trees of the same age, in parts of forests, of a known age.

2. Measurement of the linear extension of roots in a projected cross-sectional observation of a transparent cell wall.

3. Cultivation of plants in movable trays and estimation of the relationship of the elevated apparatus/root system apparatus in varied conditions.

4. Measure of the development of new roots in carrots which after having their roots removed are re-planted in their previous holes.

The sum of these procedures, is to be sure, subject to criticism but, the comparison of different results obtained permits at least an approximate measure of root system production.

Abstract No. 944

Newman, E. I. 1966. A method of estimating the total length of root in a sample. J. Appl. Ecol. 3:139-145.

Research in many fields of plant ecology could be helped by quicker and more satisfactory methods of determining the amount of root in a volume of soil. Most quantitative studies of roots have used weight as the means of assessing the amount of root; but it is generally accepted that the capacity to take up water and salts is usually more closely related to the surface area or total length of the root system than to its weight. Interest in root length has been stimulated by papers dealing with water uptake from soil, in which length of root per unit volume of soil is an important parameter. The main difficulties in determining root length arise from the great lengths which can occur in even small volumes of soil. Thus, even if it is practicable to use soil samples as small as 0.1 liter, direct measurement of the roots may take a long time. Indirect methods have been used: for instance, measuring root diameters and then determining root volume; or measuring the length of a small portion of the root sample, then weighing this portion and the remainder. However, these methods are often inaccurate because of variations in the ratios volume: length and weight: length.

This paper describes a new method of estimating the total length of root in a sample, the line intersection method. I believe that it will in many circumstances prove more satisfactory than any existing method.

Abstract No. 945

Nicholas, D. J. D. 1965. Influence of the rhizosphere on the mineral nutrition of the plant, p. 210-217. *In* K. F. Baker and W. C. Snyder [ed.] Ecology of soil-borne plant pathogens: Prelude to biological control. Univ. California Press, Berkeley. 571 p.

Not only is the rhizosphere a habitat that supports a wide variety of microflora having their own complex interactions but it is also influenced by plant roots, which in turn are affected by microorganisms. This dynamic system is constantly changing since the microflora population varies with the type and age of plant and even with plant species. The growth rate of the microbial population varies from those that grow and autolyse within a few hours to those that persist for a few weeks.

Contributors to this symposium have been asked not only to review their assigned topics but also to pinpoint gaps in knowledge and to suggest lines of work for the future. In regard to the effects of rhizosphere on the availability of mineral nutrients to plants, present-day information is scanty. Work needs to be done on the requirements of the rhizosphere microflora for mineral nutrients using pure-culture techniques. Then interactions and competition between some of these organisms for nutrient supply should be studied. The effects of inoculating known rhizosphere organisms into sterile cultures of excised roots would eliminate the difficulties involved in growing whole plants under aseptic conditions. The recent development of techniques for growing gnotobiotic plants and excised roots may add greatly to our knowledge of the nutrient interrelations between rhizosphere microflora and plant growth. The use of radioactive or stable isotopes has not been exploited to follow the fate of labelled nutrients from soil to the microorganisms and thence to the roots. This might be done in association with the pure-culture techniques discussed previously. Other contributors no doubt will stress that more effective techniques are required for screening, isolating, and identifying the microflora so that physiological and biochemical studies can be made with them.

The results from this type of work will enable a better assessment to be made of the interactions of a mixed microflora in the rhizosphere on the growth of green plants.

Abstract No. 946

Nicholson, R. A. and G. K. Hulett. 1969. Remnant grassland vegetation in the Central Great Plains of North America. J. Ecol. 57:599-612.

The ecology of undisturbed remnant grassland vegetation in the Central Great Plains of the United States was investigated.

An ordination of quantitative edaphic factors sampled in each grassland remnant resulted in a gradient of soil texture values, soil moisture indices and available potassium. Linear correlation analysis demonstrated that only three plant species were associated with this gradient: *Chenopodium lanceolatum*, *Andropogon hallii* and *Calamovilfa longifolia*. Other correlations and linear regression showed close association between soil texture and soil mositure indices.

The majority of the forb and shrub species were important in only one or two resource areas, whereas only a few species were important in most or all the areas. *Ambrosio psilostachya* was the most important forb.

The important graminoids were more widespread throughout all resource areas than the important forb and shrub species. *Bouteloua gracilis* was the most important graminoid in all resource areas.

Major land resource areas represent real delineations useful in ecological descriptions of remnant grassland vegetation in the Central Great Plains of North America.

Abstract No. 947

Nicolson, T. H. 1967. Vesicular arbuscular mycorrhiza--a universal plant symbiosis. Sci. Progress 55:561-581.

Of the various mycorrhizas reported the most widespread is the so-called vesicular-arbuscular type. These are not restricted to specific groups of plants as with other mycorrhizas but occur in practically all families of angiosperms, in most gymnosperms and in many pteridophytes and bryophytes.

It is the type of mycorrhiza present in the main crop plant families and hence of most importance. The endophytes causing the infections mostly belong to the Phycomycete genus *Endogone* and over the last few years a number of different species have been reported. For the endophytes the relationship is obligate but following the establishment of infection they can develop an extensive mycelium outside the root. Usually the host is not dependent on the mycorrhiza, but under some conditions it would appear to act as an auxiliary absorption system which operates more effectively in low nutrient regimes. In particular, phosphorus absorption is important and marked host stimulation can occur with low phosphate availability and high root infection. In certain cases the mycorrhiza has culminated in a state of mutually obligate symbiosis with both partners completely interdependent.

Abstract No. 948

Nielsen, E. L. 1953. Revegetation of alkali flood plains adjoining the North Platte River, Garden County, Nebraska. Amer. Midland Natur. 49:915-919.

Distichlis stricta and *Sporobolus airoides* form the edaphic climax on the highly alkaline and phosphorus deficient soils adjoining the North Platte River in western Nebraska. Areas formerly under cultivation appear to have slightly higher pH values and lower available phosphorus than do virgin areas. Under the conditions that existed prior to the time these observations were made, it can be inferred that the edaphic climax species had become reasonably well established in from 20 to 30 years.

Abstract No. 949

Noll, W. C. 1939. Environment and physiological activities of winter wheat and prairie during extreme drought. Ecology 20:479-506.

Studies in upland, climax prairie and an adjacent field of winter wheat were made at Lincoln, Nebraska, from September, 1933 to September, 1934.

The growing season was the driest and hottest ever recorded.

Abstract No. 950

Norman, M. J. T. 1960. The relationship between competition and defoliation in pasture. J. British Grassland Soc. 15:145-149.

Field trials were carried out on a downland permanent pasture at the Grassland Research Institute, Hurley, between 1953 and 1955, to investigate the factors involved in competition in pasture undergoing periodic defoliation. Response to competition was estimated by comparing the yield of species units (either individual plants or close groups of shoots) growing normally in the pasture with the yield of matched units from which the surrounding herbage had been removed. The species studied were cocksfoot, red fescue, creeping bent, plantain, ox-eye daisy and bulbous buttercup. In addition to the estimation of normal competition for environmental resources in pastures of differing height, two special effects upon species due to the presence of surrounding herbage were investigated following unusual results from competition tests in swards under periodic defoliation. First, the influence of surrounding herbage in modifying the growth habit of a species, causing it to grow in a more erect manner, and consequently to suffer more on defoliation at a specific height than in the absence of competition. Secondly, a decreased yield after defoliation, not associated with changes in the growth habit of the species, which was ascribed to an increased in top/root ratio brought about by shading during the preceding period of competitive growth. The effect of selective defoliation of a species in relation to the herbage surrounding it was also studied. Differences in the degree of defoliation of a species and its surrounding herbage had a marked effect upon the degree of competition exerted by the latter upon the former, increasing it when the species was preferentially defoliated and decreasing it when the surrounding herbage was preferentially defoliated. The factors involved in pasture competition under periodic defoliation are listed and discussed.

Abstract No. 951

Norquest, C. E. 1941. Climate of Texas. *In* Climate and man. U.S. Dep. Agr. Yearbook 1941:1129-1146.

The distance from the most southern point of Texas near the mouth of the Rio Grande to the northwestern corner of the Panhandle is 801 miles, while the greatest reach from east to west is 773 miles. The State has an area of 265,896 square miles and consequently presents great diversity in topography and climate. Most authorities divide Texas into four physiographical provinces: The Coastal Plains, sometimes called the East Texas Plains; the North-Central Plains; the Great Plains; and the Trans-Pecos Mountain area.

The marine, continental, and mountain types of climate are all found in Texas--the continental and mountain types in true form, but the marine type somewhat modified and subdued to a coast climate. The continental type of climate obtains over by far the greater part of the State. The mountain type is confined to a relatively small area of western Texas, the Trans-Pecos area; while the coastal type prevails over a comparatively narrow strip of the Coastal Plains.

Abstract No 952

Norris, E. 1939. Ecological study of the weed population of eastern Nebraska. Univ Stud. 39(2):29-91.

In an area of deep rich soils near the border between Prairie and Chernozem soils and including part of each zonal soil group, the author studied the weed flora of 100 tilled fields ranging from 30 to 80 acres in extent during the 3 growing seasons, of which 2 summers--those of 1934 and 1936--were the driest and hottest ever recorded in Nebraska: precipitation during the 3-yr period averaged 8.9 inches below the mean (27.8 in) and a mean day temperature of 100 F or more continued for 19 to 21 successive days. 96 species of flowering plants (in 23 families)--48 annuals, 33 perennials, 8 biennials, 7 winter annuals--of which 63 species are native to N. America, were found.

Abstract No. 953

Norris, J. J. 1950. Effect of rodents, rabbits and cattle on two vegetation types in semidesert rangeland. New Mexico Agr. Exp. Sta. Bull. 353:1-23.

This bulletin reports results of an 8-year study on the effect of rodents, rabbits, and cattle on two vegetation types in semidesert grassland.

In mesquite-snakeweed types, rodents and rabbits alone exert sufficient grazing pressure to practically eliminate vegetation improvement. Exclusion of these animals can bring about striking improvement in the stand of valuable grasses. Production of perennial grass forage in this type can be increased 4 to 5 times by protection from rodents and rabbits together, and 1½ to 3½ times by protection from only rabbits. These increases amount to 300 pounds more grass forage per acre through protection from both rodents and rabbits, and 70 pounds more through protection from only rabbits.

These figures might lead one to believe that control of rodents and rabbits is worthwile. Rodents and rabbits, however, normally inhabit deteriorated, brushy types, and control may extend as far as removal of brush, along with continuous poisoning or other measures. More information is needed on rodent and rabbit populations, methods of control, time required for residual populations to build up, and the rate at which these animals return to areas from which they have been completely removed. During this study, continual poisoning was necessary to maintain control even in supposedly rodent-proofed plots. Such continuous work is costly and soon overbalances any profit from increased forage production. It is believed that, in spite of the increased grass forage resulting from rodent and rabbit protection in mesquite-snakeweed types, the profits will not offset control costs.

In well preserved black grama grassland, no appreciable benefits result from rodent and rabbit protection. This is not surprising, since population studies indicate that rodents and rabbits are seldom numerous in well managed grassland.

Abstract No. 954

Norris, J. J., and K. A. Valentine. 1954. Principal livestock-poisoning plants of New Mexico ranges. New Mexico Agr. Exp. Sta. Bull. 390. 78 p.

Livestock poisoning from certain native range plants is one of the hazards to ranching in New Mexico. More than 100 plant species in the state are poisonous, but only about half of these are dangerous enough to cause severe losses.

Livestock losses due to plant poisoning include both actual death losses and losses through prevention of reproduction or gain. Estimates of death loss vary from a fraction of one percent to as much as 20 percent of individual herds in certain years, with an over-all average of about two percent. There is no way to evaluate losses in production where death does not occur, but in dollars and cents, they may exceed death loss.

This bulletin brings together available information about livestock poisoning from plants in New Mexico. The material was compiled from numerous sources and from observations by and reports to the authors.

No attempt was made to rank the plants in order of importance. Most of the plants discussed in detail have been responsible for poisoning animals in the state. Some are not known to cause material losses, but are included because of occasional losses attributed to them. Some plants responsible for losses may have been omitted because of lack of information about them.

Abstract No. 955

Nunn, J. R. 1971. Engineering in ecology. Agr. Eng. 52(9):458-459.

If the current ecological crusade seeking a more harmonious coexistence of man and nature is to be successful, it must solve problems of population growth; food production for the present 3 billion people of the world with insufficient diets; pollution; increasing need for open space.

These solutions cannot be obtained entirely through individual and specialized research--they require the cooperation and coordination of interdisciplinary research teams.

IBP, a biological successor to the International Geophysical Year, was developed by the International Council of Scientific Union to run from 1966 through 1972. Over 70 countries are participating.

The grasslands is one of the 6 biomes being investigated under the Analysis of Ecosystems Integrated Research Program. The others are deciduous forest, desert, coniferous forest, tundra, and tropical forest. The grassland study site consists of 15,000 acres of the ARS, USDA Central Plains Experiment Range and 110,000 acres of the western portion of Pawnee National Grasslands operated by the United States Forest Service.

To understand the grassland ecosystem, it is essential to know the interrelationships among the system components--the physical processes of the universe cannot be separated from the biological world because the organisms of the biosphere interact with their immediate physical environment as well as one another. Analysis of the grassland ecosystems must consider the relationships between the components of energy-flux exchange at the soil atmosphere interface, soil temperature and moisture profiles, rainfall, runoff, infiltration, air temperature and wind, plus the biosphere.

Making detailed measurements of hydrometeorological parameters helps the interdisciplinary team establish appropriate relationships between the biotic and abiotic variables. A semipermanent meteorological station was designed and constructed by the Agricultural Engineering Division and the Natural Resources Research Institute's Instrumentation Group at the University.

The main objective of the Wyoming engineering group is to examine appropriate models for estimating evapotranspiration.

The final test of evapotranspiration predictions and measurements is with a lysimeter. This transducer, a large undistributed body of soil within its own container, is placed upon an elaborate scale-load cell weighing system.

This system is recessed into the earth's crust so that the surfaces of the soil core and surrounding area are in visual, thermal and vegetative agreement. Thus it senses and recordes continuous changes of the soil water content. These records are used to check the validity of evapotranspiration, precipitation, and net photosynthesis prediction plus serving as a standard water loss reference for the Great Plains Area.

This lysimeter offers: Relatively undisturbed installation for both retainer and soil container; large size: 10 ft diameter, 4 ft depth, 45,000 lb; an unnatural surface area due to retainer and soil container of only 1.2%; high sensitivity--0.001 inches of moisture change.

Thus this IBP program can provide a basis for accuractely predicting the consequences of environmental stresses--both man-originated and natural--on the performance of biological systems. A knowledge of the interaction of all representative system components will be developed. An estimate of existing and potential plant and animal production as it relates to human welfare will be obtained for the major climatic regions of the world.

The ecological theory developed through this program can be the basis of a new and more intensive resource management, especially encompassing the problems of multiple-use optimization. Better scientific understanding of ecosystem operation will aid in evaluating and maintaining environmental quality. Thus we can expect to enhance the manpower, skills, tools, and the basic theory that is essential to the management of a portion of our environmental resources.

Abstract No. 956

Nunn, J. R. [Coordinator]. 1971. Meteorological data acquisition system, September 1, 1970 through December 31, 1970. U.S. IBP Tech. Rep. No. 73. 28 p.

The primary effort in the meteorological portion of IBP for this interim period was to evaluate the potential of the 36-channel data acquisition system. This evaluation was done through continuous operation of the system, analysis of typical data, and establishment of calibration procedures. The data acquisition system collected meteorological information from two contrasting plots separated 1,000 ft apart. Air and soil temperature, radiation, wind speed, wind direction, and humidity parameters were monitored by the recording system. Final plans were approved, and construction is nearing completion for a relatively undisturbed 3-m diameter lysimeter.

Abstract No. 957

Nunn, J. R. 1971. 1970 meteorological data availability for the Pawnee Site. U.S. IBP Tech. Rep. No. 97. 4 p.

A major purpose of the meteorological system of the Grassland Biome, IBP, is to make meteorological data available to other scientists. For some purposes rapid data recording is necessary. Therefore, all values are recorded at one-minute intervals and, normally, summaries are made for one-hour intervals. In order for an investigator to use hourly meteorological data, it is necessary to manually sort through voluminous computer output. Even after considerable time and effort is spent examining the output, it is practically impossible for an investigator to relate data availability of one or several parameters to one or several other parameters. As a result of these difficulties, a summary record of availability was developed.

Abstract No. 958

Nunn, J. R., L. J. Bledsoe, and R. D. Burman. 1970. Models for inferring evaporation from meteorological measurements. U.S. IBP Tech. Rep. No. 47. 20 p.

Methods for prediction of evaporation or evapotranspiration flux range from the early, simple formula of Dalton, in terms only of vapor pressures, to the recent empirical formulations of Van Bavel and McIlroy. Each of a wide range of methods have advantages and disadvantages, and different methods will be appropriate for use in different instances. Following is an attempt to summarize most of the available methods with discussion of their applicability.

Abstract No. 959

Nunn, J. R. and R. Weeks. 1970. The movable meteorological data acquisition system at the Pawnee Site. Forty-first annual meeting Colorado - Wyoming Acad. Sci., May 1 and 2, Univ. Northern Colorado, Greeley.

The Pawnee Site Meteorological Data Acquisition System is composed of 36 data input channels. The accompanying transducers sense the abiotic information necessary for biotic and abiotic modeling. A complete description of each transducer was included in the presentation. The basic principle of simultaneous and continuous recording was explained. The technique of one minute integration was shown and a schematic of the electronic devices to accomplish this was illustrated. The procedure of handling field data tapes and the data reduction system was enthusized to acquaint the investigators with data availability.

Abstract No. 960

Nunn, J. R., R. D. Burman, L. O. Pochop, and C. F. Becker. 1971. Meteorological characteristics of heavily and lightly grazed natural grass rangeland. Bull. Amer. Meteorol. Soc. 52:312.

Nunn, J. R., R. D. Burman, L. O. Pochop, and C. F. Becker. 1971. Meteorological characteristics of heavily and lightly grazed natural grass rangeland. First Conf. Biometeorology and Tenth Conf. Agr. Meteorology, June 9-11, Columbia, Missouri.

Natural grassland pastures have been heavily and lightly grazed for over 30 years on the Pawnee Site of the U.S. International Biological Program. The Pawnee Site is the intensive site of the Grassland Biome and is located just south of the Wyoming border near Nunn, Colorado. A 36-channel meteorological data acquisition system has been operated since January 1970 with a package of 18 sensors being located over a lightly grazed pasture and the remaining 18 sensors located 1000 ft away over a heavily grazed pasture. The system was also used to compare differences in climate between an upland and bottomland site in the fall of 1970.

Incoming solar radiation, albedo, net radiation and long wave outgoing radiation are being measured. Wind velocity and direction are being logged. Air temperature at 50 and 300 cm and air humidity at the same heights are being measured. Measurements of soil temperature are being taken at each location at depths of 3, 6, 10, 20, 50, and 122 cm. All samples are continuously integrated and are simultaneously entered on magnetic tape at one-minute intervals.

Results to date indicate that albedo and net radiation are influenced by grazing management as well as location with respect to hillsides or valley bottoms. Soil temperature profiles are different and the parameters in soil temperature models are, as expected, different depending upon grazing management or location.

The paper will present information on the design and installation of the meteorological data acquisition system and typical results comparing the influence of grazing management or hillside-lowland location on meteorological parameters.

Abstract No. 961

Nye, P. H. and P. B. Tinker. 1969. The concept of a root demand coefficient. J. Appl. Ecol. 6:293-300.

The study of diffusion of nutrients to plant roots in soil requires that a measure of root effectiveness should be defined. If the "root absorbing power" α for a nutrient is given by the flux across the root surface divided by the concentration in solution at the root surface (C_1), it is shown that any limitation of uptake by transport processes in the soil is determined partly by the magnitude of αr, when r is the root radius.

αr is expected to vary widely for each piece of root, but the plant mean $\overline{\alpha r}$ may be more constant, and may usually be derived from a knowledge of relative growth rate, internal/external concentration ratio and the root length per unit plant weight. These are all available in solution culture experiments. Total uptake rate is $2\pi\overline{\alpha r}C_1L$, where L is the total length of root, and $\overline{\alpha r}$ thus defines the mean effectiveness of the root system. The possible variations of $\overline{\alpha r}$ with time and external concentration changes are considered, and the difference of this approach from short-term studies on excised roots is stressed.

In the much more complex case of soil-grown plants, the variation of αr over the root system becomes important, since the external concentration C_1 tion around the roots is small, if αr varies only moderately over the root system, or if αr for each piece of root follows a similar time course. $\overline{\alpha r}$ cannot be calculated if αr for appreciable parts of a root system is very large, as soil properties then largely control uptake rate.

Abstract No. 962

Ojima, K. and T. Isawa. 1968. The variation of carbohydrates in various species of grasses and legumes. Canadian J. Bot. 46:1507-1511.

Qualitative and quantitative determinations were made of the available carbohydrates and the component sugars of hemicellulose in the aerial parts of a number of species of grasses and legumes cultured in the northern area of Japan. Plant materials used were leaf sheaths and stems from 25 species of grasses in the heading stage, and of 5 species of legumes at the flowering stage. The plants were found to vary in the type of storage carbohydrate contained in the aerial parts. Some species contained fructosan and sucrose, others starch and sucrose, while a few species contained very little fructosan or starch but mainly sucrose. The fructosan-storing species are members of the subfamily Festucoidea which are native to temperate or cooler climates. The species classified under subfamilies Eragrostoidea, Panicoidea, and Bambsoidea which are native to warmer climates, accumulated starch rather than fructosan. The hemicelluloses of southern grasses also contain a higher proportion of glucose relative to xylose than those of the northern grasses or subfamily Festucoidea. The plants were classified into groups according to differences in the type and relative proportion of individual carbohydrates and the results are discussed from a taxonomic point of view.

Abstract No. 963

Oliver, R. E. and L. D. Miller. 1971. The design of a spatial data framework, Central Basin Watershed, Pawnee Site. U.S. IBP Tech. Rep. No. 89. 19 p.

This report describes the attributes of a framework and analysis model procedure for spatially distributed data at the Pawnee Site. The needs and possible uses of the procedure are discussed along with a description of how some of the data is collected and utilized.

Abstract No. 964

Olmsted, C. E. 1944. Growth and development in range grasses. IV. Photoperiodic responses in twelve geographic strains of side-oats grama. Bot. Gaz. 106:46-74.

Twelve strains of side-oats grama (*Bouteloua curtipendula*), originating over a latitudinal range of approximately 17° from San Antonio, Texas, to Cannonball, North Dakota, have been grown for a 2-year period in the greenhouses at the University of Chicago. Their responses on Chicago natural daylength and on 9-, 13-, 16-, and 20-hour photoperiods have been analyzed.

Abstract No. 965

Olmsted, C. E. 1952. Photoperiodism in native range grasses. Sixth Int. Grassland Cong., Proc. 1952:676-682.

This work indicates a very considerable variation, both interspecific and intraspecific, in photoperiodic behavior in some of the seven native range grasses thus far tested and the implications of this variation are also numerous and diverse in both theoretical and applied plant science. A difficulty in the interpretation of its importance has been the inadequacy of the data in the literature on the actual seasonal behavior of the various species in different latitudes. Very few community studies, either pure or applied, provide sufficient data on the complete life histories of even the important species under natural conditions to allow comparison with behavior under the experimental conditions. The author is gratified, therefore, that his work has stimulated more interest in critical observations of developmental behavior of native grasses under field conditions. Only after such observations are available for these species throughout their distributional areas under conditions of competition can we hope to assess more adequately the relative importance of the photoperiodic behavior which they have shown. There is room for much more field observation and experimental work along these lines.

Abstract No. 966

Olson, J. S. 1963. Energy storage and the balance of producers and decomposers in ecological systems. Ecology 44:322-331.

While some fraction of the solar energy fixed by producing plants is released by respiration of these plants and of animals, much of it is stored in dead organic matter until released by decomposing organisms, at rates which vary greatly from place to place. The general differential equation for the rate of change in energy storage is illustrated by models for build-up and decomposition of organic matter, particularly for litter in deciduous or evergreen forests. Equations have a useful place in estimating decay parameters. For the case of steady production and decay, the ratio of annual litter production, L, to the amount accumulated on top of mineral soil in a steady state, X_{ss}, provides estimates of the decomposition parameter k. Estimates range from over 4 in certain tropical forests to less than 0.01 in subalpine forests. Decomposition rates for organic matter within mineral soils may range from near 0.01 to 0.001.

Since it takes a period of about $3/k$ years before storage has attained 95% of its steady-state level, many ecosystems continue to show a positive net community production for centuries--perhaps long after changes in numbers and biomass of some species are reduced to minor fluctuations around a "climax" composition. On the other hand, the slow change in soil conditions may in some cases facilitate the introduction of new species after some delay during succession. The change in productivity or decomposition parameters controlled by these species may lead in turn to a series of later readjustments in energy storage and release, which modify litter and soil conditions. Modified microenvironments in turn may further alter the succession and "climax".

Abstract No. 967

Orpurt, P. A. and J. T. Curtis. 1957. Soil microfungi in relation to the prairie continuum. Ecology 38:628-637.

The soil microflora of twenty-five prairies in Wisconsin was studied by a uniform isolation method. The prairies represented the full range of topographic types, from very wet to very dry. They were located in 12 Wisconsin counties in the south and central portions of the State.

Abstract No. 968

Osborn, H. B. 1952. Storing rainfall at the grass roots. J. Range Mange. 5(6):408-414.

The potential capacity of rangelands to absorb and store most ordinary rains is indicated by results of standardized tests on small field plots with a mobile raindrop applicator.

These tests showed that every deep soil studied, regardless of texture, was capable in its optimum condition of holding with little or no runoff the first 2 inches of water applied, at intensities of up to 50 year frequency.

The conditions of cover and soil which may change on the same site with time, and which are related to range condition classes, greatly influence the ability of the land to absorb the rain as it falls.

For maximum intake of water, two conditions are essential:

1. An adequate surface cover to cushion the impact of the falling raindrops.

2. Favorable soil conditions associated with a relatively advanced stage of ecological succession for the site, typical of one of the higher range condition classes.

At the extremes of conditions possible on the same site we may find almost complete absorption or almost complete loss of the rain from the place where it falls. This is true except for certain shallow profiles which lack storage or disposal capacities to handle the amounts of water involved although the surface may be capable of absorbing it.

These facts suggest remarkable possibilities for moisture conservation in the range country--where moisture is of such vital importance--through the control of cover and soil conditions by grazing management.

To be effective in storing rainfall in the soil, management needs to develop favorable cover and soil conditions uniformly over an entire land area. This goal is likely to be reached only in the highest range condition--that most nearly reaching the climax for the site. At the same time, utilization needs to be regulated to maintain an adequate cover on all the land at all seasons when rains are likely to fall, and to protect the desired conditions of the soil as well as to husband the particular forage plants favored as feed.

Abstract No. 969

Osborn, H. B. 1953. Field measurements of soil splash to evaluate ground cover. J. Soil and Water Conserv., 8(6):255-260, 266.

Plant cover on the land surface offers resistance to the kinetic energy of rain storms and protects the soil from detachment and dispersal by raindrop impact. The effectiveness of the cover in preventing soil splash is proportional to the amount present at the time the rain falls.

This is the first of three articles reporting results of field measurements of splash in relation to kinds and amounts of cover. These show that from 4,000 to 6,000 pounds of ground cover per acre, including both standing forage or crops and litter, are required to prevent the initiation of erosion by hard rainstorms, and that soil splash increases rapidly as the amount of cover declines below 2,000 to 3,000 pounds per acre.

These are among the first field measurements which relate the protectivity of the cover to quantitative descriptions of the cover itself. They provide new guides to the use of vegetation in soil conservation. The results should have wide application outside the area where the work was done.

Abstract No. 970

Osborn, H. B., and W. N. Reynolds. 1963. Convective storm patterns in the southwestern United States. Int. Ass. Sci. Hydrol. Bull., 8(3):71-83.

In the Southwestern intermountain and high plains areas, precipitation is seasonal, with the major part of the rainfall occurring in the summer. Most winter precipitation occurs as low-intensity rain or snow along slow-moving cold fronts. Most summer precipitation occurs as short-duration, high-intensity thunderstorms from purely convective buildup or from convective cells developing along a weak fast-moving cold front. Almost all runoff occurs from the summer convective storms.

Since runoff-producing precipitation is of primary interest at the Southwest Watershed Research Center, Agricultural Research Service, Tucson, Arizona, the convective storms have been most thoroughly analyzed. Duration, intensity, areal extent, movement, character, and return frequencies for varying volumes and intensities of these convective storms are analyzed from records from dense networks of recording rain gages in four study areas in Arizona and New Mexico. The primary study areas are the 58-square-mile Walnut Gulch Experimental Watershed at Tombstone, Arizona and the 67-square-mile Alamogordo Creek Watershed near Santa Rosa, New Mexico. Three "record" storms of differing character occurring in 1960 and 1961 on Alamogordo Creek Watershed and one "record" storm in 1961 on the Walnut Gulch Watershed are analyzed and compared in detail.

Abstract No. 971

Osborn, H. B., and R. V. Keppel. 1965. Dense rain gage networks as a supplement to regional networks in semiarid regions. Int. Ass. Sci. Hydrol., Pub. No. 68:675-687.

Because of their small size, widely scattered distribution, and short duration, convective thunderstorms typical of the southwestern United States and many other semiarid regions can best be described by data gathered from dense recording rain gage networks on sufficiently large areas. Data are presented from two such networks--one of 60 recording gages located on a 67-square-mile area in eastern New Mexico, and one of 80 recording gages on 58-square-miles in southeastern Arizona--showing depth-area and intensity-duration characteristics for convective thunderstorms. Comparisons are made between the frequency relationship computed from the long-time record at a point and that from a few days of dense network records based on the station-year concept. A storm on the eastern New Mexico area with exceptionally high intensities for durations up to 30 minutes is discussed.

Abstract No. 972

Ovington, J. D. and D. B. Lawrence. 1967. Comparative chlorophyll and energy studies of prairie, savanna, oakwood, and maize field ecosystems. Ecology 48:515-524.

Estimates are given of the concentrations and total quantities of chlorophyll (a + b) and energy in the plant material present in prairie, savanna, oakwood, and maize field ecosystems at different times through 1959. Marked differences in chlorophyll and energy contents were recorded both between ecosystems and seasonally at each ecosystem. While large amounts of energy are held from year to year in natural ecosystems, the annual production of plant material only accounts for a small part of the annual incident solar radiation. The results are discussed in relation to the factors affecting the potential capabilities of vegetation for energy accumulation.

Abstract No. 973

Oyer, E. R. 1946. Identification of mammals from studies of hair structure. Trans. Kansas Acad. Sci. 49:155-160.

The hair of small and medium sized mammals is often found in the stomachs, feces and pellets of predators; for example in the stomachs and feces of coyotes and in the pellets regurgitated by hawks and owls. In these pellets and feces are the undigested residue of the food these animals have eaten. It is well known that in swallowing their food whole, hawks and owls digest all the tissue except hair, feathers, and bones.

These waste products may be obtained from the nesting and roosting places of these birds of prey and along the trails and near the dens of such mammalian predators as the coyote. If the hair from these sources can be identified, then much desirable information concerning the food of predators can be obtained.

The purpose of this study has been to determine whether or not such identification is possible. It was made in western Kansas during the years 1936 to 1938. Hair samples were obtained from nineteen different species of mammals common to the fauna within a radius of 150 miles of Hays, Kansas.

Abstract No. 974

Packard, R. L. 1971. Small mammal survey on the Jornada and Pantex Sites. U.S. IBP Tech. Rep. No. 114. Approx. 45 p.

This summarizes the small mammal survey on the Jornada and Pantex study sites in the comprehensive network of the U.S. IBP Grassland Biome. A total of 371 small mammals were marked by live-trapping, and 301 small mammals were collected from snap-trapping. These animals provided data on density and biomass. Three sampling periods (spring, summer, autumn) provided comparative population and biomass data. Biomass for all species of small mammals varied from 2621 g/ha to 1130 g/ha on the Jornada, whereas at Pantex, biomass varied from 908 g/ha to 584 g/ha.

Abstract No. 975

Packer, P. E. 1957. Intermountain infiltrometer. U.S. Forest Service Intermountain Forest and Range Exp. Sta. Misc. Pub. No. 14. 41 p.

Numerous kinds of infiltrometers have been developed in recent years for obtaining information about the capacity of watershed lands to take in water at the soil surface. Some, such as the tube or closed ring type, provide information only on infiltration and percolation rates. Others have devices for collecting and measuring surface runoff and eroded soil. For studying such problems on the watershed lands of the Intermountain region, experience has indicated that an infiltrometer should embody the following features:

1. Sufficient lightness in weight for easy portability by two men over steep topography.

2. Sufficient plot size to encompass a representative sample of the interspersed vegetation, litter, and bare soil commonly found on Intermountain range lands.

3. Provision for quickly making applicator nozzle adjustments to obtain uniform distribution of rainfall over the plot.

4. Provision for applying artificial rainfall at rates up to 6 inches per hour and for changing rainfall rates during a test when it is desired to simulate the variable rates normally expected during torrential rains.

An infiltrometer to meet these requirements was developed at the Intermountain Forest and Range Experiment Station in 1947, and has since been used at various locations in Idaho and Utah. This apparatus is herein described. Suggestions are included regarding its field installation, calibration and operation, and the laboratory procedures and related measurements that are usually involved. An itemization of all parts of each of the several units and estimates of the cost of each unit are also given as a guide for those who may wish to construct the apparatus.

Abstract No. 976

Paris, O. H. 1969. The function of soil fauna in grassland ecosystem, p. 331-360. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The functional role of soil fauna in grassland ecosystems can be summarized by means of a flow chart which depicts the major pathways of energy flow and nutrient transfer between various trophic categories. It is convenient to view the grassland food web as consisting of two interlocking webs, a grazing food web and a detritus food web. The grazing food web is powered by the input of solar energy into the primary producers (vegetation). The detritus food web is powered by energy derived from the grazing food web in the form of dead plant and animal material, feces, etc.

Saprophagous primary decomposers play the same role, to a degree, as do bacteria and fungi. That is, they effect primary decomposition of dead plant and animal matter, thus dissipating energy and returning nutrient elements to the soil. Saprovores also channel energy and nutrients from the detritus food web back into the grazing food web, by serving as a food resource for carnivores. Microfloral grazers may serve to recirculate energy and nutrients in grasslands, both within the detritus food web and by transferring material back to the grazing food web.

The importance of soil fauna in hastening the decomposition of dead organic matter is firmly established. Without this group of organisms to comminute detritus and to scavenge on carrion and feces, the process of decomposition would be slowed. As a result, organic material would accumulate, successional changes might occur, and primary production would probably be reduced because of a decrease in the rate of nutrient cycling.

The soil fauna must contribute significantly to the stability of the grazing food web, by virtue of the fact that they provide additional trophic links for input of energy and nutrients into the secondary and higher trophic levels. By thus providing an alternative energy resource for carnivores, fluctuations in herbivore availability are buffered. Populations of saprovores and microbivores typically fluctuate in abundance, both seasonally and often from year to year.

The xeric conditions that characterize the shortgrass prairie at the Pawnee Site result in an absence of several groups of decomposing reducers which are important in other grasslands. Consequently, insects, because of their ability to withstand desiccation, probably assume a greater importance in prairie grassland than in many other grasslands. For these and any other soil organisms which prove to be abundant, the parameters which should be investigated include the following important ones: life cycle, population abundance and distribution, population fluctuations, annual replacement rate, food resource and feeding rate, efficiency with which ingested food is assimilated, energy requirements for maintenance and production, and influence of abiotic and biotic factors on abundance and distribution.

Abstract No. 977

Parker, E. R., and H. Jenny. 1945. Water infiltration into soil. Soil Sci. 60:353-376.

Rates of infiltration of irrigation water into Ramona loam soil of an experimental orchard of the University of California Citrus Experiment Station, Riverside, California, were found to vary widely according to fertilizer treatments. Incorporation of organic matter as cover crop or manure greatly increased the rate of water infiltration over that of plots which received only urea as a fertilizer. The improvement was related to the quantity of organic matter applied. Winter cover crops were slightly superior to dairy manure applied in amounts to supply 1 pound of nitrogen per tree annually.

The differences in water penetration are corroborated by differences in resistance values (the energy, in foot-pounds per inch, required to force the sampling tube into the soil, with soil moisture at field capacity) and in core weights (apparent densities) of the soils. To a depth of 9 or 12 inches, the soils of the urea plots were heavier and more resistant than the soils of the plots receiving organic materials.

Compared with the soils of a dry-farmed area adjacent to the orange grove, the soils of the orchard are characterized by lower rates of infiltration and by greater compaction, especially at a depth of 6 to 12 inches. It is suggested that these effects are largely the result of cultivation practices and of traffic in the orchard.

The hypothesis that soil compaction is influenced by traffic and cultivation was tested by subjecting both dry and wet plots of the dry-farmed area to intensive traffic by a track-type tractor and to repeated disking. The effects of the tractor were very detrimental to water infiltration in both dry and wet soil. In the wet soil pronounced soil compaction was produced. Disking of dry soil and of wet soil greatly reduced water infiltration and increased resistance and core-weight values, but the effect on wet soil did not occur until the second irrigation after treatment. Elimination of all cultivation on these plots, in conjunction with the growing of annual cover crops (the aboveground portions of which were removed) produced marked improvement in water penetration during a period of 8 years. Resistance values and core weights also became more normal during that period.

Abstract No. 978

Parker, J. D. 1886. Vegetation in western Kansas. Kansas State Board Agr. Bien. Rep. 10(2):190-193.

Western Kansas consists of high, rolling prairies, interspersed with bottom-lands, and has a gentle slope toward the east and southeast. Passing from the northern to the southern limit of the State, we cross six principal streams--the Republican, Solomon, Saline, Smoky Hill, Arkansas, and Cimarron. These principal streams have more than two hundred affluents, large and small, which, with countless draws, give the whole country the most perfect drainage. The soil of these high, rolling prairies is mainly a rich alluvium, and is adapted, with favorable climatic conditions, to all forms of vegetation produced in this latitude.

The meteorological conditions are important, and should be carefully studied. I have taken Fort Hays as affording about an average of meteorological conditions. The fort is in latitude 38° 59', longitude 99°, with an altitude of 2,107 feet above the sea. The mean rainfall at the fort for the last five years is between nineteen and twenty inches. The mean temperature is about 54°.

The grasses of this region are varied and sufficient for stock purposes. The buffalo grass (*Buchloe dactyloides*), whose roots are very penetrative has been the support of countless numbers of buffalo, deer and antelope in all seasons, and is the support of animals of the recent settler. Timothy and clover have not so far done well, but blue-grass flourishes. This region is peculiarly well adapted to raising stock.

The main cereals of western Kansas are wheat, rye, oats, and sorghum. At the Post garden at Fort Hays they raise lettuce, radishes, and the early varieties of green peas. The early varieties of the eight-rowed corn, yellow and flint, grow well, but the larger varieties and sweet corn are liable to be killed by hot winds. String beans grow occasionally, and early beets and turnips do well. Set onions are very sure. Irish potatoes are occasional, but sweet potatoes are more certain. Salsify does well. The climate is adapted to apples, plums and cherries. Strawberries, once started, bear well; raspberries promise well, but are liable to dry up and be small. Tomatoes are doubtful; early cabbage occasional. Watermelons grow, but muskmelons and squashes are doubtful, on account of insects which prey upon their rough leaves.

Arboreal culture is the most vital question before the people of western Kansas. If one-eighth of the territory could be covered with forests, it would become one of the most productive portions of our country. Forests would make this region a paradise. This question needs to be studied in the light of physical features, soil, rainfall, hot winds, maximum and minimum temperature, and adaptation of vegetable forms to the necessary conditions of the country. We need forests for the wood and shade which they furnish, for the moisture which they precipitate and retain, and for obstructions to the force of winds, which at times render homes and stock uncomfortable, orchards and fruit unsafe, and crops liable to great injury. Abundant forests would undoubtedly prevent the hot winds, which are more destructive to crops than any other thing, and would also have a tendency to drive tornadoes into the upper regions of the atmosphere and render them harmless.

Abstract No. 979

Parker, K. W. and D. A. Savage. 1944. Reliability of the line interception method in measuring vegetation on the Southern Great Plains. Agron. J. 36(2):97-110.

Tests of the accuracy and reliability of the line interception method as used in sampling the vegetation on experimental pastures showed this method to be admirably suited for the accurate determination of density and floristic composition of native vegetation, but the need is stressed for careful standardization and repeated checking of field procedure.

Abstract No. 980

Parker, W. B. 1856. Notes taken during the expedition commanded by Captain R. B. Marcy, U.S.A. through unexplored Texas, in the summer and fall of 1854. Hayes and Zill, Philadelphia. 242 p.

In the arrangement of my work my object is two-fold, viz, to impart all the information I can respecting the physical character of the country passed through on the whole line of our march from the frontier, and to entertain by relating from personal observation, scenes and incidents of daily occurrence, whilst roaming through so wild a region as the far South-West.

The great drawback to rapid settlement beyond the frontier of the South and West, is the depredations committed by the roving bands of Indians, who subsist in that region. These people live an entirely nomadic life, have no settled homes, wander from place to place over the vast plains in search of game or plunder, and living in this precarious way, are necessarily often reduced to a state of starvation. As they live entirely on flesh, large quantities are of course consumed, and when reduced to short allowance they eat horses and mules. This, together with the necessity of having animals to transport themselves and families, also to use in war and the chase, induces constant forays upon exposed situations, when murder, rapine and captivity are the inevitable results to the hapless settler. Many well cultivated spots have thus been broken up and abandoned, and the continuance of the evil retards emigration and enterprize to such an extent that large tracts of the most fertile land are left tenantless.

To remove this scourge from her territory, the State of Texas by an act of her legislature approved February sixth, 1854, appropriated eighteen square leagues of her unlocated lands to form a reserve, for the settlement of all the Indians within her borders, on condition that the United States government would cause these lands to be located and surveyed, and would induce the Indians to settle upon them, confine themselves to their limits, go to farming and quit their wandering and predatory habits--the United States government also agreeing to send agricultural implements, seeds, men to teach the Indians to farm and take care of stock, and subsistance for the Indians until a crop was raised.

Abstract No. 981

Parkinson, D. 1967. Soil microorganisms and plant roots, p. 449-478. *In* A. Burges and F. Raw [ed.] Soil biology. Academic Press, New York.

As a root grows through soil it alters the soil conditions in its immediate vicinity in a number of ways and in doing so has important effects on the diverse microbial population of the soil. The active root exudes, particularly from a region just behind the root tip, organic and inorganic substances which usually enhance microbial activity although some exuded materials may operate against certain microorganisms. Sloughed-off root cells, presumably derived in young roots mainly from the root cap, provide substrates for microbial development. Carbon dioxide, oxygen and water tensions in the root region must be considerably different from those in the soil distant from the roots and must affect microbial activity in the root region. Other phenomena include the tendency for the pH of the soil adjacent to roots to be nearer neutrality than that of the soil distant from roots; also the redox potential of the soil adjacent to roots is lower, presumably as a result of root exudates, than that in the general soil. Recently it has been shown that, under certain conditions, it is possible that there may be a concentration of inorganic nutrients in the immediate vicinity of roots.

These factors must all operate in one way or another to effect the now highly documented numerical and physiological stimulation of microorganisms in the root region--a region which comprises the most studied group of soil microhabitats.

Interest in this group of microhabitats stems from the discoveries in the nineteenth century of spectacular associations of soil micro-organisms and plant roots--legume nodules, mycorrhizas and pathogenic associations. The descriptions of such associations focused attention on the soil-root interface as an important zone of microbial activity. However, this attention was initially concentrated on the possibility of inoculating non-legumes with nitrogen-fixing bacteria, and although these studies were unproductive they nevertheless demonstrated microbial stimulation in the environs of roots. In 1904 Hiltner defined the zone of enhanced microbial development round roots as the rhizosphere (the soil immediately influenced by plant roots), but it was not until a quarter of a century later that detailed studies on the rhizosphere microflora were begun.

Thus it has been appreciated that soil microorganisms exhibit a range of relationships with the roots of higher plants. These may be considered as:

1. symbiotic (e.g., mycorrhizal associations, legume nodules);
2. parasitic (where the causal organisms range from unspecialized to highly specialized forms);
3. less clearly defined relationships grouped together as rhizosphere and root surface phenomena.

Abstract No. 982

Parks, J. M. and E. L. Rice. 1969. Effects of certain plants of old-field succession on the growth of blue-green algae. Torrey Bot. Club, Bull. 96(3):345-360.

Certain weeds from Stage 1 of old-field succession and *Aristida oligantha* from Stage 2 were inhibitory in several ways to the nitrogen-fixing soil algae, whereas *Andropogon scoparius* from stage 3 and the climax was not inhibitory in most tests. These results complement the findings of other research which indicated similar inhibitions of nitrogen-fixing bacteria and the inhibition of effective nodulation of legumes by many of the same species. The combined effects may result in a slowing of the rate of addition of N to infertile old-fields and, thus, the slowing of succession. This could explain why the intermediate stages remain so long.

Abstract No. 983

Parr, J. F., and A. R. Bertrand. 1960. Water infiltration into soils. Advances in Agron. 12:311-363.

This literature review is intended to serve two specific purposes:

1. To consider the dominant factors that determine the rate of infiltration of water into soils.

2. To evaluate critically the many different methods that have been used in the characterization of the relative infiltration capacity of soils.

Abstract No. 984

Partch, M. L. 1949. Habitat studies of soil moisture in relation to plants and plant communities. Ph.D. Thesis, Univ. Wisconsin, Milwaukee. 92 p.

No extensive conclusions can be drawn from the study of one hardwood stand. Many such studies are needed to give a true picture of amplitudes and optima.

All studies of forested stands will probably have to be based on at least two environmental scales--moisture and light. Several forest types may be present at the same scalar level based on moisture, but a brief inspection will reveal the great differences in light relations.

Abstract No. 985

Pase, C. P. 1966. Grazing and watershed value of native Arizona plants, p. 31-40. *In* Native plants and animals as resources in arid lands of the southwestern United States. Amer. Ass. Advance. Sci., Rocky Mountain and Southwest Division Contribution, No. 8.

Water and range forage production are two valuable products of Arizona forests and rangelands.

Both grazing and water yield values are low in the southern desert shrub and northern desert shrub formations. Extended, frequent droughts preclude adequate plant cover, so erosion rates are high.

Water yield from semidesert grassland and undisturbed chaparral areas is low to moderate. Water use by chaparral shrubs is considerably higher than by associated grasses. The rooting habit of shrubs permits withdrawal of water from much greater depth in the soil mantle than grasses can reach. Erosion rates under undisturbed chaparral or on semidesert grass range in good condition are low to moderate. Palatability of most dominant chaparral shrubs is low. Few understory grasses or forbs are present. Grazing capacity is generally low. The wide variety of palatable grasses and high productivity make the semidesert grassland a favored grazing area.

Water yields are low from the short-grass area. The summer-growing grasses use little water that would be available as streamflow, and provide very necessary soil stabilization.

The juniper-pinyon area is prime game range for both deer and elk. Erosion rates are high. Water yield is generally low, much of it associated with snowmelt or occasional high-intensity summer storms.

While little herbaceous understory occurs in dense ponderosa pine stands, more open stands produce a wide variety of grasses and forbs. The dominant grasses are important livestock feed, while forbs and occasional shrubs support large game populations. Water yield is moderate to high. Erosion rates are low.

Spruce-fir stands are generally so dense as to restrict all herbaceous growth. Areas surrounding parks may support stands of aspen and a variety of understory forbs and grasses. Such areas are important summer game range. Water use by aspen is considerably higher than by associated grasses.

Mountain grasslands are highly productive areas. Livestock grazing capacity is high. Deer and elk make extensive use of the smaller parks. Little is now known about water yield and erosion in this type.

Within limitations set by climate, soils, and individual plant species, land managers must try to maximize benefits from grazing, water yield, and other resource values. Information on water use and soil protection characteristics and grazing values of dominant species will greatly help managers in planning for optimum value cover types. However, little is known about watershed values of individual plant species in many of our most important plant communities.

Abstract No. 986

Pattel, K. R., F. W. Albertson, and G. Tomanek. 1964. Microclimate and vegetation responses on three big bluestem (*Andropogon geradi* Vitman) habits near Hays, Kansas. Kansas Acad. Sci., Trans. 67:41-49.

Three habitats found on a relict grassland area near Hays, Kansas were studied to determine differences in microclimate and vegetation. The habitats were located on two different exposures and two slope positions. One was an upper east-facing slope, one an upper west-facing slope and the other a lower east-facing slope.

Differences in microclimate due to exposure were not great but consistent. The upper east-facing slope had slightly lower temperatures, higher relative humidity, considerably less water loss and slightly less light intensity than the upper west-facing slope. In general, the west-facing slope was more xeric than the east-facing one.

Position on the slope seemed to have considerable effect on microclimate. The lower east-facing slope had deeper soil, lower temperatures, higher relative humidity, considerable less water loss and lower light intensity than either of the upper slopes. Differences in these microclimatic factors were much greater due to slope position than to exposure.

Vegetation on the two upper slopes was quite similar with a mixture of big bluestem, little bluestem and sideoats grama but was limited to the two taller grsses, big bluestem and switch grass on the lower slope. All habitats were dominated by big bluestem. Growth rate of grasses was higher on the east-facing slope and considerably greater on the lower slope. Number and size of leaves were also much greater on the lower than upper slopes. More big bluestem plants survived at the end of the season on the lower slope.

Total yield of vegetation was much higher on the lower slopes, both current and past (indicated by mulch accumulation), than on the upper slopes. The upper east-facing slope did produce slightly more than the upper west-facing slope.

Two comparisons were made in habitats containing primarily big bluestem and slope position seemed to affect microclimate and vegetation response more than variation between east- and west-facing exposures.

Abstract No. 987

Paul, E. A. 1970. Plant components and soil organic matter, p. 59-104. *In* C. Steelink and V. Runeckles [ed.] Recent advances in Phytochemistry. Vol. 3. Appleton-Century-Crofts, New York.

The application of instrumental and microbiological techniques has elucidated some of the structures involved in organic matter. Although there is still a disconcerting amount of substance in the column called "unidentified material" that always accompanies soil organic matter research, the amount and composition of the majority of carbohydrates, organic sulfur, and organic phosphorus products in soil is now generally known. The presence of large concentrations of free radicals in soil supports the theories concerning the role of oxidized degradation products of lignin in soil humus formation and helps explain the soil humic characteristics.

The heteropolycondensate of 3,000 to >100,000 molecular weight which comprises the soil humic constituents is probably formed by condensation of aromatic degradation products and amino compounds. The recent observation of larger molecular weight amino constituents existing in the soil, show some of them at least being attached to the aromatic constituents by hydrogen bonding which can be broken by phenol and PVP. This indicates that humic-like materials made by combining oxidized aromatics and larger molecular weight nitrogeneous constituents more closely resemble the humic acids than when amino acids are incorporated exclusively as single units. Direct evidence for the occurence of peptide bonds in soil humic acid has recently been shown by the action of the proteolytic enzyme, pronase, on both model and natural humic materials.

The formation of soil humic material is dependent on the phytochemicals entering the soil, the microbial population, and soil characteristics such as pH, extent of aeration, and content of stabilizing clays and cations. Humic materials from different parts of the world, although being similar, have characteristics dependent on the environment in which they were formed. Soil organic matter research could progress rapidly if laboratories in different parts of the world used exactly the same material. The alternative is to take into consideration the strong influence of environmental and soil factors in the formation of humic materials. This requires close collaboration with pedologists in collecting soil samples so that typical materials are utilized.

The dynamics of the soil organic matter are being investigated using long-term field experiments, and by the use of tracers. Normal tracer techniques will continue to be the backbone of this research for they are available to a great number of laboratories and characterize the active portion of soil humus. The use of carbon dating makes it possible to characterize the indigenous soil fraction which cannot be studied by normal techniques.

In this review, no attempt has been made to cover the extensive organic matter literature. The characterization of plant and soil components relative to their turnover in nature has been stressed.

Abstract No. 988

Paulsen, H. A., Jr. 1969. Forage values on a mountain grassland-Aspen range in western Colorado. J. Range Manage., 22(2):102-107.

The productivity, relative preference, and nutritive value of Idaho fescue makes it the most valuable forage species on summer cattle range on Black Mesa in western Colorado. Forbs that were abundant, high in nutritive value, and selected by cattle were aspen fleabane, aspen peavine, and agoseris in the mountain grassland type. Elk sedge was the major forage species in the aspen type.

Abstract No. 989

Paulsen, H. A., Jr. and F. N. Ares. 1962. Grazing values and management of black grama and tobosa grasslands and associated shrub ranges of the Southwest. U.S. Dep. Agr. Tech. Bull. 1270. 56 p.

Ecology of the range plants, grazing capacity of the forage resource, and techniques of management most suited to black grama and tobosa grasslands and associated shrub ranges of the Southwest have been interpreted from records of vegetation, climate, and livestock on the Jornada Experimental Range.

Abstract No. 990

Payne, G. F., J. E. Taylor and D. E. Whitman. 1967. Distribution of dense clubmoss (*Selaginella densa* Rydb.) in Montana. Montana Agr. Exp. Sta. Circ. 247. 2 p.

Dense clubmoss is a low-growing plant common on some Montana ranges. It is most commonly noticed after a rainstorm as green and gray mats of moss-like vegetation. When dry, it is brown to gray.

This species severely depresses grass production on ranges where it is a large part of the ground cover.

Inadequate information has been available on the extent of the dense clubmoss problem in Montana. Siebert mapped the distribution of dense clubmoss by cover classes in Blaine, Phillips, and Valley Counties, but field observations by range scientists indicated that clubmoss could be important in other areas of the state as well. Consequently, a survey of Montana was made to provide a more comprehensive picture of the distribution and abundance of dense clubmoss in Montana. This report describes its distribution as determined by the survey.

Abstract No. 991

Pearse, C. K., and S. B. Woolley. 1936. The influence of range plant cover on the rate of absorption of surface water by soil. J. Forest. 34(12):844-847.

While much attention of late has focused on the construction of engineering works as a means of meeting water deficiencies in the semiarid valleys of the West, comparatively little consideration has been given to the regulatory influence of the soil and rocks of the watersheds, or of the part played by herbaceous range plants in maintaining the efficiency of these natural reservoirs. The study herein reported, which is based upon measurements with inexpensive and portable equipment, reveals that range plants exert a marked influence on the rate water is absorbed by surface soils. Moreover, because plants which are most conducive to water absorption are also of greatest value for grazing purposes, the study clearly suggests that proper range management and adequate watershed protection go hand in hand.

Abstract No. 992

Pearson, G. W. 1906. Two diseases of pines. Nebraska State Hort. Soc. Annu. Rep. 1906: 230-232.

This paper will discuss only two pine diseases, namely, the "damping off" disease, and a new leaf disease which has, as yet, no recognized name. Both of these diseases attack pines in their seeding stage, and both are causing more or less trouble in growing pine seedlings in this state.

Abstract No. 993

Pearson, R. L. and L. D. Miller. 1971. Design of field spectrophotometer lab. U.S. IBP Tech. Rep. No. 133. 102 p.

Pearson, R. L. 1971. Design of field spectrophotometer lab. M.S. Thesis. Colorado State Univ., Fort Collins. 102 p. (Advisor: Lee Miller).

The IBP Grassland Biome Program of the National Science Foundation has funded a ground based remote sensing study of the feasibility of determining the percent cover of standing green vegetation for a shortgrass prairie ecosystem by measuring the spectroreflectance of an undisturbed patch of vegetation. The equipment assembled for this study include: a spectroradiometer, with telescope viewing optics; a computer based digital data acquisition system; and calibration and logistical support systems. The determination of spectroreflectance is made by measuring with the spectroradiometer the spectroradiance reflected from a white panel painted with barium sulfate and then measuring the spectroradiance reflected from the "in situ" sample. The ratio of these two spectroradiances at each wavelength is the spectroreflectance of the sample. Several tests have been completed which assess the suitability of the spectroradiometer for measuring spectroreflectance of various objects as well as determining percent cover of prairie vegetation.

Abstract No. 994

Pearson, R. L. and L. D. Miller. 1971. A field light quality laboratory--initial experiment: The measurement of percent of functioning vegetation in grassland areas by remote sensing methodology. U.S. IBP Tech. Rep. No. 90. 24 p.

This technical report contains the progress report from January 1970 to January 1971 and the planning report for January 1971 through January 1972 for the Field Light Quality Laboratory of the Grassland Biome of the International Biological Program. Included in the report are descriptions of the lab design as well as the experimentation completed during 1970 which determined how well the lab responds to changes in percent cover of functioning green vegetation and the spectroreflectances of some common grassland constituents in early October.

Abstract No. 995

Pechanec, J. F. 1936. Comments on the stem-count method of determining the percentage utilization of ranges. Ecology 17(2):329-331.

Stoddart's method for determining percentage utilization of grazed ranges has been tested under field conditions to verify its accuracy and to compare it with other methods already in use. Because deviations or errors tend to be positive and cumulative, is is contended that the stem count system of obtaining percentage utilization is not accurate enough for unqualified use in pasture or open range studies.

Abstract No. 996

Pechanec, J. F. and G. D. Pickford. 1937. A comparison of some methods used in determining percentage utilization of range grasses. J. Agr. Res. 54(10):753-765.

This experiment to test the limits of accuracy, the inherent personal error, and the rapidity of determining percentage utilization of range forage by grazing was carried out on sagebrush-wheatgrass range which was dominated by *Agropyron spicatum* and *Artemisia tripartita*. Clipping to simulate removal by sheep was used as a substitute for grazing which allowed the use of an accurate check in the form of the modified vol.-by-wt. method. Other methods used were (1) ocular-estimate-by-plot, (2) ocular-estimate-by-avg.-of-plants, (3) stem count, (4) measurement, and (5) ocular-estimate. From data presented it is recommended that ocular-estimate methods of obtaining percentage utilization, supplemented by comparison with determinations made by the modified vol.-by-wt. method, be considered for use in range pasture or open-range studies.

Abstract No. 997

Peden, D. G. 1971. Preliminary activities and results in bison research on the Pawnee Site. U.S. IBP Tech. Rep. No. 121. 8 p.

This report covers activities and preliminary results of the bison project during the period between September 1969 and early 1971. Data given herein pertain to that collected at the U.S. IBP Grassland Biome Site, Pawnee. A general outline for 1971 collections is given.

Abstract No. 998

Peden, D. G. and R. W. Rice. 1971. A dynamic programming approach to the management of ungulate population. Proc. Int. Conf. Behavior Ungulates and its Relation to Manage., November 2-5, Univ. Calgary, Alberta, Canada.

A dynamic programming framework is being developed which will permit objective handling of feeding behavior in a mixed-species management problem. Initial studies indicate the way solutions will vary with changes in the input data. We feel that this approach could contribute to rational management of mixed-species herds. However, interpretation of these or any dynamic programming solutions requires caution. The approach is only one of many possible. It is worth remembering the definition Woolsey (1969) gives to the whole bag of tricks called Operations Research, which includes dynamic programming: "Operations Research is the application of logic and mathematics to a real world problem in such a way that the method does not get in the way of common sense." In our case the model is at such a preliminary stage that only gross trends are worthy of discussion. On completion of this study we hope that the approach taken herein can be used as a guide to management, but not as the decision itself.

Future work will involve incorporation of more complete field data which is being collected in 1971, several value systems, and a more refined herbage dynamics model relevant to shortgrass prairie. More elaborate sensitivity analysis, such as testing the model's response to a wide range of input data, should provide a useful means for setting priorities on future data collection.

Abstract No. 999

Penfound, W. T. 1964. Effects of denudation on the productivity of grassland. Ecology 45(4):838-845.

Denudation (close mowing and removal of mulch) of ungrazed prairie and ungrazed cropland plots near Norman, Oklahoma, did not result in significant change in composition, but increased the biomass in both the prairie and cropland during the growing season. Total biomass in all plots was low in Feb.-March, increased to a maximum in late July, and declined rapidly thereafter. Although 115 species were sampled, only the following six species contributed significantly to the total biomass: *Andropogon gerardi*, *Panicum virgatum*, *Sorghastrum nutans*, *Andropogon scoparius*, *Leptoloma cognatum*, and *Panicum scribnerianum*. Average daily productivity was very low in Feb.-March, moderate in April, relatively high and approximately equal in May, June, and July, and negative in Aug. and Sept. The terminal standing crop of living material (early Sept.) was considerably lower than the maximum biomass in late July. In the denuded plots, the mulch increased steadily in weight throughout the period of the study, attained a relatively steady state in the denuded prairie by the end of the 3rd year, and in the denuded cropland by the end of the 4th year.

Abstract No. 1000

Penfound, W. T. 1964. The relation of grazing to plant succession in the tall grass prairie. J. Range Manage. 17:256-260.

The effects of complete protection from grazing upon plant composition and plant succession in tall grass prairie and revegetating cropland are reported herein. These grassland plots, located about ten miles southwest of Norman, Oklahoma, have been protected from grazing since 1949. They were designated as follows: protected prairie, grazed prairie, protected cropland and grazed cropland. In all plots, autumnal composition was determined by means of 25 quadrats of 0.1 sq. m. each.

In the protected prairie, the vegetation changed from midgrass (1950) through representative tall grass prairie (1959) to tall grass prairie with many woody species (1962). If protection continues, it seems probable that much of the protected prairie will be taken over by woody plants. In the grazed prairie the vegetation remained nearly constant since the midgrass (little bluestem) was the major dominant throughout.

In the protected cropland the vegetation changed rapidly through the following stages: annual (1950), forb-short grass (1954) to short grass-midgrass-tall grass (1962). In the grazed cropland the plant population shifted from annual grass (1950) through short grass-midgrass (1959) to a midgrass type (1962).

The most important species in all four tracts was the little bluestem. Considerable plant succession occurred in all plots but was much more rapid in the protected units.

Abstract No. 1001

Penn, R. J., and C. W. Loomer. 1938. County land management in northwestern South Dakota. South Dakota Agr. Exp. Sta. Bull. 326. 47 p.

The problem of county land management is to find some use for county landholdings that will return adequate income to the county, that will preserve the land resources, and that will safeguard private as well as public interests.

In eight counties of northwestern South Dakota, 43 percent of the total land area is nontaxable land which does not contribute tax income for the support of local governments.

Nearly two million acres (17 percent of the total area) was subject to tax deed action on February 1, 1938.

In 1938 there were 903,000 acres under contract for the payment of back taxes.

Less than a fourth of the total land area of the eight counties was taxable land on which taxes were fully paid up.

County land ownership has assumed considerable importance in westriver South Dakota. In June, 1938, four counties of the northwestern area together owned more than a million acres of land, and the other counties have acquired large acreages.

Only a small fraction of county landholdings can be sold to private buyers. Estimated total county land sales to date in the eight county area amount to about a tenth of the present county landholdings.

Leasing to private operators is the most common use for county land. In 1938, approximately 883,000 acres of county property, or 70 percent of all county land, were leased to farm and ranch operators. Grazing lands predominate, and the usual lease price is five cents per acre.

State legislation outlines the procedure to be followed by all counties in the administration of county land, but there is much variation in the policies and results of the land programs of individual counties. Actual experiences indicate that there is much room for improvement, both in local administrative policies and in the statutory provisions established by state laws.

It is recommended that where landholdings are large, local governments establish property departments capable of giving adequate supervision to the administration of county lands.

County governments should reserve the right to control the use of leased county land in order to prevent abuse and to provide the basis for conservation programs.

Lease rates should be proportional to the productive value of the land with differential rentals established for different grades of county land. Provision should be made for a flexible scale of rents that may be raised or lowered as the condition of range and crop land fluctuates from year to year.

As a means of stabilizing lease income and lease tenure, counties should offer long term renewable leases and should safeguard the interests of current lessees when leases are made subject to sale.

The practice of offering first rights to lease county land to private operators within whose units the property is situated has advantages for both the county government and private individuals.

State law should provide an effective means of dealing with trespass on county lands.

Tax deed procedure should be shorter and less expensive for the counties. The weak tax title should be given more legal strength.

Abstract No. 1002

Peterson, H. V. 1962. Hydrology of small watersheds in western states. U. S. Geol. Surv., Water-Supply Paper 1475-1. 356 p.

This report presents results of observations of runoff and sediment yield made over a period of years at 200 reservoirs located on small drainage basins distributed throughout the western States. The records were obtained in drainage basins that are typical of much of the public domain. They are useful chiefly as an aid in assessing the need for conservation and in planning conservation programs and structures.

The observation reservoirs are located in the Missouri River, Colorado River, and Rio Grande drainage basins, and they are distributed from Montana to southern Arizona. Of the 120 observation reservoirs in the Missouri River basin in Wyoming and Montana, 102 have records of sediment yield only and 18 have records of both sediment and runoff. In the Colorado River basin of Wyoming, Colorado, Utah, and Arizona, records were collected at

48 reservoirs, at 25 the measurements were made of sediment yield only, and at 23 measurements were for both sediment yield and runoff. Of the 32 reservoirs in the Rio Grande basin, all in New Mexico, measurements of sediment yield only were obtained at 7 and records of both runoff and sediment were obtained at 25 reservoirs.

In the selection of observation reservoirs an effort was made to sample a wide range in climate, topography, geology, soil, and the types of vegetation associated with each factor within the semiarid western areas. The reservoirs range in capacity from 0.2 to 1,012 acre-feet, and the contributing drainage areas range from less than 0.1 to 55 square miles. The wide variation in unit rates of runoff and sediment yield reflect all the differences in drainage basin characteristics.

Abstract No. 1003

Peterson, R. A. 1962. Factors affecting resistance to heavy grazing in needle-and-thread grass. J. Range Manage. 15:183-189.

It was postulated that the persistence of needle-and-thread grass in the heavily grazed pasture might be favored by changes in responses to herbage removed (as compared to populations of the same species which had not been exposed to heavy grazing), or to changes in the genetic structure of the population. The specific objectives of the study were to ascertain if past grazing treatments influenced: (1) regrowth pattern after clipping and whether or not the pattern persisted with time; (2) regrowth pattern in the dark; and (3) plant populations as measured by transplant responses.

Abstract No. 1004

Petrusewicz, K. and A. MacFadyen. 1970. Productivity of terrestrial animals: Principles and methods. IBP Handbook No. 13, F.A. Davis, Philadelphia. 190 p.

Under the aegis of the IBP, a working meeting on Principles and Methods of Secondary Productivity of Terrestrial Ecosystems was held at Jablonna from the 30th of August to the 6th of September 1966. The meeting was invited by the Polish Academy of Sciences and the organization was due to Professor Petrusewicz and his staff in the Department of Terrestrial Ecology of the Institute of Ecology. It was attended by 66 members from 14 countries and 54 papers were read. These were published in "Secondary Productivity of Terrestrial Ecosystems" by the Polish Academy of Sciences, Institute of Ecology, and the International Biological Programme, Section PT, in Warsaw and Cracow in 1967.

A purpose of many technical meetings convened by IBP has been to advise on methods of research. The aim is not that of standardization--for ecological science is still evolving rapidly through the improvement of its methodology--but to give workers in different parts of the world a means whereby their results will be comparable with results by other workers in other areas. Therefore, after the Jablonna meeting the authors were invited by Section PT (Productivity Terrestrial) of the IBP to collaborate in producing a handbook which should draw together into a convenient form the modern ideas and methods in this subject. We were given complete freedom as to how this should be done.

This volume, like others in the series of *International Biological Programme Handbooks*, describes methods which can be recommended to research workers. It should be stressed that these are not formally agreed methods, since a standardized methodology would not only prove impossible to compile, but would also be stultifying to science. But in any international cooperative effort a basic recommended methodology is needed in order to ensure comparability of results.

Abstract No. 1005

Petryszyn, Y. and E. D. Fleharty. 1972. Mass and energy of detritus clipped from grassland vegetation by the cotton rat (*Sigmodon hispidus*). J. Mammal. In press.

Piles of vegetational clippings made by *Sigmodon hispidus* in a remnant grassland area were collected and analyzed for vegetational composition, dry weight, and caloric content. Population densities of *S. hispidus* were estimated monthly and correlated with the number of clipped piles of vegetation collected each month.

Abstract No. 1006

Pfadt, R. E. 1949. Range grasshoppers as an economic factor in the production of livestock. Wyoming Agr. Exp. Sta. 7:1-6.

Grasshoppers are very destructive agents on the short-grass plains of the West. In certain years they appear on our range lands in such large numbers that they devour almost all the forage, while in other years they occur only in small numbers and are of little importance. Research, however, has shown that even in non-outbreak years there are local areas of approximately 1 to 10 square miles which carry heavy populations of grasshoppers. It is felt by a number of entomologists working on the range grasshopper problem that these so-called "hold-over" areas contribute to the build up of general infestations. Just how much the hold-over population is responsible for the outbreak population is not known; but there are data which show a dispersal or migration from these areas to surrounding land.

Our short-grass plains are an asset which has sufficient value to be nurtured and protected. They are the basis for our livestock industry. Without the native grass the industry can not operate. Range grasshoppers are again threatening to devour and destroy this natural crop. At this time we have the methods to prevent a general outbreak. We also have an organization to carry out the methods. What we lack is the necessary funds to carry out a control program. However this can be remedied by generous support of county, state, and federal governments.

Abstract No. 1007

Philip, J. R. 1957. The theory of infiltration: three moisture profiles and relation to experiment. Soil Sci. 84(2):163-178.

The basic assumptions of the mathematical analysis discussed in earlier papers are critically examined. A simplification of the analysis possible for initially "dry" media is given and is used in an investigation of the influence on the moisture profile during infiltration of the diffusivity D and conductivity K functions. D and K are influenced by the soil texture and initial moisture content, so that the effect of the latter factors on the moisture profile follows directly. It is shown that the analysis derived for semi-infinite columns, will often hold also until a late stage of infiltration into finite columns.

A detailed explanation is given of the "wet front" and other zones observed by Bodman and Colman during infiltration. All these zones are predicted by the present analysis, except the "transition zone," which is explained as due to a shallow surface region in which capillary potential is not a unique function of moisture content, depending also on depth from the soil surface. Physical arguments support this hypothesis. Suitable definition of the capillary potential makes the error in the present analysis due to this effect quite small.

Abstract No. 1008

Phillips, P. 1936. The distribution of rodents in overgrazed and normal grasslands of Central Oklahoma. Ecology 17:673-679.

Comparative data were obtained on the distribution of various common rodents and lagomorphs in grasslands of central Oklahoma. Pellet counts indicated that jack rabbits were most abundant in moderately overgrazed areas and cottontails preferred the cover afforded by undisturbed grasslands. Mound counts showed pocket gophers more numerous in mowed hayfields and moderately overgrazed pastures than in either heavily overgrazed or undisturbed areas. Ground squirrels occurred more often in mowed hayfields. Trapping showed that deer-mice were most numerous in moderately overgrazed grassland while cotton rats were almost entirely restricted to heavily grassed undisturbed areas.

Abstract No. 1009

Phillipson, J. [ed.] 1970. Methods of study in soil ecology. IBP/UNESCO Symp. Paris. 350 p.

A symposium on methods of study in soil ecology organized jointly by Unesco and the International Biological Programme (IBP) was held at Unesco Headquarters, Paris, in November 1967. It was attended by more than a hundred scientists from twenty-eight countries. The soil scientists present covered a number of disciplines: workers interested in primary production, soil microbiologists, population and production zoologists and others.

The purpose of the symposium was to provide an opportunity for the exchange of information on recent advances in the study of soil ecology with special emphasis on production and energy flow in soil ecosystems. On the first day of the four-day programme the broader aspects of soil ecology were dealt with, and on the remaining three days papers were presented dealing primarily with methodology.

During the course of the meeting it became apparent that some of the participants were of the belief, and much concerned, that Unesco and IBP were intending to issue directives as to which methods and techniques were to be used in the study of the different aspects of soil ecology. It was made clear during the discussions that their intention was to recommend a series of methods which are widely applicable. The symposium thus provided a forum for the clarification of this question and also for the establishment of facilities for the interchange of ideas between scientists of many different countries. The discussions also revealed the need felt by less experienced workers for guidance from visiting "consultants".

For one day preceding the symposium and two days thereafter, a working group of about twenty met to consider the production of an IBP handbook to be entitled *Methods of Study in Quantitative Soil Ecology--Population, Production and Energy Flow*. Each chapter is to be written by one or more specialists in the particular field of study.

Since the methods handbook would not cover all of the topics dealt with during the symposium, it was decided that its proceedings should be published by Unesco.

The selection of material and points of view and opinions presented in this volume engage the responsibility of the authors and are not necessarily endorsed by Unesco.

Abstract No. 1010

Pielou, E. C. 1966. Species-diversity and pattern-diversity in the study of ecological succession. J. Theoretical Biol. 10:370-383.

A measurable property of any collection of organisms containing more than one species is its "species-diversity". Methods of measuring species-diversity based on the information content of a collection are reviewed. A collection consisting of a community of sessile organisms, such as terrestrial plants, also has "pattern-diversity". The pattern-diversity of a community is high when the individuals of the various species are thoroughly mingled so that several species are usually present in any small sub-area; it is low if the species are segregated so that small sub-areas are likely to contain individuals of only a few of the species. A method of measuring pattern-diversity is proposed.

The changes that occurred in both species- and pattern-diversity, during periods of five or ten years, in young dense communities of forest trees were observed. It was found that the natural thinning resulting from competition among the trees caused an increase in pattern-diversity.

Abstract No. 1011

Piemeisel, R. L. 1951. Causes affecting change and rate of change in a vegetation of annuals in Idaho. Ecology 32(1):53-72.

Communities of Russian thistle, mustards, and downy chess make up most of the ann. vegetation on lands formerly in sagebrush-grass. In appearance time and in space covered, they have an optimum arrangement which is a potential realized on a cleared area where destruction of plants is sufficiently controlled and is open to repeated demonstration and measurement. Under this optimum rate of change Russian thistle dominates the most space the 1st 2 yrs.; mustards, the 3rd and 4th; and downy chess from the 5th yr. on. In each community there is devlpmt. that is best observed in downy chess and in an island somewhat removed from an established stand. The start is a solitaire, a beginning age; then a cluster of a few individuals, the young age; then a dense stand, the mature age; and finally a very dense stand, the degenerate age. Distinguishing these age groups in an island are color, ht., and maturity (head emergence) as well as density. The changes from 1 community to another and the processes that take place within a community are determined by plant characteristics and proceed despite differences in weather between yrs. of above or below av. precipitation. Sparse stands mature and produce seed in yrs. of below av. precipitation, and excessively crowded stands dry prematurely in yrs. of above av. precipitation. Spacing of individuals within groups--the degree of crowding--determines distrib. of the limited soil moisture supply of a unit area. The supply for an individual depends on the amount put into the soil (precipitation) and the no. of individuals (density), precipitation varying far less than density. Repeated observs., measurements, and expts. may be made on these communities because of their short life span and rapid change.

Abstract No. 1012

Pieper, R. D. 1969. The role of consumers in a grassland ecosystem, p. 316-329. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Grassland consumers are a heterogeneous group representing many species of organisms. They can be classified as herbivores, omnivores, and carnivores. A portion of the total amount of energy available to herbivores is unused and passes directly to decomposer food chains. Of the total amount of energy consumed by the herbivores, part is voided in feces and urine, part goes to decomposer food chains from herbivores succumbing to mortality factors, part is dissipated as heat through formation of gases and utilized as heat increment and heat of maintenance, part passes to carnivores--and only a small part is used for production. Ecological efficiencies have been calculated for different trophic levels in aquatic ecosystems but few for terrestrial ecosystems.

Grassland consumers alter distribution patterns of chemical elements through desposition of urine and feces. This may act as a fertilizing influence, but some chemical elements are transferred through food chains.

Abstract No. 1013

Pieper, R. D. 1971. Blue grama vegetation responds inconsistently to cholla cactus control. J. Range Manage. 24(1):52-54.

Walkingstick cholla cactus was removed from plots with light (328 plants/acre), moderate (427 plants/acre) and heavy (607 plants/acre) cholla stands, and herbage production was determined on these and corresponding control plots over a four-year period. There were no significant differences between grubbed and ungrubbed for any year on any density class. However, when the data for four years were pooled, there was significantly greater production on the grubbed plots at the light and moderate cholla densities. On the plots with heavy cholla densities, herbaceous production was significantly higher on the ungrubbed plots. Lack of clear-cut response of herbaceous vegetation to cholla removal may be related to differences in early growth and in root distribution of cholla cactus and herbaceous vegetation.

Abstract No. 1014

Pieper, R. D., M. Connaughton, and R. Fitzenrider. 1971. Preliminary report on sampling of primary producers, invertebrates, and decomposers on the Jornada Site, 1970. U.S. IBP Tech. Rep. No. 105. 47 p.

Sampling for aboveground and belowground biomass of primary producers, litter, invertebrates, and decomposers was conducted at 10-day intervals on a grazed and protected area on the Jornada site. During the 1970 growing season, precipitation was below-average for the season, and most of the biological activity occurred during the major rainy period in the last week of July. Peak standing crop of aboveground biomass of primary producers occurred in mid-August on the grazed area and early September on the ungrazed area.

Invertebrate populations peaked on both grazed and ungrazed areas in late July. Insect numbers were consistently higher on the grazed area than on the ungrazed area. The order Acarina contained the greatest numbers of individuals. Decomposer biomass also peaked following the rains in late July.

Abstract No. 1015

Pierson, R. K. 1955. Range water spreading as a range improvement practice. J. Range Manage. 8:155-158.

Range waterspreading is a multiple-purpose conservation practice of limited application due to the specific requirements of land and water. It is a desirable range improvement practice from the standpoint of forage production since highly productive valley lands can be restored to a key position in grazing use. Waterspreading areas must become integral parts of general range management plans and receive intensive management practices to maintain a high level of productivity. As a range improvement practice, waterspreading is a paying proposition in the production of an increased forage supply. To insure success all of the physical factors of the site must be carefully studied before an attempt is made to install a waterspreading system.

Abstract No. 1016

Plummer, A. P., S. B. Monsen, and D. R. Christensen. 1966. Fourwing saltbush--a shrub for future game ranges. Utah State Dep. Fish Game, Pub. 66-4. 12 p.

Fourwing saltbush--known to botanists as *Atriplex canescens* and sometimes to laymen as boxbrush, white greasewood, or chamise--is one of the most palatable and productive browse plants wherever it occurs. And it is almost as adaptable as man himself.

Superior palatability, productivity, and adaptability are three qualities that make fourwing saltbush a favored shrub of game managers and ranchers who realize its value to the restoration of western livestock and big game ranges. They agree that fourwing saltbush is a plant to encourage--that it is a forage shrub for the future when an expanding American public will increasingly look to western wildlands for game and livestock.

Abstract No. 1017

Pochop, L. O. 1969. Dynamics of the atmosphere in the grassland ecosystem, p. 89-100. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Methods of describing the variability of meteorological events have been discussed and a number of approaches which may have application to the grasslands are cited. In addition, the importance of meteorological parameters to the energy budget has been considered. Evaluation of the energy balance is described in terms of these parameters.

Abstract No. 1018

Porter, L. K. 1969. Nitrogen in grassland ecosystems, p. 377-402. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Grasses and grain crops in the Great Plains usually respond to both water and available nitrogen. Rarely is the supply of these resources sufficient for maximum productivity, and there is a strong interaction between these two resources in their effect on productivity. Only small amounts of nitrogen become available each year from the vast reservoir of organic nitrogen in Great Plains soils. Tilling the native grassland soils has caused marked declines in their nitrogen content. The effect of the environment on the nitrogen content of grassland soils is discussed. In order for man to manage judiciously the vast nitrogen reserves in grasslands he must more fully understand the transformation of nitrogen in such soils and the turnover of fertilizer nitrogen in soils and plants. Natural nitrogen inputs into grassland soils are not clearly defined; especially lacking is the contribution that native legumes make. Also, investigations are needed to clarify the magnitude of nitrogen losses from grassland soils. Such loss information will become highly important as man increases his use of commercial nitrogen fertilizers in order to maximize productivity and effectively use stored water. Fertilizer nitrogen could be another possible pollutant to our water resources. In order to avoid any pollution, it is imperative that we understand the fate and movement of fertilizer nitrogen in grassland ecosystems.

Abstract No. 1019

Post, G. 1969. The role of diseases and parasites in a grassland ecosystem, p. 300-306. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

All animals on this earth have parasites which are closely involved in their lives. Therefore, no study of a population of animals is complete without careful evaluation of the effect of parasites on each host. Parasitic life cycles have evolved which make the study of parasitism in an ecosystem, such as a grassland, very difficult.

Vertebrate hosts of a grassland ecosystem have, for the most part, been able to survive in spite of periodic losses to disease. As these vertebrate populations reach high numbers, transmission of parasites is usually increased because of the distance between hosts. Parasite numbers on or in a host may increase at times to the point where they may overwhelm the host. The final effect is reduction of host populations to the level where parasitic transmission is no longer easy. Many times the parasite does not actually cause mortality among hosts but is a carrier of pathogens which do cause the loss. Vector populations usually increase at times of high host populations.

The experience of animals coming into contact with pathogenic parasites usually limits complete mortality within a population because of the immune response among the survivors. This immune response is a protective mechanism which makes possible the survival of any of the grassland vertebrates. Some hosts have a natural immunity to pathogens. Therefore, host resistance (either natural or acquired) must be considered in any study of animal populations.

Very little is known of the number or species of parasites living in or on the vertebrate hosts within the Pawnee Grasslands study site. However, the assumption is made that each possible host will have its complement of parasites. These parasites must be supported by the energy flow pattern within the ecosystem. Most authors agree that the energy required for growth, survival, and reproduction of parasitic organisms is small. Larger numbers of parasites may collectively require considerable amounts of energy. There are a few methods of measuring the required energy if certain parts of a life cycle of the parasite are studied. Very few of the parasites of grassland vertebrates will be acceptable for in vitro study of the entire life cycle. The clinically detrimental effect of each of the pathogenic, or potentially pathogenic, parasites can be assessed with some degree of accuracy. Subclinical effects are more difficult to determine.

Research to identify and to enumerate the parasites on a chosen number of vertebrate species in the Grassland Biome is needed. When such data are accumulated, and applied to general biological data recorded for each host, the effects of parasitism may be obvious.

Abstract No. 1020

Pound, R., and F. E. Clements. 1898. The vegetation regions of the prairie province. Bot. Gaz. 25:381-394.

The vegetative covering of the North American continent falls naturally into two great areas, forest and plain. They are not to be distinguished as phytogeographical divisions but as aggregates of divisions, which are characterized by a common type of vegetation-form or by a group of such types. Disregarding division into provinces, Drude (1887) outlines a number of vegetation regions upon the floral map of North America. These are fourteen in number. A detailed review of Drude's regions is given.

The main features of the regional limitation and characterization, and the formations, briefly discussed in this article, are based upon a treatise entitled The Phytogeography of Nebraska, recently published by the authors of the present paper. The data have been extended, however, to cover the entire prairie province, while in the work referred to only Nebraska is considered. Floral covering falls into four vegetation-regions: (1) Wooded bluff and meadow-land region; (2) Prairie region; (3) Sand hill region; and (4) Foothill region. The most noticeable topographic feature that gives character to the floral covering is soil composition. This, with altitude and precipitation, comprises the great factors which have brought about the differentiation of the prairies. Of equal if not greater importance for the flora is the question of environment, the derivation of the floral elements. The vegetative covering of the foothills is derived primarily from the mountains. That of the prairies proper has come in part from the wooded region to the east. The characteristic formations for the prairie province are xerophytic, occasionally poophytic. These are meadow, prairie, sand hill and foothill formations. Prairie formations are of two types, the prairie grass, and the buffalo grass formation. The sand hill formations are three, the bunch grass, the blow out and the sand draw formations. The foothill formations are three, (1) the undershrub formation of table lands and bad lands, (2) the mat and rosette formation of buttes and hills, (3) the grass formation of high prairies and sandy plains. Halophytic and ruderal formations play a more or less prominent part in the constitution of the floral covering of the prairie province, but they are rarely characteristic, and hence scarcely within the scope of a short paper.

Abstract No. 1021

Power, J. F., and J. Alessi. 1971. Nitrogen fertilization of semiarid grasslands: Plant growth and soil mineral N levels. Agron. J. 63:277-280.

To evaluate the fate of mineral N in a grassland ecosystem, fertilizer N was applied to native grassland in North Dakota at rates up to 540 kg N/ha either (a) all in 1 year, (b) one-third in each of 3 years, or (c) one-sixth in each of 6 years. Cumulative production of grass tops for the 6 years increased with increased amounts of total N applied, but was not affected by timing of fertilizer application. With continued annual fertilization, responses were measured at progressively lower rates. At 270-kg N or more, residual effects were still significant 6 years later. Dry weights of three oats crops grown on these soils in the growth chamber indicated that greater N availability in fertilized soils contributed appreciably to these residual effects. Soil NH_4^+- and NO_3^--N levels for many treatments exhibiting residual effects were no higher than for unfertilized plots, indicating residual N was present in other than mineral forms. Fertilizer N is probably immobilized by all components of the soil-grass ecosystem (especially grass roots) and the mineralization of this immobilized N may contribute to residual effects. Fertilizer N applied in excess of the immobilizing capacity of the ecosystem remains in mineral form until required by the grass. Consequently, the presence of a mineral N pool indicates that N has been eliminated as a growth-limiting factor and maximum production from the available water is being achieved.

Abstract No. 1022

Prasad, N. 1967. Influence of microclimate on diurnal water relations in western wheatgrass leaves. Ph.D. Thesis, North Dakota State Univ., Fargo. 161 p.

Diurnal changes in relative turgidity in leaves of western wheatgrass (*Agropyron smithii*) in relation to certain physical factors of the environment were studied during the summer of 1966 in the mixed grass prairie at the Dickinson Experiment Station in southwestern North Dakota. This part of study was one phase of a more comprehensive study of the influence of microclimatic factors on growth and development of native grasses in the mixed grass prairie environment.

The relationships between diurnal variations in relative turgidity and changes in environmental factors established by this study indicate that vapor pressure deficit is the single most important governing influence in determining relative turgidity of grass leaf tissue under field conditions. On the seasonal basis, soil moisture and vapor pressure deficit together have a key role in determining variations in relative turgidity values.

Abstract No. 1023

Quinnild, C. L., and H. E. Cosby. 1958. Relicts of climax vegetation on two mesas in western North Dakota. Ecology 39:29-32.

Relicts of climax vegetation were discovered in 1955 on two mesas in western North Dakota. Data were taken in the spring and fall of 1956. The mesas, separated by a distance of a mile, are completely surrounded by precipitous slopes. They remain ungrazed by domestic livestock and virtually ungrazed by big game. The larger mesa was burned over about 1940 and the other apparently escaped fire for a half century or more. The site is characterized by 15 inches of average annual precipitation and normal Chestnut deep silt loam soil.

The plant cover, including surficial organic materials of all kinds, accumulates to the amazing total of eight tons per acre air-dry. Of this amount about one ton is herbage, two tons are fresh mulch in which leaf forms are clearly discernible, and five tons are humic mulch between the layer of fresh mulch and the mineral soil.

The climax is characterized by overwhelming dominance of *Agropyron smithii* and *A. dasystachyum*. Two other cool-season mid grasses, *Stipa comata* and *S. viridula*, are important, sharing a secondary position in the total cover with *Bouteloua gracilis*, and a short form of *Koeleria cristata*.

Abstract No. 1024

Race, S. R. 1964. An improved method for determining colony vigor of western harvester ants, *Pogonomyrmex occidentalis*. J. Econ. Entomol. 5:558-559.

The selection of colonies of the western harvester ant *Pogonomyrmex occidentalis* (Cresson), of similar population size and stage of development, without destroying parts of their mounds, is important for the successful evaluation of insecticidal controls. It was found that a drop of liquid, obtained by mascerating large numbers of harvester ants in a blendor, when placed near the primary mound opening of the colony, caused an immediate and frenzied emergence of ants from the opening. It was noted that colonies of equal vigor, regardless of mound appearance or ground surface temperatures, produced similar intensities of reaction to the liquid, thus facilitating the selection of intact colonies for study.

Abstract No. 1025

Rahimian, H. and G. W. Tomanek. 1963. Wilting coefficients and infiltration rates of soils on four common plant communities near Hays, Kansas. Trans. Kansas Acad. Sci. 66(3):496-500.

The amount of available soil water greatly affects the kind and amount of plants that grow on any habitat, especially in arid and semiarid climates. The mixed prairie of western Kansas was so named by Clements (1920) because the climate of the area supports a mixture of tall-, mid-, and shortgrasses. However, certain communities within this grassland association are quite xeric in nature and contain nearly pure stands of shortgrasses instead of a mixture of grasses of different stature. Other communities either have a mixture of short- and mid-grasses or pure stands of mid- and tallgrasses. In order to learn more about causes of variation in vegetation on the mixed prairie some soil water relation studies were made on four common grassland communities near Hays, Kansas.

Abstract No. 1026

Raitt, R. J. and R. L. Maze. 1968. Densities and species composition of breeding birds of a creosotebush community in southern New Mexico. Condor 70(3):193-205.

Censuses of breeding birds were carried out in 1964 and 1965 on a one-square-mile tract of desert scrub in southern New Mexico. Variation in the vegetation on the area permits recognition of three different types or habitats: major arroyo vegetation, small arroyo vegetation, and undissected upland or "divide" vegetation. These are under obvious control of soil water and constitute a series of increasingly xeric conditions. All three types are dominated by creosotebush, but the more mesic habitats contain vegetation with denser and taller shrubs and richer floristic composition.

Census results yielded definite evidence of breeding for nine bird species; and additional six almost certainly breed on the area or in similar nearby communities. Black-throated Sparrows attained the highest breeding densities and widest distribution within the area, presumably in part because they were the only birds to use creosotebushes for nesting. Verdins also were abundant but were restricted for nesting to sites with tall, thorny shrubs. Mourning Doves nested on the ground and were the only birds that nested in numbers in open upland vegetation. Other species nested in low densities and only in larger arroyos.

The avifauna of the area is poorer in species than those of other North American desert shrub communities. It is probably typical of Chihuahuan Desert scrub avifaunas and thus is more similar to those of other North American desert shrub communities. It is probably typical of Chihuahuan Desert scrub avifaunas and thus is more similar to those of western Texas than to those of southern Arizona. The absence of trees or tall shrubs accounts for absence of some birds species found on other deserts. Problems involved in faunistic comparisons of desert avifaunas are discussed.

Total density of breeding pairs (17.7 per 100 acres in 1965) was also low in comparison with other deserts. Variation in density in desert areas is correlated with available moisture, diversity, and productivity of vegetation, and number of breeding bird species. Increase in total density is achieved by addition of species under conditions of greater vegetational diversity and productivity.

Abstract No. 1027

Rasmussen, J. L. 1971. Abiotic factors in grassland ecosystem analysis and function, p. 11-34. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

The time and space distributions of the abiotic driving forces are the topics of consideration of this paper. The climate as defined by solar radiation, temperature, precipitation, evaporation, runoff, and wind is discussed. The distribution of these quantities across the grassland of the United States is shown by a series of maps developed from the long-term climatic records. Discussion of these parameters is focused on the factors that delineate the boundaries of the grassland and variations within the grassland area.

A simple energy and water balance of the earth-atmosphere interface is described (Thornthwaite-Mather model), and the model is applied to the mean monthly data at each of seven IBP Grassland Biome intensive observation plots. Characteristic soil water variations for each site are computed, and intersite comparisons are made. An identical analysis is performed for the 1970 data at each site. Variations in 1970 soil water between sites as well as deviations from the long-term average are noted.

Abstract No. 1028

Rasmussen, J. L., G. Bertolin, and G. F. Almeyda. 1971. Grassland climatology of the Pawnee Grassland. U. S. IBP Tech. Rep. No. 127. Approximately 90 p.

This report is presented in two parts: first, an analysis of historical data provides a climatological summary principally concerning precipitation and temperature of the Pawnee Grassland; and second, an analysis of historical data describes the solar radiation distributions in time and space over the North American grassland region.

Abstract No. 1029

Rauzi, F. 1960. Water-intake studies on range soils at three locations in the northern plains. J. Range Manage. 13:179-184.

Water-intake studies were conducted with a mobile infiltrometer on rangelands at three locations in the northern plains. Two of the three areas (Williston, North Dakota and McCone County, Montana) are in the 10- to 14-inch rainfall belt. The other area (Glacier County, Montana) is in the 15- to 19-inch rainfall belt. Fenceline comparisons were made between pastures rated in either a high or low range condition. Soil texture for the sites was either silt loam or loam.

Although significant relationships between water-intake rates and amount of forage yield and mulch were established for all areas, the individual regressions for the different areas show a closer degree of association among the variables and therefore greater accuracy can be obtained from their use.

Abstract No. 1030

Rauzi, F. 1963. Water intake and plant composition as affected by differential grazing on rangeland. J. Soil Water Conserv. 18:114-116.

Studies of water intake on rangeland soils were conducted at the Northern Great Plains field station, Mandan, North Dakota, during July 1961. The study areas, native range pasture grazed at three different intensities over a long period of time, afforded an unusual opportunity to determine the effect of livestock use on the rate of water intake. The investigation showed that the loss of surface cover and heavy use by livestock decreased the rate of water intake. Total water intake on the moderately grazed pasture was 1.6 times as great as on the heavily grazed pastures during the 1-hour test. Water intake on the ungrazed area was 1.8 times as great as on the moderately grazed pasture.

The composition of vegetation on the sites showed marked differences as a result of different histories of grazing. Blue grama was the dominant grass on the heavily grazed pasture, while western wheatgrass and needle-and-thread were more abundant on the moderately grazed pastures than on the other areas. Sedges were dominant on the area that had not been grazed since 1940 but prior to that time had been heavily grazed.

Since range herbage production is limited by the amount of water entering the soil, and since this is greatly influenced by the amount of old and new growth, management of grazing is a tool that can be used to increase the amount of precipitation available for plant use.

Abstract No. 1031

Rauzi, F. 1964. Late-spring herbage production on shortgrass rangeland. J. Range Manage. 17:210-212.

A study to determine the kinds and amounts of native vegetation present in late spring on native shortgrasss rangeland was conducted at the Archer Substation in Wyoming during the years 1959 through 1963. Clipping studies were conducted in late May on a pasture moderately grazed since 1945 to 1954 and lightly grazed thereafter.

Nearly three times more midgrass was produced on the moderately grazed pasture than on the lightly grazed pasture. Recovery of the pasture grazed lightly since 1955, previously heavily grazed, is slow and not reflected in the clipping data. Observations show that midgrasses are increasing, but the abundance of buffalograss and prevailing climatic conditions have not been conducive to the rapid reestablishment of the desirable species. There was no significant difference in the amount of short or warm-season grasses produced between the moderately and the lightly grazed pastures.

During the 5-year period there was wide variation in the amount of herbage produced and amount of precipitation. Average total herbage for the 5-year period was 303 and 241 lb. per acre, respectively, for the moderately and lightly grazed pastures.

May-June and April through August precipitation when correlated with yields gave highly significant correlation coefficients of 0.675 and 0.754, respectively.

Abstract No. 1032

Rauzi, F. and R. L. Lang. 1956. Improving shortgrass range by pitting. Wyoming Agr. Exp. Sta. Bull. 344. 11 p.

Two 15-acre pastures were pitted with an eccentric one-way disc in 1942 to determine the feasibility of increasing rangeland production with this implement. The published results of the first 10 years of the study showed a material increase in grazing capacity and in pounds of lamb produced per acre from pitting. To determine the expected longevity of range pitting in relation to increased forage and consequent meat production, the study was continued for another 3-year period for a total of 13 years.

Abstract No. 1033

Rauzi, F., R. Lang, and O. K. Barnes. 1958. Dual-purpose pastures for the shortgrass plains. Wyoming Agr. Exp. Sta. Bull. 359. 16 p.

Green forage for early spring and fall grazing, and hay for feeding livestock during winter storms, are generally in short supply for farmers and ranchers in the shortgrass plains area. Native grasses are, for the most part, warm-season species and are not adapted to hay production. The need for an early forage has been partially met by use of supplemental pasture seeded to crested wheatgrass and other cool-season species. In view of these grazing needs, a study was set up to determine hay production, fall grazing capacity, forage quality, and period of productivity of four introduced grass species seeded with alfalfa. Results of this study covering a 5-year period (1951 to 1955) are presented in this bulletin.

Abstract No. 1034

Rauzi, F. and A. H. Kuhlman. 1961. Water intake as affected by soil and vegetation in certain western South Dakota rangelands. J. Range Manage. 14:267-271.

During the summer months of 1957 and 1958, water-intake studies were conducted on instrumented rangeland watersheds in the 10- to 14-inch precipitation belt near Newell, South Dakota.

Data from four range sites on four watersheds showed that water-intake rates were correlated with range sites, as mapped by SCS, where the range condition class was comparable. With good range condition class, the water-intake during the first 15-min period of the 1-hr test was high even on thin or fine-textured soils. However, the rate of intake declined much more rapidly on such sites in later periods of the test except on thick well-structured clays which maintained a rate comparable to a sandy loam.

The effects of surface conditions such as texture, cracking, and amount of cover are important factors, but during prolonged rainfall subsurface features becomes important in determining the amount of water absorbed during the storm event.

Abstract No. 1035

Rauzi, F., R. L. Lang, and C. F. Becker. 1962. Mechanical treatments on shortgrass rangeland. Wyoming Agr. Exp. Sta. Bull. 396. 16 p.

Water intake studies were conducted with a mobile raindrop applicator on rangeland sites in six states in the Northern and Central Plains. Tests were designed to measure the effect of vegetational differences on the water intake of comparable soil mapping units at range fenceline contrasts. In addition, concentrations of tests were made on certain small experimental rangeland watersheds containing permanent hydrologic installations.

Results of 670 tests on nine range-soil groups located throughout a wide range in precipitation zones and latitudes were evaluated. Statistical analyses of the data included simple and multiple stepwise regressions. Equations were developed for estimating water intake rates for each range-soil group.

Abstract No. 1036

Rauzi, F., R. L. Lang, and C. F. Becker. 1963. Interseeding Russian wildrye into native shortgrass rangeland. Wyoming Agr. Exp. Sta. Bull. 406. 8 p.

In the spring of 1955, replicated native pastures at the Archer Substation near Cheyenne, Wyoming, were mechanically treated with a sod drill, a range pitter, and a range seeder, the latter two having been developed by the Wyoming Agricultural Experiment Station. Standard crested wheatgrass, alfalfa, and ammonium nitrate, at different rates, were applied to the native pastures by use of the sod drill and the Wyoming range seeder. There was no seeding or fertilization on the pastures treated with the range pitter at the time of pitting. The grazing results of this 5-year study show the following:

1. An average of 71.5 sheep days of grazing per acre was obtained from the pastures treated with the Wyoming range seeder. This was 17 and 12.6 days more grazing than was obtained from the pastures treated with the sod drill and the range pitter, respectively, and 29.2 days more than from the moderately grazed pastures.

2. Differences in lamb gain per head between treatments were negligible, but differences in lamb gain per head between years were significant. The best lamb gains per head were made in 1957 and the poorest during 1960, a very dry year.

Abstract No. 1037

Rauzi, F. and D. E. Smika. 1963. Water intake on rangeland as affected by simulated grazing and fertilization. J. Range Manage. 16:125-128.

Water intake studies were conducted at the Northern Great Plains Field Station, Mandan, North Dakota, during July 1961. Native rangeland was treated with three different harvesting conditions for a 4-year period (1958 to 1961) to simulate grazing. The influence of nitrogen fertilization was also studied.

Statistically significant differences between treatments were obtained in rates of water intake and kinds and amounts of herbage. Greater water intake rates were obtained where the herbage was clipped in the fall compared with frequent clippings throughout the season. There was no consistent decrease in water intake due to complete removal of the herbage with fall clipping compared with leaving one-half of the herbage. There was no consistent influence of nitrogen fertilization on water intake. Water intake rates during the second 30-min period of the 1-hr test were more closely correlated with total herbage and amount of mid-grasses than with the amount of blue grama or threadleaf sedge. Mid-grasses increased and blue grama decreased on plots receiving nitrogen and harvested in the fall.

Abstract No. 1038

Rauzi, F. and C. L. Hanson. 1966. Water intake and runoff as affected by intensity of grazing. J. Range Manage. 19:351-356.

Water intake rates on differentially grazed rangeland watersheds were nearly linear with the heavily grazed watershed having the lowest and the lightly grazed watershed the highest rate. Annual runoff was greatest from the heavily grazed watersheds and least from the lightly grazed. Storm characteristics were a factor in the production of runoff.

Abstract No. 1039

Rauzi, F., C. L. Fly, and E. J. Dyksterhuis. 1968. Water intake on midcontinental rangelands as influenced by soil and plant cover. U. S. Dep. Agr. Tech. Bull. 1390:1-58.

Water intake studies were conducted with a mobile raindrop applicator on rangeland sites in six states in the Northern and Central Plains. Tests were designed to measure the effect of vegetational differences on the water intake of comparable soil mapping units at range fenceline contrasts. In addition, concentrations of tests were made on certain small experimental rangeland watersheds containing permanent hydrologic installations.

Results of 670 tests on nine range-soil groups located throughout a wide range in precipitation zones and latitudes were evaluated. Statistical analyses of the data included simple and multiple stepwise regressions. Equations were developed for estimating water intake rates for each range-soil group.

Abstract No. 1040

Rauzi, F. and F. Smith. 1971. Infiltration rates by three soils with three grazing levels at the Central Plains Experimental Range. U. S. IBP Preprint No. 18. 21 p. [Submitted to J. Range Manage.]

Infiltration studies on native pastures grazed at different levels have generally shown that as the grazing level increased, infiltration rates decreased (Rauzi, 1963; Rauzi et al., 1968; Rhoades et al., 1964). Runoff, the hydrologic complement of infiltration, supports the same conclusions. Runoff studies from rangeland watersheds reveal the same trends as those obtained from infiltration studies (Hanson et al., 1970; Dragoun and Kuhlman, 1968; Sharp et al., 1964).

Physical properties of the soil mass and physical conditions of the soil surface control the infiltration process. In terms of the properties of the soil mass, Allis and Kuhlman (1962) found that runoff from native rangelands in South Dakota was three times greater from the fine-textured soils than from the medium-textured soils.

Hanks (1965) states that the physical condition of the soil surface can indeed control the amount and rate of water entering the soil during a rain, but when the soil surface is well covered with plant material, surface sealing is quite small. Therefore, the properties of the soil mass determine the infiltration. However, for rangelands, the surface conditions are precisely what are affected by grazing levels, both through removal of plant material and through compaction.

Physical changes in the surface soil itself (i.e., compaction) resulting from grazing occur more slowly than changes in the vegetation. Compaction is not always a permanent change, but often disappears after seasonal wetting and drying or freezing and thawing. Nevertheless, Rauzi et al. (1968) has shown that changes in both soil and in vegetation can be evaluated by infiltration experiments.

Plant material, both standing crop and litter, have a pronounced effect on infiltration. In northern Utah, Meeuwig (1970) found that the weight of live plants and litter accounted for 73% of the variance in the amount of water infiltrated by the soil. At Mandan, North Dakota, Rauzi (1963) found that the weight of total plant material accounted for 88% of the amount of water infiltrated.

Dee et al. (1966) showed that the amount of water entering a Pullman silty clay loam was positively correlated with the amount of standing crop and litter on the soil.

Abstract No. 1041

Ray, T. D. 1967. A study of the wintering population of golden eagles in northeastern Colorado. Colorado State Univ., Fort Collins. 5 p. (unpublished term paper).

The objectives of this study were (i) to establish a transect route for censusing wintering Golden Eagles on the plains of Colorado northeast of Fort Collins, Colorado; (ii) to determine movements of Golden Eagles into this area during the course of the fall migration; (iii) to determine approximate age of the eagles seen in the area; (iv) to sight eagles marked as nestling birds in previous seasons; and (v) to record the place of sighting, date and time of sighting, and to record such sightings on topographical maps.

Abstract No. 1042

Rechinthin, W. E. 1956. Elementary morphology of grass growth and how it affects utilization. J. Range Manage. 9:167-170.

There seems to be two primary reasons why grasses are efficient forage producers: (i) the location of the meristematic tissue and growth habits of the plant and (ii) the ability to produce new shoots from buds at the nodes, the process known as "tillering." Another feature adding somewhat to the value of grasses for grazing is their ability to withstand trampling. The plant is able to tiller if the shoot is removed by grazing or trampling. Thus we can see in grasses a type of plant that is adapted to withstand grazing and to be an efficient producer of forage for grazing animals.

Abstract No. 1043

Redmann, R. E. and G. Hulett. 1964. Factors affecting the distribution of certain species of compositae on an eastern North Dakota prairie. North Dakota Acad. Sci. 18:10-21.

It is because of the evident importance of the family compositae on the prairie that this group of plants was chosen for our investigation. The purpose of this project was to (i) determine the most abundant of compositae and (ii) to investigate some of the factors which might influence the distribution of these species.

Abstract No. 1044

Reed, E. B. 1957. Mammal remains in pellets of Colorado barn owls. J. Mammal. 38(1): 135-136.

Literature references to the food habits of the barn owl (*Tyto alba pratincola*) in eastern, mid-western, and Pacific regions of the United States are many, but since no records of small mammals utilized by this bird in the Rocky Mountain region were noted, the following may be of interest. In the autumn of 1953, 275 owl pellets were collected from an excavation 4 miles southwest of Fort Collins, Larimer County, Colorado. Several owl burrows were found in the vertical walls of this pit. The number of owls and length of time during which these burrows had been inhabited is not known, but two birds were seen simultaneously and the carcass of a third was found.

Pellets ranged in weight from 3.0 to 16.9 g and averaged 6.0. The number of skulls per pellet varied from one to seven. One thousand and eighteen skulls taken from the 275 pellets were identified as follows: (*Microtus ochrogaster*, 288; *Peromyscus* sp., 266; *Microtus pennsylvanicus*, 157; *Reithrodontomys* sp., 108; *Perognathus* sp., 65; mammal too fragmentary for identification, 49; *Mus musculus*, 36; passerine birds, 33; *Sylvilagus* sp., 11; *Rattus* sp., 2; *Dipodomys* sp., 2; and *Neotoma* sp., 1.

Crushing of the occipital and parietal bones was the most common damage to this group of skulls. In any one pellet both members of paired bones could usually be located, perhaps indicating that each pellet is the remnants of a particular meal. Figures above are conservative as "odd" bones were not enumerated.

The strongly nocturnal hunting habits of the barn owl are reflected by the absence of remains of diurnal mammals such as the least chipmunk (*Eutamias minimus*), rock squirrel (*Citellus tridecemlineatus*), and blacktailed prairie dog (*Cynomys ludovicianus*), all of which were known to occur in the immediate vicinity.

Abstract No. 1045

Reed, J. L. and D. D. Dwyer. 1971. Blue grama response to nitrogen and clipping under two soil moisture levels. J. Range Manage. 24(1): 47-51.

Effects of N-fertilization and clipping on production and water use of blue grama were evaluated under two soil water levels, field capacity and 1/5 available water. Nitrogen increased shoot production 77% on unclipped plants. Clipping decreased shoot production 287% below the control averaged across N levels. Soil water levels produced no differences in yields. Root weights were decreased an average of 253% below the control by clipping. No differences were observed in total water used between fertilized and unfertilized plants, but clipping reduced water used by 95%. Unclipped plants fertilized with 80# N/acre used more water than unfertilized unclipped plants. The amount of water required to produce a unit of a shoot was reduced 37% when fertilized. Clipping lowered this water requirement an average of 98%. Nitrogen greatly increased seed stalk numbers of seed stalks.

Abstract No. 1046

Reed, M. J. and R. A. Peterson. 1961. Vegetation, soil, and cattle responses to grazing on northern Great Plains range. U. S. Dep. Agr. Tech. Bull. 1252. 79 p.

During the period 1932-46, vegetation and soil responses to different intensities of grazing on mixed-prairie cattle range were determined at the U. S. Range Livestock Experiment Station near Miles City, Montana. Included were measurements of cattle responses associated with grazing intensity and estimates of proper stocking and herbage utilization.

Abstract No. 1047

Repp, W. W. and W. E. Watkins. 1958. Carotene, vitamin A, and inorganic phosphorus in the blood plasma of range cows. New Mexico State Univ., Agr. Exp. Sta. Bull. 420. 23 p.

Results of a 3-year investigation of the relationship between forage carotene and vitamin A in range cows from six ranches representative of the important ranching areas of New Mexico are presented. Complete supplementary tables and graphs are included in the appendix.

Abstract No. 1048

Reppert, J. N., R. H. Hughes, and D. A. Duncan. 1963. Herbage yield and its correlation with other plant measurements. U. S. Dep. Agr. Misc. Pub. 940:15-21.

Herbaceous plant responses may be evaluated in many ways, but researchers generally agree that weight is one of the best quantitative measure. Other plant measures may be important in the way that they are related to or are indicative of herbage yield.

Knowledge of herbage yield is seldom an end in itself, but is usually important only as it is related to some grazing animal product or ecological response. Objectives which are served, with varying degrees of success, by measures of herbage yield can be listed in five questions:

1. How do range improvement practices or malpractices affect herbage yield? Many practices can be included, such as fertilization, type conversion, reseeding, and rodent control, to mention a few. Here the yield of herbage may be the end product of evaluation.

2. How does grazing treatment affect herbage yield? The information may be determined for a given time, seasonally or from year to year. The study of effects of grazing intensity or system of grazing fit here.

3. How does grazing a known yield of herbage affect livestock weight response? Included are questions of live-weight increase per acre as well as individual animal performance based on the yield of important components of the herbage crop.

4. How does the quantity of herbage crop affect grazing capacity?

5. How well do yields reflect the impact of the weather year?

Abstract No. 1049

Reuss, J. O. 1971. Decomposer and nitrogen cycling investigation in the Grassland Biome, p. 133-146. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Microbial numbers and biomass have been measured at the Pawnee Site, and some data are available from comprehensive sites. Peak bacterial numbers in the surface soil are generally in the range of 20 to 40 × 10^6/g, with some higher values noted at Pawnee. At the Pawnee Site fungal populations have influenced long-term grazing treatments. Higher propagule densities were found on the lightly grazed pastures, but a larger number of high frequency species were present under heavy grazing. Estimates of dry weight microbial biomass at the Pawnee Site indicate a maximum of about 100 g/m^2 to a depth of 30 cm. The substrate supply is apparently only sufficient for 5 to 10 generations of cells per year.

Decomposition of filter paper and grass material were more rapid at the more humid Osage Site than at Pawnee. However, there was no evidence for differences in inherent decomposition rate other than those due to temperature and moisture availability. Carbon dioxide evolution rates were relatively constant at the Osage Site, but at Pawnee were highly dependent on moisture supply.

Nitrogen fixation measurements by the acetylene reduction method have failed to detect significant amounts of nonsymbiotic fixation at the Pawnee Site. Native legumes are present, but the density is low, and total symbiotic fixation is small. Total biological fixation is estimated at <0.1 g/m^2 annually. The major input of fixed nitrogen is apparently that contained in rainfall. Nitrogen losses from the system appear to be small, and present data indicate that the system could be self-sustaining on the rainfall input.

Abstract No. 1050

Reuss, J. O. 1971. Soils of the Grassland Biome sites, p. 35-39. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Although widely separated geographically and formed on diverse parent materials, 9 of the 10 dominant soils on the biome sites are classified in the Mollisol order. This order is comprised mainly of the dark, base rich soils of the semiarid and subhumid steppes. Even though they are consistent as to order, the soil properties vary widely. Texture varies from silty clay to loamy sand. Depth to bedrock varies from 35 to greater than 150 cm, and estimated available soil water storage capacity to 100-cm depth varies from 4.5 to 20 cm. While a few are acidic in the surface, with the exception of the mountain grassland, the soils tend to be largely base saturated. Native vegetation could be expected to respond to nitrogen fertilizer during periods when soil water availability is not limiting growth. Phosphorus responses might be expected at some sites. It is unlikely that native vegetation will respond to additions of other nutrients on these soils.

Abstract No. 1051

Reuss, J. O., and P. W. Copley. 1969. Soil nitrogen investigations, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 7. Colorado State Univ., Fort Collins. 13 p.

Biological nitrogen fixation is brought about largely by free-living bacteria or blue-green algae, which make use of N_2 by nonsymbiotic means, and by symbiotic associations composed of a microorganism and a higher plant. Fixed nitrogen is one of the more important inputs of nitrogen to be considered in the flow of nitrogen through and within a grassland biome. The investigation of biological nitrogen fixation on the Pawnee Site made use of the acetylene reduction technique.

Abstract No. 1052

Reuss, J. O., and P. W. Copley. 1971. Soil nitrogen investigations on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 106. Colorado State Univ., Fort Collins. 44 p.

Nitrogen fixation studies were conducted by an acetylene reduction technique on a variety of soil cores from the Pawnee Site under varying conditions of aeration, temperature, and energy supply. Both highly artificial, soluble energy source and anerobic conditions are required to achieve significant free living fixation. At saturation without artificial energy source, a maximum of a few grams per hectare per day are fixed. At field moisture, fixation is less than 1 g/ha/day. Under otherwise favorable conditions, a temperature regime of 0° C during the night and 16°C during the day essentially stopped fixation; and, when temperatures were increased, fixation was much less than in soils not subjected to cold treatment. Fixation rates on single potted legume plants were highly reproducible. No N fixation could be detected in pond waters.

Sampling variability studies indicate a high variability in total N content between similar soil mapping units at different locations. Where fertilizer N was spring-applied at the rate of 150 kg/ha, an average of 60 kg/ha remained as mineral N in the top 40 cm of soil. A few measurements of N in precipitation averaged about 1 ppm N.

Abstract No. 1053

Reynolds, H. G. 1958. The ecology of the Merriam kangaroo rat (*Dipodomys merriami* Mearns) on the grazing lands of southern Arizona. Ecol. Monogr. 28(2):111-127.

This study reports some life history, habitat, and economic relations of the Merriam kangaroo rat (*Dipodomys merriami*) for the Santa Rita Experimental Range and similar rangelands of southern Arizona.

Abstract No. 1054

Reynolds, H. G., F. Lavin, and H. W. Springfield. 1949. Preliminary guide for range reseeding in Arizona and New Mexico. U.S. Forest Service, Southwest Forest Range Exp. Sta. Res. Rep. 7. 14 p.

Range reseeding, properly done, can aid in restoring forage on many rangelands. It is the purpose of this publication, based on experience and research to date, to explain briefly the why, when, where, and how of reseeding for several different kinds of rangelands in Arizona and New Mexico.

Abstract No. 1055

Reynolds, H. G., and P. E. Packer. 1963. Effects of trampling on soil and vegetation. U.S. Dep. Agr. Misc. Pub. 940:117-122.

The role and importance of microorganisms, plants, and animals on soil factors in primary and secondary successions of grasslands and shrublands need further study. Knowledge of these factors and processes is basic to proper management of the soil-plant-animal complex.

In general, soil compaction decreases penetration of water, reduces water-storage capacity, lowers aeration, inhibits root penetration, and restricts activities of soil animals. These effects are reflected in depressed top growth of many plants. The effect of soil compaction on range plants has not been adequately studied. More information for specific range plants and soils is needed to guide management decisions.

Trampling effects on range soils have been measured as increased bulk density and reduced total porosity, organic matter, and infiltration. These effects are most pronounced in the surface 6 inches of the soil mantle. Trampling effects are most severe for moderately wet soils and those with a high clay fraction. Compaction standards will be needed for most plant associations and soil series as range management practices become more intensive.

Measurement of the effect of trampling upon plant cover and litter are mostly confounded by grazing. Unconfounded studies show that plant cover and litter are reduced by trampling. Dissipation of litter decreases infiltration of precipitation and increases moisture losses from surface layers of the soil. The main research lag is that of determining what effect compaction and trampling have upon reproduction, growth, and production of range vegetation.

Abstract No. 1056

Rhoades, E. D., L. F. Locke, H. M. Taylor, and E. H. McIlvain. 1964. Water intake on a sandy range as affected by 29 years of differential cattle stocking rates. J. Range Manage. 17:185-190.

Water relations for a Pratt loamy fine sand on the Southern Plains Experimental Range in northwestern Oklahoma were investigated after four levels of continuous cattle grazing had been imposed for 20 years. Water-intake rates were determined with a sprinkling infiltrometer and with a double-ring infiltrometer. In addition, the following measurements were obtained from each level of grazing: soil water retention, bulk density, penetration resistance, organic matter, nitrogen content, vegetative cover, and basal cover.

Abstract No. 1057

Rice, E. L. 1950. Growth and floral development of five species of range grasses in central Oklahoma. Bot. Gaz. 111:361-377.

Growth and floral development of little bluestem (*Andropogon scoparius*), big bluestem (*A. furcatus*), switch grass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), and side-oats grama (*Bouteloua curtipendula*) under prairie conditions were investigated near Norman, Oklahoma, during the growing season of 1948. Three plots--one on a ridge-top, one on a southeast slope, and one on a northwest slope--were fenced to exclude cattle. In addition to field observations on the condition of the five species, one culm was collected from each of ten different plants of each species (except little bluestem) each week for dissection and microscopic examination to determine whether inflorescences were being formed. For little bluestem, one culm was collected from each of five plants on each site each week to determine whether there were differences in growth and floral development on the various sites. Fairly complete microclimatic data were obtained for each plot.

Abstract No. 1058

Rice, E. L., and W. T. Penfound. 1954. Plant succession and yield of living plant material in a plowed prairie in central Oklahoma. Ecology 35(2):174-180.

The present paper presents a comparison of plant succession, plant production, and certain physical factors in three half-acre prairie plots near Norman, Oklahoma: unmulched, plowed; mulched, plowed; and unplowed (control).

Abstract No. 1059

Rice, E. L., W. T. Penfound, and L. M. Rohrbaugh. 1960. Seed dispersal and mineral nutrition in succession in abandoned fields in central Oklahoma. Ecology 41:224-228.

In an effort to explain why triple-awn grass, little bluestem, and switch grass come in at different stages of succession in revegetating old fields in central Oklahoma, a brief study of fruit dispersal in two of the species was made, and a more thorough investigation of the nitrogen, phosphorus, and potassium requirements of all three species was carried out.

Abstract No. 1060

Rice, R. W. 1970. Diet sampling of grazing herbivores. Colorado-Wyoming Acad. Sci., May 1-2, Greeley, Colorado.

Bifistulated wethers (esophageal and rumen) were used to collect samples of the diet while grazing shortgrass native range. The esophageal and rumen grab samples were different botanically. There were fewer forbs and more grasses found in rumen samples. The nitrogen content of rumen samples was higher than that of esophageal samples. Rumen samples had lower in vitro dry matter digestibility than esophageal samples. Rumen grab samples cannot be expected to yield quantitative botanical information on grazing animals diet or on nitrogen content and dry matter digestibility.

Abstract No. 1061

Rice, R. W. 1971. Consumer function in the grasslands, 1971. U.S. Forest Service Short Course, April 7, Fort Collins, Colorado.

Herbivores represent the connection between primary productivity and the food web of nonherbivores, principally man. These herbivores under reasonable stocking rates will not remove a large proportion of the fertilizing constituents from the ecosystem. They are important processors of primary production and accelerate the decomposition of primary productivity in the system. Mixtures of herbivores are generally able to utilize primary production more than single species when the primary production consists of mixed species of plants.

Abstract No. 1062

Rice, R. W., D. R. Cundy, and P. R. Weyerts. 1969. A comparison of the esophageal fistula with rumen samples for the determination of the botanical and chemical composition of the diet of herbivores. U.S. IBP Grassland Biome Tech. Rep. No. 11. Colorado State Univ., Fort Collins. 13 p.

Bi-fistulated wethers (esophageal and rumen) were used to collect samples of the diet while grazing shortgrass native range. The esophageal and rumen grab samples were different botanically. There were fewer forbs and more grasses found in rumen samples. The nitrogen content of rumen samples was higher than that of esophageal samples. Rumen samples were lower in in vitro dry matter digestibility than esophageal samples. Rumen grab samples cannot be expected to yield quantitative botanical information on grazing animals diet or on nitrogen content and dry matter digestibility.

Abstract No. 1063

Rice, R. W., and M. Vavra. 1969. Botanical species of plants eaten and intake of steers grazing light, medium, and heavy use shortgrass range. U.S. IBP Grassland Biome Tech. Rep. No. 12. Colorado State Univ., Fort Collins. 18 p.

It is difficult to determine the diet of grazing herbivores. These animals select plant species and can even discriminate for or against portions of plants while grazing. Prior to the adaptation of the esophageal fistula to grazing studies, dietary information about plants selected and the nutritional quality of herbivore diets was determined largely by close observation of animals as they grazed or by before and after herbage sampling techniques. Where exact dietary information is necessary, it is most accurate to use the animal as the direct sampling agent rather than to rely on indirect information.

Quantitative information on the amount of individual plants eaten and the nutritive value of the diet requires that there be a direct measurement of intake or excretion coupled with dietary utilization information.

The purpose of this study was to measure the botanical species eaten, the dietary nitrogen content, and the intake of grazing steers as affected by season and intensity of use of shortgrass rangelands.

Abstract No. 1064

Rice, R. W., D. R. Cundy, and P. R. Weyerts. 1971. Botanical and chemical composition of esophageal and rumen fistula samples as sheep. J. Range Manage. 24(2):121-124.

Bifistulated wethers (esophageal and rumen) were used to collect samples of the diet while grazing shortgrass native range. Rumen samples were obtained by grab sampling rumen contents. The rumens were not evacuated prior to sampling. The esophageal and rumen grab samples were different botanically. There were fewer forbs and more grasses found in rumen samples. The nitrogen content of rumen samples was higher than that of esophageal samples. Rumen samples were lower in in vitro dry matter digestibility than esophageal samples. Rumen grab samples cannot be expected to yield quantitative botanical information on grazing animals diet or on nitrogen content and dry matter digestibility.

Abstract No. 1065

Rice, R. W., J. G. Nagy, and D. G. Peden. 1971. Functional interaction of large herbivores on grasslands, p. 241-265. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

The herbivore forms a link in the food chain of man by degrading plant structural carbohydrates which are not utilized directly by improvement of nutritive value of primary plant production, by the use of poor quality protein and nonprotein nitrogen for synthesis of high quality protein, and by the synthesis of the B vitamins and vitamin E. The herbivore also harvests primary production where topography or productivity precludes other harvesting methods. The herbivore also accelerates the decomposition of plant biomass.

The U.S. IBP Grassland Biome large herbivore group is studying the impact and interrelation of the pronghorn antelope, American bison, domestic cow, and sheep on grasslands. Studies to date indicate that there is a similar basal metabolic relationship among these herbivores. Their functional interaction should be described in terms other than metabolic efficiency. The American bison was shown to have a higher digestive power than domestic cattle on grassland forages; the difference was greater when mature forages were consumed. The utilization of diets by cattle was not greatly different according to grazing intensity. Summer diets had a higher nutritive value than spring or winter diets. Cattle on the heavily grazed pasture ate a larger proportion of grass, forbs, and shrubs than those on the light use pastures. Cattle gained more per head on the light use pasture whereas a total gain per hectare was greater on the heavy use pasture. Differences in cattle productivity were largely due to differences in the total intake of forage per individual animal or per pasture and on diet utilization. Antelope consumed a higher quality diet than cattle regardless of the season; cattle ate a higher proportion of grasses than antelope while antelope ate more forbs and the half-shrub fringed sagewort. The similarity of cattle and antelope diets was affected by seasons; the diets were least similar during the growing season when selection opportunity was greatest and most similar during the winter, with fewer varieties of plants available and with all plants more mature. Dietary comparisons among summer diets of antelope, bison, cattle, and sheep were made; cattle and bison ate the most similar diets, while antelope ate diets least similar to the other herbivores; sheep were intermediate between cattle, bison, and antelope in dietary habits. Preliminary observations on grazing behavior indicate that location of grazing and season are important factors influencing herbivore interaction. Preliminary optimization of primary production used by herbivores indicates that mixtures of herbivores should be more efficient secondary producers from grasslands than single species.

Abstract No. 1066

Rice, R. W., and M. Vavra. 1971. Botanical species of plants eaten and intake of cattle and sheep grazing shortgrass prairie. U.S. IBP Grassland Biome Tech. Rep. No. 103. Colorado State Univ., Fort Collins. 21 p.

Esophageal fistulated heifers were used to obtain samples of the diets of light and heavy use pastures. Esophageal fistulated heifers and sheep were used to collect dietary samples on the herbivore diet pastures. Grasses made up a major portion of the diet in 1970. They were relatively more important than in 1969. This was probably due to a reduced availability of forbs because of 1970 precipitation. Blue grama (*Bouteloua gracilis*) was the most important grass eaten. Other grasses of importance were western wheatgrass (*Agropyron smithii*), red threeawn (*Aristida longiseta*) and needle-and-thread (*Stipa comata*). The sedge, *Carex heliophila*, was also important. Forbs were less prominent in the diets of cattle on the light use pasture in 1970 than in 1969. Environmental limitations due to precipitation may have reduced the availability of forbs to cattle. Scarlet globemallow (*Sphaeralcea coccinea*) was again the most important forb and was apparently a preferred forb. Many other forbs were noticed in the diet, but were not of continued individual importance. Shrubs were a very minor component of the diet. Dietary crude protein was adequate throughout the summer. Dry matter digestibility declined through the season and was lower in July and August on the heavy use pasture. Dry matter intake and digestible energy intake increased seasonally. The intake per animal was lower in the heavy use pasture. Winter samples were collected in December of 1969. These indicate that winter diets include a much greater proportion of the half shrub fringed sagewort (*Artemisia frigida*) in the light use treatment, whereas shrubby plants on the heavy use pasture were not nearly as important. The thistle (*Cirsium undulatum*) was evidently eaten in unusual quantity in the heavy use pasture at the time winter samples were obtained.

Abstract No. 1067

Rickard, W. H. 1970. Ground dwelling beetles in burned and unburned vegetation. J. Range Manage. 23(4):293-294.

Pitfall trapping of ground dwelling beetles in burned and unburned stands of shrub steppe vegetation showed that the same four species occurred in both places. However, more *Eleodes hispilabris* and *Pelecyphorus densicollis* were caught in the unburned vegetation.

Abstract No. 1068

Rickard, W. H., and T. P. O'Farrell. 1970. Comprehensive Network Site description, ALE. U.S. IBP Grassland Biome Tech. Rep. No. 36. Colorado State Univ., Fort Collins. 5 p.

ALE Site is located on the arid land ecology project whose land and facilities are owned by the U.S. Atomic Energy Commission and operated by the Pacific Northwest Laboratories, Battelle Memorial Institute, Richland, Washington. The project is located in southeastern Washington, north and west of the confluence of the Yakima and Columbia Rivers, Benton County. The project can be reached via State Highway 240, 10 miles northwest of Richland. The total land area involved is approximately 120 square miles, all in one piece, and is completely fenced. There are no public roadways through the area.

Abstract No. 1069

Riegel, A. 1940. A study of the variations in growth of blue grama grass from seed produced in various sections of the Great Plains region. Kansas Acad. Sci., Trans. 43: 155-171.

This study is concerned with the variations in the root and top growth of blue grama grass when grown from seed which was produced in various sections of the Great Plains region. The three phases of this problem which were investigated are: the number and extent of variations, whether or not these variations are inherited, and will these grass plants grow and establish themselves in sections to which they are not native.

Abstract No. 1070

Riegel, A. 1941. Life history and habits of blue grama. Kansas Acad. Sci., Trans. 44:76-83.

The caryopsis of blue grama is enclosed by the lemma and palea, the lemma being awned. The floret is about 0.5 cm long and the caryopsis is about 2.5 mm in length and triangular in cross section.

The seed germinates in about 3 days to 2 weeks after planting. The seminal root grows to a depth of 6 to 14 cm, becoming inactive after 4 to 6 weeks. After the seedling has produced three or four leaves the first crown root and the first tiller start to elongate. Moist surface soil is necessary for crown roots to become established. Tillers may develop and increase in number without the establishment of crown roots causing a severe drain on the few established roots. Adventitious roots elongate rapidly when moisture becomes available growing 6 to 8 cm in 4 days.

The blue grama plant produces a raceme type of inflorescence bearing one-sided spikes upon which two rows of sessile spikelets are attached to the rachis. The three anthers of the fertile floret mature and emerge from the lemma about 1 to 2 weeks after the spike has elongated from the heat. Soon after the anthers have emerged and the pollen has been dispersed, the two stigmas appear on either side of the palea becoming receptive soon after emerging.

When the seed becomes mature the spikelets disarticulate from the glumes and are disseminated by the wind. Blue grama seed apparently is not carried far because the species is very slow to invade new areas. The seed is readily harvested.

Blue grama is an important grass throughout the Great Plains Region tending to form sods in the north and bunches in the south. It endures freezing and drought by becoming dormant. Its vigor and resistance to these factors are greatly lessened by prolonged dry conditions and overgrazing. It resumes growth slowly in the spring and quickly after summer rains.

The blue grama grass grows to a height of 8 to 24 inches and produces a dense, fibrous root system which extends 6 or more feet in depth.

It is highly recommended for use in artificial revegetation of abandoned farm land and depleted ranges.

Abstract No. 1071

Riegel, A. 1941. Some coactions of rabbits and rodents with cactus. Kansas Acad. Sci., Trans 44:96-103.

The dissemination of prickly pear (*Opuntia humifusa*) seed by jackrabbits (*Lepus californicus melanotis*) as a result of eating the fruits of the plants, and the planting of the seed by ground squirrels in satisfying their food-storing habit, are the principal means by which seed of this cactus is scattered in this part of Kansas. The using of the seed for food by the rodents acts as a check on the increase of cactus by growth from seed. Ground squirrels remove cactus seed from fecal pellets of rabbits, further reducing the chances of increasing cactus from seedling production.

Abstract No. 1072

Riegel, A. 1942. Some observations of the food coactions of rabbits in western Kansas during periods of stress. Kansas Acad. Sci., Trans. 45:369-375.

The jackrabbits and cottontails are common residents of the Great Plains and the most numerous spp. of wild game. Prickly pear cactus, broomweed, pigweed, and sand dropseed grass appear to be the favored food plants of rabbits on the range during favorable and unfavorable times. During drought periods, forbs with succulent roots are sought out and cactus pads and fruits are eaten in large quantities. While heavy snows covered the ground rabbits ate quantities of dried remnants of Russian thistle, buffalo bur, sand dropseed, yucca, and cottontails ate cedar berries and twigs of ornamental shrubs. Considerable numbers of spines of buffalo bur and prickly pear were found in the pellets of rabbits. Rabbits act as agents of dispersal for several species of plants by disseminating them in their fecal pellets, sand dropseed, prickly pear and pigweed being principal seeds observed in fecal pellets. Germination tests indicate that some of these seeds are viable. Rabbits may have a part in the early appearance of sand dropseed in land retired from cultivation.

Abstract No. 1073

Riegel, A. 1943. A source study of blue grama grass and the effect of different treatments on establishing stands of grass under field conditions at Hays, Kansas. Kansas Acad. Sci., Trans. 46: 102-109.

The study was conducted to obtain data on source plantings of blue grama and seedling establishment under different treatments of seed bed preparation and clipping.

Seed from 10 sources in the Great Plains region was planted and subjected to 6 different experimental treatments involving weed competition and grazing or clipping.

This report is not conclusive and due to limited investigation can only show trends.

Apparently better results will be obtained if the weeds are destroyed by cultivation before planting if seeding is to be done late in the spring.

It appears that northern blue grama grass is more resistant to grasshopper damage than that from central and southern sources and establishes itself better under weeds than the other sources if the weeds are mowed occasionally during the first growing season. Where weeds are numerous and are neither destroyed by cultivation before planting nor by clipping or mowing afterward, blue grama seedlings from any source have little chance of establishing themselves.

Abstract No. 1074

Riegel, A. 1944. A comparative study of natural and artificial revegetation of land retired from cultivation at Hays, Kansas. Kansas Acad. Sci., Trans. 47:195-214.

The major portion of the crop land in the central and western Great Plains region has been under cultivation for 25 years or less, but in this time many fields have been abandoned for various reasons and allowed to be revegetated by nature.

Surveys conducted by several investigators indicate the return of the more important native grasses to these fields is slow and the establishment of the original disclimax vegetation requires many years.

A cultivated field on the college farm at Hays, Kansas, was retired from cultivation in 1920 and made a part of the native grass pasture. Twelve years after its abandonment, buffalo grass covered about 10% of the area and 3 years later the grass had increased to a cover of about 35%.

Twenty-four years after being retired from cultivation the grasses of the field totaled about 36%, of which 26% was buffalo grass, and 2% was blue grama. The native shortgrass prairie at the same time had over 90%.

A second field was taken out of cultivation and part of it sown to blue grama in the spring of 1941. The grass occupied about 16% of the area sown at the end of the first growing season and had attained a cover of 38% by 1943. Heavy infestations of weeds were present in the field during the first two growing seasons, but were few in number and small in size in 1943. In three seasons of growth, blue grama, seeded on retired farm land, had a basal cover of grass exceeding that of the field which had been undergoing natural revegetation for 24 years.

The cost per acre of natural revegetation is confined primarily to interest and taxes on the land, while in artificial revegetation the immediate cost per acre is considerable. An expenditure of over five dollars per acre was made in establishing the stand of blue grama in 1941. After 3 years growth the area seeded to blue grama had about the same carrying capacity for livestock as the area undergoing natural revegetation had 15 years after retirement from cultivation.

The cost of artificial revegetation could be liquidated within 10 years after seeding.

Abstract No. 1075

Riegel, A. 1947. Forage yields (1945) of various native pasture grasses established artificially at Hays, Kansas, in 1941. Kansas Acad. Sci., Trans. 50:174-190.

Eight species of native pasture grasses were established artificially in the spring of 1941 at Hays, Kansas, under the same field conditions of seed bed preparation and weed control. Five of the species, buffalo grass and blue grama, were subjected to three different treatments of seed bed preparation and control of weeds after seeding. Three different sources of blue grama (southern, central, and northern) were used in the above study.

Data were collected from the various grasses for forage yield, basal cover, growth increment, accumulation of debris, and depth of litter.

Abstract No. 1076

Riegel, A., F. W. Albertson, and H. H. Hopkins. 1950. Yields and utilization of forage on a mixed prairie in west central Kansas. Kansas Acad. Sci., Trans. 53:455-472.

The purpose of this study was to obtain information concerning yield, utilization, and composition of the vegetation in a typical mixed-prairie pasture.

Abstract No. 1077

Riegel, A., F. W. Albertson, G. W. Tomanek, and F. E. Kinsinger. 1963. Effects of grazing and protection on a twenty year old seeding. J. Range Manage. 16:60-63.

Study of a seeded area after 20 years of protection and 17 years of moderate grazing revealed many characteristics of an upland area in west-central Kansas.

Three different grass mixtures were seeded on a clay upland site characterized by a heavy silty clay loam to silty clay soil. The grass mixtures used were bluestem mixture containing big and little bluestem, sideoats grama, and switchgrass; blue grama only; and western wheatgrass-grama mixture with western wheatgrass, blue grama, and sideoats grama.

Average yields of native and seeded grasslands for the past 17 years were about equal indicating that the site potential under grazing is about the same regardless of species.

Results of this study of a 20-year-old seeding trial would indicate that use of dominant, native grasses in a seeding mixture is most satisfactory. Results of this study indicate that the clay upland site is capable of maintaining tallgrasses with complete protection but not with moderate use.

Previous history of cultivation may influence the type of grasses the soil will support.

Abstract No. 1078

Risser, P. G. 1969. Competitive relationships among herbaceous grassland plants. Bot. Rev. 35: 251-283.

The present state of the art of grassland competition is one of imminence rather than eminence. We know many fragments and bits of information, but heretofore have been unable to unite all of what we do know into an integrated system.

It is possible to describe mathematically one and two species competitive systems both in terms of numbers and amount of plant material produced. Likewise, it is possible to predict the conditions under which a third species may invade and certain facts about the reproductive capacity required for particular environmental conditions. At present most of these models are derived from theoretical or experimental populations, and in some cases expansion will be necessary for application to field conditions. The groundwork is available.

This survey of previous investigations provides an indication of those important aspects of plant growth which are most likely to assist in the elucidation of competitive relationships. If for any given species the seed size and number, time of germination, rate of vegetative reproduction, rate of growth, maximum number and size of individuals attained under optimum conditions, soil level at which roots operate, time of and conditions for initiation of root and shoot growth, and any allelopathic considerations are known, a reasonably good prediction can be made concerning the success of that species relative to any other for which the same information is known.

Abstract No. 1079

Risser, P. G. 1969. Competitive relationships among herbaceous plants and their influences on the ecosystem function in grasslands, p. 153-171. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Competition among organisms may be defined as the simultaneous demands for the same resources in a common environment when these demands are in excess of the immediate supply. The resources for which competition may occur among plants are water, nutrients, light, oxygen, carbon dioxide; and during the reproduction phase, agents of pollination and dispersal. Mathematical models developed from both theoretical and experimental populations of pure and mixed species are examined in terms of the conditions for which they are valid and for the expansions which will be necessary for application to field conditions. The fragmented information now available can be united into a general model. This number, time of germination, rate of vegetative production, rate of growth, maximum number and size of individuals attained under optimum conditions, soil level at which roots operate, time and conditions for initiation of root and shoot growth, and any allelopathic considerations are known for any given species, a reasonably good prediction can be made concerning the success of that species relative to any other for which the same information is known. The competitive relationships for a community can then be represented by a species-by-species matrix in which the elements would represent nonlinear coefficients by which the total productivity would be differentially partitioned among species under the constraints imposed by soil water, nutrients, grazing, etc.

Abstract No. 1080

Risser, P. G. 1970. Comprehensive Network Site description, OSAGE. U.S. IBP Grassland Biome Tech. Rep. No. 44. Colorado State Univ., Fort Collins. 5 p.

The Osage Site is located on the Adam's ranch which is owned by Mr. K. S. Adams. This is a functioning beef ranch now operating under the direction of the manager, Mr. Dick Whetsell, Foraker, Oklahoma. The site is located in Osage County which is in the northeast corner of Oklahoma. The ranch is 35,000 acres in size, but the headquarters and study area are located 12 miles north and 5 miles east of Shidler, Oklahoma. The experimental design consists of two areas. The ungrazed control is a 12.6-acre (500 ft × 1100 ft) rectangle which has been ungrazed (but probably mowed) for approximately 15 years. The grazed area is approximately 400 acres and is adjacent to the control area. Although there is some variability in the range use, the pastures are lightly to moderately grazed.

Abstract No. 1081

Risser, P. G. 1971. Osage Site, 1970 report, primary production. U.S. IBP Grassland Biome Tech. Rep. No. 80. Colorado State Univ., Fort Collins. 41 p.

Results of the study of primary production on the Osage Site in the 1970 season are summarized in tabular form. These include meteorological data, sampling dates, and results of above- and belowground biomass, and litter collection on the grazed and the ungrazed treatment areas.

Abstract No. 1082

Risser, P. G. 1971. Plant community structure, p. 41-58. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

The 1970 field season data show that 65% of the aboveground plant biomass on the Grassland Biome study sites was composed of grasses and that the tribes Andropogoneae and Chlorideae and the family Compositeae contribute well over half the total live biomass. The Hays, Osage, Bison, and Bridger Network Sites have bunchgrasses as the dominant growth form, while Jornada, Pantex, and Pawnee have mostly sod grasses. Dickinson and Cottonwood have a substantial representation of both growth forms. If the Network Sites are ordinated by either floral or vegetational similarities, the resulting configurations are very similar and closely approximate a site ordination based on environmental variables. There appears to be a general increase in phenological diversity with an increase in the amount of live standing crop.

The concepts of pattern, species diversity, and aerial cover were evaluated on only a few sites, so biome-wide comparisons were not possible. Phenology was measured throughout the 1970 growing season, but the interpretation of these data has proved difficult. Certain elementary characteristics such as height of vegetation, and proportion of warm and cool season grasses, showed a consistent relationship across the network. However, one of the most interesting aspects of the grassland structural data is the fact that many characteristics do not show a uniform response, indicating the multitude of adaptive strategies employed within the grassland ecosystem.

Abstract No. 1083

Robbins, C. S., and W. T. Van Velzen. 1967. The breeding bird survey, 1966. U.S. Dep. Interior, Spec. Sci. Rep.-Wildlife No. 102. 43 p.

A Breeding Bird Survey of a large section of North America was conducted during June 1966. Cooperators ran a total of 585 survey routes in 26 eastern states and 4 Canadian provinces. Future coverage of established routes will enable changes in the abundance of North American breeding birds to be measured.

Routes are selected at random on the basis of 1° blocks of latitude and longitude. Each 24½-mile route, with 3-min stops spaced ½-mile apart, is driven by automobile. All birds heard or seen at the stops are recorded on special forms and the data are then transferred to machine punch cards.

The average number of birds per route is tabulated by state, along with the total number of each species and the percent of routes and stops upon which they were recorded. Maps are presented showing the range and abundance of selected species. Also, a year-to-year comparison is made of populations of selected species on Maryland routes in 1965 and 1966.

Abstract No. 1084

Robbins, W. W. 1917. Native vegetation and climate of Colorado in their relation to agriculture. Colorado Agr. Exp. Sta. Bull. 224. 56 p.

A close relationship exists between climate and vegetation, whether vegetation in the native state or under cultivation. Each climatic region has its characteristic natural plant life. There are, also, certain crop plants best suited to every distinct climatic area.

Colorado has a variety of climates. One may travel from the warm valleys of the Western Slope, or from the Great Plains, to the crest of the Continental Divide, and pass through as many distinct climates as he would in travelling from Virginia to arctic Greenland. This variety is largely a result of differences in altitude, although range of latitude and topographic diversity are also responsible. The lowest point in Colorado has an elevation of 3386 ft, and the highest, 14,402 ft, thus giving an altitudinal range of 11,016 ft. The latitudinal range is 4° (37° to 41°). Chiefly as a consequence of the great altitudinal variation, Colorado has many distinct climates, each with native plants and with crop possibilities peculiar to it.

Abstract No. 1085

Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hurlbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. J. Range Manage. 23(4):295-297.

Visual obstruction measurements were used to determine height and density of vegetation in a Kansas grassland. These visual obstruction measurements were compared with the weight of vegetation collected from each site. The weight of vegetation collected was significantly correlated with the visual obstruction measurements.

Abstract No. 1086

Robertson, J. H. 1933. Effect of frequent clippings on the development of certain grass seedings. Plant Physiol. 8:425-447.

Seedlings of six range and pasture grasses were grown in soil in the greenhouse and their development was studied after each of four clipping treatments.

Abstract No. 1087

Robertson, J. H. 1939. A quantitative study of true-prairie vegetation after three years of extreme drought. Ecol. Monogr. 9(4):431-492.

The drought of 1936 continued the destruction which in 1934 so greatly changed the composition of native vegetation of the true prairie. The summer of 1936 was the hottest and driest ever recorded in eastern Nebraska.

Studies were made of 100 permanent list plots, together with estimates of abundance of all species occurring in randomly selected temporary plots on nine annually mowed, but ungrazed, prairies in 1936 and 1937.

Abstract No. 1088

Robertson, P. A., and R. T. Ward. 1970. Ecotypic differentiation in *Koeleria cristata* (L.) Pers. from Colorado and related areas. Ecology 51(6):1083-1087.

The phenological and morphological response of populations of *Koeleria cristata* (L.) Pers. from Colorado and related areas in a transplant garden at Fort Collins indicated marked heritable differences. Most significantly, and contrary to what would be predicted on the basis of other such studies involving elevational gradients, the highest collections from Colorado (about 2850 m) were latest in development. The moisture regime of the native habitats was a more important selection force than the length of the growing season. Plants from the northern plains were similar in phenology and morphology to plants from the plains-foothills region of eastern Colorado. Two, and possibly three, regional relationships are suggested for the Colorado populations.

Abstract No. 1089

Robinson, R. D. 1970. IBP Grasslands Biome budget program. U.S. IBP Grassland Biome Tech. Rep. No. 25. Colorado State Univ., Fort Collins. 10 p.

The program computes the benefits, indirect costs, subtotals and totals for each budget. The benefits are calculated at a given rate of all salaries except graduate students, pre-baccalaureate students and professional school students. The rate used depends on the institutional code number. The indirect funds for each budget are calculated at a given rate of one of three different bases. The three bases used are: (i) total salaries and wages; (ii) total salaries, wages, and benefits; and (iii) total direct costs less capital.

Abstract No. 1090

Robocker, C. W., and B. J. Miller. 1955. Effects of clipping, burning, and competition on establishment and survival of some native grasses in Wisconsin. J. Range Manage. 8:117-121.

The effects of fire, cutting, and competition from bluegrass and weeds on the establishment and survival of big bluestem, little bluestem, sideoats grama, Canada wildrye, Virginia wildrye, switchgrass and Indian grass were studied in the years 1949 through 1952. Field experiments were conducted on an infertile, badly eroded soil on the University West Hill Farm and on a field of low fertility, vegetated with a dense sod of bluegrass, quackgrass and perennial forbs in the University Arboretum at Madison, Wisconsin.

Abstract No. 1091

Roe, F. G. 1951. The North American buffalo. A critical study of the species in its wild state. Univ. Toronto Press, Toronto, Ontario, Canada 957 p.

The object of this essay has been not so much to suggest conclusions as to present facts. First and foremost, if our evidence can be considered to bear any meaning whatever, it has demonstrated beyond disproof the inapplicability to the buffalo species, even to the degree of absurdity, of any theory of uniformity or regularity in their habits.

Certain phases of buffalo history are inseparable from the history of the Plains Indians. I have noted what I consider to have been the evil effects on our knowledge of the true history of the buffalo which followed from Indian haters' contemptuous rejection of anything and everything which Catlin had to say, whether concerning Indians or not. It does not appear to have been realized to what degree of absurdity this reckless anti-Indian attitude is reduced when some of its disconnected assertions are brought into conjunction one with another.

Perhaps impartiality was not to be expected in 1889. But despite the splendid endeavors of American scholars who have honored themselves and their country alike by their efforts to secure a posthumous justice for the Indian of the nineteenth-century era of wars and hatreds, it is painful to note a similar difficulty some 20 years later, and even more nearly the present time. The varied relationships of buffalo and Indian make it impossible to doubt that the determination to discredit the Indian in defiance of evidence, by fair means or foul, must have contributed to seriously distort the world's conception of many aspects of buffalo history. But we do know from a careful examination of comparative data that more than one critic has eagerly seized upon anything discreditable to the half-breed and has ignored other evidence. I have endeavored to set these facts in their true light.

I may remind the critical reader that in my own ignorance of biology, I have steadfastly refrained from intrusion into that sphere. In dealing with an animal now extinct as a free wild species in its most characteristic native habitat, the first task is to ascertain and classify the historical evidence; and not until this has been done can biological investigation proceed with much profit.

Abstract No. 1092

Rogers, C. M. 1953. The vegetation of the Mesa de Maya region of Colorado, New Mexico, and Oklahoma. Lloydia 16(4):257-290.

The Mesa de Maya is a tableland capped by a layer of basalt believed to have been extruded in Pliocene time. It was chosen for vegetational study because of its critical location at the meeting point of the flora of the plains with that of the Rocky Mountains. The present collections proved to be important in delimiting the ranges of a number of species.

The vegetation is classified into (i) the prairie community, (ii) the foothill community, (iii) the mountain community, and (iv) the riparian community, including an alkali flat. A list of the species collected during the study is given and the relative abundance of each in each of these communities is indicated.

Several species are endemic. In addition a number of species extend into the surrounding areas, but the Mesa de Maya may be regarded as the nucleus of their geographic distribution. Some of these and a number of species with disjunct distributions appear to be relict species which are related to the flora of the region toward the southwest.

The climate, the immaturity of many of the soils, and the topography have been the major factors in determining the development and distribution of the present vegetation. The prairie community represents the climatic vegetational type under the present climatic conditions.

Abstract No. 1093

Rogers, C. M. 1954. Some botanical studies in the Black Mesa region of Oklahoma. Rhodora 56: 205-212.

Of the nearly 600 species collected by the writer over the whole Mesa de Maya, approximately 500 were found, or could be found in Oklahoma. The remaining 100, still unknown in the state, came from adjacent New Mexico and/or Colorado. Of these some grow near the western end of the Mesa de Maya, 30 miles or more from the Oklahoma state line and up to 1800 feet higher in elevation, and can scarcely be expected within the state. A number, however, were collected within 20 miles of the state line, in habitats almost identical to those existing on and about the Black Mesa. These should be looked for within the state.

Abstract No. 1094

Rogers, L. E. 1972. The ecological effects of the western harvester ant *Pogonomyrmex occidentalis* in the shortgrass plains ecosystem. Ph.D. Diss. Univ. Wyoming, Laramie. 114 p.

Ecological effects of the western harvester ant, *Pogonomyrmex occidentalis* (Cresson) were studied on the IBP grassland intensive study site located in northeast Colorado. Energy values were determined for populations in differentially grazed pastures by estimating the energy required for ant production and respiratory heat loss.

Abstract No. 1095

Rogers, L. E., and R. J. Lavigne. 1972. Asilidae of the Pawnee National grasslands, in northeastern Colorado. Wyoming Sci. Monogr. No. 25. Univ. Wyoming. 62 p.

There are 21 species of Asilidae (robber flies) known to occur on the IBP Pawnee Intensive Study Site. This report contains keys and descriptions of these species as well as a discussion concerning their ability to coexist in the grassland ecosystem.

Abstract No. 1096

Rogler, G. A. 1951. Twenty-five year comparison of continuous and rotation grazing in the northern plains. J. Range Manage. 4:35-41.

A deferred and rotation pasture was established in 1918 as part of the long time grazing experiment at the Northern Great Plains Field Station. Results on the rotation pasture are compared to those on two continuously grazed pastures, one grazed moderately and one heavily.

Abstract No. 1097

Rogler, G. A., and H. J. Haas. 1947. Range production as related to soil moisture and precipitation on the northern Great Plains. J. Amer. Soc. Agron. 39(5):378-389.

Whether fall soil water in rangeland could be used to predict the following season's forage yields and cattle gains was studied from 18 years of forage yields and 19 years of cattle gains. The relations to yields and gains of April-July precipitation alone and together with the preceding fall soil water were also studied. Highly significant coefficients were obtained for the correlation of forage yields and available fall soil water in the surface 3 ft (0.72) and 6 ft (0.74). For cattle gains, the coefficient of correlation with fall soil water was significant (0.52 in the surface 3 ft) or highly significant (0.64 in the surface 6 ft). April-July precipitation showed approximately the same correlation to yields and gains as fall soil water in the surface 6 ft. When April-July precipitation and soil water were added together, the correlation with yields and gains was higher. The data indicate that below average yields and gains can be predicted fairly accurately when the soil is dry the preceding fall. With increasing quantities of moist soil, higher yields and gains can be expected on the average, but prediction is less accurate.

Abstract No. 1098

Rogler, G. A., and L. C. Huritt. 1948. The northern Great Plains: Where elbowroom is ample. U.S. Dep. Agr., Yearbook 1948:477-479.

The Northern Great Plains covers roughly a tenth of the total land area of the United States. Parts of North Dakota, South Dakota, and Nebraska, Montana, Wyoming, and Colorado are included in the Northern Great Plains, which is part of an extensive mid-continental belt known as the Great Plains. Generally the land is gently rolling, but some areas are rough and broken. Soil types and structure vary widely. The surface features of lake beds, river valleys, plateaus, and buttes are the result of glacial action or erosion.

The climates is semiarid and has wide extremes. Medium and shortgrasses, largely hardy, drought-resistant species, are the predominant vegetation. Tree growth is absent except along streams, coulees, and north slopes of rough terrain.

The Northern Great Plains is sparsely populated. About 25% of the land is under cultivation, but the cropland is not evenly distributed. The proportion of cropland decreases generally from east to west. Between cultivated areas are large expanses of native grassland. Production varies greatly from year to year and from locality to locality because of the limited and variable precipitation.

A realistic look ahead shows that opportunities for industrial developments are restricted by long distances to central markets, high transportation costs, and a sparse population. To achieve safety, farming practices must be adapted to existing climatic hazards. A livestock economy based on the proper utilization of native range and seeded pastures supplemented by locally produced annual forage and feed crops can do much toward stabilization. In some places irrigation developments are under way. These developments will bring a new era of stability in livestock production if the forage and other feeds thus produced are properly integrated with the use of large acreages of native range.

Abstract No. 1099

Rongstad, O. J. 1965. A life history study of thirteen-lined ground squirrels in southern Wisconsin. J. Mammal. 46:76-87.

A population of thirteen-lined ground squirrels in Madison, Wisconsin, was studied during the spring and summer of 1961 and 1962. Conception dates varied within and between years. Males moved greater distances than females. Spring seemed to be the period when longest movements took place. Adults had a 29% annual survival rate, juveniles, only 16%. Females had a higher survival rate than males. High mortality among juveniles mainly occurred prior to hibernation. Three distinct types of burrows were noted.

Abstract No. 1100

Rosenbaum, V. C., D. M. Thatcher, and H. M. Webster, Jr. 1950. Winter bird-population study-western plains-heavily grazed grassland. Aud. Field Notes 4(3):220.

Location: In NE Jefferson County, Colorado, 8½ miles northwest from NW corner of Denver (12 miles by road), in SE part of Sec. 7, T2S. R69W, and 7 miles east of foothills of Rockies. Description of Area: Grassland, closely summer-grazed by cattle, measuring approximately 1500 × 3000 feet (long axis NW-SE) on an alluvial extension of a pediment surface known as "Rocky Flats". The general slope is southeastward, about 90 feet per mile. A southerly slope of about 15% separates the flat NE and SW halves of the area, the former being about 30 feet higher than the latter. The upper flat and the slope are gravelly, with a few scattered boulders under 1 foot in diameter, while the lower flat is relatively free of stone. Elevation 5640 to 5730 feet above sea level. Mapped from U.S.G.S., Louisville quadrangle, with pacing. Prairie Dog holes dot much of the lower flat, but are unoccupied except a few used by Cottontail Rabbits. The area is covered almost entirely by a fairly well-stocked growth of short Mesquite Grass (*Bouteloua oligostachya*), mixed irregularly with taller (1 to 1½ feet) grass. Clumps of soapweed (*Yucca glauca*), mostly 2 to 6 feet in diameter, cover 1 or 2% of the area. Each clump holds many wind-blown plants of a small tumbleweed on the windward (west) side and, after every storm, an elongated snowdrift on the lee side. Other plants are a few Prickly pear (*Opuntia vulgaris*) and scattered thistles and similar plants. The area, bounded by fence, field road, power line and a dry watercourse, is surrounded by similar habitat, extensive except on the south, where it is 200 to 600 feet wide with cultivated (wheat) dry land beyond. A covered and completely overgrown irrigation pipe line crosses the area near the north edge. Water: A 100-acre reservoir 1000 feet north of the area and 100 feet lower has no apparent effect on its ecology. Climate: Daily mean temperature during period: 34°F, 6° above normal (extremes 8° to 69°). Precipitation: All snow, in two storms, was .64 inches (normal, .66 inches). (U.S. Weather Bureau, Denver, city station). Ground was free of snow on all but 6 or 7 days, except drifts mentioned above. Food: Grass and weed seed appeared plentiful. Census

Dates: December 27, 31; January 8, 12 (2), 16, 22, 28; February 7 (2). Total, 10 trips. Hours averaged one per trip, between 9 AM and 4:30 PM. Census--Average number of birds seen per 100 acres of habitat (actual average number per trip in parenthesis): Horned Lark, 4 (4.3); Marsh Hawk, + (0.1). Total: Average of 4 birds per 100 acres. Remarks: All Horned Larks observed closely appeared to be the Desert subspecies (*leucolaema*). A flock of 23 was seen on first trip; other trips found none to seven. On two occasions, flocks of 200 to 300 were seen on the cultivated land, where food was more plentiful, within 100 yards of the study area. It appears likely that the clumps of soapweed serve as shelter at night for many of these birds.

Abstract No. 1101

Rosenberg, N. J. 1964. Solar energy and sunshine in Nebraska. Nebraska Agr. Exp. Sta. Res. Bull. 213:1-31.

Direct solar radiation to the earth's atmosphere is steady and dependable. Receipts at the surface of the earth, however, vary depending upon season, day length, latitude, upon local conditions of cloudiness and atmospheric turbidity.

Weather Bureau records of measured solar radiation useful in interpreting the solar energy regime in Nebraska are available from Lincoln-Omaha, Nebraska; Dodge City, Kansas; Laramie, Wyoming; and Rapid City, South Dakota. Pertinent records of sunshine duration (percent of possible sunshine) are available from Lincoln, Omaha; North Platte and Valentine, Nebraska; from Concordia and Dodge City, Kansas; from Cheyenne, Wyoming; from Rapid City and Huron, South Dakota; and from Sioux City, Iowa.

These records have been subjected to statistical summarization and analysis with the following major conclusions:

1. A comparison of Lincoln-Omaha and Laramie records indicates an east to west increase in solar radiation due apparently to lower atmospheric turbidity at the higher elevation of Laramie.

2. A comparison of Dodge City, Kansas and Rapid City, South Dakota records indicates greater solar radiation at the southerly location despite the longer days in summer in the north. This is due to the more direct incidence of the solar beam at the southerly location.

3. The Lincoln-Omaha region receives less radiation than do any of the other three locations studied. The difference between Dodge City and Lincoln-Omaha is significant at the 5% level of probability throughout the year.

4. Sunshine duration (percent of possible sunshine) patterns across the state change greatly during the year in Nebraska. A region of low sunshine duration is centered over Omaha in the Missouri Valley and a region of high duration is centered over Valentine in the northern Sandhills.

5. The proportion of weeks with high sunshine duration increases from early spring to late summer, decreasing to a low during the winter months.

6. Regression equations relating solar radiation and percent possible sunshine are presented for the three stations at which both parameters have been measured; Lincoln-Omaha, Nebraska; Dodge City, Kansas and Rapid City, South Dakota. These indicate the greater dependency of solar radiation on sunshine duration at the two more southerly locations. Estimates of future maximum and minimum solar energy receipts may be made on a weekly basis for the locations represented by these equations. Probability may be applied to predict future percentages of possible sunshine for a given week. The projected percentages of possible sunshine may then be used in the regression equations to predict future solar radiation on a weekly basis.

Abstract No. 1102

Roux, E. R., and M. Warren. 1963. Plant succession on abandoned fields in central Oklahoma and in the Transvaal Highveld. Ecology 44:576-579.

Succession on abandoned fields in Oklahoma is compared with succession on abandoned fields in the Transvaal Highveld, near Johannesburg, South Africa. In Oklahoma the primary grass stage immediately following the ruderals consists of an annual grass, *Aristida oligantha*, which is capable of growing under conditions of low available nitrogen. On the Highveld, ruderals are always followed by perennial grass species which require relatively high concentrations of available nitrogen. This difference is attributed to the fact that in Oklahoma the surface soils have generally been removed by erosion, whereas in the Transvaal abandoned lands usually retain a layer of soil.

Abstract No. 1103

Rovira, A. D. 1965. Interactions between plant roots and soil microorganisms. Annu. Rev. Microbiol. 19:241-266.

The emphasis in rhizosphere research should be changed from the descriptive type of studies to that of investigating the fundamental factors operating on and around plant roots.

More needs to be known about the energy balance of the rhizosphere--how much do root exudates and sloughed off and moribund root cells contribute to the nutrition of the microorganisms? What is the state of the rhizoplane and rhizosphere microflora--is it simply surviving in a resting state over most of the root system or is the population continually changing with various groups of organisms rising and falling according to the conditions?

The interrelationships between the various colonizing microorganisms need to be studied in situ rather than on laboratory media. Direct observations of roots have shown different patterns of colonization--sometimes areas of the roots are covered with what appears to be a pure culture of a single bacterial species while, in other areas, many different types are intimately associated. What governs these patterns of development--is it that separate areas of the roots exude different compounds or is it simply a chance factor that depends upon the particular soil organisms which the roots contact during their growth through the soil? What part is played by such properties as the production of growth factors, amino acids, toxins, and antibiotics in the colonization of the rhizoplane and the rhizosphere?

Few of these questions will be answered unless there is a radical departure from the traditional methods of soil microbiology which have been employed in most of the above studies. It will be necessary to simplify the system from the normal studies--as now conducted--in soil with its wide range of chemical, physical, and biological conditions from one soil type to another or even from one soil particle to the next. The use of model systems in which the various components of the system can be studied separately and in varying degrees of complexity offers the greatest hope of finding out what is responsible for the selective stimulation of soil microorganisms by plant roots and what effect the organisms have upon plant growth.

Abstract No. 1104

Rovira, A. D. 1969. Plant root exudate. Bot. Rev. 35:35-57.

For the purpose of this review root exudates are defined as those substances which are released into the surrounding medium by healthy and intact plant roots. A survey of the literature reveals a wide range of compounds exuding from intact roots; these include sugars, amino acids, peptides, enzymes, vitamins, organic acids, nucleotides, fungal stimulators, inhibitors and attractants, eelworm hatching and attracting factors, and many miscellaneous compounds.

I propose to discuss the subject of plant root exudates in a general manner, without emphasis on any particular group of compounds whether stimulatory or inhibitory. I will draw only on those articles which illustrate relevant points and not attempt to cover the many publications on plant root exudates.

Abstract No. 1105

Rule, G. K. 1941. Toward soil security on the northern Great Plains. U.S. Dep. Agr., Farmer's Bull. 1864. 76 p.

The Northern Great Plains, whose soil and water we are to consider here, lies within the boundaries of five states--Montana, North Dakota, South Dakota, Wyoming, and Nebraska. The combined area of these five states exceeds 470,000 square miles. During the drought years in the early and middle 1930's, foreclosures, delinquent taxes, mounting relief rolls--these grim memories need not here be stressed. But they are sharply remembered by those who still remain on the land and by those who have been forced to leave.

The fact is that Plains farming practices have been, for the most part, out of harmony, and still are out of harmony, with the soil and climate. The drought during the two tragic years had only accentuated a situation which had long been developing. In many instances farming practices have injured the land. Some areas have become decreasingly productive even in good years. In the years of scant rainfall, the losses of both crops and forage have been severe. Furthermore, neither reserves of feed, money, nor moisture could be stored against the hazards of another season.

The only permanent solution for the agriculture of the Plains is to use the land in ways that are compatible with the soil and weather. The major portion of the bulletin is devoted to a discussion of the controls and cures for land misuse. These suggested practices, in the main, represent the methods of control that are now being used in the several demonstration areas of the Soil Conservation Service. The use of these practices in a few specific demonstration areas is included. The last section points out a democratic procedure whereby landowners and operators may effect a more appropriate use of the land through soil conservation districts.

Abstract No. 1106

Rumbaugh, M. D., and T. Thorn. 1964. Interseeding legumes in South Dakota grasslands. South Dakota Farm Home Res. 16:7-9.

South Dakota's greatest single natural resource is its grassland.

More than half the land surface of the state is covered with grass and most of it is native range. These ranges are among the finest in the nation. Their condition, however, is not static--it is everchanging. Forage species differ in their tolerance to grazing. Some desirable plants tend to decrease in number and productivity whereas much weedy and less desirable vegetation tends to increase.

This trend toward an increase in less desirable species is accelerated by misuse--especially overstocking.

One serious aspect of deterioration is the elimination of native legume species which had previously contributed nitrogen to the soil and increased quantity and quality of grass forage. Attempts to reintroduce these plants by reseeding and interseeding have been restricted by difficulties in growing and producing suitable quantities of native legume seed.

Alfalfa and sweet clover have, therefore, received serious consideration as possible substitutes in range improvement programs. Both are familiar to ranchers and farmers. Both are relatively easy to grow, produce seed abundantly, and seed costs are not prohibitive. Research shows that mixtures of either sweet clover or alfalfa with grass produce more forage than either grass or legumes alone. Furthermore, protein content of grass grown in mixtures with legumes is higher than when grown in pure stands. Interseeding native shortgrass sod with crested wheatgrass and alfalfa in investigations near Cheyenne, Wyoming, allowed an increase in sheep-days per acre and in pounds of sheep gain per acre.

Abstract No. 1107

Runyon, H. E. 1936. Distribution of seeds by dust storms. Trans. Kansas Acad. Sci. 39:105-113.

1. No growth was obtained from numerous samples taken from buildings.

2. Usually no seeds germinated in the samples taken in large moderately grazed pastures, where surface blowing was at a minimum.

3. Fewer seeds germinated per unit volume from the sandy soil area than from the darker soil area. (56 contrasted with 357 seeds per soil sample 12 × 12 × 1 inches.)

4. Most of the seeds that germinated were of the type usually considered as weeds.

5. Small seeds may be carried from some distance over the surface where there is no vegetation to collect the moving soil.

Abstract No. 1108

Runyon, N. R. 1943. The effect of season of growth and clipping on the chemical composition of blue grama (*Bouteloua gracilis*) at Hays, Kansas. Trans. Kansas Acad. Sci. 46:116-121.

The tendency for blue grama to become unpalatable to livestock is indicated in these analyses by the decrease in soil water, the decrease in protein and N-free extract, and the increase in fibrous material in the first clippings. The second clipping and recurrent clippings have been a deciding factor in retaining a higher percentage of both water and protein. This may be an answer to the question, "Why do cattle graze some areas off short while other areas are untouched?" It certainly has a direct relation to the frequency of loss in weight of cattle in late summer as mentioned in the report of the Rocky Mountain Forest and Range Experiment Station.

According to Watkins for best results with cattle, their forage should contain about 0.25% calcium and 0.12% phosphorus. On that basis, cattle wintered on blue grama should be supplied with a supplement rich in protein, calcium, and phosphorus.

The Agricultural Conservation Program has given conservation credit to the ranchman who would defer his pasture until August 1, or withhold the stock from the range until that time. This practice is hardly justifiable except where revegetation has become neccessary because much of the value of the forage is wasted under such a practice.

Abstract No. 1109

Runyon, N. R. 1947. The chemical composition of forbs in the native pastures at Hays, Kansas. Kansas Acad. Sci. Trans. 49:441-443.

Cattle are often seen grazing weeds and perennial herbaceous plants (forbs) in their search for food. This habit, if it may be called a habit, is followed where grass forage is plentiful as well as where it is not so plentiful. The purpose of this research was to determine the chemical composition of these forbs and to determine the contribution of each one to the diet of the cattle.

The greatest apparent contribution of the forbs to the cattle diet seems to come from their high percentage of calcium and phosphorus. The quantities of crude protein, fiber, and dry matter were not significantly different from those found in blue grama from the same general area.

Abstract No. 1110

Rydberg, P. A. 1932. Flora of the prairies and plains of central North America. New York Bot. Garden, N. Y. Hafner Pub. Co., New York. 969 p.

From a brief prospectus left by Dr. Rydberg, one gathers that this flora aims to be a complete manual of the Spermatophyta and Pteridophyta of the states of Kansas, Nebraska, Iowa, Minnesota, South Dakota, and North Dakota, and of southern Manitoba and southeastern Saskatchewan. It includes also most of the species occurring in the prairie regions of Illinois, southern Wisconsin, and northern Missouri, and on the plains of eastern Colorado, eastern Montana, and southern Saskatchewan. No flora of just this area has previously been published, although its borders have been invaded by other well-known manuals. Extralimital ranges are freely cited in the text. A posthumous paper by the author, entitled "Taxonomic Notes on the Flora of the Prairies and Plains of Central North America," published in October, 1931 (Brittonia 1:79-111), included Latin diagnoses of the new species and one new genus (Denslovia) recognized in the present volume--also new combinations and discussions of changes in nomenclature, in respect to which the author has now endeavored to follow the International Rules.

Abstract No. 1111

Ryder, R. A. 1969. Diurnal raptors on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 26. Colorado State Univ., Fort Collins. 16 p.

The hawks, eagles, and falcons are important consumers on the Pawnee Site, preying on a variety of primary and secondary consumers ranging from insects to birds, rodents, and other small mammals. These diurnal raptors have been censused during routine bird counts and also by means of special, more extensive counts designed specifically to take into consideration these raptors' rather large home ranges and relatively low population densities.

The objectives were: (1) to determine the numbers and biomass of diurnal raptors frequenting the Pawnee Site; (2) to compare data from the Pawnee Site with those collected in similar areas elsewhere; and, eventually, (3) to determine the food habits and energy demands of these birds in the grassland ecosystem.

Abstract No. 1112

Ryder, R. A. 1970. Banding of grassland birds under the International Biological Program in Colorado and Saskatchewan. Annu. Meeting Western Bird Banding Ass., April 24-26, San Diego, California.

United States and Canadian biologists have been routinely banding and color-marking a variety of birds as part of detailed studies of avian populations and energy flow through grassland ecosystems. On the Pawnee Site northeast of Fort Collins, Colorado, over 1000 birds representing 49 species have been banded since 1961 by 10 banders. Since 1967, 744 birds representing 25 species have been banded at the Matador Site north of Swift Current, Saskatchewan by four banders under the direction of Dr. W. J. Maher. Birds have been captured in mist nets, sweep nets (Matador), taken in small mammal live traps, or banded as nestlings or flightless young. Total bandings at the Pawnee Site include: Lark Bunting, 358; Mountain Plover, 214; Horned Lark, 136; McCown's Longspur, 96; Loggerhead Shrike, 87; Mourning Dove, 55; Brewer's Sparrow, 49; and Western Meadowlark, 43. At Matador, the primary species banded have been: Sprague's Pipit, 207; Savannah Sparrow, 99; Horned Lark, 85; Chestnut-collared Longspur, 82; Western Meadowlark, 44; and Baird's Sparrow, 42. Details regarding known returns and recoveries will be summarized.

Abstract No. 1113

Ryder, R. A. 1970. Censuses of avian populations at the Pawnee Site, Colorado, under the International Biological Program. U.S. IBP Preprint 14. 3 p. (Submitted to Bird Study)

Ryder, R. A. 1970. Censuses of avian populations at the Pawnee Site, Colorado, under the International Biological Program. 3rd Int. Symp. Bird Census Studies, Oosterbeek, The Netherlands.

Birds are being studied on the shortgrass prairie in northeastern Colorado as part of an analysis of the Grassland Biome under the International Biological Program. Since mid-June 1968, birds have been regularly counted in six 20-acre (8-ha) plots that were established on the Central Plains Experimental Range (CPER) as well as along a 50-stop roadside census route, 24½ miles (39.2 km) long, laid out through CPER and into the Pawnee National Grassland. Larger raptors are censused approximately twice monthly along a 50-mile (80 km) route which permits coverage of a 56-sq mile (14,504-ha) area on the CPER.

Abstract No. 1114

Ryder, R. A. 1970. Colorado breeding bird surveys, 1968-1969. Colorado-Wyoming Acad. Sci., May 1, Greeley, Colorado.

In 1968 eight observers and in 1969 nine observers participated in the North American Breeding Bird Survey in Colorado by counting along randomly selected routes designated by the U.S. Bureau of Sport Fisheries and Wildlife. Each 24½-mile route consisted of 50 stops spaced at ½-mile intervals. All birds heard or seen at each stop during a 3-min period were recorded on special forms and the data later transferred to machine punch cards for computer analysis. There was a 29% increase in the mean number of birds observed per stop in 1968 (12.2) and those observed in 1969 (15.9). The mean number of individuals per stop on "plains" routes was more than twice that on "mountain" routes, but more species per route were noted in the mountains. In 1968, 110 species were noted (9 routes) and in 1969, 124 species (10 routes). In order of decreasing abundance, the most abundant birds were: Lark Bunting, Horned Lark, Western Meadowlark, House Sparrow, Red-winged Blackbird, Mourning Dove, and Robin. The relative changes for various species and comparison with results from routes covered in nearby states will be presented.

Abstract No. 1115

Ryder, R. A. 1970. Seasonal fluctuations of bird populations on some Colorado grasslands. Joint Annu. Meeting Cooper Ornithol. Soc. and Wilson Ornithol. Soc., June 19, Fort Collins, Colorado. p. 27. (Abstr.)

Since mid-June 1968, birds have been regularly counted in six 20-acre plots that were established on the Central Plains Experimental Range as well as along a 50-stop roadside census route, 24½ miles long, laid out through the CPER and into the Pawnee National Grassland. During the breeding season these counts were made weekly; the remainder of the year, every 2 weeks. The larger raptors were censused twice monthly along a 50-mile route which permits coverage of a 56-sq. mile area on the CPER.

Twenty-two species have been recorded on the plots to date; 81 species on the roadside routes. The Horned Lark was the most abundant year-round resident. During the breeding season, Lark Buntings arrived in early May and their numbers increased to peaks in July. They were followed in decreasing order of abundance by: McCown's Longspur, Western Meadowlark, Brewer's Sparrow, and Mountain Plover. In late fall, all of these species except the Horned Lark departed. The niche vacated by the McCown's Longspurs was filled in the winter by Lapland Longspurs. Twenty-five species were known to breed regularly on the area. These included in addition to those previously mentioned: Ferruginous Hawks, Swainson's Hawks, Great Horned Owls, Burrowing Owl, Golden Eagles, Eastern Kingbird, Western Kingbird, Say's Phoebe, Barn Swallows, and Chestnut-collared Longspurs.

The winter bird fauna typically consisted of 9 to 12 species, primarily Horned Larks, Lapland Longspurs, Rough-legged Hawks, Golden Eagles, Prairie Falcons, Ferruginous Hawks, and Marsh Hawks.

Abstract No. 1116

Ryder, R. A., and D. A. Cobb. 1969. Birds of the Pawnee National Grassland in northern Colorado. J. Colorado-Wyoming Acad. Sci., Abstr. 6(2):5.

For the past year, species and numbers of birds have been censused at weekly intervals on the Central Plains Experimental Range (CPER) of the Agricultural Research Service and the adjacent Pawnee National Grasslands of the U.S. Forest Service as one part of an intensive study of the grassland ecosystem under the International Biological Program. Counts were made on six 20-acre plots on the CPER and on a 50-stop roadside route, 24½ miles long through the CPER and into the Pawnee National Grasslands. To date, 160 species of birds have been observed during this study or reported in the literature. Most are merely migrants through the shortgrass prairie but over 60 probably nest in the area. Thirteen seem to be only winter residents. Lark Buntings and Horned Larks accounted for more than 75% of all birds observed on roadside counts during the summer. Horned Larks and McCown's Longspurs favored the more heavily grazed pastures whereas Lark Buntings were more abundant in less heavily grazed areas. Horned Larks were by far the dominant wintering bird, accounting for over 85% of all individuals seen. Data regarding population densities, banding and collecting will also be presented.

Abstract No. 1117

Ryder, R. A., and J. B. Giezentanner. 1970. Diurnal raptors of the Pawnee National Grasslands in northern Colorado. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

The nesting ecology of grassland birds was studied on the Pawnee Site of the International Biological Program to learn more of nesting densities, nest-site preferences, and nesting successes as they relate to overall avian productivity. Based upon regular censuses made on six 20-acre plots, the numbers of breeding pairs per 100 acres increased from a mean of 41.2 in 1968 to 64.5 in 1969. Horned Lark nests were most abundant on the more heavily grazed plots subjected to less intensive grazing by cattle. Data pertaining to nest locations, times of egg laying, clutch sizes, hatching and fledging success will be summarized for 157 nests of 17 species that were followed on the Pawnee Site. The tree-nesting Loggerhead Shrike had better hatching success (89%) than the ground-nesting Horned Lark (48%) or the Lark Bunting (69%). The total avian breeding biomass (wet weight) of the six species observed nesting on the six study plots was calculated to be 6.5 kg/120 acres (0.0134 g/m^2) in 1969. The total weights of fledglings calculated to have been produced on the 120 acres ranged from 1130 g for Western Meadowlarks to 993 g for Lark Buntings and 660 g for Horned Larks. Lesser amounts were produced of McCown's Longspurs, Brewer's Sparrows, Mountain Plovers, and Mourning Doves.

Abstract No. 1118

Ryder, R. A., and J. B. Giezentanner. 1970. Productivity of birds on the Pawnee National Grasslands in northern Colorado. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

The nesting ecology of grassland birds was studied on the Pawnee Site of the International Biological Program to learn more of nesting densities, nest-site preferences, and nesting successes as they relate to overall avian productivity. Based upon regular censuses made on six 20-acre plots, the numbers of breeding pairs per 100 acres increased from a mean of 41.2 in 1968 to 64.5 in 1969. Horned Lark nests were most abundant on the more heavily grazed plots subjected to less intensive grazing by cattle. Data pertaining to nest locations, time of egg laying, clutch sizes, hatching and fledging success will be summarized for 157 nests of 17 species that were followed on the Pawnee Site. The tree-nesting Loggerhead Shrike had better hatching success (89%) than the ground-nesting Horned Lark (48%) or the Lark Bunting (69%). The total avian breeding biomass (wet weight) of the six species observed nesting on the six study plots was calculated to be 6.5 kg/120 acres (0.0134 g/m^2) in 1969. The total weights of fledglings calculated to have been produced on the 120 acres ranged from 1130 g for Western Meadowlarks to 993 g for Lark Buntings and 660 g for Horned Larks. Lesser amounts were produced of McCown's Longspurs, Brewer's Sparrows, Mountain Plovers, and Mourning Doves.

Abstract No. 1119

Sampson, A. W. 1914. Natural revegetation of range lands based upon growth requirements and life history of the vegetation. J. Agr. Res. 3:93-148.

The easiest way to overcome the deteriorating effect of premature grazing and overstocking, as well as of trampling, is to approach it as similar problems in farm practice are approached--that is, (1) by a careful study of the vegetation making up the forage crop, (2) by a study of the natural factors upon which depends the success or failure of the forage crop and its perpetuation, and (3) by a study to find a method of grazing which will both fully utilize the forage and at the same time protect it from deterioration.

Such studies were undertaken by the Forest Service in cooperation with the Bureau of Plant Industry during the spring of 1907 in the Wallowa Mountains of northeastern Oregon.

The system developed as a result of the studies--a combination of deferred and rotation grazing--is now being applied with minor variations to range lands throughout the National Forests, and promises to be of the greatest value in bringing about the efficient utilization of the forage resources.

This article gives in full the data upon which the new system is based. The area where the intensive studies were carried on is first described. Following this are given the life histories of the important forage species, including growth requirements and the factors influencing the establishment of reproduction. This in turn is followed by a discussion of the relative merits of different systems of grazing. Finally there is presented a rational and economical grazing system based upon the requirements of the forage plants and of the stock industry.

Abstract No. 1120

Sanderson, R. H. 1959. Relationships between jack rabbit use and availability of forage on native sandhills range. M. S. Thesis, Colorado State Univ., Fort Collins. 85 p.

The objective of this study was to obtain information on the ecology of the black-tailed jack rabbit in relation to the effects of livestock grazing activities. The data were collected during the year of April, 1958 to April, 1959 at the Eastern Colorado Range Station. The study area consisted of six native sandhills range pastures that were summer grazed at light, moderate, and heavy intensities.

Abstract No. 1121

Sarvis, J. T. 1920. Composition and density of the native vegetation in the vicinity of the Northern Great Plains Field Station. J. Agr. Res. 19:63-72.

The data and conclusions presented in this paper have been obtained in connection with a grazing experiment at the Bureau of Plant Industry Field Station near Mandan, N. Dak. This experiment is designed to determine the carrying capacity of the native vegetation and the effects upon it of different intensities and methods of grazing.

Abstract No. 1122

Sarvis, J. T. 1923. Effects of different systems and intensities of grazing upon the native vegetation at the Northern Great Plains Field Station. U.S. Dep. Agr. Dep. Bull. 1170. 46 p.

The cooperative grazing experiment reported upon in this bulletin was established at the Northern Great Plains Field Station, near Mandan, N. Dak., in 1915. Its objects were to determine the grazing capacity of the native range and the effects of different systems and intensities of grazing upon the native vegetation.

Abstract No. 1123

Sarvis, J. T. 1941. Grazing investigations on the northern Great Plains. North Dakota Agr. Exp. Sta. Bull. 308:1-110.

The cooperative grazing experiment reported upon in this bulletin was established by the United States Department of Agriculture in cooperation with the North Dakota Agricultural Experiment Station, at the Northern Great Plains Field Station, near Mandan, North Dakota in 1915. Its objects were to determine the grazing capacity of the native range and the effects of different systems and intensities of grazing upon the native vegetation.

Abstract No. 1124

Sarvis, J. T. 1941. Value of North Dakota grasses for grazing, p. 9-16. *In* Grass. North Dakota Agr. Exp. Sta. Bull. 300.

A cooperative grazing experiment was established at the Northern Great Plains Field Station, Mandan, North Dakota. It was conducted by the United States Department of Agriculture and the North Dakota Agricultural Experiment Station. The purpose was to obtain information on the grazing capacity of the range under different intensities and systems of grazing. Cultivated pastures were later established in order to compare their value with native pastures.

Abstract No. 1125

Sauer, C. O. 1950. Grassland climax, fire, and man. J. Range Manage. 3:16-21.

Plant associations are contemporary expressions of historical events and processes, involving changes in environment and biota over a large span of geologic time. The last million years are one of the biologically most critical periods of Earth history. The over-all picture is one of maximal environmental disturbance, with a succession of climatic swings in opposite directions. This time of great and rapidly changing tensions for the major part of the organic world, inevitably brought unusual opportunities for natural selection of variant organisms. It has been, and probably continues to be, a time of marked advantage for mobile and labile forms, for those that are tolerant of environmental change, and those that can change. Fast and heavy seeders, vigorous vegetative reproducers have been favored. Changing environments have favored survival of mutants. Enforced and invited migrations have brought together previously disjunct forms and multiplied opportunities for successful hybridization.

The second great agent of disturbance has been man who has been in existence throughout the Pleistocene. Possessing fire, man was free to move, to keep the other predators at a distance, and to experiment with foods. Fire and smoke became labor saving devices. The fire-setting activities of man perforce brought about deep and lasting modifications in what we call "natural vegetation".

Grasses have fared especially well in the lategeologic past and have expanded as dominants in many parts of the world and in many climates. The normal history of vegetation is an accommodation into the plant society of increasing diversity. In grasslands on the contrary we have a simplification of plant structure and scale. The explanation has commonly been sought in climate. The more we learn of climatic data the less success is there in identifying climate with grassland. Grasslands are found chiefly (a) where there are dry seasons and (b) where the land surface is smooth to rolling. Their occurrence points to the one known factor that operates effectively across such surfaces--fire. Recurrent fires, sweeping across surfaces of low relief, suppress woody vegetation. We may over-rate the durability of grassland fertility in our short-term civilized view of time and neglect the importance of deeply feeding trees and shrubs in maintaining a productive Earth. A drift of vegetation toward more grassland has been going on for many thousands of years. This deformation has probably derived its driving force from fires, chiefly a cultural phenomenon. The question now is whether civilized man can or should undertake to maintain grass cover and "forb-herb" ratios. Largely the world has lost the better plains for grazing and its shrunken range lands are in mountain, hill, and foothill areas, critical for storing and spreading water for lowland populations. What place will be left in them for palatable grasses and herbs under full fire protection? What happens to runoff if grasses yield to shrubs? Fire, or its elimination, is still a main problem in the applied total ecology by which western foresters and graziers must attempt to work out a durable modus vivendi for man in a non-static environment.

Abstract No. 1126

Saunderson, M. H. 1950. Montana stock ranches and ranching opportunities. The Montana Stockgrower 22(2):12-14, 16-17.

In the following we see how Montana stock ranches operate and consider possibilities and prospects for the development and improvement of Montana's cattle and sheep ranching. Opportunities for this development and improvement are apparent, and the economic basis for future progress appears favorable.

Abstract No. 1127

Saunderson, M. H., and N. W. Monte. 1936. Grazing districts in Montana: Their purpose and organization procedure. Montana Agr. Exp. Sta. Bull. 326. 39 p.

Montana range livestock producers are organizing into cooperative groups for the control, conservation, and economic use of grazing land under the provisions of recent state and federal laws and administrative procedure. This publication is an economic analysis of the present situation in grazing land use in Montana and the adjustments possible through the establishment of grazing districts.

Abstract No. 1128

Saunderson, M. H., and D. W. Chittenden. 1937. Cattle ranching in Montana: An analysis of operating methods, costs, and returns in western, central, and eastern areas of the state. Montana Agr. Exp. Sta. Bull. 341. 32 p.

This publication gives an economic analysis of the specialized stock ranches that are engaged primarily in the production of range beef cattle. The information used consists mainly of a series of detailed records on the resources and operations of about 100 Montana cattle ranches and covers the period 1929 to 1934, inclusive. The ranches studied are fairly typical of the cattle ranches of the different regions of the state. Their location is shown. Their size varies from 100 head of cattle to as high as 3,000 head, with most of the ranches carrying about 400 head.

Abstract No. 1129

Savage, D. A. 1937. Drought survival of native grass species in the central and southern great plains, 1935. U.S. Dep. Agr. Tech. Bull. 549. 55 p.

A large percentage of the native grasses in the central and southern Great Plains was killed by the severe drought of 1933-34.

The original cover on sandy soils was apparently less than on the heavier soils, and the cover, after the drought, was correspondingly less on sand except on certain areas at Dalhart, Tex.

Buffalo grass and blue grama together constitute more than 90 percent of the total vegetation on all except very sandy soils. On the heavier soils only a few scattering plants of the tall grasses survived, principally bluestem (western wheatgrass), sand dropseed, and red three-awn (wire grass).

Blue grama is adapted to a much wider range of soil textures than buffalo grass and was an important species on all soil textures in all localities studied.

On sandy lands the grass associations consisted principally of blue grama, bluestem (western wheatgrass), red three-awn (wire grass), sand dropseed, hairy grama, side-oats grama, prairie beardgrass (little bluestem), bluejoint turkeyfoot (big bluestem), switchgrass, long-leaved reedgrass, silver beardgrass, needle-and-thread (needle-grass), and blowout grass.

Soil blowing and overgrazing contributed materially to the damage, but climatic extremes caused much more injury than that traceable directly to grazing.

The grass cover on closely clipped areas was consistently better than on lightly clipped areas in all comparisons at Hays, Kans., and Dalhart, Tex.

As grazing was intensified the actual ground cover of buffalo grass declined in all areas where the drought was severe; however, the relative proportion of ground cover represented by buffalo grass increased with each successive increase in the degree of grazing.

Buffalo grass was more abundant than any other grass in pastures on the heavier soils, and grazing, when not extreme, appeared to be indirectly beneficial to this grass probably in reducing the competition of taller grasses.

Blue grama was less resistant to clipping, heavy grazing, and perhaps drought than buffalo grass, but was superior to all other grasses in these respects.

The ground cover of practically all tall grasses was consistently and successively reduced as grazing was intensified. Sand dropseed was less injured by grazing than any other tall species.

Most of the perennial and biennial forbs declined under grazing and drought in about the same degree as the tall grasses.

Annual grasses, such as *Festuca octoflora, Hordeum pusillum, Panicum capillare, Chloris verticillata,* and *Munroa squarrosa* represented only a small part of the total vegetation. These grasses, as well as the annual forbs, were most numerous on heavily grazed and severely damaged pastures where the perennial grasses were covered by wind-deposited soil.

Although much of the grass is dead, the surviving plants are rather uniformly distributed and may be expected to recover rapidly under favorable climatic conditions.

Abstract No. 1130

Savage, D. A. 1943. Methods of reestablishing buffalo grass on cultivated land in the Great Plains. U. S. Dep. Agr. Circ. 328. 20 p.

Native buffalo grass is the only grass adapted to the Great Plains area that may be successfully used for pastures, athletic fields, golf courses, lawns, and general landscaping purposes. It occurs in varying degrees of abundance from southeastern Montana and southwestern North Dakota to south-central Texas and from the foothills of the Rocky Mountains to the ninety-seventh degree of longitude on the Great Plains.

From 20 to 50 years are required for buffalo grass to become reestablished naturally on abandoned farm land. It is not practical to establish it by seeding, because seed is difficult and expensive to collect and of low germination.

Buffalo grass may be propagated by setting out the runners or stolons in moist soil, but this method is not successful on strictly dry land. The most practical method where watering is not possible is to set small pieces of sod in well-prepared soil at intervals of 3 to 4 feet. Solid spacing of sods is practical only for very small areas, such as lawns, where the chief consideration is immediate results.

Buffalo grass has been successfully transplanted every month from March to August, inclusive.

Extreme care is necessary in grading the land in advance and setting the sods level with the surface of the ground if it is desired to have the final surface smooth and even for landscape purposes.

An effective way of planting large areas is to slide pieces of sod in sheet-iron chutes from wagons to the surface of deeply cultivated land and press them into the ground with a heavily weighted surface packer.

Buffalo grass spreads largely by surface runners which should not be disturbed by hoeing or cultivating. Cultivation also encourages erosion.

Clipping at a height of 2 inches or moderate pasturing at intervals throughout the season to control other growth and admit sunlight is beneficial to the spread of buffalo grass.

Sweetclover if properly grazed may be grown continuously on areas being resodded with buffalo grass, thus providing additional pasturage while the grass is becoming established.

Top dressing with soil after the grass has become established, to level the uneven surfaces caused by wind and water erosion, is advisable on lawns and other areas intended for landscape purposes. The exclusive use of pistillate plants is preferred for lawn purposes.

Buffalo grass may be used to advantage in controlling run-off and erosion on well-drained sloping land, but it will not withstand protracted excesses of water on low land.

Buffalo grass ranks high for grazing purposes. Although it is a rather low producer, it is highly regarded as a nutritious and exceedingly palatable pasture grass, capable of producing excellent summer and cured winter pasturage.

Abstract No. 1131

Savage, D. A., and L. A. Jacobson. 1935. The killing effect of heat and drought on buffalo grass and blue grama grass at Hays, Kansas. J. Amer. Soc. Agron. 27:566-582.

Buffalo grass and blue grama grass are generally considered to be highly resistant to the effects of heat and drought, but in the vicinity of Hays, Kans., many plants of these grasses appear to have been injured beyond recovery by the record-breaking heat and drought of 1933-34.

According to local weather records this was the hottest and driest biennium since 1894-95. A nearly continuous and disastrous drought prevailed in this locality from October 21, 1932, to August 30, 1934.

The charting of live and dead plants in the fall of 1934 was done on typical short-grass pastures and lawns on the Fort Hays (Kansas) Branch Experiment Station.

Abstract No. 1132

Savage, D. A., and H. E. Runyon. 1937. Natural revegetation of abandoned farmland in the Central and Southern Great Plains. Int. Grasslands Congr., Proc. 4:178-182.

The rate and manner in which abandoned farmland reverts naturally to native vegetation were determined in 1936 by chartographing the basal cover occupied by 124 different species of grass and 448 species of forbs, sedges, and shrubs on 167 abandoned fields and 138 adjacent virgin pastures, on different textures of soil and under different grazing treatments at eleven locations in the Central and Southern Great Plains. Data were obtained from 1,834 square meter quadrats and 124 cross-stringed gridiron plats, representing a grand total of 33,802 meter squares. The period of cultivation ranged from 1 to 41 years and of abandonment from 1 to 46 years.

Succession of growth on abandoned fields assumed four rather distinct but overlapping stages. These are listed in descending order of dominance within each group, (1) annual weeds and annual grasses, (2) the less palatable short-lived perennial grasses and biennials and perennial forbs, (3) short-lived perennial grasses, perennial forbs, and a few sturdy long-lived perennial grasses, and (4) dominant and subdominant perennial grasses accompanied by varying amounts of other plant species, depending upon environmental conditions.

Abstract No. 1133

Savage, D. A., and V. G. Heller. 1947. Nutritional qualities of range forage plants in relation to grazing with beef cattle on the Southern Plains experimental range. U.S. Dep. Agr. Tech. Bull. 943. 62 p.

The forage from 29 species of native and introduced grasses, forbs, and browse plants was collected on the United States Southern Plains Experimental Range at monthly or less frequent intervals during the 6-year period 1940-45 and analyzed to determine the more important chemical constituents, including crude protein, calcium, phosphorus, fat, nitrogen-free extract, crude fiber, ash, and moisture. Carotene determinations were added to the studies during the last 2 years of the period.

Factors other than the chemical composition considered included (1) the mineral and carotene content of the blood plasma of beef cattle receiving various mineral supplements on the experimental range, (2) the gain in weight of almost 500 head of yearling Hereford steers used annually in conducting comprehensive grazing and range management investigations on the range, (3) the relative quantities of different minerals consumed by the livestock, (4) the comparative quantities of each species of plant available to and eaten by the cattle, (5) the type of soil and its composition, and (6) the wide diversity of plants represented in the vegetational association.

During the 6-year period the climatic conditions prevailing on the experimental range were similar in nearly every respect to those occurring generally in drier parts of the southern Great Plains. The experimental area represents that type of land most subject to wind erosion and least suited to farming in the region and is typical of land most likely to remain in or to be restored to grass. The nutritional results are therefore considered to have direct application to the drier parts of the region and broad application to the area as a whole.

Abstract No. 1134

Savage, D. A., and D. F. Costello. 1948. The southern great plains: The region and its needs. U.S. Dep. Agr., Yearbook 1948:503-506.

The Southern Great Plains includes about 130 million acres of Nebraska, Kansas, Wyoming, Colorado and New Mexico. The region represents about a third of the total area of the five States. Wide variations occur in surface features, soils, and plant cover. The general aspect is a fairly level plain with shallow drainage channels often interspersed with rolling lands or steep broken areas. The principal rivers flow eastward. The climate is highly variable from month to month and year to year. Rainfall is comparatively light and infrequent; humidity is low; there are high winds and quick evaporation. Drought periods make dry-land farming hazardous. Plants to be fully adapted to the entire region must be able to withstand these conditions and temperature extremes from 118° to -30° F.

The soils range in texture from dune sand to heavy clay. Most of them are well supplied with minerals and other essential elements in available form. There are two broad classes of soils in the region: The hard lands, that can grow wheat and cotton, and the sandy lands, where sorghums or corn are best suited. Two other broad distinctions are made in considering proper land use: The heavy, semiheavy, and sandy soils adapted to cultivation; and the loose sandy soils, heavy clays, and rough broken lands suitable for range.

The Southern Great Plains is out-standing in the production of feeder cattle. The comparatively high feed value of the native grasses at all stages of growth accounts for the reputation of the region for yearlong grazing. Most of the farmer-stockmen and increasing numbers of the ranchmen are making considerable progress in using a combination of range, pastures, and harvested crops for producing and fattening feeder-cattle and other classes of livestock. This desirable practice could be expanded to advantage throughout the area and should include the increased use of reseeded pastures.

Grassland agriculture in the Southern Great Plains is represented by all gradations of land use, ranging from complete livestock grazing to strict crop production. The beef cattle industry in the Southern Great Plains can be placed and maintained on a much more stable basis through the adoption of improved practices for the care and management of both the range and the cattle. These possibilities are indicated by the results of range studies and grazing tests conducted in the region. Stockmen are urged to make annual appraisals of the condition of their lands and determine the trend for better or worse. Accurate inventories of this kind are dependent upon a thorough knowledge of, and ability to recognize, the desirable and undesirable plants, a practical working knowledge of the production capacity of his grasslands, what degree of forage utilization will result in optimum returns from his livestock and at the same time allow sustained maximum production of grass. In the long run, conservative use of the grass pays the best dividends in grass and livestock production.

Abstract No. 1135

Savić, I. R., and F. B. Golley. 1971. Bibliography on the species and genus *Sigmodon* (Cricetidae, Rodentia). U.S. IBP Tech. Rep. No. 129. 44 p.

Sigmodon are abundant mammals in grass and herb dominated communities in southern United States. They serve as an important link in the complex of natural food-chains, and may be significant in the spread of parasites on infective diseases. Because of their importance, a relatively large literature has developed which reports data on the life history, taxonomy, physiology, health, and ecology of the genus. *Sigmodon* have also been adopted as a laboratory animal for medical studies. We have prepared this bibliography on *Sigmodon* as an aid to further research.

Abstract No. 1136

Sayre, R. M., Z. A. Patrick, and H. J. Thorpe. 1965. Identification of a selective nematocidal component in extracts of plant residues decomposing in soil. Nematologica 11:263-268.

Extracts obtained from rye (*Secale cereale*) and timothy (*Phleum pratense*) plant residues decomposing in soil under laboratory and field conditions were tested and found to be selectively nematocidal to two species of plant parasitic nematodes, *Meloidogyne incognita* and *Pratylenchus penetrans*. They were nontoxic to saprophytic nematode species when used at similar concentrations. By means of chromatographic and nematode bioassay techniques some of the nematocidal components in the extracts were isolated. One of these was identified as butyric acid. Chemical behavior and nematocidal activity of chemically pure butyric acid and that isolated from the decomposing plant residues were compared and found to be identical. Butyric acid and residue extracts were nematocidal only in the pH range of 4.0 to 5.3. Significance of these results to biological control of plant parasitic nematodes in the field is discussed.

Abstract No. 1137

Scarborough, A. M. 1970. The soil microfungi of a Colorado grassland. M.S. Thesis. Univ. Wyoming, Laramie. 68 p. (Advisor: Martha Christensen).

Soil microfungi from three sites on a native shortgrass prairie were surveyed. Eighty-one species and nine variants, obtained by the dilution plate technique, were identified and recorded to show percent frequency and density. Keys to *Fusarium* and *Trichoderma* taxa, as well as taxonomic descriptions of these and other isolates, have been included and population comparisons are made with other microfungal surveys.

Abstract No. 1138

Schaffner, J. H. 1926. Observations on the grasslands of central United States. Ohio State Univ. Studies, Contrib. 178:1-56.

The prairies and plains occupying the interior of the North American continent are of the greatest importance as agricultural lands and for this reason the natural vegetation has been practically destroyed over large areas. Since the writer has been acquainted with the western part of the prairie since the beginning of its settlement he has had unusual opportunities for making observations both on the original vegetation and on the changes which have been brought about through the white man's occupancy of the region.

Abstract No. 1139

Schaffner, J. H. 1938. Spreading of *Opuntia* in overgrazed pastures in Kansas. Ecology 19: 348-350.

A special study was made of a small pasture of 34 acres in Bloom Township. This pasture is at present nearly surrounded by very large contiguous pastures of original but overgrazed prairie. The writer herded cattle on this prairie for six years. He knew every *Opuntia* patch in the area. Originally there were several small colonies on each of three little hill-tops and two or three colonies on a buffalo grass patch which was about as large as a small city lot. This spot also has "gumbo soil" and, although on rather high land, had in the past served as a buffalo-lick. This pasture was fenced up in the early eighties and pastured up to 1918, but was never overgrazed. In 1918 cattle were not put into it until August 1 and the following four years it was not pastured, but the grass on the more level areas was cut for hay. By 1921 the prairie had almost returned to the original condition with an abundance of big bluestem (*Andropogon furcatus* Muhl.). In 1923 cattle and horses were again put in the pasture and during the past few years it has been decidedly overgrazed. At present all parts of this pasture--hill-tops, general levels, and two deep ravines--contain *Opuntia* colonies. In one ravine, colonies were found growing within four feet of a surviving clump of slough-grass (*Spartina michauxiana* Hitchc.). A complete, although rather superficial survey of the *Opuntia* colonies, ranging from a single isolated plant to patches several feet in diameter, was made and 1655 colonies were counted in this 34-acre patch. Occasionally a colony was found dying out but whether because of tramping by horses and cattle or through some other cause was not discovered.

Three immediate causes for the rapid spread of the prickly pear were in evidence. First, the great destruction of the *Andropogon furcatus* Muhl., *A. scoparius* Mx. and other tall grasses and prairie plants and the development of a shortgrass (buffalo grass) prairie through intense pasturing; second, the distribution of joints of the plant by the feet of cattle; and third, the extreme drought of the past few years.

The spreading of the prickly pear in the pastures is a serious farm problem, since the plants are not only a great nuisance to man and animals but cover much ground which should be occupied by nutritious grasses, and about the only way to control the trouble at present is to dig out the colonies and haul the plants away.

Abstract No. 1140

Schmitz, H. 1939. A silver anniversary on the golden plains. J. Forest. 37(8):593-594.

Foresters naturally enough have a greater and more direct interest in the Forest Service than in any other governmental agency. Many other governmental agencies, however, are engaging in or contributing to forestry activities on an ever broadening front. It is not unlikely, as time goes on, that these agencies will make even greater contributions to American forestry than they are making today.

The Bureau of Plant Industry employs only a small number of foresters, but some agencies of this bureau have made substantial contributions to a considerable number of forestry enterprises. One of the more important of these agencies is the Northern Great Plains Field Station at Mandan, North Dakota, which is now completing twenty-five years of active and fruitful work on prairie tree planting problems.

There are many indications that the work of the Northern Great Plains Field Station has not received the recognition by the Forest Service, the Soil Conservation Service, and other governmental agencies it so richly deserves. This station, operating on a budget which in the light of present day governmental expenditures appears to be ridiculously small, and hampered directly and indirectly in many ways, has made both practical and scientific contributions to prairie tree planting of which even a well supported organization might well feel proud.

Anniversaries always should be happy occasions. The many foresters in the Great Plains region interested in prairie tree planting problems take this opportunity to express the hope that the workers at the Northern Great Plains Field Station may find joy in the fact that under very trying conditions they have made significant contributions to one of the most difficult and urgent American forestry problems--prairie tree planting--and the hope that the golden anniversary to be celebrated twenty-five years hence may be an occasion for even greater and wider rejoicing.

Abstract No. 1141

Schreiber, R. K. 1970. Shorebird migration in Ellis County, Kansas. Trans. Kansas Acad. Sci. 73(1):11-19.

A survey of shorebirds was conducted in Ellis County, Kansas from 22 March to 10 June and 17 July to 15 November, 1968. A total of 3658 shorebirds comprising 22 species was recorded during the migration season. Of this total, 22 species comprising 1222 individuals were observed in spring and 17 species totaling 2436 individuals were sighted in the fall. The Killdeer was the most abundant species during both spring and fall. Of the remainder, the Spotted Sandpiper and Baird's Sandpiper constituted 13% and 14% respectively of the spring movement while the Upland Plover and Western Sandpiper totaled 15% and 17% of the fall movement. The White-rumped Sandpiper, Hudsonian Godwit, Dunlin, Long-billed Curlew and Willet were observed only in the spring. The Spotted Sandpiper and Lesser Yellowlegs were most common in the spring while the Solitary Sandpiper, Western Sandpiper, Least Sandpiper and Upland Plover were observed most often in the fall. In the spring, a positive relationship existed between the peaks of shorebird movement and passages of low pressure systems.

Abstract No. 1142

Schroeder, M. H. 1970. Mourning dove production in a Kansas osage orange planting. J. Wildlife Manage. 34(2):344-348.

A mourning dove (*Zenaidura macroura*) production study was conducted during the 1962 nesting season in an osage orange (*Maclura pomifera*) planting in Ellis County, Kansas. Altogether 389 nests built by an estimated 92 pairs of doves were followed to termination between May 2 and September 11. Of these, 166 nests (43 percent) were lost to predators, storms, or abandonment. Two hundred and forty-two (32 percent) of the 766 eggs laid and 114 (22 percent) of 524 nestling doves were lost during the nesting season. Four hundred and ten nestlings were fledged, averaging 4.5 young per pair. The greatest number of active nests found at any one time was 92, a density of 17.3/acre. The fall dove hunting season resulted in the cessation of nesting activity. Doves were still in the process of nest building and incubation when the season began, but no new nests were started after this time and many active nests were deserted.

Abstract No. 1143

Schulz, H. F. 1935. Causes of decadence in the old groves of North Dakota. U.S. Dep. Agr., Circ. 344. 38 p.

The survey was carried on with two distinct objectives in view: (1) To examine in a general way as many groves as possible within a single field season, and (2) to study intensively a few groves with relation to survival, soil, species, and all related factors.

The extensive survey comprised 447 groves in Pierce, Benson, Ramsey, Wells, Foster, Eddy, and Stutsman Counties. Since both rainfall and the number of shelter belts decrease from east to west, it was deemed desirable to obtain an average of conditions, if possible, by locating the survey in the east-central part of the State.

It was hoped that from this extensive survey a broad picture of the condition of the planted shelter belts in the area might be obtained--something in the nature of a statistical sampling of the situation. This part of the study was carried out through a roadside survey. All groves or windbreaks within 10 chains (660 feet) of either side of the road were included. The following information was taken for each grove: (1) Estimated percentage of living trees among those present, without distinction as to species; (2) number of rows planted, extent; (3) orientation of the long axis of the grove in regard to cardinal directions; (4) species; (5) estimated age; (6) estimated height; (7) spacing between trees; (8) classification of the soil according to texture--light or heavy; (9) present policy in regard to grazing--grazed or not grazed; and (10) area of each windbreak.

Abstract No. 1144

Schuster, J. L. 1964. Root development of native plants under three grazing intensities. Ecology 45:63-70.

The purpose of this study was to examine the cumulative effects of two grazing intensities on the characteristics of individual plants and community root patterns on ponderosa pine-bunchgrass ranges. The species described specifically were mountain muhly, Arizona fescue, blue grama, fringed sagebrush, and Rocky Mountain pussytoes.

Abstract No. 1145

Schuurman, J. J., and M. A. J. Goedewaager. 1965. Methods for the examination of root systems and roots. Centre Agr. Publ. Doc., Wageningen, Holland. 86 p.

The following properties of the root system are important for eco-morphological research:

1. *The total amount of roots*. This gives an approximate idea of the absorptive capacity of the root system, but two plants are only comparable provided they have similar root systems. This means that strictly speaking such a comparison is limited to plants of the same species. The total amount of roots is nearly always expressed in grams after the roots have been dried, but it is equally possible to calculate the total length of all roots or to measure the total surface area.

The total surface area of all roots may be regarded as an important characteristic, but it is one which is extremely difficult to calculate, and moreover not every part of the surface area is functionally similar.

In connection with the problems of supplying the soil with organic material it may also be important to calculate the total weight of roots, or the weight in the tilth only.

2. *The formation of branch roots and the diameter*. The absorptive capacity of a root system is partly determined by the degree of branching and the diameter of the roots. It is also important to calculate the root diameter in order to judge the comparability of two root systems.

3. *The vertical distribution in the profile*. It is ascertained which layers have dense root development and which less dense. From this it is possible to draw conclusions on the nutrient and the moisture uptake from these layers. This may be important for the drought resistance of a crop.

4. *The lateral distribution in the profile*. It is important to determine this in connection with such cultural practices as mechanical hoeing. The plant spacing may be related to lateral root growth.

5. *The maximum depth and width*. The maximum depth is important in connection with the problem of the depth to which the plant can still absorb nutrients and moisture from the soil. The maximum width is important in connection with the layer in which it occurs.

6. *The rate of development*. Comparison between a number of stages of growth affords an idea of the rate of growth. This may be important in connection with periods of drought or frost which may be fatal when root growth is less rapid. Rapid root growth may also be important when nutrients are washed out of the soil.

Abstract No. 1146

Schwan, H. E., D. J. Hodges, and C. N. Weaver. 1949. Influences of grazing and mulch on forage growth. J. Range Manage. 2:142-148.

This study compares total annual as well as spring and summer forage production on heavily grazed, moderately grazed, and ungrazed Kentucky bluegrass range. Also, forage production on heavily grazed range is compared to that on similar areas on which moderate and heavy artificial grass mulches were applied.

Abstract No. 1147

Scott, H. D., and R. E. Phillips. 1971. Diffusion of herbicides to seed. Weed Sci. 19:128-132.

Prior to germination, seed of some plant species either adsorb or absorb some herbicides applied to the soil. Equations were developed describing the concentration of the herbicide expected in the seed both when diffusion of the herbicide in the soil is the limiting factor and when diffusion of the herbicide within the seed is the limiting factor. Expected concentrations of the herbicide in the seed were presented for combinations of three seed radii (seed were assumed to be spheres), five diffusion times, and fice diffusion coefficients. The calculated concentrations of the herbicide in the seed in ppm increased as seed size or radii decreased. This theoretical result was consistent with experimental data and potentially explains why some large-seeded plant species are difficult to control with the use of herbicides. The equation developed for a perfect "sink" predicted within experimental error the concentration of isopropyl *m*-chlorocarbanilate (chlorpropham) absorbed by soybean (*Glycine max* (L.) Merr.) seed from aqueous solutions of chlorpropham.

Abstract No. 1148

Seidensticker, J. C. 1968. Notes on the food habits of the great horned owl in Montana. Murrelet 49(1):1-3.

This pellet analysis indicates that the great horned owl preys on no fewer than 20 species of mammals, birds, and fish in Montana. Of the 744 prey specimens identified, 93% were mammals. White-tailed jackrabbits (*Lepus townsendii*), voles, cottontails, and Richardson ground squirrels (*Citellus richardsonii*) comprised almost 90% of the total recognizable biomass consumed. Birds composed 4% of the total number of prey items. Blackbilled magpies (*Pica pica*) were the most prevalent. The sucker represented only 2% of the total prey items. Game, domestic and fur-bearing species represented less than 1% of the recorded prey items: one muskrat (*Ondartra zibethica*) and 2 grey partridge (*Perdix perdix*). The great diversity in the prey reported here can be accounted for in part by the larger size of the great horned owl. In addition, this species appears to hunt over a variety of habitats and is not strongly confined to nocturnal hunting, as are some of the other owl species.

Abstract No. 1149

Selleck, G. W., and K. Schuppert. 1957. Some aspects of microclimate in a pine forest and in an adjacent prairie. Ecology 38(4):650-653.

Some aspects of microclimate were measured in a planted red pine forest, and in a prairie at the University of Wisconsin Arboretum. Water loss from the soil was measured by the Lowry (1956) method. Water loss from soil in pans (30 x 30 x 8.75 cm) at the ground surface indicated relative humidity to be an approximate measure of evaporation in the open. A line with a slope = 1 was approximated by plotting on log-log paper the area representing the vapor pressure deficit on the chart of a hygrothermograph against gm of water lost per unit time. The corner test of association showed the association of peripheral points to be significant at the 0.1 percent level. Pans which permitted water drainage lost 12.8 percent less water through evaporation than pans without holes and provided data with a higher degree of statistical significance. Water loss in the open exceeded that in the forest by more than four times. The scattered points representing water loss in the forest revealed no definite relationship between evaporation and relative humidity, and the peripheral points were not significantly associated.

The forest canopy modified the extremes of temperature and humidity and maintained longer periods of higher humidity than the grassland. Random distribution of the trees in a forest or plantation may be an important factor in the modification of temperature extremes as compared with a plantation of regularly spaced trees.

Abstract No. 1150

Semple, A. T., and B. W. Allred. 1937. Range improvement by water spreading. Soil Conserv. 2: 269-270.

Frijole and San Francisco Creeks, sister tributaries of the Purgatoire River in southeastern Colorado, the one an ugly twisting barranca, void of trees or brush along its course, its flood-season waters gnawing gullies in the naked soil; the other a pretty, meandering drainage with thickets and tree growths to its water's edge, present today convincing examples of the over-grazed watershed stream and the stream flowing through land that has known the solicitude of soil-conscious owners.

The explananation lies in the story of Louis Cortese and his brother Charlie who in the year 1910 purchased a ranch in the San Francisco Creek basin.

When the Corteses acquired the land, the San Francisco Creek and its tributaries were wild, uncontrolled gullies which were eating away the heart of the ranch.

Each fall these men buy 600 head of white-faced weaners, and these are sold again late the next spring after having wintered on the Cortese pastures and hay. By this program they sell their hay and grass in the most economical way possible, and at the same time the manure from the calves returns a rich food to the soil.

Today there are trees and shrubs along San Francisco Creek channel, and gullies have filled up instead of growing into gulches. Springs have appeared in parts of the creek bed which formerly were dry as bones, and in place of the sparse stands of grama grass the higher-yielding western wheatgrass has taken strong hold.

Given owners with stout hearts, discernment, and a knowledge of best stream-control methods, Frijole could, within 20 years or less, match her sister basin in the matter of fine pasture, heavy hay, and fat cattle.

Abstract No. 1151

Shantz, H. L. 1906. A study of the vegetation of the mesa region east of Pike's Peak: the *Bouteloua* formation. Bot. Gaz. 42:16-47.

The region under consideration in this study lies at the base of Pike's Peak and north and west of Colorado Springs. It is the portion known as the Mesa and the Garden of the Gods and contains 3200 to 4000 hectares. While attention has been confined largely to this region, studies have been pushed out in all directions, and have attempted to make familiar the mountain and plains conditions of vegetation, as well as that of the area under consideration. Especial attention was given to the plains which extend eastward from the area first studied.

Abstract No. 1152

Shantz, H. L. 1911. Natural vegetation as an indicator of the capabilities of land for crop production in the Great Plains area. U.S. Bur. Plant Ind. Bull. 201. 100 p.

The natural vegetation is largely used to indicate the agricultural capabilities of land, but there are many possibilities of error, as this indicator is ordinarily employed.

The object of the present publication is to show how this indicator may be employed accurately for the ready classification of new land.

Abstract No. 1153

Shantz, H. L. 1917. Plant succession on abandoned roads in eastern Colorado. J. Ecol. 5:19-42.

The natural vegetation at Akron, Colorado consists largely of two grasses--the Grama grass, *Bouteloua gracilis* (*B. oligostachya*) and the Buffalo grass, *Buchloë* (*Bulbilis*) *dactyloides*. This vegetation, discussed by the writer as the Grama-Buffalo grass association of the short-grass formation, is the principal type of the central portion of the Great Plains. If turned under by the plough and abandoned after having been cultivated for some time, the native sod will be re-established in from twenty to fifty years. The following stages may be recognized in the succession:

(1) an early weed stage consisting usually of comparatively large plants, scattered and far enough apart not to compete with each other for soil moisture;

(2) a late weed stage, a dense growth of stunted plants, the amount of growth indicating the total amount of water which was available for growth;

(3) a short-lived grass stage;

(4) a perennial stage;

(5) an early short-grass stage; and

(6) a late short-grass stage leading to the fully re-established typical short-grass sod.

The succession on abandoned roads differs from that on abandoned fields only in minor details.

Abstract No. 1154

Shantz, H. L. 1923. The natural vegetation of the Great Plains region. Ass. Amer. Geogr. Ann. 13:81-107.

In the area here considered the supply of rainfall is not sufficient to moisten the soil below the reach of the grass roots. No moisture is lost to the subsoil, and there is normally no storage of soil moisture from year to year. The subsoil is permanently dry. Over much of the area the soil is filled to its carrying capacity only to a depth of 1 to 4 feet below the surface. This soil moisture is absorbed and passed out into the air by transpiration before the first frosts in autumn. The growth period is therefore initiated by favorable temperature but terminated by drought.

The total quantity of water stored at the beginning of the season is equivalent to from 2 to 5 inches of rainfall. To this initial supply must be added the rainfall during the growing season. This may vary from 2 to 15 inches.

The moisture supply is greater in the south than in the north, but the water requirement of the plants is proportionately greater. For the growing plant the moisture conditions are therefore similar.

The needle-grass and slender-wheat-grass area is one of rich, deep, black soil moistened to a depth of 2 to 3½ feet at the beginning of the growth period. The water requirement of plants is lower than in any other area of the region considered. The area produces a good stand of relatively tall grasses valuable for forage and native hay. The land, under cultivation, has become the great spring-wheat-area of the United States.

South of the needle-grass and slender-wheat-grass area the bluestem--bunch-grass association characterizes a soil moist from 2 to 4 feet. A good growth of tall grass is produced, valuable both for pasturage and native hay. This association characterizes the great winter-wheat area of the United States. This area is also productive of corn and alfalfa.

South of the bluestem--bunch-grass area, the mesquite and mesquite-grass area is one of alternating severe drought and good moisture supply. The area is not as favorable for plant growth as those just mentioned. Cotton is produced throughout the area and grain sorghums are grown chiefly in the north.

The groups of plant associations just considered represent land primarily valuable for crop production. Lying just west of this group of plant associations are the grama and western-needle-grass, the wire-grass, and the western-wheat-grass associations. Here crop failures are more likely to occur and agriculture rests both on crop production and grazing. Still farther west crops can only be produced during exceptionally good years, and the land is chiefly valuable for grazing.

On the basis of agricultural potentiality of the land the plant communities may be arranged as follows:

Land primarily valuable for crop production:

1. Needle grass and slender wheat-grass (spring wheat and other spring cereals)
2. Bluestem bunch-grass (winter wheat, corn, and alfalfa)
3. Mesquite and mesquite grass (cotton and grain sorghums)

Land valuable for crop production and grazing: (crop failures during years of less than normal rainfall):

4. Grama and western-needle-grass (spring wheat and other spring grains)
5. Wire-grass (winter wheat, corn, and grain sorghums in the south)
6. Wheat-grass (spring grains and corn)
7. Grama and mountain sage (spring grains)

Land valuable for grazing and crop production: (good crops only during years of more than normal rainfall):

8. Grama and buffalo-grass (grain sorghums, corn, and small grains)
9. Mesquite grass and thorn bush (cotton and grain sorghums during good years only)
10. Sand sage and sand grass (corn and sorghum except in the southwest)
11. Grama grass (spring grains during good years only)

Land valuable for grazing only:

12. Sagebrush and western wheat-grass
13. Black grama

Numbers 1, 2, 4 and 10 are best as hay land. As grazing land the numbers would run about as follows: 1, 2, 6, 4, 5, 10, 7, 8, 3, 11, 9, 13, 12.

Abstract No. 1155

Shantz, H. L. 1927. Drought resistance and soil moisture. Ecology 8(2):145-157.

True drought can occur only when the available soil water has been exhausted. With a dry subsoil, the field carrying capacity of the soil will be approximately twice the non-available water. The minimum point of exhaustion may vary from a little below the wilting point to about one half this amount under extreme desert conditions. It is impossible to moisten soil by the addition of water to less than the field carrying capacity, and all experiments based on effect of different water contents of soil on plant growth are likely to be subject to grave errors. Experiments on the effect of different amounts of soil moisture can not be accepted as reliable without a careful analysis of the methods employed. Exposed soils can not be kept at a definite water content during an experiment unless this water content is higher than that normally encountered in drained soils under field conditions. In order successfully to carry on experiments with drought resistance, or to understand the relation of plants to moisture supply, it is necessary to have a fairly clear understanding of the whole subject of the moisture retaining power of the soil.

The plants which succeed in a country subject to drought (1) escape the drought by a short, rapid growth period; (2) evade the drought by conserving the scanty moisture supply by small size, restricted growth, wide spacing or low water requirement; (3) endure the drought by passing into a drought dormant condition; or (4) resist the drought by storing up a supply of water in their plant bodies to be used when none can be secured from the soil, and have the ability to push their roots in dry soil. They do not possess any superiority in their ability to make growth in a dry soil, and often no greater efficiency in the use of water.

No satisfactory explanation is given for the difference in the water requirement of plants, but it is true that one plant may produce a pound of dry matter with only a third as much water as another. Plants with a high water requirement in dry air and sunshine usually maintain a temperature below the air temperature, while those with a low water requirement under similar conditions maintain a temperature above that of the air.

Abstract No. 1156

Shantz, H. L. 1954. The place of grassland in the earth's cover of vegetation. Ecology 35:143-145.

About half (57%) of the land surface of the earth is covered with pedalfer soils. In these soils, the moisture is in excess of the demands of the vegetation and water passes down through the soils leaching them and moistening the subsoils down to the water table. About half (43%) of the land surface of the earth is covered with pedocal soils. In these soils, moisture is held in a surface layer and usually completely absorbed by the growing vegetation and none passes down into the sub-soils which remain dry.

As a rule, forests are found on pedalfer soils and can only succeed on the very best of the pedocals. Grasslands are confined to largely to pedocals and when growing on pedalfers are not strictly climax but except for the aid of clearing, cutting, or burning of the forest growth would be replaced by trees or brush.

If one excludes alluvial bottom lands, the most productive soils are built up under grasslands on the moister side of the pedocals.

Abstract No. 1157

Shantz, H. L., and R. L. Piemeisel. 1917. Fungus fairy rings in eastern Colorado and their effect on the vegetation. J. Agr. Res. 11(5): 191-246.

The present paper deals with fairy rings caused by fleshy fungi. The rings due to other causes, such as the grass rings, are not considered. The fungus rings are marked either by the fruiting bodies of the fungus or by a stimulated or a depressed growth of the natural vegetation or the cultivated crop. Fairy rings may become so abundant locally as to affect materially the crop yields of fields. On lawns they cause unsightly bare spots and dark-green areas, and in small experimental plots cause either a total loss of crop or a greatly increased yield. They are undesirable in all cases, and their eradication is a matter of practical importance. The studies herein recorded were made on the High Plains at Akron, Colorado, during the period 1907 to 1916, inclusive. The soil studies were made during the summers of 1914, 1915, and 1916.

Abstract No. 1158

Shantz, H. L., F. W. Albertson, W. A. Albrecht, R. Daubenmire, H. S. Fitch, R. L. Piemeisel, W. G. Whaley. 1959. Aspects of needed research on North American grasslands. Trans. Kansas Acad. Sci. 62:175-183.

Grasses constitute one of the world's most important resources. They dominate the vegetation of vast areas of the earth. Because of their abundance, they play a tremendous part in the building and holding of soil; their presence is critical for the conservation of water in many regions; and as food for grazing animals they are the source of materials of much of the world's supply of meat, and of a host of other animal products. Much of the land taken over for the cultivation of basic food crops was once grassland.

The improvement of the plant cover of millions of acres of land and of the management of this land is one of the most challenging problems in further development of the natural resources, both in the United States and in many other parts of the world.

The aim of research is, basically, maintenance of the grasslands and increase in their usefulness to man. Their specific role will differ from area to area and with changing circumstances, but is is of utmost importance to recognize that with increasing population pressures and generally decreasing soil fertility the production potential of these lands is the paramount consideration. The grassland problem is predominantly one of management, to assure the greatest yield commensurate with rebuilding of damaged lands, and prevention of further deterioration.

Abstract No. 1159

Sharpe, A. L., J. J. Bond, J. W. Neuberger, A. R. Kuhlman, and J. K. Lewis. 1964. Runoff as affected by intensity of grazing on rangeland. J. Soil Water Conserv. 19:103-106.

In studies initiated at the Cottonwood Range Field Station, Cottonwood, South Dakota, in 1963, runoff was measured on ranges that had been subjected to light, moderate, and heavy grazing since 1942. Vegetation on the experimental watersheds also was characterized.

Abstract No. 1160

Sheals, J. G. [ed.] 1969. The soil ecosystem. Systematics Ass. Publ. No. 8, Systematics Ass., London. 247 p.

The papers published in this volume were presented at a Symposium, "The Soil Ecosystem: Systematic Aspects of the Environment, Organisms and Communities," arranged by the Systematics Association and held at the University of Nottingham School of Agriculture, Sutton Bonington, 26-28 March, 1968. The object of the Symposium was to bring together people interested in systematic aspects of the soil and its flora and fauna, for an exchange of information and ideas, and for a discussion of problems of common interest. The meeting was divided into three sections, dealing with the environment, the organisms and with communities and interactions. Each section was chaired and introduced by an invited speaker.

Abstract No. 1161

Shear, C. L. 1901. Field work of the division of Agrostology; a review and summary of the work done since organization of division, July 1, 1895. U.S. Dep. Agr. Div. Agrostology Bull. 25. 67 p.

The Division of Agrostology was established by Congress in 1895 for the purpose of investigating the various problems relating to the grasses and forage plants of the United States. Progressive farmers, stockmen, and dairymen had for some time recognized that there was urgent need of a thorough study of the various forage problems which were presenting themselves in different parts of the country. Consequently the then Secretary of Agriculture, Hon. J. Sterling Morton, recommended to Congress that a separate Division be established to take charge of and prosecute the work.

The stock-growing industry is one of great importance and one that should be carefully fostered. The vast areas of land throughout the Western States and Territories, which are at present unavailable for general agricultural purposes, and the greater part of which probably never will be available for such use on account of the insufficient water supply, should be properly controlled so as to conserve their usefulness.

The various evils arising from overstocking and denuding extensive areas of grazing and timber lands bear such a direct relation to the general welfare of the whole West that it is incumbent upon the General Government to make a thorough investigation of all the questions involved and if possible devise some means of remedying the present conditions. The relation of the grazing industry to forest reserves, to the water supply, to erosion, and the various other matters to which it more or less directly relates can not be solved except by long and careful investigation of the actual facts and conditions prevailing. The questions involved required, first of all, a thorough and accurate knowledge of the actual facts and conditions existing. Thus, field work was commenced as soon as the Division was established in order that the necessary data might be secured as a basis for future work and recommendations.

Abstract No. 1162

Sheedy, J. 1971. Calcium, magnesium, phosphorus, and potassium budgets of a tallgrass prairie. M.S. Thesis. Univ. Oklahoma, Norman. 33 p. (Advisor: Paul Risser).

The purpose of this paper is to present a nutrient budget for magnesium, calcium, potassium, and phosphorus for a tallgrass prairie.

This study indicated the magnitude of nutrient flux in the tallgrass prairie. Mineral content was a reflection of the amount of biomass in each compartment and there was a constant and dynamic change in this mineral content. The amount of each nutrient varied not only from one compartment to another, but also with time. The individual nutrients studied reached their maximums and minimums independently of each other.

Abstract No. 1163

Sherman, R. J. and P. Klug. 1970. CO_2 flux over shortgrass vegetation on the Pawnee National Grasslands. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

A portable gas analysis system incorporating an automatic multi-channel gas switching system and a continuous flow infra-red gas analyzer with associated pumping and flow metering systems has been developed to monitor CO_2 concentrations in the canopy of short grass vegetation either aerodynamically or within a 24 inch diameter plexiglass chamber at various elevations above the canopy. Aerodynamic measurements obtained in August of 1969 (approaching the onset of dormancy for some of the components of the canopy) indicated a diurnal flux in CO_2 concentration of approximately 20 ppm (310-330 ppm) at 6 meters and about 40 ppm (300-340 ppm) at .01 meters. The onset of changes in trends from CO_2 depletion to accumulation at dusk at the 6 meter level was observed to lag approximately 1½ to 2 hours behind the onset of that trend in the vegetation canopy. The lag following sunrise was approximately one hour. These late-season results are considered especially noteworthy in view of speculation by other workers that differentials in CO_2 concentrations over shortgrass vegetation could not be detected by aerodynamic techniques.

Abstract No. 1164

Shimek, B. 1911. The prairies. Stud. Natur. Hist., Iowa Univ. Bull. 6:169-240.

Exposure to evaporation as determined by temperature, wind, and topography is the primary cause of treelessness of the prairies.

The prairie flora persists on the exposed areas because it is xerophytic.

Rainfall and drainage, while of importance because determining the available supply of water in both soil and air, are not a general, determining cause, both frequently being equal on contiguous forested and prairie areas.

Soils and geological formations are of value only in so far as they affect conservation of water; the porosity of the former determining its power of holding moisture, and the latter often determining topography.

Prairie fires were an effect rather than a cause, and where acting as a cause were local.

Seed-dispersal probably largely accounts for the grouping of plant societies on the prairies, but does not account for the presence of the prairie flora as a whole.

Abstract No. 1165

Shimek, B. 1925. The persistence of the prairie. Univ. Iowa, Stud. Natur. Hist. 11:3-24.

A critical study through many years of selected tracts in Iowa shows that areas originally prairie are naturally restored after having been cultivated and otherwise disturbed. The prairie does not represent a transition state but is a climax flora in its own right. In the restoration of prairies the earlier transition stages contain various mixtures of plants determined by the character of adjacent floras. Certain native plants, termed prairie weeds, quickly take possession of disturbed areas and form the advance guard of the prairie flora. Certain introduced weeds assist in this process of restoration but disappear as the prairie association is renewed. The prairie remnants still persisting in Iowa are sufficient to furnish seed for the restoration of undisturbed areas. Protected tracts such as state parks may be returned to prairie at slight expense. The views that the prairie will disappear for all time if broken, and that with the cessation of fires the forest will take possession of prairie are untenable in the light of the behavior of these tracts studied and similar areas observed elsewhere.

Abstract No. 1166

Shimek, B. 1925. The prairie flora on Manitoba. Univ. Iowa, Stud. Natur. Hist. 11:25-36.

A brief discussion is given of the prairie flora as it appears in a portion of southern Manitoba near the northern border of the prairie area. The vicinity of Carberry, abouth 100 miles north of Winnipeg, was chosen for study because of an earlier study of the flora of that region published by Christy (1887). This region was visited by the author in 1883 and 1884 when first being settled, and in 1920 when the prairie of the region was mostly under cultivation. The paper includes observations on the floras of swamp, forest, dune, and prairie. Lists of prominent species are given for both the sand prairie and the more fertile prairie. Attention is given also to the weed flora both native and introduced, most of the latter having entered since the publication of Christy's list nearly 40 years ago.

Abstract No. 1167

Shimek, B. 1931. The relation between the migrant and native flora of the prairie region. Univ. Iowa Stud. Natur. Hist. 14(2):10-16.

The great majority of 267 species recorded in the immigrant flora of Iowa are found in the areas most completely dominated by man. Of this foreign flora, probably 20 species have come from other parts of the U.S.A. (chiefly west and south), while nearly 240 were received from the Old World. The foreign flora comes into competition with the native flora of the prairies on disturbed areas, especially where cultivation is stopped. There is also a group of migrant native prairie plants which mingle freely with the foreign species in taking possession of disturbed areas along railways; while on areas remote from the main lines of travel the native species take possession almost to the exclusion of the foreign forms. The more stable prairie flora gradually invades such areas and finally crowds out the migrants. The prairie flora is not permanently destroyed by the breaking up of the prairie turf; it will come back, especially if remnants of it have been preserved near by. Well-selected preserves of the native prairie flora should be established.

Abstract No. 1168

Shirley, H. L. 1934. A method for studying drought resistance in plants. Science 79(2036):14-16.

Potted plants were placed in a closed, illuminated chamber at constant temperature. Air dried by $CaCl_2$ was passed through the chamber. Time of survival of plant was taken as a measure of drought resistance.

Abstract No. 1169

Shoop, M. C., and E. H. McIlvain. 1971. Efficiency of combining improvement practices that increase steer gains. J. Range Manage. 24(2): 113-116.

Contrary to general expectations, four improvement practices used in combination increased yearlong gain per steer as much as the sum of the practices used alone. The improvement practices studies were moderate grazing, additional winter cake, late-summer cake, and stilbestrol. The basic practice was heavy grazing. The 100% efficiency of gain obtained with the combined practices indicates that an improvement practice should produce about the same increase in gain regardless of the number of other improvement practices used on a ranch or in an experiment.

Abstract No. 1170

Short, L. R. 1943. Reseeding to increase the range of Montana range lands. U.S. Dep. Agr. Farmers Bull. 1924. 26 p.

War demands on western range lands have intensified a major problem confronting the livestock industry in Montana--the great need for more and better range. Additional range forage is imperatively needed to meet emergency demands for production of beef, lamb, wool, and hides. Today several million acres of range lands are yielding only a small fraction of the forage they should produce. A considerable portion of the best of these low-productive lands consists of areas that have been plowed, used briefly for farm crops, and then abandoned. Three-fourths of this plowed land is not coming back satisfactorily to forage plants, and much of it is deteriorating through wind erosion. Tests by the Forest Service and other agencies have shown that many of them could be brought back quickly to better forage through artificial reseeding. By inexpensive methods, it is usually possible to double or even quadruple the grazing capacity of the lands within 2 to 4 years.

To safeguard against costly mistakes, however, and to insure reasonable and early results in reseeding at moderate expense, certain rules should be observed. The guides herein outlined as to where, what, when, and how to reseed, based on experience and research, supply this essential information for those Montana ranchers who contemplate increasing their forage supply. They may also be helpful on other western ranges.

Abstract No. 1171

Shreve, F. 1917. A map of the vegetation of the United States. Geogr. Rev. 3:119-125.

The interest of the writer in the compilation of the map which is presented has been to secure a basal delineation of the geographical features of plant distribution in the United States for use in an investigation of the influence of climate on the range of the principal types of vegetation. For this reason it has been particularly important to base the subdivisions and boundaries of the map upon purely vegetational criteria, with complete disregard of climatic, physiographic, geological, floristic, historical, or other considerations.

Abstract No. 1172

Shubert, M. L. 1969. The nature and importance of competition between wood and herbaceous plants in a grassland ecosystem, p. 172-182. *In* R. L. Dix and R. G. Beidleman [ed.]. The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The intensity of competitive interaction between woody and herbaceous plants is conditioned by these factors: inherent qualities of the competing individuals, the abiotic environment, other kinds of interaction with plants and animals which affect the vigor of the competing individuals, catastrophic events such as fire, and man's activities. Literature is reviewed to illustrate these factors and to provide information as to the importance of this type of competition in a grassland ecosystem.

Abstract No. 1173

Silow, R. A. [Convener] 1966. The use of isotopes in soil organic matter studies. FAO/IAEA Technical Meeting, Pergamon Press, New York. 505 p.

The nature, content, and behavior of the organic matter, or humus, in soil are factors of fundamental importance for soil productivity and the development of optimum conditions for growth of crops under diverse temperate, tropical and arid climatic conditions. Unfortunately, the study of soil organic matter presents some of the most complex problems with which the soil specialist and his collaborators in soil biochemistry and soi;l microbiology have to deal. However, tracer techniques involving the use of radioactive and stable isotopes have recently resulted in substantial advances in knowledge of the behavior and functions of organic matter in soil.

The wide application of tracer techniques in agricultural research has become possible in recent years as a result of the ready availability of radioactive isotopes from the atomic energy industry. It is only if such developments in modern science and technology are utilized to the fullest possible extent that governments will be able to meet one of the most urgent tasks facing them--the task of providing more plentiful and more nutritious food for a world population that by the end of this century is expected to be twice as large as it is today.

As part of their cooperative contributions to the international program for promoting the peaceful uses of atomic energy, and to the Freedom from Hunger Campaign, which has as its aim the mobilization of all resources to free the world from hunger and malnutrition, the Food and Agriculture Organization of the United Nations and the International Atomic Energy Agency jointly convened in 1963 an international meeting to review the progress that has been achieved through the use of tracer techniques in studies of soil organic matter and the ways in which it can contribute to the growth of better crops. On the basis of that review the manner in which those techniques can best be used in future research on those subjects was assessed. The proceedings of that meeting and the papers presented are included in this report with a view to providing a wider exchange of information that will lead to further knowledge of the ways in which soil organic matter contributes to increased production of crops for food and industrial purposes.

The program for the meeting ranged over a wide field and included such topics as the fundamental processes involved in humus formation, the chemical reactions involved, the role of microorganisms, and the inter-relationship between levels of soil organic matter, cultural practices and soil structure, all of which were considered in relation to their influence on soil productivity under various climatic conditions the world over.

Abstract No. 1174

Sims, P. L., D. N. Hyder, L. J. Ayuko, and R. K. Lang'at. 1970. Developmental morphology of four warm-season grasses. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

Vegetative expansion, floral development and responses to mowing were studied on four species of grasses important for grazing in the Great Plains.

The developmental morphology of switchgrass (*Panicum virgatum* L. var. Caddo), sand blustem (*Andropogon halli* Hack. var. Elida), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr. var. El Reno) and blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud. var. Lovington) was studied during the growing season, 1967, at the Eastern Colorado Range Station. Growth curves of blades, sheaths, and internodes were constructed from phytomer measurements of plants collected from nurseries planted in May, 1965. In addition, the effects of mowing eleven plots of each species at weekly intervals were studied. Data sets included the measurements of the effects of plant tissue removal on regrowth, tillering, reproduction, and leaf replacement.

The growth curves conform to a typical s-shaped growth curve with the majority of growth occurring in late May, June, and early July. Shoots arose from several sources depending on the species. Blue grama shoots grew from basal auxillary buds of old culms. Sand bluestem shoots grew from rhizomes and shoot apices enclosed in dead leaves of the previous year's growth. Vegetative expansion in switchgrass was by rhizomes, crown buds, stem buds and the continuation of arrested growth. In sideoats grama, vegetative expansion was by crown and stem buds and the continuation of the previous year's arrested growth.

Generally, mowing after late June resulted in increased tillering, reduced regrowth, and failure to produce seedheads. A reduction in internode elongation of some reproductive shoots of sideoats grama was also noted.

Abstract No. 1175

Sims, P. L., G. R. Lovell, and D. F. Hervey. 1971. Seasonal trends in herbage and nutrient production of important sandhill grasses. J. Range Science 24(1):55-59.

Aboveground biomass and nutrient production of important grasses were estimated on two range sites in the eastern Colorado sandhills. Apparent seasonal net production of blue grama and western wheatgrass on the sandy plains site was 144 g/m^2 compared to 90 g/m^2 for blue grama, prairie sandreed, and needle and thread grasses on the deep-sand range site. Production rates for the grasses studied were 1.8 and 0.8 g/m^2/day for the sandy plains and deep-sand range sites, respectively. Herbage biomass decline 28% from the peak standing crop to fall (October 2) on both sites. During the late summer and winter months the biomass declined 50% on the deep-sand site and 35% on the sandy plains site. The sandy plains site produced a larger amount of crude protein than the deep-sand range site. This was accounted for by a larger herbage biomass and a higher percentage of crude protein in grasses grown on the sandy plains site. This more productive site appears to retain more herbage of higher nutritive value throughout the winter than the deep-sand site.

Abstract No. 1176

Sims, P. L. and J. S. Singh. 1971. Herbage dynamics and net primary production in certain ungrazed and grazed grasslands in North America, p. 59-124. *In* N. R. French [ed.], Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Nine U.S. IBP Grassland Biome sites are characterized according to the abiotic and vegetational characteristics and their relationship to grazed and ungrazed conditions by analysis and synthesis of 1970 field data. Abiotic characteristics including length of growing season, usable solar radiation, mean annual temperature, mean annual precipitation, potential and actual evapotranspiration, and aridity indices are used to interpret intraseasonal herbage dynamics and net primary productivity. Synthesis of vegetation data involved categorization of plant species into cool and warm season vegetation classes (grasses, forbs, shrubs, and succulents) and into compartments by live, current year's dead, old dead, litter, and belowground plant material. The belowground biomass is characterized according to the seasonal average and peak biomass, percentage of total plant biomass situated belowground, and the vertical distribution of this material. Annual increment and turnover rates are presented. The relationship of these characteristics to abiotic factors is examined. Estimated net primary productivity and accumulation rates are calculated for ungrazed and grazed grasslands on each site. These data are further analyzed by evaluation of system transfer functions and efficiency of energy capture by various vegetation compartments.

Results show that grasses are the most important class of vegetation. Cool season species dominate some northern sites, warm season species the southern sites, while some sites have both types. Other vegetation classes not having significant production are, however, important in explaining variability in grazing treatments. Vegetation compartments show similar intraseasonal dynamics, but still reveal interesting site characteristics. Belowground biomass parameters (state variables) show characteristic time and space relationships. Abiotic factors (driving variables), such as mean annual temperature, assist in explaining these relationships. Net primary productivity and accumulation rates are presented which indicate that grasslands have inherent mechanisms to adjust to grazing pressure. Net primary production is similar on grazed and ungrazed grasslands, but the predominant pathways vary. System transfer functions indicate that under grazing pressure, productivity of grasslands belowground is more important relative to aboveground productivity. Values for efficiency of energy capture indicate similar results for both grazed and ungrazed grassland.

Abstract No. 1177

Sims, P. L., D. W. Uresk, D. L. Bartos, and W. K. Lauenroth. 1971. Herbage dynamics on the Pawnee Site: Aboveground and belowground herbage dynamics on the four grazing intensity treatments; and preliminary sampling on the ecosystem stress site. U.S. IBP Tech. Rep. No. 99. 95 p.

Sampling on the grazing intensity treatments was much the same as in 1969. The methods for sampling aboveground and belowground herbage are included in Section I. Section II and Section III are figures and tables for the aboveground and belowground herbage dynamics, respectively. The descriptions of raw and "first pass" data for these figures are in Appendix A and B, respectively.

Preliminary sampling design for the ecosystem stress study site is in Section IV.

Abstract No. 1178

Sinclair, R. and D. A. Thomas. 1970. Optical properties of leaves of some species in arid South Australia. Australian J. Bot. 18(3): 261-273.

Reflection and transmission spectra were measured for the leaves of a number of species of South Australian arid zone vegetation, over the wavelength range 350-1350 nm. Spectra were also obtained for several non-arid species for comparison. Coefficients of reflection, transmission, and absorption of solar radiation were calculated from these spectra, and also obtained from direct measurements made with a specially constructed reflecting hemisphere.

The coefficients of reflection for the arid zone species covered a wide range of values, and the group as a whole could not be clearly separated from the comparison group on the basis of reflection or absorption coefficients. Of the species in the group, *Atriplex vesicaria* had the highest coefficient of reflection, and also the lowest coefficient of absorption.

Abstract No. 1179

Singh, G. 1959. Some effects of differential clipping on six native grasses and one introduced species. M.S. Thesis, Oklahoma State Univ., Stillwater.

A study was conducted at the Lake Carl Blackwell area. Six native grass species and one introduced species were selected for the research.

Different ecological methods were used to determine the botanical composition, basal density, yield and root weight and volume of the grass species in question resulting from various clipping treatments.

Annual brome and six week fescue were the principal invading species in all plots. In general these were most abundant in plots clipped least frequently and where abundant litter had acumulated on the soil.

Basal density of grass species decreases with the increase in intensity of clipping except in the case of K. R. bluestem where the density increased with the increase in frequency and intensity of clipping.

Root weight and volume was also larger under the 2 inch clipping height as compared to the 4 inch clipping height in K. R. bluestem.

The root weight and volume of native grass species decreased with the increase in intensity and frequency of clipping.

The line transect method was quicker than hand separation for finding out botanical composition.

The quadrat method was faster than the line transect in determining the basal density.

The soil core sampling method appeared to be a satisfactory method for determining root weight and volume of grass species in the top 4 inches of soil. It could be used, however, only when soil moisture was adequate.

Abstract No. 1180

Sitler, H. G. 1958. Economic possibilities of seeding wheatland to grass in eastern Colorado. Agr. Res. Service, U.S. Dep. Agr. ARS 43-64.

The study reported here deals with the costs and returns of seeding cropland to grass in the eastern Colorado wheat area north of the Arkansas River. In this semiarid plains area, approximately two-fifths of the land is under cultivation and three-fifths is in pasture. Since 1929, the acreage of cultivated land here has increased from 2.8 million to 4.2 million acres.

Abstract No. 1181

Sloan, C. E. 1970. Biotic and hydrologic variables in prairie potholes in North Dakota. J. Range Manage. 23(4):260-263.

Prairie potholes or sloughs are depressions of glacial origin that occur north of the Missouri River in the prairie region of the United States and Canada. Potholes provide valuable wetland habitat for migratory waterfowl and are widely used for stockwater supplies. Differences in climate, geology, topography, ground-water hydrology, and land use create wide variations in pothole hydrology. Plants in and adjacent to potholes are useful indicators of water permanence, depth, and salinity--variables that are important in wetland management.

Abstract No. 1182

Smith, C. C. 1940. Biotic and physiographic succession on abandoned eroded farmland. Ecol. Monogr. 10(3):421-484.

Quantitative studies of the populations of plants and animals and soil analyses were made on a series of areas representing stages in the development from the recently abandoned eroded land to the climax prairie community. Though many plants and animals are common to all stages of succession, the numbers of each species vary from stage to stage and some have a very limited successional range. The first plants to occupy a recently abandoned area are mostly forbs. These are replaced by annual grasses which dominate the midseral stages of succession. The annual grasses are replaced by the prairie dominants as climax conditions are approached. The perennial grasses have a bunch-grass growthform when they first invade the midseral communities. As soil conditions become more favorable and the number of perennial grass plants per unit area increases, the bunch-grass form is lost by the spreading of the plants vegetatively to form a sod. The midseral stages in succession show a much larger number of species of insects than the climax prairie community. This may be accounted for by the fact that the midseral community population of insects is made up of (1) the majority of the pioneer organisms, (2) a large group of insects characteristic of the midseral stages of succession and (3) most of the insects found in the climax which were present in or invaded during the midseral stages. The drop in the number of species of insects in the climax stage may be accounted for by the dropping out of many midseral and pioneer species. The pioneer stage, with its large-seeded species of plants such as *Helianthus* spp., *Ambrosia* spp., *Aplopappus ciliatus*, etc., had a larger population of small mammals than the midseral stages but fewer species than the climax prairie. Meadowlarks are most abundant in the midseral stages in succession. Increase in humus content is only one of many soil changes which occur as the prairie community develops. Other workers have found that increase in the degree of aggregation of soil particles, reduction of the ease with which soil particles are dispersed, increase in organic colloid content of the soil complex, increase in water-holding capacity and ease of percolation of water are changes associated with the development of a stable soil. Evidence was obtained that due to the open character of recently abandoned soil, the humus content may decrease for few years after abandonment until the soil surface has become more or less stabilized through biotic activity.

Abstract No. 1183

Smith, C. C. 1940. The effect of overgrazing and erosion upon the biota of the mixed-grass prairie of Oklahoma. Ecology 21:381-397.

The work of Weaver and Fitzpatrick and others have shown that the removal of vegetative growth after maturity has little effect upon the future growth and reproduction of the components of the prairie. On the other hand, it has been the universal experience of cattlemen that when grasslands are grazed heavily and continuously throughout the year the original palatable components are replaced by inedible or unpalatable species. It has been the observation of the writer that when grazing is suspended during the spring months in central Oklahoma, later grazing has little more effect upon the composition of the vegetation than does mowing for hay in the summer.

Pasturing of perennial grasses in spring just as new stems and leaves are developing means more than just removing a portion of the plant. The young shoots have been produced at the expense of reserves in the underground parts of the plant and their premature removal does not allow the reserves to be replensihed. Thus the vitality of the perennial plants is rapidly depleted. Removal of the same parts after they have attained their full size would allow them to return to the underground stems and roots a quantity of food equal to that utilized in their product and at the same time would provide far more food for the harvesting animal. The effects of overgrazing upon the biota of the prairie are summarized.

Abstract No. 1184

Smith, D. R. 1967. Effects of cattle grazing on a ponderosa pine-bunchgrass range in Colorado. U.S. Dep. Agr. Tech. Bull. 1371:1-60.

This bulletin helps answer the question, "How should a ponderosa pine-bunchgrass range be grazed to maintain maximum sustained production of forage and beef?" It reports a study of the relationships of three intensities of cattle grazing on this range type to: (1) range utilization, (2) herbage production, (3) other plant responses, (4) soil conditions, and (5) cattle weight gains.

The experimental area is on the Manitou Experimental Forest, 28 miles northwest of Colorado Springs, Colorado. It varies in elevation from 7,600 to 8,200 feet. Soils, developed primarily from Pikes Peak granite, are unstable and low in organic matter. The climate is characteristic of that along the eastern slope of the central Rocky Mountains. Winters are dry and often cold. Summers are relatively cool. Average annual precipitation during the 23 years (1937-1959) was 15.4 inches; 73 percent fell in the five month period between April 1 and August 31.

The most extensive vegetation types within the experimental ranges are open timber and grassland. In addition, there are small areas of dense timber and a fourth class, abandoned fields--areas once cultivated, then abandoned, and now slowly returning to native cover. Two perennial bunchgrasses, Arizona fescue and mountain muhly, are the most abundant and the most important forage producers.

Studies were conducted from 1941 through 1958 within six fenced ranges of 254 to 309 acres. These ranges were grazed by yearling Hereford heifers except for a few seasons when some Aberdeen Angus heifers were present. The grazing season generally was June 1 through October 31. Three levels of grazing tested were: (1) light--10 to 20 percent removal of the current growth of dominant forage grasses, (2) moderate--30 to 40 percent, and (3) heavy--more than 50 percent.

The principal findings from this study are reviewed.

Abstract No. 1185

Smith, F. M. 1971. Central Basin hydrologic process studies. U.S. IBP Tech. Rep. No. 91. 26 p.

This report summarizes the objective and approach to the Central Basin Studies and reports the progress to date. In general, the objective of the Central Basin Study is to model the hydrologic behavior of the basin as a complement to the microwatershed studies. For modeling purposes the basin represents a much more complex system than the microwatersheds.

Progress during 1970 includes the preparation of a set of topographic maps of the basin, the tabulation of 30 year rainfall data from the ARS Network, and a field study of infiltration rates on four soil types and three grazing treatments.

Abstract No. 1186

Smith, F. M. 1971. Growing season precipitation records, Central Plains Experimental Range ARS, Nunn, Colorado. U.S. IBP Tech. Rep. No. 74. 73 p.

Precipitation measurements for the growing season (ca. April through October) have been collected on the Central Plains Experimental Range (CPER) since 1940 and are continuing. In an area of about 36 km^2, data has been collected from 29 rain gages. Twenty-one gages have complete records to the present.

Abstract No. 1187

Smith, J. G. 1896. Forage conditions of the prairie region. U.S. Dep. Agr. Yearbook 1895: 309-324.

The forage question in the prairie States practically resolves itself into--Shall we raise more cattle upon the farm? or, opposed to that, Shall we plant more corn? A proper discussion of the subject of the forage conditions of the prairie States can not be undertaken without a thorough understanding of the necessity that has arisen for the more extensive use of forage crops. The entire cattle and sheep industry is absolutely dependent upon the question of forage.

The prairies in their wild state were covered with the richest possible grass flora. There was no similar region that had so many useful species and so few poisonous or injurious ones. Almost any square mile of the whole extent of territory could furnish in one season 50 kinds of grasses and native forage plants, grasses that would make from one and a half to two tons of hay per acre as rich as that from an Old World meadow. It was a magnificent legacy to the rancher and the farmer. To the one it promised food for a million cattle; to the other it proved the golden possibilities of a soil that would bring forth bountiful harvests. But within the last thirty years all this has changed. We can no longer point to our broad prairies and say that the natural forage conditions here are the best in the world.

The nutritious mesquite and buffalo grasses have been driven to occupy the waste lands along roadsides and railway tracks, where they are rapidly being choked out and exterminated by weeds. Many of these wild grasses are superior in nutritious qualities, as shown by chemical analyses and digestive tests, to the cultivated or "tame" grasses of which we buy seeds from foreign countries. Many of the native prairie species have seeds that are just as easy to harvest as those of timothy, rye grass, tall oat grass, and dozens of other tame species, but they have never been collected in sufficient quantities to place upon the market or to make long-continued tests as to their adaptability to cultivation. These wild species should be taken care of until we are sure that we have not something better. They are acclimated. They will endure drought and freezing and flooding and all the other climatic excesses to which they have been subject for centuries. They are the best grasses for the region, because they are the natives of the region. It behooves us to plant seeds of these prairie species before some foreign seedsman sells them to us for their weight in gold, with the promise that they will yield a hundred tons of fodder to the acre.

East of the ninety-seventh meridian the yearly precipation averages from 30 to 40 inches. This belt has been termed the "humid" prairie region, having sufficient rainfall nine years in every ten to insure fair crops. Here tame grasses and clovers are uniformly successful. It is in the "arid" and "semiarid" prairie belts that there is the greatest need of thorough and long-continued experiments with the grasses and forage plants. It is in the arid prairie region that native grasses will be especially valuable in cultivation, because they will not have to be acclimated.

Abstract No. 1188

Smith, J. G. 1899. Grazing problems in the Southwest and how to meet them. U.S. Dep. Agr. Div. Agrostology Bull. 16. 47 p.

The vast areas of grazing lands in the Southwest have long been justly famous, and the almost numberless herds of cattle and bands of horses raised and fattened upon the nutritious grasses of that region have enriched thousands of individuals and have been a source of great commercial wealth to the nation.

Less than thirty years ago 4,000,000 buffaloes and countless numbers of wild horses roamed unrestricted over the region in question, gradually moving northward as the season advanced, returning southward at the approach of winter. This natural movement of the stock permitted alternation of pasturing and rest for the land, resulting in the maintenance of the forage supply.

The nature and extent of the interest here, make this region an especially important one in the line of grass and forage plant investigation. The carrying capacity has diminished fully 40 percent through overstocking and bad management during the past fifteen years, and the grazing and forage problems of the region demand serious and careful attention.

The Secretary of Agriculture, fully appreciating these conditions, directed this Division early in 1897 to begin investigations of these forage problems and conditions throughout the region of the Southwest, with instructions that particular attention be given to the native grasses and forage plants, their abundance and value, their preservation, and the possible methods to be employed in restoring the former carrying capacity of the ranges. The Division was also empowered to establish experiment stations for testing the grasses and forage plants in different sections of this region and to practice such methods of range renewal as might seem worthy of trial.

This work in range improvement is the first that has been tried either by the Government or by any State experiment station.

Abstract No. 1189

Smith, L. F. 1940. A growth-ring study of an unusually old bur oak in Miami County, Kansas. Kansas Acad. Sci., Trans. 43:173-175.

This study of the oak section indicates that the first growth ring in the sound wood was formed in 1635. A few rings which have decayed were formed prior to that time. Since a few rings were missing it was not possible to determine the exact age of the tree.

The record of this bur oak from Miami County is unusually interesting as it is an exceptionally old tree for which growth-ring data have been obtained in this state. Since only one growth ring is usually formed each year this oak was probably a seedling tree one hundred and forty years before the Declaration of Independence was signed by the thirteen colonies.

Abstract No. 1190

Smoliak, S. 1956. Influence of climatic conditions on forage production of shortgrass rangeland. J. Range Manage. 9:89-91.

In a study to determine the influences of climatic factors upon range forage production, correlation coefficients were determined for numerous variables. May plus June precipitation when correlated with yield gave a highly significant correlation coefficient of 0.859.

Seasonal mean temperature, hours of bright sunlight, and wind mileage were all significantly, negatively correlated with forage production. A low insignificant negative relationship existed between forage production and seasonal evaporation.

The data presented may be of considerable value in forecasting range production and stocking rates within certain limits. In years of high precipitation, the forage production may be high and the carrying capacity may consequently be increased. In event of drought, livestock numbers may be decreased to cope with reduced production.

Abstract No. 1191

Smoliak, S. 1960. Effects of deferred-rotation and continuous grazing on yearling steer gains and shortgrass prairie vegetation of southeastern Alberta. J. Range Manage. 13(5):239-243.

A two-field deferred-rotation system of grazing was compared with continuous grazing over a nine-year period. There were no significant differences in the response of the vegetation between the two pastures. The main forage producing species, blue grama grass, needle-and-thread grass, Junegrass, and western wheatgrass, reacted similarly under both systems of grazing. The total grass and sedge cover and the total forb and shrub cover increased on both pastures. Little club-moss decreased on the continuous pasture but increased in ground cover in the rotation pasture.

Forage production was greater on the rotation pasture than on the continuous pasture but the difference was not significant. Utilization of forage was lower than that recommended, leaving abundant carryover in all years on both fields.

Total seasonal gains of yearling steers were greater on the continuously grazed pasture than on the rotation pastures. The major portion of this advantage in gain occurred during the summer grazing period when steers on the rotation pastures were moved to a field deferred from spring grazing. This field contained more mature forage, which was lower in protein content, than the continuously grazed field during this period.

Abstract No. 1192

Smoliak, S. 1965. A comparison of ungrazed and lightly grazed *Stipa-Bouteloua* prairie in southeastern Alberta. Canadian J. Plant Sci. 45:270-275.

A comparison of ungrazed and lightly grazed *Stipa-Bouteloua* prairie was made at Manyberries, Alberta. Basal area of the vegetative cover; yields of green grasses and sedges, green forbs and shrubs, fresh mulch, humic mulch; and amounts of underground plant material were determined. Leaf height and basal diameter of *Stipa comata* were also measured.

Protection from grazing favored a *Stipa-Bouteloua* type of cover that produced greater amounts of dry matter of surficial and underground plant material. Light grazing resulted in a *Bouteloua-Stipa* type of cover that was less productive. *Stipa comata* plants on lightly grazed sites were shorter than those on protected sites.

Light grazing had an ecological influence upon plant composition that favored the short-grasses over the mid-grasses. Favorable climatic conditions, also, influenced secondary ecological succession.

Abstract No. 1193

Smoliak, S. 1965. Effects of manure, straw, and inorganic fertilizers on northern Great Plains ranges. J. Range Manage. 18(1):11-15.

One application of manure, straw, and straw plus fertilizer increased forage production significantly up to eight years after treatment. Forage on these plots generally contained greater amounts of nutrients than on control plots and the species composition was changed. Fertilization is a valuable range management technique for increasing livestock production.

Abstract No. 1194

Smoliak, S., and H. F. Peters. 1952. Range and livestock management in the shortgrass prairie region of Southern Alberta and Saskatchewan. Canada Dep. Agr. Pub. 876. 11 p.

The shortgrass prairie extends eastward from south central Alberta to the Wood Mountains in Saskatchewan and northward some 200 miles from the International Boundary. The climate of the area is characterized by low rainfall, high summer temperatures, and high evaporation rates. The upland soils are typically loam with shallow eroded pits, known as blowouts, exposing a layer of impervious hardpan. This generally lies about 12 inches below the surface and marks the lowest depth of moisture penetration. These factors limit vegetative growth and preclude the efficient production of cereal crops, except in the most favorable seasons. The native grasses, while not tall growing, are palatable and nutritious, and, during the period of plant growth, livestock feeding on them make rapid and economical gains. Production of cattle and sheep are primary enterprises throughout the area. Efficient utilization and continuity of supply of the grass, the main resource, is of prime importance to the permanence of a grazing enterprise and the profits to be realized therefrom.

Abstract No. 1195

Smoliak, S., R. A. Wroe, A. Johnston, and L. M. Forbes. 1969. Alberta guide to range condition and stocking rates. Alberta Dep. Lands and Forest., Alberta. 12 p.

Range management is defined as "The art and science of planning and directing range use to obtain sustained maximum animal production, consistent with perpetuation of the natural resources."

The principles of range management are:

Balance the number of animals with the available forage supply.

Use the kinds of livestock most suited to the forage supply and the objectives of management.

Alternate periods of grazing and rest to manage and maintain the vegetation.

Obtain a uniform distribution of animals over the range.

The principles of range management are based, in turn, upon two fundamental ecological principles:

Physical factors, plants, and animals, function as a unit and any change in one factor, such as that caused by fire or grazing, changes the whole complex.

Vegetational changes are natural phenomena, which follow certain patterns.

This publication is concerned primarily with the second ecological principle, namely, "that vegetational changes are natural phenomena, which follow certain patterns."

Abstract No. 1196

Snow, F. H. 1906. Change in the climate of Kansas. Kansas Acad. Sci., Trans. 20(Part II):288-291.

The observations of nearly forty years, made continuously by and under the direction of the writer, indicate a gradual change in the climate at Lawrence, Kansas. And as this locality presents a typical illustration of the climatic conditions of eastern Kansas, it is safe to infer that the same changes are taking place over the entire region of which it forms a part. The rainfall and atmospheric humidity have increased, and the wind velocity has decreased. The change in the rainfall and wind velocity has been in each case more than ten percent, while the increase in the atmospheric humidity has been more than six percent. And these results are based not "upon the recollections of the oldest inhabitants," but upon the faithful records of actual observations.

Abstract No. 1197

Snyder, L. A., and J. R. Harlan. 1953. A cytological study of *Bouteloua gracilis* from western Texas and eastern New Mexico. Amer. J. Bot. 40:702-707.

Chromosome counts were made from meiotic material of *B. gracilis* plants from 108 localities in western Texas and eastern New Mexico and one locality in western Oklahoma. The previously unrecorded number $2n = 20$ was found in plants from thirty-six collections, all but one of which were from the area between the Pecos River and the Rio Grande. Plants from fifty-six localities over a wide area of the upland plains of eastern New Mexico and western Texas, the Guadalupe and Davis Mountains of trans-Pecos Texas, and the mountains of central New Mexico were found to have the tetraploid number $2n = 40$. Maximum chromosome association in the tetraploids varied from almost complete bivalent pairing to almost complete quadrivalent association. The hexaploid number $2n = 60$ was found in plants in eleven localities in New Mexico on the high upland plains west of the Pecos River and in the Abo Mountains. The hexaploids exhibited a maximum of five hexavalents plus a variable number of quadrivalent associations. The aneuploid number $2n = 42$, presumably derived through non-disjunction in the tetraploids or through aneuploid variation at the diploid level and subsequent polyploidy, was found in plants from six localities. The single collection from Oklahoma yielded plants which had $2n = 84$ and regularly exhibited 42 bivalents. It has been assumed that the basic chromosome number in the genus *Bouteloua* is $x = 7$, but the present material indicates that a basic number of $x = 10$ is more likely for the genus. It was not possible to demonstrate any consistent correlation between growth habit or other morphological characters and chromosome number, probably because *B. gracilis* is a polyploid complex with several diploid members and marked by varying degrees of auto- and allopolyploidy. Ecological and geographical factors exhibit some correlation with chromosome number. The polyploids have a wider geographical range than do the diploids, but the ranges of the two overlap widely. The polyploids also appear to have a wider range in relatively more recently available habitats. The diploids, on the other hand, exhibit a wider range of ecological adaptation than do the polyploids.

Abstract No. 1198

Soper, J. D. 1944. The mammals of southern Baffin Island, Northwest Territories, Canada. J. Mammal. 25:221-254.

As the Dominion Government was desirous of obtaining further information from Baffin Island, the writer was assigned to Arctic investigations in the summer of 1928. Arriving at Cape Dorset, Foxe Peninsula, in late July, headquarters were established at the Hudson's Bay Company post for the following year. Most of this time was devoted to widespread faunistic and other explorations to the north and east. All measurements are given millimeters in the order of total length, tail, and hind foot. Specimen numbers are those of the original field catalogs. All study skins collected in Baffin Island were deposited in the permanent collection of the National Museum of Canada.

The present paper should be read in conjunction with the author's earlier report "A Faunal Investigation of Southern Baffin Island, 1928," as a great deal of additional information on the mammals appears there, based on the findings of the 1923, and 1924-1926 expeditions, as well as on the observations of earlier naturalists and explorers.

Abstract No. 1199

Soper, J. D. 1946. Mammals of the northern Great Plains along the international boundary in Canada. J. Mammal. 27(2):127-153.

For the first time, this paper deals with all species and subspecies of mammals known to occur in the southern extremities of the three Prairie Provinces in Canada. It discusses occurrences and general geographical distribution and gives measurements and weights of specimens. The survey is based on about 900 study skins and field notes accumulated since 1927. The territory examined amounts to approximately 51,000 square miles along the International Boundary from Ontario to the Rocky Mountains. There is a brief description of the physical characteristics of the region, involving Canadian, the humid and semiarid divisions of the Transition, and the Upper Sonoran Life Zones.

Abstract No. 1200

Sosebee, R. E., and C. H. Herbel. 1969. Effects of high temperature on emergence and initial growth of range plants. Agron. J. 61:621-624.

The daily soil temperatures used in this light chamber study were patterned after observations made under field conditions: 18 to 39C where the surface was sparsely shaded by brush, and 18 to 53C where the surface was left bare. The soil moisture was maintained at field capacity. Emergence of sacaton (*Sporobolus wrightii* Munro), vine mesquite (*Panicum obtusum* HBK.), bush muhly (*Muhlenbergia porteri* Scribn.), and fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.) was adversely affected by the high temperature regime. Survival of all 14 accessions except rhodegrass (*Chloris gayana* Kunth), "Vaughn" sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), and black grama (*B. eriopoda* (Torr.) Torr.) was reduced by the high temperature regime.

At the close of the 21-day trial most species had stopped growing or were growing very slowly under the high temperature regime. The shoot weights for the plants growing in the low temperature regime averaged nearly twice as much as those growing in the high temperature regime. There was no significant difference in root weight per seedling between temperature regimes. The root lengths of black grama, "Vaughn" sideoats grama, tobosa (*Hilaria mutica* (Buckl.) Benth.), lehmann lovegrass (*Eragrostis lehmanniana* Nees), and alkali sacaton (*Sporobolus airoides* (Torr.) Torr.) were not reduced significantly by the high temperature regime.

The high temperatures were detrimental, in one way or another, to all species even when moisture was adequate but black grama and sideoats grama performed satisfactorily.

Abstract No. 1201

Sosebee, R. E., and H. H. Wiebe. 1971. Effect of water stress and clipping on photosynthate translocation in two grasses. Agron. J. 63: 14-17.

Photosynthate translocation incrested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and cultivated barley (*Hordeum vulgare* (L.) cultivar "Hiland") was studied under controlled environments. Treatments consisted of two levels of internal water stress (soil at field capacity or withheld for 4 to 7 days before isotope application) and three levels of defoliation (none, entire plant clipped to 10 to 15-cm stubble height except for one tagged leaf with the tip removed 8 to 10 cm from the collar.) Radiophosphorus applied to a photosynthetically active leaf was used to trace translocation to various plant parts.

Increased water stress decreased the total amount translocated from the mature leaf in both species. In barley, the water stress became more severe, and translocation beyond the sheath of the tagged leaf was negligible. Partial defoliation increased the translocation from the tagged leaf to other plant parts, especially in plants grown without adequate water. Reduced water consistently increased the proportion of radiophosphorus translocated downward to the roots and crowns, while partial defoliation consistently increased the proportion transported to the younger leaves.

Abstract No. 1202

Soulides, D. A., and F. E. Allison. 1961. Effect of drying and freezing soils on carbon dioxide production, available mineral nutrients, aggregation, and bacterial population. Soil Sci. 91(5):291-298.

This paper is concerned with the impact of drying and freezing of soils on organic matter decomposition, structure, nitrogen mineralization, and microflora, with special attention to any possible interrelations among these changes.

Abstract No. 1203

Sparks, D. R. 1968. Diets of black-tailed jackrabbits on sandhill rangeland in Colorado. J. Range Manage. 21:203-208.

The diet and forage preferences of the black-tailed jackrabbit (*Lepus californicus*) were studied by stomach content analysis to determine the degree of competition between cattle and jackrabbits on sandhill rangeland. Grasses were most important in the diet in early spring and summer. Forbs were important during summer and fall and shrubs were eaten in fall and winter. Competition for forage between jackrabbits and cattle was greatest in early spring and least in late fall and winter. Jackrabbits influence the longevity of reseeded forage stands and the secondary succession on old fields. A thorough knowledge of diet and forage preferences of jackrabbits permits the land manager to make better decisions for efficient range use.

Abstract No. 1204

Spedding, C. R. W. 1970. Grassland ecology. Clarendon Press, Oxford. 221 p.

This book is written in the belief that grassland ecology is a subject, of great importance biologically, agriculturally, and socially. This preface may be said to be *about* grassland ecology, but the book is primarily an attempt to describe what grassland ecology is about. There is a great temptation to expand in all directions with examples to illustrate the wide range of the subject, but this has been resisted in order to present a concise picture of the complex to be comprehended.

Since it is written for readers who may be specialists in some of the components but relatively new to others, the treatment has been kept simple without being elementary.

For those who dislike mathematics, it is worth pointing out that a quantitative approach is indispensable for a full understanding of the subject, and a degree of abstraction is necessary in order to manipulate even the minimum of factors involved. Figures have been used to help in conveying a picture of the main processes, and an introduction to the use of mathematical models is provided in the Appendix.

Abstract No. 1205

Spencer, J. L. 1955. Reingestion in three American species of Lagomorphs. Lloydia 18:197-199.

Sufficient data have been accumulated to report on three species including both captive (caged) and collected (wild) animals. These species are *Lepus townsendii comapanius* Hollister (prairie hare), *Lepus americanus virgineanus* True (Virginia varying hare), and *Sylvilagus transitionalis* (Bangs) (cottontail). A total of 172 adults of both sexes, 72 captive and 100 collected, was examined and found to contain soft feces in their recta. All of the collected animals were from either Massachusetts, New York, or New Hampshire. The captive hares had been maintained on a pelletted, commercial rabbit food for at least three weeks prior to examination.

These three species of American Leporinae: *L. townsendii campanius*, *L. americanus virgineanus, and S. transitionalis*, have a diurnal rhythm concerned with the reingestion of a special, amorphous feces that is well defined and apparently similar to the coprophagy reported for two European lagomorphs.

Abstract No. 1206

Springfield, H. W., and R. M. Housley, Jr. 1952. Chamiza for reseeding New Mexico rangelands. U.S. Forest Service, Southwest Forest Range Exp. Sta. Res. Note 122. 3 p.

Plants which will provide forage the year round, especially during the critical winter and spring months are especially needed for reseeding southwestern ranges. Such a plant is chamiza, or fourwing saltbush (*Atriplex canescens*), long prized by New Mexico stockmen. It is relished by sheep and cattle and is palatable throughout the year. It remains green during the winter and the height of the plants makes the forage available whenever snow covers the grasses and lower shrubs. The nutritive value of chamiza compares favorably with alfalfa hay, the crude protein content ranging from 8 to 12 percent in late fall and winter to 22 percent during the growing season. These characteristics make chamiza a particularly valuable plant for seeding winter ranges in the low woodland and semidesert range types.

Abstract No. 1207

Springfield, H. W., and G. Peterson. 1964. Use of the grazed-plant method for estimating utilization of some range grasses in New Mexico. Rocky Mountain Forest Range Exp. Sta., Forest Servic, U.S.D.A., Note RM-22. 6 p.

The grazed-plant method of estimating utilization has stimulated much interest among range managers. Because the method is rapid and easy to use, it could be a valuable tool in managing large range areas. Several investigators have found the grazed-plant method gives reasonable reliable estimates of utilization. The method has been used successfully for estimating the utilization of Idaho fescue (*Festuca idahoensis*), bearded bluebunch wheatgrass (*Agropyron spicatum*), and crested wheatgrass (*A. desertorum*).

Grazed-plant guides for estimating the utilization of blue grama (*Bouteloua gracilis*), Kentucky bluegrass (*Poa pratensis*), mountain muhly (*Muhlenbergia montana*), and Arizona fescue (*Festuca arizonica*) were developed in New Mexico from studies conducted on National Forest ranges grazed by cattle in 1961 and 1962. The guides give reasonably precise estimates of utilization up to about 40 to 45 percent utilization by weight.

Abstract No. 1208

Spuhler, W., W. F. Lytle, and D. Moe. 1968. Climatological summary of Cottonwood, South Dakota. South Dakota Agr. Exp. Sta. Climatol. Sum. 14. *In* Climatography U.S. 20-39. 5 p.

Cottonwood is located in northwestern Jackson County in the southwestern part of the state. The topography is gently rolling. There are no nearby bodies of water that affect the climate. The eastern edge of the badlands lies about 12 miles to the south.

The climate is a continental type with a large contrast in temperature from winter to summer and occasionally from day to day. Precipitation is marginal for adapted crops.

Livestock grazing along with hay production and wheat farming are the main sources of income although some oats and other small grain are grown.

Abstract No. 1209

Stadtman, T. C. 1971. Vitamin B_{12}. Science 171 (3974):859-867.

In spite of the considerable progress made in recent years toward the understanding of the chemistry and biological function of the cobalt-containing B_{12} group of compounds, much of the information still is more descriptive than definitive in nature. In general terms, it is known that the free vitamin forms can function as methyl group carriers and that the 5'-deoxyadenosyl or coenzyme forms serve as hydrogen carriers; but the mechanism of these processes is not understood in detail. More systematic studies of the pure chemistry of these complex molecules containing a carbon-cobalt covalent bond are needed before the biochemist can interpret many of his observations on the enzyme-catalyzed reactions. Even in relatively simple solutions it is difficult to ascertain the state of oxidation of several of the vitamin forms, and these problems are compounded when the reactive thiol compounds and complex proteins of the biological systems also are present. For example, both vitamin B_{12_r} (the Co^{2+} form) and corresponding analogs are known to disproportionate in solution to B_{12_s} (Co^{1+}) and B_{12_a} (Co^{3+}) under a variety of mild conditions. This means that in the biological systems it is exceedingly difficult to ascertain the chemical nature of many B_{12} intermediates and reaction products. The role of the protein moiety of the various B_{12}-linked enzymes in the catalytic processes is little known as is, also, the mode of binding of the B_{12} derivative to the protein. These types of questions perhaps can be answered eventually by the crystallographers, whose are is becoming increasingly sophisticated.

Abstract No. 1210

Stallings, J. H. 1951. Mechanics of wind erosion. U.S. Soil Conserv. Service Tech. Paper 108. 12 p.

Wind erosion has been active in some degree since prehistoric times but has become much more active and more destructive because of activity of man. This "accelerated" erosion has been due to wrong methods of handling the land or use of the land for purposes to which it is not adapted.

Wind erosion is perhaps most active in arid and semiarid regions where the land surface is often dry and vulnerable to erosion and the protective vegetation is sparse or absent. But the wind may also move large quantities of soil material in humid regions; and, agriculturally considered, wind activity in such regions may be more important because of the greater value of much of the land affected.

The movement of soil by wind is a complex process influenced by conditions of wind, soil (including the nature of the eroding surface), amount of water in the soil, and many other factors.

The cutting and transporting power of wind is determined by the interaction of several factors--some favoring soil movement, others opposing it. The activity in each individual case depends upon the net effect of these factors acting together. Soil material, in order to be transported by wind, must first be loosened from its position on the surface of the land. It may then be lifted, rolled, slid, or bounced along on the surface of the ground. These processes are largely the result of wind turbulence, mainly eddies and irregularities of wind movement.

Differences in soil erodibility suggest that properties inherent in the soil and those brought about by land use--especially cultivation and other man-made disturbances--play an important part in the wind erosion process. Wind erosion is dependent directly on the physical character and condition of the soil. Only dry soils are moved. Wet or damp soils are not appreciably affected. The structure of the soil in an air-dry state is, therefore, a much more reliable index of erodibility than the structure in a wet state.

Abstract No. 1211

Stanley, E. B., and C. W. Hodgson. 1938. Seasonal changes in the chemical composition of some Arizona range grasses. Arizona Agr. Exp. Sta. Tech. Bull. 73. 15 p.

Seasonal changes in the chemical composition of blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), and curly mesquite (*Hilaria belangeri*) were determined for the growing seasons of 1934 and 1935. Moisture, crude protein, and phosphorus were high in young plants, decreasing to a minimum after the plants has become mature.

The percentage of total ash and of ether extract showed no definite trends. Nitrogen-free extract and lignin tended to increase from the early-growth stages until the end of the season. The crude fiber content rose rapidly during the early part of the growing season but showed no definite trend from September to January, when a slight drop occurred. The percentage of calcium was high during August, when the plants were young, and low during the winter months but was somewhat variable during the intervening period.

The digestibility and palatability of young range grasses are high but decrease to relatively low values when the plants are mature and dry. Range cattle increase rapidly in weight while the forage is young and green but decrease rapidly in weight during the dry seasons. It is suggested that a low intake of total digestible nutrients and, possibily, of digestible crude protein may account for these losses in weight.

Abstract No. 1212

Starkey, R. L. 1958. Interrelations between microorganisms and plant roots in the rhizosphere. Bacteriol. Rev. 22:154-172.

Plants affect microorganisms in soil in many ways. They remove water and mineral salts from the soil and, on death, leave their roots in the soil and the aerial parts on the soil surface. There is a decrease in the amounts of soluble mineral substances and a desiccating effect on the soil. During periods of growth, the roots permeate the soil, affecting its structure and the movement of gases and water. The roots attract various organisms, some of which feed on them directly. Roots absorb oxygen and release carbon dioxide, thus increasing the amounts of carbonates. The root area is a critical one for terrestrial plants and the site of intense chemical and biological activity in soil.

Where reference is made to soil in comparison to rhizosphere in the following discussion, reference is made to that portion of the soil that is not the rhizosphere. The rhizosphere had indefinite dimensions, depending on the soil and plant. The greatest effects of the plant appear on the root surface and in the soil in contact with the root, but effects may extend for several millimeters beyond the root where fungus mycelium penetrates the soil from the rhizosphere which is the food base.

Most rhizosphere microorganisms are saprophytes, but not all of their relations to plants are incidental. Some microorganisms live on the root surface, whereas others penetrate the roots. Some are restricted to the cortical cells, but others go deeper, passing between the cells and invading them. Some are innocuous and others are destructive or have favorable effects on development of the host. In this discussion attention will be focused on the nonsymbiotic and nonpathogenic microorganisms.

Abstract No. 1213

Steiger, T. L. 1930. Structure of prairie vegetation. Ecology 11(1):170-217.

Investigations of the vegetation of virgin prairie were carried on during 1927 and 1928 near Lincoln, Nebraska.

Extensive measurements of the edaphic and aerial factors of the environment were made on both upland and lowland prairie. The water content of soil showed the greatest and most consistent variation, and is the most important factor determining the differences in the structure of the vegetation. Available water for growth is sometimes deficient in the surface layers of the upland soil.

There are 237 species in the grassland studied; and they are distributed as follows: high prairie, 70; low prairie, 45; ravines, 77; and wet meadow, 45. Grasses and sedges make up 24 percent of the flora, composites and legumes ranking next in importance.

Prevernal, vernal, estival, and autumnal aspects are pronounced in both high and low prairie, the high prairie reaching its climax of flowering earlier in the summer, due to limited soil moisture. Ravine and wet meadow show a maximum in August.

Quadrat studies were made to determine the rank and relative importance of the various species with regard to the area occupied as well as their number and frequency.

Abstract No. 1214

Stephens, J. M., R. Wilson, W. P. Baird, J. T. Sarvis, J. C. Thysell, T. K. Killand, and J. C. Brinsmade, Jr. Plains field station for the 10-year period, 1913-1922, inclusive. U.S. Agr. Dep. Bull. 1301. 79 p.

The purpose of this report is to discuss briefly the experiments conducted at the Northern Great Plains Field Station, located in Morton County, N. Dakota, 2 miles south of Mandan. No attempt is made to describe the experiments in detail, but rather to present the lines and scope of the work at the station and give a summary of results obtained from the various experiments. The projects are grouped and divided into three departments: Arboriculture, horticulture, and agronomy. The cooperative grazing experiment is a coordinate part of the agronomic work. The work and the results are reported separately by the men in charge of the respective departments.

Abstract No. 1215

Stevenson, K. R., and R. H. Shaw. 1971. Diurnal changes in leaf resistance to water vapor diffusion at different heights in a soybean canopy. Agron. J. 63:17-19.

The effect of soil moisture content and evaporative demand on diurnal variations of leaf resistance to water vapor diffusion were studied at two heights in a soybean (*Glycine max* L. (Merr.)) canopy. Under soil moisture stress, leaf resistance to water-vapor diffusion of middle leaves in the canopy increased approximately 2 hours earlier in the day and to a greater extent than the resistance of upper leaves. This indicated a preferential flow of water to upper leaves. It is speculated that the degree of out-of-phase change in leaf resistance under stress conditions is related to canopy density.

Leaf resistances of middle leaves decreased at a slower rate under adequate soil water supply than under drier conditions. On days with low evaporative demand, leaf resistances of upper leaves tended to be less (0.8 sec/cm) under the low soil moisture than under the high soil moisture supply. The apparent reduction of stomatal activity in leaves under low evaporative demand and high soil moisture supply is believed related to the lack of development of a small leaf-water deficit necessary for maximal stomatal opening.

Abstract No. 1216

Stewart, G., and S. S. Hutchings. 1936. The point-observation-plot (square-foot density) method of vegetation survey. Amer. Soc. Agron. J. 28: 714-722.

The point-observation-plot method is much more accurate, easier to learn and to apply, and provides much greater consistency in the forage-volume estimates made by individual estimators than does either the chart quadrat or the large-estimate plot hitherto used for this purpose. The method is so distinctly timesaving as to make possible 10- or 20-fold replication; its system of randomizing plot locations at mechanical intervals obviates "selecting" plots, the ordinary procedure in former vegetation studies. The plots are circular and of 100 square feet area. One or more series of plots in a line or in a gridiron arrangement are used to supply representative samples so highly useful for forage inventories, comparative surveys, permanent study plots, and erosion surveys. The method has been widely tried and found suitable for providing quantitative data in range, agronomic, and ecological invests.

Abstract No. 1217

Stewart, G., and I. Clark. 1944. Effect or prolonged spring grazing on the yield and quality of forage from wild-hay meadows. Amer. Soc. Agron. J. 36:238-248.

During the 7-year period, 1936-1942, inclusive, three fields used for wild-hay production were grazed from beginning of growth to about May 3, May 26, and June 9. After spring grazing for the time specified in the study, the native forage plants were allowed to grow until late July or early August when all three fields were harvested for hay at about the same time. Just previous to haying, 20 4 × 4-foot plots in each field were harvested, all within a 48-hour period, and the forage dried to constant air-dry weight. From these samples, hay yields were calculated and samples were drawn for chemical analysis in which standard methods were used to determine crude protein and total ash. Careful records were kept as to the grazing days of each age class of cattle, from which the amount of pasturage was calculated and added to the weight of hay to get total forage yields from the three fields grazed to early, mid-, and late spring.

Abstract No. 1218

Stewart, O. C. 1951. Burning, and natural vegetation in the United States. Geogr. Rev. 41(2): 317-320.

Although the influence of burning on vegetation is well known, it is not always fully understood. Many botanists have based their judgments on the present picture alone, without considering the problem in the light of history and ethnology, and the result has been, I believe, a shortsighted and often quite inaccurate estimate of the effect of burning in determining the life situation. This paper presents some of the historical and ethnological facts concerning burning in the United States and its influence both on the vegetation found by the first Europeans and on that existing in various parts of the country today, and points out that in certain areas the interpretation has completely changed with increasing knowledge.

Abstract No. 1219

Stewart, O. C. 1953. Why the Great Plains are treeless. Colorado Quart. 2:40-50.

It is my present considered opinion that all grasslands occurring on deep, fertile soil are man-made, by peoples who periodically set fire to the grass and kept woody vegetation from growing. This judgment I share with some other scientists, though not all, and the facts which justify this conclusion are not generally known.

In 1939, when I had an opportunity to undertake some individual research in conjunction with my duties as supervisor of a WPA project sponsored by the University of California, I decided to search ethnological and historical literature for other examples of burning by Indians. At first, I was somewhat disappointed, for most anthropologists seem to have neglected to ask Indians about the practice of setting fire to fields and forests. Early travelers' accounts, however, yielded more information. Our search produced over two hundred definite statements that Indians throughout the United States deliberately set vegetation on fire for a dozen different reasons.

The number of tribes reported using fire leads to one conclusion, that burning of vegetation was a universal culture pattern among the Indians of the United States. Furthermore, the amount of burning leads to the deduction that nearly all vegetation in America at the time of discovery and exploration was what ecologists would call fire vegetation. That is to say, fire was a major factor, along with soil, moisture, temperature, wind, animals, etc., in determining the types of plants occurring in any region. It follows, then, that the vegetation of the Great Plains was a fire vegetation. However, there is more evidence which should be considered, particularly since it applied to the high plains, that part of the Great Plains on the northern and western periphery where the climate is colder and drier and perhaps less suitable to tree growth. This evidence will be given in three parts: one, the survival on the plains of trees from prehistoric times, called relicts; two, the ability of trees planted and protected to grow and reproduce on the plains; and, three, the natural, unaided spread of woody vegetation on to the plains in historic times.

Abstract No. 1220

Stickney, P. 1961. Range of rough fescue (*Festuca scabrella* Torr.) in Montana. Montana Acad. Sci., Proc. 20:12-17.

On many of Montana's mountain range lands rough fescue (*Festuca scabrella* Torr.) is the dominant species in the fescue grassland type. Rough fescue is a desirable species to maintain in this type because it produces abundant forage palatable to cattle, horses, and elk and possesses an extensive fibrous root system excellent for holding soil.

A study of the ecology of this grass necessitates, first, the determination of the extent and limits of its range. Practically all of the work on this species has been done in the western provinces of Canada. Here a general picture of the range may be obtained from grazing and ecological studies made on the fescue grasslands. In the United States, the ecology of rough fescue is little known, and its range is only imperfectly known. Neither a description nor the limits of its range have been previously worked out for Montana. Information from regional floras on its range indicates only that it is present in the State.

Abstract No. 1221

Stoddart, L. A. 1935. Osmotic pressure and water content of prairie plants. Plant Physiol. 10: 661-680.

1. Osmotic pressure is regarded as an expression of the environment, indicating the relative forces with which the soil supplies water to the plant and the air removes it through transpiration.

2. As the soil dried with the progress of the season the osmotic pressure of all prairie plants studied increased. This increase was frequently 30 or more atmospheres among moderately deeply rooted upland plants. Among deeply rooted upland plants and plants growing in low moist habitats the increase was usually only 2 to 10 atmospheres.

3. As the soil dried, the water content of the tissue very regularly decreased, although the change was much less marked in lowland plants and in those having very deep roots.

4. Water content of plant tissue is a rather exact indicator of osmotic pressure, plants with high pressures usually having low water content and plants with low pressures usually having high water content.

5. Osmotic pressure of the sap and water content of the tissue responded readily to increases in soil moisture, but the response was much less in the case of water content of tissue.

6. Osmotic pressure and water content of the tissue, except in very deeply rooted plants, are both excellent criteria of the water content of the habitat.

7. Variation of both humidity and soil moisture indicated that these factors had a great influence on both osmotic pressure and water content of tissues. Minimum osmotic pressure and maximum water content of tissues were attained with a high humidity and a high soil moisture.

8. Determinations of both osmotic pressure and water content of *Andropogon scoparius* every two hours during a day and a night showed a reverse correlation between osmotic pressure and humidity, and a direct correlation between humidity and water content of the tissues.

9. Similar determinations on a lowland species, *Helianthus grosseserratus*, rooted in moist soil, showed much less daily variation.

10. Roots of *Panicum virgatum* had a lower osmotic pressure and a higher water content than the tops.

11. New growth of plant tissue had a lower osmotic pressure and a higher water content than old growth.

12. Artificial watering in late summer lowered osmotic pressure and increased water content of tissues. The values approached those of spring.

13. Soil moisture and humidity are considered the major factors affecting osmotic pressure.

Abstract No. 1222

Strange, J. G. L. 1954. A short history of prairie agriculture. Searle Grain Co. Ltd., Winnipeg, Canada. 104 p.

This booklet consists of a series of articles which were published in the Searle Grain Company's "Market Features Letter" during 1953 and 1954.

The articles were written in response to a considerable number of inquiries that came from school children, college and university students, school teachers, farmers and business men, asking for details of various phases of the agriculture of the West since the very beginnings. The answering of these many letters became quite a task, so it was decided to write a series of articles that would answer most of the inquiries. Soon requests came in for sets of these articles and later to have them in bound form, hence this booklet. It is hoped, therefore, that this booklet, comprising a short history of prairie agriculture, will supply information to those who are interested in the study of our Western country from the days when agriculture first started.

Abstract No. 1223

Streeter, C. L. 1970. Standardized processing and storage scheme for samples collected for IBP Grassland Ecology Research Laboratory. U.S. IBP Tech. Rep. No. 55. 5 p.

Investigators submitting samples to the grassland ecology research laboratory for chemical analyses should use: (1) a standardized processing and storage scheme, and (2) the analysis request sheet. The form describing the standard processing and storage scheme is used by the investigators requesting analysis to determine processing required prior to sending samples to the laboratory. The analysis request sheet is used to indicate the required analyses.

Abstract No. 1224

Striffler, W. D. 1969. The grassland hydrologic cycle, p. 101-116. *In* R. L. Dix and R. G. Beidleman [ed.]. The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Of the many factors which contribute to the physical environment of the grassland ecosystem, the movement of water into, through, and eventually out of the system is without doubt a major stimulus in the functioning of the system. This movement or cycling of water in the ecosystem essentially consists of precipitation inputs, runoff outputs, and a series of intermediate processes influencing the magnitude of the precipitation/runoff relationship. These include interception, infiltration, percolation, evapotranspiration, surface runoff, and storage at various levels of the system.

Hydrologic investigations in grassland environments reveal some of the characteristics of the various processes. Precipitation in the shortgrass prairie type generally ranges from 250 to 500 millimeters, with less than 10 percent occurring during the winter months and May and June receiving 30 to 50 percent of the annual rainfall. Summer storms are frequently intense thunderstorms with small areal distribution. Rainfall interception of storage capacity on grassland vegetation may range from .50 to 5.0 millimeters depending on the density of the vegetation and stage of growth. Litter interception has been measured between .20 and 1.50 millimeters depending on the amount. Infiltration rates on rangelands depend on soil characteristics, topography, season, and vegetation or grazing pressure. Measured rates vary from essentially zero to as high as 125 millimeters per hour. Evapotranspiration losses depend primarily on the evaporative potential of the environment and the availability of water. Measured daily maximum rates ranged from 1.5 to 2.0 millimeters per day. Seasonal consumptive use generally amounts to about 90 percent of annual precipitation. Runoff from grasslands is very low, averaging about 25 millimeters for the Great Plains. Although highly variable, small watersheds may have greater yields than large watersheds due to the limited distribution of rainfall events and channel transmission losses.

Abstract No. 1225

Striffler, W. D. 1970. Hydrologic research in the IBP Grassland program. Amer. Soc. Range Manage. Annu. Meeting, February 9-12, Denver, Colorado.

The Grassland Biome Program, one of six such programs proposed and the first to be funded, began operation in July 1968. Broadly stated the objectives of the program are to study the structure and function of the grassland ecosystem, determine the rates and variability of energy flow and nutrient cycling, and to encompass these processes and parameters into a mathematical model. To meet these objectives, a unique group of scientists representing varied disciplines and interests have joined together in an integrated research program. The intensive site for the many diverse, yet inter-related studies, is the Pawnee site, a portion of the ARS Central Plains Experimental Range. Studies conducted at the site can be generally classified as producers, consumers, decomposers, and abiotic. The abiotic studies include edaphic, meteorologic and hydrologic processes.

Because of the limited moisture supply at the site (12 inches average annual rainfall) and over the mixed grass prairie type in general, the distribution, storage, and movement of water are extremely important to the ecosystem productivity. The objectives of the Hydrology Project are therefore designed primarily to determine the magnitude and variability of the various hydrologic processes and components of the grassland ecosystem and ultimately to develop a hydrologic model compatable with the overall ecosystem model. Studies to date have been centered around a series of microwatersheds established primarily to determine the magnitude of the hydrologic processes under varying levels of grazing pressure. Eight microwatersheds have been installed, two each on light, medium, and heavy grazed pastures and two in non-grazed exclosures. Pastures and exclosures have been held at the same treatment for the past thirty years.

Microwatersheds are ½ hectare (1¼ acres) in size, bounded on the top and sides with a 4 inch concrete sill, and on the down slope end with a concrete collecting trough leading to an H-flume and stilling well. Each microwatershed has been instrumented with a precipitation gage, a water level recorder, and a stack of soil moisture and temperature units. In addition, a grid of ten neutron access tubes has been installed to provide information on soil moisture recharge and depletion rates.

Data from the microwatersheds are collected and telemetered from each site to the Headquarters Building via a buried cable system. Incoming data are sequenced through a small data processor which converts raw data to a real time output. Data are time referenced and recorded on a digital magnetic tape, and a teletype print-out. The data system is designed to read all stations and sensors once each hour. However, during a storm event, a rainfall sensor triggers the system to a 30-second recording rate. Data thus collected will permit an evaluation of storm runoff, rainfall amounts and intensities, and water additions or losses from the soil.

Abstract No. 1226

Striffler, W. D. 1971. Hydrologic data, 1970, Pawnee Grasslands. U.S. IBP Tech. Rep. No. 75. 23 p.

This paper presents the data collected during the 1970 calendar year as part of the hydrologic process studies of the Grassland Biome Intensive Site Studies, IBP. Data presented are from the field recording instrumentation and daily observations and include precipitation, runoff from the microwatersheds, and observations from an evaporation station.

In general, the 1970 year was drier than normal with an annual total of 245 mm as compared to the 30-year mean annual rainfall of 310 mm. The greatest deficit occurred during the summer months from May through August. Precipitation during March and April was above normal, which helped to recharge soil water storage and offset the lack of rainfall later in the growing season.

Three runoff events occurred during the year. However, only one was of sufficient magnitude to produce runoff from all the microwatersheds and permit a comparison between treatments.

Abstract No. 1227

Striffler, W. D., and F. M. Smith. 1969. Pawnee Site microwatersheds: Selection description and instrumentation. U.S. IBP Tech. Rep. No. 5. 29 p.

It has long been recognized that the flow of energy through the primary producers and the cycling of nutrients in an ecosystem depends on the availability of water to the plants. An obvious hydrologic characteristic of grasslands is the absence of stream flow, although overland flow and re-infiltration probably occur much more frequently than commonly supposed. To evaluate the behavior of water in grassland ecosystems emphasis is being placed on the soil water balance, its input (direct infiltration and re-infiltration), and its outputs (evaporation, transpiration, percolation, and runoff). It is the purpose of this paper to describe the criteria for selection and design for construction and instrumentation of eight microwatersheds, the basic units of investigation for studying the behavior of water in grasslands.

Abstract No. 1228

Strong, M. A., and R. A. Ryder. 1971. Avian productivity on the Pawnee Site in north-central Colorado. U.S. IBP Tech. Rep. No. 82. 54 p.

Reproductive rates, relative nesting success, and growth rates of nestlings as well as the peaks of nesting activity were determined for horned lark (*Eromophila alpestris*), McCown's longspur (*Rhynchophanes mccownii*), western meadowlark (*Sturnella neglecta*), lark bunting (*Calamospiza melanocorys*), loggerhead shrike (*Lanius ludovicianus*), mourning dove (*Zenaidura macroura*), and Brewer's sparrow (*Spizella breweri*) on and adjacent to the Pawnee Site. Horned lark and McCown's longspur nests were mainly in heavily grazed shortgrass, whereas lark buntings preferred moderately to slightly grassed areas. Brewer's sparrows were confined to areas of fourwing saltbush (*Atriplex canescens*). The percent of nests successful in fledging at least one young varied from 26.2% for horned lark to 53.6% for mourning dove. All ground nesting passerines grew at essentially the same rates. A total of 766 birds representing 31 species were banded and 116 birds of 6 species collected for food habits and reproductive analyses. Homing of 6 of 15 color marked horned larks and 1 of 10 color marked lark buntings was demonstrated.

Abstract No. 1229

Strong, M. A., and R. A. Ryder. 1971. Preliminary observations of avian productivity on the Pawnee Site in northcentral Colorado. Colorado-Wyoming Acad. Sci., April 30, Pueblo, Colorado.

During 1970, reproductive rates, relative nesting success, growth curves of nestlings and periods of nesting activity were estimated for horned lark (*Eromophila alpestris*), McCown's longspur (*Rhynchophanes mccownii*), western meadowlark (*Sturnella neglecta*), lark bunting (*Calamospiza melanocorys*), loggerhead shrike (*Lanius ludovicianus*), mourning dove (*Zenaidura macroura*), and Brewer's sparrow (*Spizella breweri*) on the shortgrass prairie in northcentral Colorado. The percent of nests successful in fledging at least one young varied from 26.2 for horned lark to 36.8 for lark bunting among strictly ground nesters, but mourning doves were the most successful with 53.6 percent. A total of 300 nests of 21 species were observed during the nesting season of 1970. Horned larks were the earliest nesters, but mourning doves had the longest nesting season and showed three peaks of nesting activity. All ground nesting passerines appeared to grow at the same rate, but data were insufficient for proper comparisons.

Abstract No. 1230

Stubbendieck, J. L. 1969. Growth and development of blue grama. Univ. Nebraska, Coll. Agr., Progress Rep. to GP-9. 7 p. (Not for publication.)

Blue grama (*Bouteloua gracilis*) is an opportunist plant. It tolerates wide diversity of soil, moisture, and temperature. There are many references to blue grama in the literature of the last half century. Few deal specifically with ecotypic variation or with physiologic factors associated with growth and development of this species.

Work at the University of Nebraska has centered about growth and development, critical temperatures for germination, renewal of growth, initiation of tillers, initiation of reproductive culms. To some extent the work has been exploratory in nature.

Abstract No. 1231

Stubbendieck, J. L., and D. F. Burzlaff. 1970. Effects of temperature and day length on axillary bud and tiller development in blue grama. J. Range Manage. 23:63-66.

A study was conducted to determine the nature of tiller development and the influence of light and temperature on growth and development of the axillary buds and tillers of blue grama. An axillary bud, enclosed in a prophyllum was found at each node of the culm. The development of the axillary bud into a tiller is a function of temperature. Controlled increase of temperatures in early spring increased the rate of axillary bud and tiller development in blue grama. The data also indicate controlled reduction in length of photoperiod decreased the growth of axillary buds and development of tillers.

Abstract No. 1232

Stubbendieck, J. L., and D. F. Burzlaff. 1971. Nature of phytomer growth in blue grama. J. Range Manage. 24(2):154-156.

The pattern and relative growth rates of the individual phytomers of blue grama were determined. A mature blue grama shoot from the site had an average of 13 complete phytomers. The first six phytomers appeared to be initiated in the growing season prior to the one in which the plant reached maturity. Internodal elongation of over 100 mm in a period of two weeks was not uncommon. In most instances the internodes did not elongate before the sheath and blade reached maximum length. The leaf of the last phytomer was initiated just prior to the middle of June. Mature sheath length varied from 15 mm in phytomer 13 to nearly 80 mm in phytomers 11 and 12. Blade length varied from 4 mm in phytomer 2 to 134 mm in phytomer 10.

Abstract No. 1233

Svihla, R. D. 1931. Notes on desert and dusky harvest mice (*Reithrodontomys megalotis megalotis* and *R. m. nigrescens*). J. Mammal. 12:363-365.

During the summer of 1928, one female and two male, *R. m. megalotis* from Carrizozo, New Mexico, were added to the now increased Alamogordo stock. Besides these, six female and two male *R. m. nigrescens* from Prescott, Washington, were sent in during this summer. Observations and notes chiefly on the subspecies *R. m. megalotic* extended from September, 1927, to June, 1930. Twenty-five litters of mice were born in captivity during the period of observation. The dispositions of both species were ferocious, killing each other or killing and eating new born litters. However, some information was obtained concerning the period of gestation, development of the young, average duration of life in captivity and infertility of subspecies. A description of the physical development of a litter of young in also given.

Abstract No. 1234

Svihla, R. D. 1936. Breeding any young of the grasshopper mouse (*Onychomys leucogaster fuscogriseus*). J. Mammal. 17:172-173.

For two years a stock of grasshopper mice, secured from Lind, central Washington, has been kept under observation. During the first year in captivity very little breeding occurred, and the females which did reproduce usually killed and ate their young shortly after birth. The mice were fed on a diet of ground whole wheat, powdered milk and iodized salt, with the addition of green food twice a week. Since the cannibalism of the females indicated a dietary deficiency, a piece of raw beef liver about an inch square was given each mouse once a week. The avidity with which they consumed the liver was so astonishing that this addition to the diet was continued in routine feeding. After this, breeding and the number of litters raised to maturity increased perceptibly.

Perhaps the most difficult information to obtain in studying the breeding habits of wild animals is the period of gestation. As this period varies greatly and usually is influenced by lactation, the time interval can only be set within certain limits. In mating these grasshopper mice a male usually was placed in the cage of a female just before or immediately after the birth of a litter. The next morning the male was removed. Thus the time of gestation was known within 12 hours. Three gestation periods were obtained by this method. Female 5 had a period of 39 days, during which time she was nursing 4 young. Female 1 had one gestation period of 47 days while nursing a litter of 4 young, and another of 33 days during which she nursed 2 young. Two more gestation periods were obtained, at least as maximum limits, since the males were left with the females during the entire interval.

The birth of 10 litters in the laboratory was noted, while several others occurred unobserved during the summer months. The number of young per litter varied from 2 to 5. At birth the young were pink, and hairless except for the vibrissae which were quite evident. Their eyes and ears were closed, and the tails characteristically were short and thick. Twenty-two newly born mice representing 7 litters were weighed and measured. In weight they averaged 2.2 (1.7 to 2.7) grams; total length, 46 (41 to 51) mm.; tail 8.5 (7 to 10) mm.; hind foot, 6.3 (5.7 to 6.9) mm. Within 3 days the ears unfolded and the dorsal parts became pigmented. In

12 days the backs were covered with soft gray fur while the feed and underparts were white. The eyes opened in 19 to 20 days, and at this time they practically were weaned.

Abstract No. 1235

Swartzman, G. 1969. A preliminary bird population dynamics and biomass model. U.S. IBP Tech. Rep. No. 3. 16 p.

In this paper a preliminary model for the population and biomass change over time is given for bird populations. The interaction between biologist and modeler in the development of the model and its parameters is emphasized. The model consists of two constant coefficient differential equations. The output of the model, applied to the lark bunting, is compared with results of field experiments. Discussions of further extensions of the model as well as present difficulties are also included.

Abstract No. 1236

Swartzman, G. [Coordinator]. 1970. Some concepts of modelling. U.S. IBP Tech. Rep. No. 32. 142 p.

It is difficult to estimate the amount of time and funds that have been spent on mathematical modelling per se, because no one individual or group is working solely on this effort. Individuals working in this area split their time among various experimental, data-processing, and modelling efforts. Secondly, it is difficult to indicate when modelling starts, because it requires much discussion and analysis to develop even tentative graphic models before they are eventually implemented into analytical models. However, for purposes of comparison the following estimates are made. Nearly 16 man-months have been expended in the modelling effort to date. Perhaps 50% of this time has been in the category of analytical implementation, about 33% of the time in conceptual development and reviewing of methods and techniques, and about 10% of the time in planning of the program related to modelling. Categorized in another manner, somewhat over 40% of the time is spent each by analysts per se and by programmers, and somewhat less than 10% of the time by each project scientists and project management personnel. Understandably, these figures are imprecise but provide an "order of magnitude" estimate of the input.

This report has as its major role simply to take stock of what we have done and where we stand. In keeping with the disclaimer notice for the technical report series, this is a preliminary review of concepts and ideas examined within the framework of our modelling efforts in the grassland biome. It is through such analysis of efforts we hope to determine where we are going and examine the direction, magnitude, and distribution of our activities. Nothing herein can be construed as a definitive statement.

Abstract No. 1237

Swartzman, G. 1971. A nonlinear programming approach to game management. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

The objectives of game managers in many states are to maximize the total kill throughout the state without decimating deer populations, while spreading hunting pressure away from areas of high human population densities. The manager may control this by setting bag limits, lengthening or shortening the season, limiting numbers of licenses and building access roads into sparsely hunted regions. This paper investigates the effect of these controls on achievement of the above stated objectives and structures the problem using the engineering techniques of nonlinear programming. Extensions to the problem are also discussed and other areas of application of this technique indicated.

Abstract No. 1238

Swartzman, G. 1971. Optimization approaches to operational grassland ecosystem management. Inst. Environmental Sci. Annu. Meeting, April, Los Angeles, California.

Techniques of operations research may be brought to bear in managing grazed grassland systems. Using linear, nonlinear, or dynamic programming the effects of human control via grazing pressure, nutrient and irrigation treatments, and other management controls may be investigated on such management criteria as beef yield (short or long term), total productivity (or primary productivity), erosion, range utilization, or dollar profit under a multiple use framework. The criteria of interest can be formulated into an objective function which may be maximized under the right control combination.

Alternatively, the effects of human intervention in a "natural" grassland community may be investigated with the objective function being to maximize system stability. Two kinds of stability are considered. Stability in an unperturbed system requires plant and animal density to remain approximately constant from year to year under "ordinary" environmental conditions. The other kind of stability requires the system to return to some non-null steady state within some desired time period after a large system perturbation (e.g., a large summer hailstorm or introduction of domestic herbivores.

Abstract No. 1239

Swartzman, G. L. 1972. Concepts and techniques in ecological modeling. U.S. IBP Preprint No. 26. 40 p. [Submitted to J. Human Ecol.]

This paper deals with some of the techniques used in modeling ecological systems by the U.S. International Biological Program Grassland Biome modeling group. The three modeling or system simulation frameworks or approaches discussed are compartment models, transfer functions, and electrical analog models. Examples of the use of each of these techniques is given focusing on the interaction between the natural biotic ecosystem and the human ecosystem.

Abstract No. 1240

Swartzman, G. L. [Ed. and Coordinator]. 1972. Optimization techniques in ecosystem and land use planning. U.S. IBP Tech. Rep. No. 143. 164 p.

This paper reviews a series of techniques which have been used by the systems planner to aid him in best achieving his objectives in light of the physical limitations imposed upon him by the system. These techniques have been collectively called optimization techniques. The report briefly reviews these techniques from a mathematical veiwpoint and then proceeds to summarize the applications of these techniques to ecosystem problems. Another section speculates on other possible applications of optimization techniques in ecosystem problems.

Finally, the paper reviews the general application of optimization techniques to land use planning and tries to develop a general procedure for maximizing the "equality of life" in a community by the proper allocation of land in the community between the urban, agricultural, and range sections. This problem represents an interdisciplinary approach to the solution of land resource planning problems and combines the inputs of the various disciplines into an optimization framework.

Abstract No. 1241

Swartzman, G. L., and G. M. Van Dyne. 1972. An ecologically based simulation-optimization approach to natural resource planning. U.S. IBP Preprint No. 31. 83 p. [Submitted to Annu. Rev. Ecol. and Syst.]

A simulation, consisting of a system of difference equations, is combined with a linear programming optimization to provide a dynamic decision-making model. The simulation is driven by a probabilistic climate generator. The simulation is interrupted by the optimization program at discrete time intervals and results in decisions (optimal for that time interval) which affect the initial conditions of the simulation for the following period. The simulation results, in turn, affect the constraints in the optimization.

The technique is applied to an Australian arid grassland-shrub range problem in which cattle and sheep are managed on private holdings with a commons area also available. Decisions are made at yearly intervals on animal sales and transfers to or from the commons using linear programming. The simulation determines the population dynamics and energetics of the animal and plant populations. The objective function of the optimization is to maximize long-term profit while maintaining or improving the rangeland condition. There are 94 state variables and 243 flows in the simulation portion and more than 1000 parameters in the total model.

Details of the model are described, including algebraic listing of the simulation and optimization submodels and their coupling. Results are given graphically of selected variables in a two-year simulation run and of a 10-year simulation-optimization run. In the latter case the optimization management procedure is compared with a constant management strategy.

Possible improvements are described for the present model, as are possible kinds of experiments to perform on it. The model structure and philosophy is discussed in relation to other approaches and examples described in the literature and in relation to potential applications in ecological and renewable natural resource planning.

Our example, though not claiming final well-validated equations, contains enough reality and complexity to show the utility, as well as many of the difficulties, of the approach in dealing with real-life problems. This approach bridges the gap between theory and practice in that it utilizes information from basic ecological investigations in developing the simulation segment and considers the pragmatic problems of the resource planner in the optimization segment.

Abstract No. 1242

Swartzman, G. L., and G. M. Van Dyne. 1972. A nonlinear programming approach to regulating state-wide hunting pressure. U.S. IBP Preprint No. 27. 33 p. [Submitted to J. Wildlife Manage.]

This paper examines the possible application of nonlinear programming to the problem of trying to best allocate the hunting pressure throughout a state. A general framework is presented in which setting bag limits, lengthening or shortening the hunting season, and limiting the numbers of licenses in various of the game management units can be used to achieve the objectives of having as large a total kill as possible throughout the state without decimating deer populations in any region, while spreading hunting pressure away from areas of high human population densities. Extensions to the problem, as for example the effects of weather, are also discussed. A sub-problem dealing with a single hunting management region is solved and some of the implications of this solution are discussed.

Abstract No. 1243

Swift, D. M. [Coordinator]. 1970. Current generalized computer programs used in Grassland Biome analyses. U.S. IBP Tech. Rep. No. 34. 286 p.

This report deals with the functioning programs which are available at the Natural Resource Ecology Laboratory at Colorado State University and have been useful in the IBP Grassland Biome activities. These include generalized statistical programs as well as generalized mathematical programs such as routines for solving differential equations.

All programs are described in general terms so that investigators not familiar with programming may evaluate their utility to various types of data. Those programs which are most frequently used or which are deemed most useful to the field investigator or the modeler are discussed in some detail. The reader will note that most of the programs can be set up and run very simple by merely adding a few control cards and a data deck to the source deck. Others, however, require a user-supplied subroutine, which presupposes that the potential user has a knowledge of FORTRAN programming. FORTRAN listings are included for these programs unless such listings are readily obtainable from some other source.

Abstract No. 1244

Swift, D. M., and N. R. French [Coordinator]. 1972. Basic field data collection procedures for the Grassland Biome 1972 season. U.S. IBP Tech. Rep. No. 145. 86 p.

Details of the treatment design and sampling scheme to accumulate a basic set of state variable and driving variable data from the Grassland Biome sites during the 1972 field season is described. Sample data forms are included, and their uses are explained. *Changes from procedures followed in the 1971 field season* (described in Technical Report No. 85) *are signified by a double asterisk (**) in the right-hand margin.*

Abstract No. 1245.

Taber, R. D. 1966. Land use and native cervid populations in America north of Mexico. Montana Forest Conserv. Exp. Sta. Bull. 29:201-225.

Extensive changes have taken place in land use in North America over the last three centuries and have profoundly influenced cervid populations. At present, all cervids are dependent at some season on some sort of wooded environments.

On the whole cervid populations in America north of Mexico are at substantial levels except for the dwarf wapiti and the caribou. However, there is a pressing need for the development of methods to attain control of populations, since local overpopulations of wapiti, deer, and moose are causing range damage. Once population control is achieved, methods of improving the carrying capacity of many environments could quite readily be put into practice. The continued or enhanced maintenance of cervid populations in America north of Mexico thus constitutes, at present, a social or political as well as a biological problem.

Abstract No. 1246.

Taft, D. L. 1950. The effects of habitat on stomatal frequency. Kansas Acad. Sci. 53:477-487.

Studies on stomatal frequency as a result of the habitat, carried out at Douglas County.

Abstract No. 1247.

Tannehill, I. R. 1947. Drought: Its causes and effects. Princeton Univ. Press, New Jersey. 264 p.

An extremely readable survey of what is known and suspected about the occurrence of drought in North America, its effects, and its causes, intended for the general reader rather than the professional meteorologist. Incidentally, the author has also broadly compassed the field of climatic variations, or "cycles." The text is free from involved statistical analyses, but there are many effective diagrams and photographs, some climatic tables, a long bibliography, and a good index. Some original studies of the author are included. The reality of climatic variations, their world-wide interconnections, and their indubitable relation to solar variations are clearly portrayed. The author is very fair and open-minded about the various theories of climatic variations; in some cases he appears to be insufficiently critical as to the evidence so that the reader is not given a balanced scientific view of the matter. In general, the emphasis is on meteorological processes rather than the agricultural manifestations.

Abstract No. 1248.

Tanner, C. B., and C. P. Mamaril. 1959. Pasture soil compaction by animal traffic. Agron. J. 51(6): 329-331.

Animal traffic caused serious compaction of fine textured pasture soils, severely decreased pore-space open to aeration, and caused a 20% decrease in alfalfa-brome-Ladino yields during the first pasturing year on Ontonogan clay loam.

Abstract No. 1249.

Taylor, E. L. 1939. Does the rabbit chew the cud? Nature 143:981-983.

Morot stated that rabbits produce two sorts of faeces, the first during the night--soft, mucous; the second during the day--of the familiar appearance. The night faeces are taken directly from the anus and, without being chewed, are swallowed like pills. These pills, which are regularly met with in the stomach are only seen free when the animals are prevented from getting at their anus. The rabbit was provided with a wooden collar. In a cage with wire mesh floor two sorts of faeces immediately appeared in a day-night rhythm. Nine rabbits were fed simultaneously and killed intermittently. It appeared that the food in about 24 hours had passed through the intestines twice. The difference in consistency must be due to an intestinal rhythm in the rabbit itself. Presumably, for reasons of the digestion of cellulose, the rabbit is in the habit of swallowing large amounts of its faeces in bolus form directly from the anus, so providing an example of physiological refection to a more marked degree than had previously been thought to exist. This point in the special physiology of the rabbit is of considerable significance for the correct interpretation of metabolism experiments in which this animal has been used.

Abstract No. 1250.

Taylor, S. A., and N. C. Heuser. 1953. Water entry and downward movement in undisturbed soil cores. Soil Sci. Soc. Amer., Proc., 17(2):195-201.

Water moves downward in a dry soil from a constant source at the surface according to Darcy's law which, combined with the law of conservation of mass, results in an equation for the downward flow of water in unsaturated soils. This equation has previously been discussed and solved for special conditions. This paper reports progress that has been made in measuring and evaluating the components of this equation for undisturbed soil cores.

The results indicate that the infiltration rate depends primarily on the gradient of the moisture potential and has secondary dependence on the capillary conductivity. Potential gradients in the wetting zone and across the wetting front may be much greater than in the transmission zone and they appear to be a principal factor in determining infiltration rates. Potential gradients were measured and used to calculate apparent capillary conductivity values which are always smaller than infiltration rates. As a result of large potential gradients, the infiltration rates exceeded the saturated permeability in five of the six cores studied.

Abstract No. 1251.

Taylor, W. P., and D. W. Lay. 1944. Ecologic niches occupied by rabbits in eastern Texas. Ecology 25(1):120-121.

The jackrabbit (*Lepus californicus merriami*) occurs mostly in blackland prairie type soil, remaining only as long as the ground is open. The cottontail (*Sylvilagus floridanus alacer*) is found in all the early stages of second growth, being most abundant 5 to 12 years after cutting, that is, during the period of greatest variety and abundance of herbaceous plants. Swamp rabbits (*S. a. aquaticus*) are usually more common than any other species in second growth timber over 12 years old, as well as in the hardwood bottoms. Up to a certain point the jackrabbit benefits from grazing, which tends to eliminate vegetative cover and increase visibility; but the cottontail tends to decrease under these conditions.

Abstract No. 1252.

Terwilliger, C., Jr. 1969. Physical properties of grassland soils and their influence on primary productivity, p. 65-70. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The size, shape, and arrangement of soil particles influence primary productivity through their individual and interacting effects on soil aeration, soil water, soil temperature, and soil-plant-nutrient relationships.

The chemical environment in which roots and microorganisms live depends upon the exchange of gas between atmospheric air and soil air. Diffusion accounts for the largest proportion of this gas exchange. Total soil porosity and moisture content are the most important soil characteristics influencing diffusion rates. Growth of dry grassland plants is reduced by poor aeration. This reduced growth may be due to: (1) reduced water uptake, (2) reduced nutrient uptake, and (3) the toxic effect of excessive carbon dioxide.

Interaction between soil physical properties and climate determines the moisture regime of a particular system. In a dry grassland system where moisture is received during the growing season, sandy soils are more mesic than heavier soils. This effect is due to the relative importance of water-holding capacity, infiltration, and evaporation.

Increasing moisture stress reduces rate of plant growth, but a modest reduction in growth rate may favor sugar and starch accumulation in plants and thus favorably affect the primary consumer.

Soil temperature is important in controlling the physiological processes of the plant and the activity of the soil microorganisms. Soil temperature depends upon the amount of radiation received, the amount absorbed, the heat capacity of the soil, and its conductivity. The last three factors are dependent upon soil physical properties.

Cation exchange capacity is influenced greatly by soil texture. This characteristic is very important in determining the retention of nutrients by the soil, the chemical characteristics of the soil solution, and the uptake of nutrients by the plant.

Abstract No. 1253.

Terwilliger, C., Jr., and J. E. Jensen. 1957. Analysis of range reseeding results. Springfield Land Utilization Proj., Colorado Agr. Exp. Sta., Colorado State Univ., General Ser. Paper 666. 16 p.

Range reseeding on the Springfield Land Utilization Project since 1941 has provided valuable information on the conditions under which reseeding has been successful and on the species of grass most likely to give good results throughout an extended period of time.

The experience at Springfield indicates that a high percentage of successful seedings can be expected only in those years when the precipitation-evaporation ratio is 0.3 or above, or as low as 0.2 if adequate reserve soil moisture is available. When precipitation to evaporation ratios remained below 0.2 low seeding success was obtained.

The species that have proved most successful are all native species such as blue grama, sideoats grama, sand lovegrass, galleta, and western wheatgrass. Generally those with warm-season growth habits have produced the best, but western wheatgrass may give excellent results on fine textured soils and on favorable sites. One requirement of a vegetative stand in this area in addition to being a good forage producer is that it must provide adequate ground cover in the dry years or it may be killed out by having the soil blown away from around its root system.

Abstract No. 1254.

Tharp, B. C. 1944. The mesa region of Texas: An ecological study. Texas Acad. Sci., Proc. & Trans., 27:81-91.

The mesa region of Texas centers in Pecos County with margins in Crane, Upton, and Crockett Counties. The composition of vegetation follows topography closely. The most abundant components, designated the characteristic types of the topographic units are: mesquite-buffalo grass (well watered inter-mesa valleys); blackbush (broad valley flats and interior of large mesa tops); creosote bush (low valley ridges and interior of large mesa tops); short grama--*Acacia* (lower mesa slopes); hairy grama-needle grass (middle and upper mesa slopes); persimmon-buckeye (base of cap-rock); mixed grama--*Lechuguilla* (mesa margins atop cap-rock); creosote bush (mesa tops); cedar-walnut-oak (large deep canyons leading from mesas). It is suggested that range qualities could be improved by the construction of spreader dams and terracing, by decreasing the quantity of black-bush, creosote bush, mesquite, and broom weed and by restricting the number of livestock.

Abstract No. 1255.

Thatcher, T. O., G. Inyamah, and J. E. Mitchell. 1970. Sampling insect populations by sweep net on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 50. Colorado State Univ., Fort Collins. 10 p.

Insect samples collected by sweep net on the Pawnee Site were influenced by weather at the time of sampling as well as by population changes. Consideration of these effects allows a better understanding of insect behavior and reduces the sampling required.

Abstract No. 1256.

Theron, E. P., and P. de V. Booysen. 1966. Palatability in grasses. Grassland Soc. South Africa, Proc., 1:111-120.

In an attempt to explain the causes for differences in palatability amongst local grasses an experiment was designed to measure the differences in relative preference amongst 10 local grasses and to investigate some of the fundamental chemical and physical reasons for these differences. In the measurement of the differences in preference amongst grasses an attempt was made to determine whether time had any influence on the difference in relative palatability and if so whether these influences were due to the changes in environment or the changes in herbage maturity which occur with time.

Abstract No. 1257.

Thomas, B. O., R. E. Cameron, and J. D. Holmes. 1970. The importance and role of amphibians and reptiles in grassland ecosystems, p. 307.1-307.23. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. *A supplement*. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The amphibians and (especially) the reptiles are important organisms in the Grassland Biome. The following extensive review of the literature and synthesis of existing data emphasizes the unanswered problems facing herpetological researchers in grassland ecosystems. Reptiles and amphibians are widespread; e.g., 15 of the 44 reptiles and 8 of the 14 species of amphibians listed for Colorado occur on the Pawnee Grassland Site. Population parameters, density, home range, sex, and age ratio, etc. have not been determined for many of these organisms at the Pawnee Site. The mobility of some species has been described in the literature for different habitats. Population size, variation, and other data concerning these taxonomic documented species are not known. The majority of the terrestrial poikilothermous vertebrates utilize the grassland for only a portion of the year, but during the warm period of the year their positions in the food web and energy flow may be a very important part of the grassland. The trophic levels range from primary consumers of both terrestrial and aquatic ecosystems through secondary as well as mixed consumers of terrestrial ecosystems. Little is known of the endemic amphibians' and reptiles' food consumption in any life history stage of development or biotic coactions. Very little comparative data are available for indices. Most of the existing data are concerned with adaptation to arid environments for amphibians. The amphibian and reptilian biomass per unit area varies with development and time of year. Biomass data are also lacking. The major abiotic factors that influence amphibian and reptilian activity patterns and numbers have not been well investigated. Some information is available for spadefoot toads, but other species have not been scrutinized from the standpoint of associated soil type, climate, etc. The existing energy flow knowledge is deficient for the Pawnee Site.

Abstract No. 1258.

Thomas, G. W., and V. A. Young. 1954. Relation of soils, rainfall, and grazing management to vegetation, Western Edwards Plateau of Texas. Texas Agr. Exp. Sta. Bull. No. 786. 22 p.

Experiments were conducted from 1938 to 1953 at the Texas Range Station near Barnhart to study the effects of climate, soils, and grazing on the vegetation. This station comprises approximately 3,160 acres of land, is owned by the University of Texas, and is operated by the Texas Agricultural Experiment Station.

The 16 pastures on the station have been subjected to different rates of stocking with various combinations of sheep and cattle since grazing experiments were started in 1938.

Vegetation on the experimental pastures is fairly representative of that supported by several million acres of rangeland on the Edwards Plateau of Texas. The most important forage species are tobosa, buffalo, and curly mesquitegrass. Associated with these grasses, but in smaller amounts are three-awn grasses, side-oats grama, vine mesquite, and many others. The poisonous bitterweed and annual broomweed are the most abundant weeds. Dominant woody species are mesquite, pricklypear, and cholla.

The nature of the soil has had a pronounced effect on the kind and amount of vegetation on the area. The soil also has influenced the response of the vegetation to grazing and rainfall.

Abstract No. 1259.

Thompson, J. R. 1968. Effect of grazing on infiltration in a western watershed. J. Soil Water Conserv. 23(2):63-65.

Erosion and runoff from arid rangelands in the western United States create hazards to man-made structures downstream. Controlling runoff and its accompanying sediment is a problem facing the land manager.

Reseeding in this climatic zone has generally been unsuccessful, and eliminating grazing altogether adds little protective vegetation. However, soil management (including controlled grazing) to maintain a maximum infiltration capacity may substantially reduce runoff and erosion.

The purpose of the study reported herein was to test the effects of livestock exclusion on infiltration and erosion within the major soil types of Badger Wash in western Colorado.

Abstract No. 1260.

Thompson, L. S. 1951. Montana cooperative state grazing districts in action. Montana Exp. Sta. Bull. 481.

All but a few of the 37 cooperative state grazing districts now operating in Montana have been in existence for 10 years or more. This device by which many Montana livestock operators gained security in the use of grazing land was an innovation in land tenure. The men who drew up the grazing district laws and who have formed and administered the cooperative state grazing districts in these early years have followed an uncharted, or at least a faintly marked path.

Mistakes have been made. Lessons have been learned. Corrections have been made. The Enabling Act, now termed the Grass Conservation Act, has been rewritten and amended as experience with its administration has shown the need. Administrative policy, district by-laws, and working procedure which began to take form soon after the appointment of the Grass Conservation Commission have been revised and improved. It seems appropriate to examine state grazing districts in action and appraise them. What are their weaknesses? What benefits can be claimed for them? Have they served a good purpose? Is there still a need for them? If so, what can be done to correct their weaknesses and make them more useful? To answer these questions was the purpose of this study.

Abstract No. 1261.

Thomson, L. B. 1938. Results of experiments 1927-1936 inclusive. Canadian Dep. Agr., Dominion Range Exp. Sta., Manyberries, Alberta.

In 1925 a delegation of stockmen from western Canada made representations to the Dominion Department of Agriculture for investigational work to be carried out immediately. The delegation recommended to the government that work be conducted in cooperation with a stockman of long experience in the cattle business. After a careful survey of the whole problem by the Department, the Range Experiment Station was established in 1927 on an area southeast of Manyberries, Alberta. The work at the Station is conducted in cooperation with Gilchrist Brothers, who have been operating a cattle ranch for many years. This report is a summary of the work to 1936 and is presented to give the reader a general picture of the results.

In 1931 a similar demand arose for range investigational work in British Columbia. A survey was conducted that year and preliminary plans were made for establishing a program of work that would obtain information on the best use of the grazing resources. Fortunately, the British Columbia Government operated a ranch in connection with the Sanatorium at Tranquille, near Kamloops. This presented an excellent opportunity for cooperative work. When the preliminary survey work was completed, an agreement was entered into between the Provincial and Dominion governments. Since 1934 a number of experimental projects have been established. While there are few conclusive results to report, a summary of the work undertaken and some results to date are given in a section of this report.

Abstract No. 1262.

Thornber, J. J. 1901. The prairie-grass formation in region I. Univ. Nebraska Bot. Surv. Rep. 5:29-143.

The more important lines of investigation, with brief explanatory notes, are here given:

I. Physical factors.
   1. Physical data consisting of,
      a. Soil temperature at a depth of 10 cm.
      b. Psychrometer readings (wet and dry bulb thermometers) at surface of ground and 1 m above.
      c. Meteorological conditions as to amount and direction of wind, amount and seasonal distribution of precipitation and sky conditions, whether clear, overcast, or cloudy.
      d. Determination of physical water-content.
      e. Determination of light-intensity.

II. Vegetation-forms of the flora, including accessory biological characters.
   1. Classification of the flora according to vegetation-forms.
   2. The study of rosettes and rosette-forming plants.
   3. The study of buds with especial reference to protection.
   4. Observations concerning seed-production and dissemination.
   5. The study of the pollination of plants.
   6. The preparation of a complete phenological record for each species to include the following:
      a. Earliest appearance of leaves.
      b. Earliest appearance of flowers.
      c. Maximum flowering period.
      d. Length of flowering period.
      e. Earliest maturation.
      f. Period of maturation.
      g. Dying of parts of herbs and leaf-fall of trees.
   7. Observations upon various other phenomena, as foliage movements, etc., falling under accessory biological characters.

III. Ecological relations.
   1. The classification of the flora into habitat-groups.

IV. The study of the formation, summing up all the previous lines of investigations.

Abstract No. 1263.

Thornthwaite, C. W. 1931. The climates of North America according to a new classification. Geogr. Rev. 21:633-655.

Geographers, ecologists, and soil scientists for the most part have been working independently each in ignorance of the discoveries made by the other group. Yet it is evident that the distributions of the soils and vegetational elements of the natural landscape are causally interrelated, as well as causally related to climate. It is hoped that soil science and ecology may find in this classification a common ground which may bring them together and which can be used in the explanation of climax formations and mature soils. It is not suggested that the climatic classification here presented is in its final form or is satisfactory in every detail. It is believed, however, that the climatic elements of the landscape are here analyzed with a greater precision than has heretofore been attained. Köppen's scheme brings out the general relations of vegetation and soil to climate over the earth but fails in detailed local analyses: the present classification insofar as it has been tested has been found to work as well in detailed as in general analyses. The ultimate value of the general classification will not be known until the climatic regions of the whole earth are mapped and are compared with the distributions of the various elements of the natural landscape. In the meantime it is hoped that other geographers may be inspired to make further studies of climate on a quantitative basis.

Abstract No. 1264.

Thornthwaite, C. W. 1933. The climates of the earth. Geogr. Rev. 23:433-440.

Köppen was the first to apply to the entire earth a climatic classification based mainly on quantitative analyses of meteorological data. He recognized that the critical limits in the distribution of various types of vegetation were climatic and attempted to discover empirically climatic values that would at least approximately coincide with the various vegetational limits. He tried to determine minimum or maximum values of mean monthly, seasonal, or annual temperature and rainfall that might be said to account for limits of individual vegetation types. A further innovation of Köppen was the use of a symbolic nomenclature in the designation of the individual climates.

The present classification is like Köppen's in that it is quantitative and attempts to determine the critical climatic limits significant to the distribution of vegetation and also in that it employs a symbolic nomenclature in designating the climatic types. It differs from Köppen's classification in that it makes use of two new climatic concepts, precipitation effectiveness, and temperature efficiency. Vegetation transitions due to diminished effective rainfall are: (A) rain forest, (B) forest, (C) grassland, (D) steppe, (E) desert, and those due to diminished temperature efficiency are: (A') tropical rain forest, (B') temperate rain forest, (C') microthermal rain forest, (D') taiga, (E') tundra, (F') perpetual frost (no vegetation). The dry or cold boundaries of any of these regions are critical climatic limits beyond which the vegetation type cannot go. Of course it is understood that because of edaphic, cultural, or historical factors vegetation types do not always extend out to their climatic limits.

Three climatic factors are thus considered: (1) precipitation effectiveness, (2) temperature efficiency, and (3) seasonal distribution of effective precipitation. These factors have five, six, and four aspects, respectively, and each is designated by a symbol. There are 120 different possible combinations of these 15 symbols, making 120 theoretically possible climates. However, certain combinations of symbols are eliminated by definition; and others, being meteorologically impossible, do not occur anywhere on the earth; so that of the 120 possible combinations only 32 represent actual climatic types.

The distribution over the earth of the 32 different climates is shown on the world map. A study of the climates of the various continents reveals a very definite pattern or systematic arrangement in their distribution. The distributional pattern on the generalized continent of each climatic element is shown.

A summary of the areal extent of the eight great climatic types and the relation of the types to the total area of each continent is presented. The relative degree of accuracy of the classification in the grand divisions of the earth is extremely variable. Also shown is the numbers of stations for which computations were made and the average number of square miles per station in each continent.

Abstract No. 1265.

Thornthwaite, C. W. 1941. Atlas of climatic types in the United States 1900-1939. U.S. Dep. Agr., Misc. Pub. 421. 58 p.

The maps in this atlas are restricted to a presentation of the moisture factor of climate and show the normal position of the principal climatic types, their variation in position from year to year, and finally, the frequency of occurrence of the various individual climates. From a study of these maps, an appreciation of the diversity of the problems of soil and water conservation in the different parts of the country may be obtained.

Abstract No. 1266.

Thornthwaite, C. W. 1941. Climate and settlement in the Great Plains. U.S. Dep. Agr. Yearbook 1941: 177-187.

In a desert, you know what to expect of the climate and plan accordingly. The same is true of the humid regions. Men have been badly fooled by the semiarid regions because they are sometimes humid, sometimes desert, and sometimes a cross between the two. Yet it is possible to make allowances for this too, once the climate is understood. The author argues that the semiarid regions are now understood well enough to do a good job with them and avoid the failures and tragedies of the past.

Abstract No. 1267.

Thornthwaite, C. W. 1948. An approach toward a rational classification of climate. Geogr. Rev. 38:155-194.

Superficially the present system is similar to its predecessor in that the same factors are employed; namely, a moisture factor, a heat factor, and the seasonal variation of the two. Actually, the two systems are fundamentally different. In the earlier classification, climatic types were identified and boundaries were located, empirically, through study of the distribution of vegetation, soils, drainage features, and so on. In the present classification, climates are defined rationally, and boundaries are determined by the data.

The difference may be illustrated by the change in point of view respecting vegetation. The earlier study adopted Köppen's position that the plant is a meteorological instrument which integrates the various factors of climate and which, with experience, can be "read" like a thermometer or a rain gauge. In the present study, vegetation is regarded as a physical mechanism by means of which water is transported from the soil to the atmosphere; it is the machinery of evaporation as the cloud is the machinery of precipitation.

Climatic boundaries are determined rationally by comparing precipitation and evapotranspiration. The subdivisions of the older classification were justly criticized as being vegetation regions climatically determined. The present climatic regions are not open to this criticism, since they come from a study of the climatic data themselves and not from a study of vegetation.

Abstract No. 1268.

Thornthwaite, C. W., and B. Holzman. 1941. Evaporation and transpiration. Climate and man, U.S. Dep. Agr. Yearbook 1941:545-550.

Among the various climatic factors of hydrologic and agricultural significance the return of moisture to the atmosphere from natural land surfaces has resisted measurement most strongly and is consequently least well understood. In precipitation and runoff the water is eventually in the liquid state and can be measured by means of straightforward sampling techniques, but upon evaporating water becomes an invisible gas which mixes with the other gases of the atmosphere and is disseminated through it. Continental evaporation includes evaporation from the soil or ground surface, evaporation from ponds, lakes, streams, reservoirs, and other water bodies, evaporation of moisture intercepted by vegetation during rains, and the transpiration of moisture by vegetation.

For the farmer, the soil is a reservoir to which water is contributed by precipitation and from which it is withdrawn by evaporation and transpiration from the growing crops. During a prolonged period without rain the soil moisture may be drawn upon until the wilting point is approached and plant development and crop yields are adversely affected. A storm may partially or completely replace the moisture that has been lost, but during the period between storms evaporation and transpiration will again deplete the moisture supply. In determining the drought hazard, the measurement of the varying rates of evaporation and transpiration is as essential as information concerning the amount and distribution of rainfall, because they determine the rate at which the water supply is consumed.

Abstract No. 1269.

Thorp, J. 1948. How soils develop under grass. U.S. Dep. Agr. Yearbook 1948:55-66.

The formation of grassland soils involves the accumulation of mineral soil materials, the invasion of these materials by grass, and the accumulation of organic matter and development of soil structure. Mineral soil materials accumulate through the direct chemical and physical weathering and deposition. When grasses and other herbaceous plants secure a foothold, the soil materials are held in place by a network of roots. The decay of grass roots and leaves and the formation of humus so improve the fertility, physical condition, and moisture-holding capacity of the soil that more luxuriant grasses will survive as time goes on. Light-colored soils, shallow to the underlying parent soil material, which are characteristic of the first stages of development, are thickened and darkened.

As soon as vegetation is established, many kinds of animals take up their abode in the soil. Burrowing operations stir the soil, mix it with fresh minerals, kill some of the roots, and hasten the process of humification.

Organic matter in grassland soils acts as a sponge to absorb rain water, as a home and as food for the microscopic plants and animals that prepare the soil for the use of higher plants, and as a water reservoir to supply plants with needed moisture and to cushion them against drought. Much of the all-essential nitrogen is stored in the organic material. Organic matter accumulates somewhat slowly during the first few years. Following this the rate of accumulation increases rapidly for many years and more slowly after that.

A more specific account of the development of soils follows. Analyzation of specific regions of occurrence, resultant qualities and properties of an area's grasses and soil, effects of weather factors and mineral content, and some peculiar properties which distinguish a soil from the "normal" of a zone are discussed.

Abstract No. 1270.

Thorp, J., B. H. Williams, and W. I. Watkins. 1948. Soil zones of the Great Plains states--Kansas to Canada. Soil Sci. Soc. Amer, Proc., 13:438-445.

The area discussed comprises chiefly the area commonly known in the United States as the Northern Great Plains. The region is drained by three principal river systems: (a) the Red River of the north, which flows into Lake Winnipeg and thence into Hudson Bay; (b) the Missouri River; and (c) the Arkansas River.

The soil zones of the Great Plains are aligned in a generally north and south direction corresponding to climatic belts. Along the foothills of the Rocky Mountains the westward trend toward aridity is reversed. The semiarid parts of the Great Plains grade first into dry-subhumid areas just east of the mountains, then rapidly through a moist-subhumid zone into humid climates in the mountains. Corresponding reversals in vegetation types and soils, from one end of the Rocky Mountains to the other, exemplify the phenomena commonly called vertical zonation. A similar reversal of soil and vegetation zones may be seen around and into the Black Hills and the smaller isolated mountains of central Montana.

Boundaries drawn on maps between soil zones suggest sharp breaks between the regions of Prairie and Chernozem soils, between the Chernozem and Chestnut soils, and so on.

Not only do broad zones of soils correspond to broad differences in climate and vegetation, but there are also many local areas where climate, vegetation, and parent materials are sufficiently different from surrounding areas to be reflected in soils. Many local conditions in soils are caused by local differences in moisture regime. Thus, a few acres of Chernozem soils on moister sites are surrounded by Chestnut soils on drier sites. It is not unusual to find representatives of Chernozem, Chestnut, and even Brown soils in close association corresponding to local differences in moisture regime and vegetative cover. Local differences in soils are commoner along the zones of transition than within the broader parts of any given soil zone.

Abstract No. 1271.

Thorp, J., W. M. Johnson, and E. C. Reed. 1951. Some post-Pliocene buried soils of central United States. J. Soil Sci. 2:1-19.

This paper touches on buried soils in central United States from the southern border of the Mankato (last glacial) drift to the Gulf of Mexico, and from the Appalachian Mountains west to the Rocky Mountains. Emphasis is on the buried soils of Nebraska, Iowa, Illinois, Missouri, and Kansas where considerable work has been done in recent years. Co-author Johnson is collecting profile descriptions and is analyzing samples of the buried soils in order better to estimate the conditions under which they developed. His findings will be collected later in a thesis connected with his graduate studies at the University of Nebraska.

Although buried soils have long been known in central United States, and much has been written about them, we find little published information on the details of profile characteristics. The strongly developed buried soils in the glaciated and periglacial areas were formed primarily during interglacial stages of the Pleistocene. Weakly developed buried soils, especially notable in the late Pleistocene loess, may or may not be related to fluctuations of the Wisconsin ice front. A brief review of selected references outlines previous work and suggests the need for more detailed studies.

Abstract No. 1272.

Thorsteinsson, I., G. Olafsson, and G. M. Van Dyne. 1971. Range resources of Iceland. J. Range Manage. 24:86-93.

Animal agriculture in Iceland is second only to fisheries. At least half the forage consumed by large herbivorous animals comes from rangelands. During the period June to September most of the sheep and large numbers of unbroken horses graze on mountain ranges where they roam freely in large grazing districts or commons. There is urgent need for land reclamation and range improvement. Only 25% of the country is covered with vegetation, much of which does not provide adequate protection against soil erosion and has low carrying capacity. With increasing population and demands upon rangelands for food production, an aggressive program of rangeland improvement and management, supported by adequate research, is essential.

Abstract No. 1273.

Tiemeier, O. W. 1965. Bionomics, p. 5-37. *In* The black-tailed jackrabbit in Kansas. Kansas State Univ. Agr. Appl. Sci., Agr. Exp. Sta. Tech. Bull. 140. 75 p.

1. Sudanophilic material (fat-straining) of the adrenal glands was restricted to the cortical tissue; however, cortical cells frequently were found mingled with medullary tissue.

2. The adrenal cortex exhibited three distinct zones from the differential staining intensity of Sudan III. The outer zone characteristically had less lipoid material than did deeper zones.

3. Variations in adreno-cortical lipoid density and distribution with stages of reproductive activity in both males and females suggested activation of the adaptive mechanism.

4. Adrenal glands of female jackrabbits contain more lipoid than those of males.

5. Adrenal gland weight varied by the amount of cortical tissue present.

6. Pregnant adult females demonstrated greater mean adrenal weight than nonpregnant females, suggesting that pregnancy is a stress factor.

7. Female adrenal glands were larger than male adrenals within both juvenile and adult age groups.

8. Multiple regression techniques account for 16.6% of the variation in male adrenals and 52.4% in females.

9. Simple correlation of biotic and environmental variables with adrenal gland weight showed that temperature, pregnancy, age, and body weight were important factors in determining adrenal weight.

Abstract No. 1274.

Tileston, J. V., and R. R. Lechleitner. 1966. Some comparisons of the black-tailed and white-tailed prairie dogs in north-central Colorado. Amer. Midland Natur. 75:292-316.

Black-tailed and white-tailed prairie dogs in north-central Colorado were compared in a study made from January 1959 through September 1960. The black-tailed prairie dogs were well organized socially with males playing prominent roles. The organization of the white-tailed species consisted of loosely-knit temporary family groups headed by the female parents. Both species used tactile, visual, and auditory communications. The species differed markedly in the type, number, and construction methods of the burrow entrances. The black-tailed prairie dogs altered their aboveground environment behaviorally, but the white-tailed did not. Both were diurnal, with two periods of maximum surface activity during the summer. Black-tailed prairie dogs generally confined their daily activities to definite boundaries; the white-tailed did not. Pups of both species spent considerable time in play. Pups of the black-tailed species displayed much care-soliciting behavior directed at the adults; pups of the white-tailed species did not. Black-tailed prairie dogs remained active above ground throughout the year, but with less total activity during winter than summer. White-tailed prairie dogs completely terminated surface activity during winter; adult males were the first to appear above ground in early spring and the first to become inactive in early summer; adult females appeared a little later and remained active slightly longer; pups remained active above ground until fall. Food habits varied with the time of year and the availability of vegetation. The black-tailed species ate mostly forbs and grasses, the white-tailed mostly grasses and sedges. The black-tailed prairie dogs consumed many roots; the white-tailed never ate roots. The density of burrow entrances and animals was greater for the black-tailed than for the white-tailed prairie dogs. The black-tailed species bred during late February; births occurred in late March and April, and the pups appeared above ground in early May. The white-tailed species bred in late March; births occurred in early May, and the pups appeared above ground in early June. There was no evidence to indicate yearlings were less successful breeders than adults with either species. There appeared to be no mortality between the time of conception and the initial appearance of the pups above ground for the black-tailed species, but almost 40% of the embryos were lost in this interval with the white-tailed species. Immigration and emigration played little part in the dynamics of the black-tailed species, but were more important for the white-tailed species. Badgers were the principal predators for both species and drowning contributed to mortality at both study sites. The black-tailed prairie dogs were longer than the white-tailed species, mostly because their tails were longer. Females of both species were similar in weight, but male white-tailed prairie dogs were heavier than the black-tailed of either sex.

Abstract No. 1275.

Till, A. R., and P. F. May. 1970. Nutrient cycling in grazed pastures. II. Further observations with [^{35}S] Gypsum. Australian J. Agr. Res. 21:253-260.

The incorporation of sulphur-35 (^{35}S) into the wool of sheep grazing radioactive pasture was measured in two successive experiments on the same site following application of [^{35}S] gypsum. Equilibrium between the applied sulphur and sulphur present prior to the application was established at different rates with different rainfall. After three years the sulphur from the original gypsum application was still being turned over in the soil-plant-animal system; there had been no change in the total soil sulphur, and a large portion of soil sulphur did not enter the sulphur cycle.

A diagram of a proposed sulphur cycle in grazed pasture is given, and the assumptions made are discussed.

Abstract No. 1276.

Tisdall, A. L. 1951. Antecedent soil moisture and its relation to infiltration. Australian J. Agr. Res. 2(3):342-348.

Methods of expressing infiltration data are discussed and a series of experiments designed to determine the relation between antecedent soil moisture and various infiltration data is described. It is concluded that the regression equations obtained offer a means of correcting infiltration data to a common antecedent soil-moisture tension and that measurements of initial infiltration should be accompanied by determination of antecedent soil moisture.

Abstract No. 1277.

Tolstead, W. L. 1941. Plant communities and secondary succession in south central South Dakota. Ecology 22(3):322-328.

The district studied is made up of level prairies and low rolling hills; mean annual temperature is 46°F and rainfall 18 to 20 inches. The chief grassland communities are *Stipa-Bouteloua* on sandy loam and *Agropyron-Buchloe* on silt loam. On dune habitats species of *Redfieldia*, *Muhlenbergia*, and *Sporobolus* are the chief grasses, with numerous flowering dicotyledons. Western wheatgrass (*Agropyron smithii*) and little blue stem (*Andropogon scoparium*) form communities of ravines and north slopes. Severe drouth occurred from autumn of 1935 to autumn 1937, and quadrat studies showed in the *Stipa-Bouteloua* community a decrease of 55.5% in basal cover, while the *Agropyron-Buchloe* community lost 73.4% in basal cover. Annual weeds increased somewhat in both communities. Studies of abandoned fields exhibited four stages of succession: (1) annual forb, (2) annual and perennial forb, (3) early perennial grass, (4) climax bunch grass. Woodland communities of shallow ravines suffered a loss due to drouth of 75 to 85% of their trees, but in the vicinity of permanent streams trees were not injured.

Abstract No. 1278.

Tolstead, W. L. 1942. Vegetation of the northern part of Cherry County, Nebraska. Ecol. Monogr. 12:255-292.

The sand-hill region in Nebraska is grassland with a variety of habitats caused by differences in soil and sand textures, drainage, and topography.

The annual average rainfall is 18 inches. High temperature, low humidity, prevailing south wind, and frequent drought are unfavorable to plant growth through a part of the summer. Greatest growth is made in spring and fall.

Sand efficiently absorbs moisture. There is no runoff, and loss by evaporation from the surface is small. Fine sandy loams are less efficient in absorption of rain. Efficiency of absorption is especially important during the critical months of summer and is the major cause for differences in composition of vegetation on the several textures of soil on the uplands. Topography also modifies aerial environment and causes local differences in composition of vegetation, especially in the sand hills.

Abstract No. 1279.

Tomanek, G. W. 1948. Pasture types of western Kansas in relation to the intensity of utilization in past years. Kansas Acad. Sci., Trans., 51:171-196.

Shortgrass pastures on the high plains of western Kansas vary in their ability to produce forage for livestock consumption. One of the reasons for this difference is a variation in the degree of utilization in past years. Forage production of shortgrass ranges has been reduced to about one-half after only a few decades of improper grazing; therefore the problem of proper utilization is becoming more important every year. When the early settlers came to western Kansas they found an almost complete cover of native vegetation, and for a number of years only a small portion of the range was put under cultivation. With the coming of the dry land farmer, however, a large percentage of the native prairie was broken. A recent survey shows that in the Great Plains Region there are about 17 million acres of rangeland as compared to approximately 11 million acres of cropland.

The purpose of this study is to determine the characteristics of five pastures that have been subjected to different intensities of grazing in the past 15 years.

Abstract No. 1280.

Tomanek, G. W. 1959. Effects of climate and grazing on mixed prairie, p. 371-377. *In* Grasslands. Amer. Ass. Advance. Sci. Pub. 53.

Since grasslands of the mixed prairie in the central Great Plains are fairly well controlled by degree of grazing and climate, ranchers need to become intimately acquainted with effects of both in order to plan a livestock program that will insure good returns as well as conservation of their grasslands and soils. They must be able to maintain a flexible program that will enable them to weather periods of drought without overuse of their resources or without damaging their program. They must also be equipped to take advantage of the above average years in order to receive maximum benefit of the extra production of forage. Drought and overgrazing go hand in hand and they have a double-barreled effect on our grasslands. Each of these two environmental effects will be discussed separately before discussing their combined effects.

Abstract No. 1281.

Tomanek, G. W. 1964. Some soil-vegetation relationships in western Kansas. Amer. Soc. Agron. Spec. Pub. No. 5:158-164.

This paper is a collection of soil-vegetation studies conducted at Fort Hays Kansas State College. Soil and topography characteristics discussed are soil texture, soil depth, calcareous nature of the soil, parent material, soil types, and slope exposure. Classification of plant communities is based on range site descriptions used by the Soil Conservation Service, USDA.

The grasses are generally mentioned collectively as short, mid-tall, and tall grasses. Western Kansas is a part of the mixed prairie, a mixture of all three types of grasses, except along the more arid western border of the state which is mostly shortgrass. The relative amount of these three types of grass will be used to illustrate the effects of differences in soils and topography. Other vegetation differences used are production and species composition.

Abstract No. 1282.

Tomanek, G. W. 1969. Dynamics of mulch layer in grassland ecosystems, p. 225-240. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Numerous studies were reviewed which included some measurement of the amounts and effects of mulch in the grassland ecosystem. Mulch increases soil moisture through its effects on infiltration, evaporation, and runoff. It stabilizes soil moisture and soil temperature, which improves conditions for germination; and often the presence of mulch alters the botanical composition. All of these effects influence the amount of green herbage produced which eventually replenishes the mulch. Factors affecting the amount of mulch in the grassland ecosystem include soils, topography, grazing, rainfall, temperature, mowing, and fire. Mulch does play a vital role in the grassland ecosystem in its effects on the environment and organisms that inhabit the environment.

Many terms have been used to describe the old dead vegetative material that covers the surface of the earth. Most forest ecologists refer to forest floor material as "litter." Horticulturists and agronomists use "mulch," but no definite term has been adopted by grassland ecologists. Many terms have been used such as mulch, litter, debris, duff, protection cover, etc.

Abstract No. 1283.

Tomanek, G. W. 1970. Comprehensive Network Site description, HAYS. U.S. IBP Grassland Biome Tech. Rep. No. 41. Colorado State Univ., Fort Collins. 6 p.

The Hays Site consists of an ungrazed and a grazed stand of mixed prairie vegetation on the farm of Fort Hays Kansas State College. The remnant prairie consists of 35 acres of grassland which has been free of grazing and burning for more than 60 years. The grazed site is part of a large well-managed pasture of about 1,000 acres operated by Fort Hays Kansas State College. The study areas on both sites are located on long, gentle east-facing slopes. Approximately five acres along each slope have been selected and enclosed for intensive study of primary production. The two areas are on similar soils and separated by less than one-fourth mile. Both study areas are approximately two miles southwest of the city of Hays in west central Kansas.

Abstract No. 1284.

Tomanek, G. W., and F. W. Albertson. 1953. Some effects of different intensities of grazing on mixed prairies near Hays, Kansas. J. Range Manage. 6:299-306.

Three pastures were studied near Hays, Kansas, to determine the effects of different grazing intensities upon the vegetation. Three sites which are common in this area were studied in nongrazed, moderately grazed, and heavily grazed locations. All three sites had shallow immature soils. The rocky breaks were comprised of mostly rock fragments with only a thin filler of soil, and even the soils on the hillside were very shallow and contained many small fragments of rock. The soils of the ridgeline were somewhat deeper and less rocky.

Abstract No. 1285.

Tomanek, G. W., F. W. Albertson, and A. Riegel. 1955. Natural revegetation on a field abandoned for thirty-three years in central Kansas. Ecology 36:407-412.

A grassland area which had been abandoned from cultivation was studied to determine the percent of climax composition attained after 33 years of recovery and the effect of moderate grazing on the rate of secondary succession.

The site was located on a gentle slope with an immature soil varying in depth from a few inches on the upper slope to over 6 ft on the lower one. The near-climax vegetation for the same kind of site was found to be a mixture of mid- and short-grasses.

After 33 years of recovery under protection, the vegetation had a basal cover of 32.8%. It was composed of 55.6% long-lived and 44.1% short-lived perennials. The grazed area had only 32.8% short-lived species, and the rest were long-lived. The principal long-lived species under grazing was buffalo grass which helped to account for the higher basal cover (52.3%).

The protected area had attained 53.1% of climax composition while the grazed location had only 27.8%. Comparisons were made with a previous study by Riegel (1944) on the same area after 23 years of recovery.

Abstract No. 1286.

Tomanek, G., and F. W. Albertson. 1957. Variations in cover, composition, production, and roots of vegetation on two prairies in western Kansas. Ecol. Monogr. 27(3):267-281.

Four sites, hilltop, hillside, sharp breaks, and lowland, were studied on prairies in northwestern and southwestern Kansas. Both ungrazed and grazed areas were investigated. Ungrazed areas contained both mid and short grasses but were reduced to short grasses with grazing. Grasses reacted differently under grazing. Some decreased while others increased or even invaded from other areas. Moderately-used grasslands produced nearly twice as much forage as those heavily grazed. Most forb roots reached depths of 9 to 20 ft in soil without obstructing rock layers. Grass roots penetrated from 6 to 10 ft.

Abstract No. 1287.

Tomanek, G. W., E. P. Martin, and F. W. Albertson. 1958. Grazing preference comparisons of six native grasses in the mixed prairie. J. Range Manage. 11(4):191-193.

A study was conducted on a moderately grazed range near Hays, Kansas, to determine the preference of cattle for the six major grass species of that area. Samples were on upland, breaks, and lowland sites. Three types of determinations were made from the samples: (1) percent occurrence of species on each site, (2) percent of grazed samples on each site, and (3) number of times a species was grazed in relation to the number of times present. From these data an attempt was made to determine whether a species had a significant positive preference, no preference, or negative preference rating.

Abstract No. 1288.

Tomanek, G. W., and G. K. Hulett. 1970. Effects of historical droughts on grassland vegetation in the Central Great Plains, p. 203-211. *In* W. Dort [ed.] Pleistocene and recent environments of the Central Great Plains. Dep. Geol., Univ. Kansas Spec. Pub. No. 3.

Variation in the weather of the Central Great Plains has been well documented during the past century. During the past 100 years, 48 years have been below average precipitation, 44 years above, and eight years near average. Several drought periods have been recorded, but the two most recent extended droughts, 1933-1939 and 1952-1956, can be used to illustrate drought effects on vegetation. Vegetation records have been continuously kept of the area near Hays, Kansas, for the past 36 years. The reaction of the cover, composition, and production of the vegetation to drought is reviewed.

The composition of three major communities in grassland near Hays was greatly altered by the two drought periods. Dominant plants often were completely replaced by other plants, and often the changes still are apparent 10 years after the last drought.

Although detailed studies on animal responses to drought are not available for the area, observations indicate that certain species such as the prairie vole (*Microtus ochrogaster*) and the dickcissel (*Spiza americana*) almost disappear during drought periods. However, some species such as the white-footed mouse (*Peromyscus maniculatus*) seemed unaffected by drought, whereas others such as the black-tailed jackrabbit (*Lepus californicus melanotis*) increased three-fold during drought years.

Extended drought periods have resulted in changes in the nature of our native grasslands and the animals they support.

Abstract No. 1289.

Tomanek, G. W., and G. K. Hulett. 1971. Survey of remnant prairie stands in the Central Great Plains. Second Midwest Prairie Conf., Proc. In press.

Some 142 prairie remnants which included 242 separate stands were studied in western Kansas, western Nebraska, eastern Colorado, and southeastern Wyoming. Floristic composition of stands was determined and related to various habitat characteristics. The geographical region was divided into land resource areas. Some of the data has been analyzed to determine (1) factors responsible for prairie remnants, (2) relative importance of plant families, (3) grass and forb basic distribution in relation to moisture regime, topographic characteristics, and other related factors, and (4) distribution of woody vegetation in prairie remnants.

Abstract No. 1290.

Toole, E. H., and V. K. Toole. 1939. Germination of carpet grass seed. J. Amer. Soc. Agron. 31(6): 566-567.

Two samples of seed of carpet grass (*Axonopus affinis*) of the crop years 1934 and 1935 were tested over a period of three years. Germination at a daily temperature alternation of 20° to 35°C gave comparable results with or without exposure to daylight and with or without use of dilute KNO_3 solution to moisten substratum. Other temperature alternations and all constant temperatures used gave lower germination. The 1935 crop seed, received soon after harvest, maintained a good germination over the period of three years. The 1934 crop seed had been injured by previous storage and fell markedly in germination during the three years it was held in the laboratory.

Abstract No. 1291.

Toole, V. K. 1941. Factors affecting the germination of various drop-seed grasses (*Sporobolus* spp.). J. Agr. Res. 62(12):691-715.

A study was made of the optimum conditions for the germination of seven species of *Sporobolus*, of the variability of germinating power within the species, and of some special treatments for overcoming the resistance of some species to germination.

Abstract No. 1292.

Transeau, E. N. 1935. The prairie peninsula. Ecology 16:423-437.

It is the purpose of this paper to locate more accurately the eastern extension of the prairie at the time of settlement and to assemble the observations and problems which either directly or indirectly will be cleared up when we have a satisfactory group of explanations for the origin, development, and maintenance of the prairie peninsula.

Abstract No. 1293.

Trewartha, G. 1961. The earth's problem climates. Univ. Wisconsin Press, Madison. 344 p.

The present treatise attempts to do more than one thing. While its focus is the regional climates of the earth's larger land areas, it is not a general regional climatology in the usual meaning of that title. Rather it is a specialized treatment of climatic differentiation which emphasizes (1) the earth's problem climates, (2) the perturbation element in climate, and (3) genesis, or the dynamic processes in which climatic differentiation is rooted. It is designed to meet the needs of those interested in the professional aspects of climate rather than of laymen. A methodical description of all the earth's climates is not attempted, for many areas are climatically so normal or usual that they require little comment in a book which professes to emphasize the unique. This endeavor is meant to supplement the existing books on regional climates and not to cover the same ground. It is assumed, also, that the reader is already acquainted with the rudiments of meteorology and of physical climatology and that he has been introduced to climatic classification and is familiar with the world pattern of climatic types.

Abstract No. 1294.

Trimble, G. R., Jr., R. S. Sartz, and R. S. Pierce. 1958. How type of soil frost affects infiltration. J. Soil and Water Conserv. 13(2):81-82.

Concrete frost in the forest and open was impermeable, but in the forest it was traversed in places by large open holes that allowed water to enter the soil. Granular frost was more permeable than unfrozen soil.

Abstract No. 1295.

Troughton, A. 1957. The underground organs of herbage grasses. Commonwealth Bur. Pasture Field Crops Bull. 44:1-163.

A grass plant may be conveniently divided into roots and shoots. The functions of the shoot system are chiefly photosynthesis and sexual reproduction; those of the root system are anchorage, absorption of water and minerals, and the storage of food reserves. The shoot system is characterized by being mainly above ground while the root system is below. Certain organs, e.g., rhizomes, stolons, corms, and leaf-bases, belong morphologically and anatomically to the shoot system, but are akin to the root system in that they act as storage organs for food reserves and are normally found, at least partially, underground.

The object of this bulletin is to review the literature concerned with the underground organs of herbage grasses, i.e., the roots, rhizomes, corms, etc. of grasses valued for their foliage. A consideration of the growth of these underground organs without reference to the aboveground parts would be unjustifiable because, under natural conditions, all parts of a plant are mutually dependent upon one another. Therefore, the growth of aboveground organs in relation to those underground has been discussed in the appropriate chapters.

In the first part of this bulletin the morphology, anatomy, chemical composition, and life histories of the underground organs are reviewed. The second part deals with the environmental factors which influence the growth of these organs, while the third part is concerned with their decomposition and their influence on the soil in which they grow. The length at which any one subject has been treated has depended largely upon the amount of information available on that topic, and not solely upon its importance. Material outside the scope of the work, as indicated by the title, has been excluded, because it was thought that to include it would result in too great a mass of facts being presented in one publication, without adequate detail, and might lead to conclusions which were not strictly applicable to the species indicated by the title.

Such general conclusions as were thought justifiable from the evidence on a particular subject have been given within the first few sentences of the section dealing with that topic. When the evidence did not justify conclusions, no summaries have been attempted because these would be frequently more misleading than helpful, since they would cause conflicting results to be considered without full knowledge of the experiments from which they were obtained.

Abstract No. 1296.

Tukey, H. B., Jr. 1969. Implications of allelopathy in agricultural plant science. Bot. Rev. 35:1-16.

Substances potentially involved in allelopathy are liberated from plants by (a) leaching of foliage by rain, (b) abscission and litter fall, (c) volatilization from foliage, and (d) root exudation.

Substances, including metabolites such as mineral nutrients, carbohydrates, amino and organic acids, and growth regulators, can be leached from a wide variety of plants by rain and dew, and the quantity and quality of losses are affected by a great number of both external and internal factors. Materials leached from one plant may have an influence upon the development of the same or other adjacent plants.

Plant/plant chemical interactions have been well recognized in commercial agriculture and, in fact, form the basis of many common agricultural practices. They are currently being utilized in modern plant science in the development of bioassay systems for detecting growth regulators, the use of rootstocks to influence the growth and development of scions, in detection and eradication of diseases, and in fruit storage and ripening.

Abstract No. 1297.

Turnage, W. V., and T. D. Mallery. 1941. An analysis of rainfall in the Sonoran Desert and adjacent territory. Carnegie Inst. Washington Pub. 529:1-45.

The Sonoran Desert includes the southwestern third of Arizona, the southeastern tip of California, the western half of Sonora, and the lowlands of Baja California. Only for Arizona, northern Sonora, and southeastern California are there sufficient records for an analysis. These were obtained by the U.S. Weather Bureau, the Meteorological Service of Mexico, and the Desert Laboratory. There are two well-defined rainy seasons in this region of such character that a study of annual values alone is misleading. The months of May, June, July, August, September, and October are treated as the summer rainy season. The months of November, December, January, February, March, and April are classed as the winter season. The winter storms are similar to those of the entire western part of the United States, approaching from the Pacific Ocean. Most of the rain falls from clouds of the stratus group. The summer storms blow in at high altitudes from a southerly direction and are similar to the rainfall regime in Mexico. The rain falls mainly from clouds of the cumulus group. The topography of the region is desert only with reference to the details which are thought to have an effect on rainfall. The entire area can be divided into three geographical regions in winter, and in each region the stations group themselves fairly well around a curve calculated by the method of least squares when winter rainfall is plotted against elevation. The entire area, likewise, can be divided into four geographical regions in summer, the stations grouping themselves around a least-squares curve when summer rainfall is plotted against elevation. The scatter of the stations away from the several curves is interpreted as being the result of (a) nearness of the station to another geographical region, or (b) the relief of the land in the vicinity of the station. The differences in the values of the equations for the several curves are discussed and tentatively explained. Several types of land relief modify rainfall, and most of the evidence shows a greater modification in winter than in summer. The amount of rain is lessened by the well-known "rain shadow" effect, by the location of a station on the slopes of a low mountain, or by its location on an abrupt peak. Rain is increased by the location of a station on the slopes of a high mountain, in a deep and narrow canyon, or immediately to leeward of higher land. The amount of winter and of summer rain varies considerably over the desert region. Some portions receive a negligible amount of winter rain and others as much as 10 inches. Likewise, certain portions of the desert receive an almost negligible amount of summer rain while others receive nearly 15 inches. The northwestern half of the region receives more winter rain than summer rain. The southeastern half receives more summer rain than winter rain. Individual showers are much more erratic from spot to spot in summer than in winter. Several lines of evidence indicate that in the vicinity of Tucson a season of winter rain is more erratic from spot to spot within a small area than is a season of summer rain. The reverse is true at Yuma, where rainfall is much less in amount. Over the entire region a season of summer rainfall is more erratic in space than is a season of winter rainfall. All the stations were averaged in such a manner as to give a more or less arbitrary expression of rainfall for individual seasons for the entire region. Of the 20 winter seasons, 7 were wet, 8 were dry, and the remaining 5 were irregular rather than normal. Of the 20 summer seasons, 5 were wet, 5 were dry, and the remainder were irregular. The concept of normal rainfall for the entire area is imaginary. The actual rainfall of a given season may be any amount from less than 50% to more than 150% of an arithmetical average of a long record. Concomitant rainfall variations in space and time reveal the winter season to have more marked extremes than the summer.

Abstract No. 1298.

Turner, G. T., and D. F. Costello. 1942. Ecological aspects of the pricklypear problem in eastern Colorado and Wyoming. Ecology 23:419-426.

1. Plains pricklypear has increased greatly in abundance on shortgrass ranges in the Great Plains in recent years. This increase has created problems in range management because the space occupied by these cacti would otherwise be available for desirable forage species.

2. Plains pricklypear has the ability to increase and spread under conditions unfavorable to associated species. It reproduces by seeds, adventitious roots, root sprouts, and by death of the older portions of the plant. The plants are comparatively slow in their development, the average cluster of plants being 10 to 15 years of age.

3. Extended periods of drought or of subnormal rainfall appear to favor an increase of pricklypear. The shallow but extensive root system is adapted to make efficient use of moisture from light summer showers. The sharp spines serve as a protection from grazing by livestock.

4. Various environmental factors favor or retard the development of plains pricklypear in localized areas; among these are various species of insects and drifting of wind-blown soil.

5. Overgrazing of shortgrass ranges by livestock does not appear to be an outstanding cause of the recent increase in abundance of pricklypear. Protected areas possess dense stands of cacti about as frequently as adjoining heavily-grazed ranges. Detailed studies of grazed and ungrazed areas have shown no demonstrable deviations in trend of cactus density over five or six year periods.

Abstract No. 1299.

Turner, G. T., and G. E. Klipple. 1952. Growth characteristics of blue grama in northeastern Colorado. J. Range Manage. 5:22-28.

Growth of blue grama and its response to different systems of clipping were measured during four years of variable growing conditions on the Central Plains Experimental Range in northeastern Colorado. Herbage production was measured periodically by recording the length of leaves and flower stalks, and by harvesting plots that contained approximately the same amount of blue grama sod. The effects of complete and partial harvesting were observed.

Abstract No. 1300.

Turner, G. T., and E. J. Dortignac. 1954. Infiltration, erosion, and herbage production of some mountain grasslands in western Colorado. J. Forest. 52:858-860.

Herbage production, water infiltration, and soil erosion were determined for six common plant cover types of mountain grasslands. Infiltration and erosion were measured on small plots to which artificial rain was applied at a rate of 5 inches/hr for 50 min. Both dense and open stands of Thurber fescue provide abundant forage and ample watershed protection. Lush weed sites, when managed to prevent soil exposure and compaction, also give good watershed protection. The lush weed type furnishes little forage for cattle but is satisfactory for sheep and game. The bluegrass type normally produces adequate forage yields and the sod prevents excessive erosion although the volume of surface runoff is greater than on other grassland types. The needlegrass type is not a good forage producer and unless carefully managed can deteriorate to a condition where serious erosion occurs. The poor weed type provides inadequate watershed protection and little forage--only about a tenth as much as dense Thurber fescue sites.

Abstract No. 1301.

Turner, J., and R. M. Pengra. 1971. Decomposer studies at the Cottonwood Site. U.S. IBP Grassland Biome Tech. Rep. No. 126. Colorado State Univ., Fort Collins. 15 p.

Carbon dioxide collection and measurement for a known surface area and time period was made in an attempt to assess decomposer activity under good and poor range conditions. Data collected and the method employed have aided in devising methods that will be more quantitative for use in subsequent studies.

Through litter and filter paper studies we have also developed and adapted methods to be used in further studies of decomposer activity at the Cottonwood Site.

Abstract No. 1302.

Ueckert, D. N. 1968. Seasonal dry weight composition in grasshopper diets on Colorado herbland. Entomol. Soc. Amer. Ann. 61:1539-1544.

Microscopic examination of crop contents was used to determine the diet dry-weight composition and food preferences of adults of *Aeropedellus clavatus* (Thomas), *Xanthippus corallipes* Haldeman, and *Circotettix rabula* Rehn & Hebard from a ponderosa pine bunch-grass community in northern Colorado. Grasses and sedges comprised about 97% of the diet of *A. clavatus*. Grasses and grasslikes comprised about 86% of the diet of *X. corallipes* while forbs supplied about 12%. The diet of *C. rabula* consisted of about 80% forbs and 14% grasses or sedges. A seasonal change in the diet and food preference occurred during the adult instar of the species studied. Insect parts and fungi were common minor constituents in the grasshopper diets.

Abstract No. 1303.

Ueno, M., K. Yoshihara, and T. Okada. 1967. Living root system distinguished by the use of carbon-14. Nature 213:530-532.

There is no adequate method to distinguish a functional root from a non-functional or presumably dead root. An electrical technique has been used to diagnose the vitality of portions of roots of some weeds by measuring the resistance and capacitance of the tissue. Vital staining, in many cases with triphenyl tetrazolium chloride, has also been used for seedlings of grasses such as rice. These methods, however, can only be used when the root is thick enough to allow insertion of an electrical probe into tissues or when the root is so young that a stained portion may be easily seen.

Accordingly, there is need of a satisfactory and more widely applicable method, for grasses which are grown in the field, to distinguish functional or non-functional parts of the root system.

We applied carbon-14 to the leaves of seedlings of Italian ryegrass (*Lolium multiflorum* Lam.) and traced the translocation of labeled assimilates to various parts of the root system to ascertain whether they were readily translocated to non-functional roots, because carbohydrates are metabolites of living cells of the tissue.

This technique provides an approach to the understanding of the function of the roots particularly in perennial herbs.

Abstract No. 1304.

Ungar, I. A. 1966. Salt tolerance of plants growing in saline areas of Kansas and Oklahoma. Ecology 47(1):154-155.

Analyses of soil salinity in Kansas and Oklahoma marshes indicate that the most salt-tolerant species have the widest salinity tolerance and can survive under low as well as high salinities. The less tolerant species are limited in their distribution to low and nonsaline areas.

Abstract No. 1305.

U.S. Department of Agriculture, Office of the Secretary. 1948. Irrigation agriculture in the West. U.S. Dep. Agr., Misc. Pub. 670. 39 p.

In this publication we view the West as a distinct agricultural region because of the widespread dry climates and because of the great part that irrigation plays in crop production. Without irrigation, the West would still be an important agricultural region as a dry-land wheat-producing area and as a vast grazing area capable of producing a notable share of the country's demand for beef, mutton, hides, and wool. With irrigation, the West has become a region of utmost importance to the nation, for here are grown many agricultural products--fruits, vegetables, sugar beets, and nearly all types of crops.

The general public has a major stake in the future health and expansion of the nation's irrigation agriculture. The way in which our remaining water resources are conserved and used directly affects the agriculture of local areas and of the nation as a whole. The development and use of these water resources for irrigation purposes is basically an agricultural undertaking. We can have but one national agricultural plant into which all production segments must be integrated. The United States Department of Agriculture has major responsibilities in connection with the welfare and further development of that segment of the agricultural plant that is supported by irrigation. The policy of the Department is to encourage and aid in the development of any feasible irrigation project that will contribute toward attaining a more efficient agriculture. The wise development of our limited remaining frontiers must be the goal of all who are interested in the uses which our available water and land resources can be made to serve. That goal must be sought with increasing vigor.

Abstract No. 1306.

U.S. Department of Commerce. 1965. Weather Bureau annual summary of climatological data. 73 p.

Highlights:

1. Floods in Pacific Northwest in January.
2. Record-breaking spring floods in upper Mississippi Valley, Red River of the North, and portions of the Great Plains.
3. Frequent tornadoes.
4. Longest drought in history of Northeast.
5. Good snowfall in western mountains.
6. Most damaging hurricane on record.

7. Cool summer.

8. Wet September.

9. Favorable weather for bumper crops.

Abstract No. 1307.

U.S. Weather Bureau. 1961. Rainfall frequency atlas of the United States. Weather Bur. Tech. Paper No. 40, May 1961. 115 p.

This publication is intended as a convenient summary of empirical relationships, working guides, and maps, useful in practical problems requiring rainfall frequency data. It is an outgrowth of several previous Weather Bureau publications on this subject prepared under the direction of the author and contains an expansion and generalization of the ideas and results in earlier papers. This work has been supported and financed by the Soil Conservation Service, Department of Agriculture, to provide material for use in developing planning and design criteria for the Watershed Protection and Flood Prevention program (P.L. 566, 83d Congress and as amended).

The paper is divided into two parts. The first part presents the rainfall analyses. Included are measures of the quality of the various relationships, comparisons with previous works of a similar nature, numerical examples, discussions of the limitations of the results, transformation from point to areal frequency, and seasonal variation. The second part presents 49 rainfall frequency maps based on a comprehensive and integrated collection of up-to-date statistics, several related maps, and seasonal variation diagrams. The rainfall frequency (isopluvial) maps are for selected durations from 30 minutes to 24 hours and return periods from 1 to 100 years.

Abstract No. 1308.

Uresk, D., and P. L. Sims. 1969. Preliminary methodology and results for aboveground herbage biomass sampling on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 33. Colorado State Univ., Fort Collins. 13 p.

Biweekly sampling of herbage biomass including (1) standing vegetation of all species, (2) standing live and dead of blue grama (*Bouteloua gracilis*), and (3) litter was conducted during the summer 1969. Phenology data was taken on the primary species at each sampling date. The procedures of data collection and data summaries are presented.

Abstract No. 1309.

Valentine, K. A. 1947. Distance from water as a factor in grazing capacity of rangeland. J. Forest. 45:749-754.

An important factor influencing use of range forage is nearness to water supply. The author points out how intensity of grazing use declines with increased distance from water. Applying these results to a specific pasture made possible a correction in ordinary range-carrying capacity estimates to values in accordance with good range use.

Abstract No. 1310.

Van Bavel, C. H. M. 1953. A drought criterion and its application in evaluating drought incidence and hazard. Agron. J. 45:167-172.

It is proposed that the incidence of drought be characterized by determining for a particular crop the number of days during its growing season on which soil moisture tension exceeds a value which is known to impede appreciably crop growth. The frequency of these drought-days depends on the rainfall pattern, on the moisture characteristic of the soil, on the depth of rooting, on the physiological reaction of the plant to moisture tension, and on the rate of evapotranspiration. Drought, thus evaluated, has a truly agronomic character and is a yardstick for measuring adequacy of climate and soil for providing optimal soil moisture conditions.

A first approximation to calculate drought incidence using past rainfall records and an estimate of evapotranspiration is given and exemplified with an actual calculation for Raleigh, N. C., using 59 years of record. It is shown how the proposed drought criterion reflects the differences in moisture characteristics of different soils, in depth of rooting, and in drought tolerance of the plant. It is also shown how the results obtained may be used by direct calculation to find the need for supplemental irrigation and the safe size of storage reservoirs for a given location, crop, and soil.

As a matter of theoretical interest, it is demonstrated that the drought-days, as defined, occur at random and that a basic probability for their incidence may be computed.

Abstract No. 1311.

Van Bavel, C. H. M. 1966. Potential evaporation: The combination concept and its experimental verification. Water Resources Res. 2:455-467.

Using a combination of a surface energy balance equation and an approximate expression of water vapor and sensible heat transfer, an equation is formulated relating potential evaporation for net radiation, ambient air properties, and surface roughness. As an improvement over the earlier Penman version, the proposed model contains no empirical constants or functions. Tests of the model in Phoenix, Arizona, using open water, wet bare soil, and well-watered alfalfa, show excellent agreement of calculated and measured values on an hourly and daily basis under a variety of circumstances. Test conditions typically included advection of sensible heat to the evaporating surface in a large proportion to the latent heat flux, as well as high values of radiant flux, ambient temperatures, and vapor pressure deficits. The use of daily average values for the weather variables in the model, rather than hourly data, did not give appreciably different results or conclusions on a series of mostly clear days, suggesting that the combination model is not only accurate but also practical and generally applicable.

Abstract No. 1312.

Van Dyne, G. M. [Ed.]. 1969. The ecosystem concept in natural resource management. Academic Press, Inc., New York. 383 p.

This volume is based on a symposium held at the annual meeting of the American Society of Range Management in Albuquerque, New Mexico on February 12-15, 1968. The papers, of course, are not restricted to one natural resource field. They cover range, forest, watershed, fishery, and wildlife resource science and management. Collectively, a large number of scientists, educators, and technicians are employed in these professions. These scientists and managers have an increasingly important role in developing and utilizing the biosphere for human welfare.

Several of the chapters in this volume, particularly in Section I, include brief reviews of the development of the ecosystem concept and its adaptation in natural resource management fields. Examples of the concept in research on natural resource phenomena are considered in Section II. Evaluation of ecosystem applications and implications in several natural resource management fields is considered in Section III. The implications of even more intensive resource use in the future and of the implementation of ecosystem concepts on training tomorrow's resource managers and scientists are considered in Section IV.

This volume is not written as a textbook, but it should be a useful reference in resource management courses, especially providing a comparative evaluation of the ecosystem concept in several resource management fields. This volume has particular pertinence to research in the International Biological Program whose theme includes understanding biological productivity to enable adequate estimates of the potential yield of new, as well as existing, natural resources. The ecosystem concept is central to the planning, conduct, and analysis of many of these studies.

Abstract No. 1313.

Van Dyne, G. M. 1969. Grasslands management, research, and training viewed in a systems context. Range Sci. Dep. Sci. Ser. No. 3. Colorado State Univ., Fort Collins. 50 p.

This paper focuses on the role of mathematical modelling and analysis in grasslands research, management, and training. Examples are given of intraseasonal dynamics models of herbage biomass and of total-system energetics models. A generalized, computer-compatible notation is provided for modelling ecosystems. The complexity of grassland ecosystems imposes an interdisciplinary team approach for research and management. This complexity also requires a new approach in training. We now must train many grassland scientists and managers as multidisciplinarians to work in interdisciplinary teams.

Abstract No. 1314.

Van Dyne, G. M. 1969. Implementing the ecosystem concept in training in the natural resource science, p. 327-367. *In* G. M. Van Dyne [ed.] The ecosystem concept in natural resource management. Academic Press, Inc., New York.

The preceding chapters clearly show there are many applications of ecosystem concepts in the natural resource fields. They also show that there are major differences in definitions of ecosystems and ecosystem concepts. The title of my chapter includes the terms "ecosystem," "training," and "natural resource sciences." In order to prevent ambiguity, my uses of some of these terms are defined below. Authors of several of the preceding chapters use various kinds of models to illustrate properties of ecosystems or entire ecosystems. I will indicate how models can be used more in training in natural resource sciences. The diversity of disciplines, skills, and ideas that characterize good ecology are clearly illustrated in preceding chapters. The need for this diversity itself represents a dilemma--that of interactions which are necessary in our training and working approaches. These items are considered briefly in this section.

Abstract No. 1315.

Van Dyne, G. M. 1969. Measuring quantity and quality of the diet of large herbivores, p. 54-94. *In* F. B. Golley and H. K. Buechner [ed.] A practical guide to the study of the productivity of large herbivores. Blackwell Sci. Pub., Oxford, England.

Most of the methods and information concerning the quantity and quality of the diet of large herbivores has been derived in studies with domestic animals. This review places emphasis on those studies, for they possibly provide an upper limit to the precision and accuracy attainable in studies with wild herbivores. Primary emphasis is given to studies with grazing cattle and sheep rather than to investigations in metabolism rates or in feedlot trials. Methods used solely with wild animals are discussed and compared with those used only with domestic animals. Original literature is referenced throughout this review, but special attention will be given to review papers. Coverage is not intended to be exhaustive, but instead in many instances representative studies are cited.

Study of the quantity and quality of the diet of grazing animals has three basic components. *First*, estimates must be obtained of the chemical and botanical composition of the diet. In the current review emphasis is given to stomach analysis and fistula techniques. *Second*, estimates must be made of the digestibility of the diet. Herein, both field methods and laboratory methods will be discussed. It would appear that in future studies the field and laboratory techniques could be used in a complementary, double-sampling procedure. *Third*, to estimate total herbage intake of grazing animals a measure of fecal production is required so those methods also will be considered. Throughout this review attention will be given to estimates of numbers of animals required for sampling quantity and quality of the diet, based primarily on studies with domestic animals. An appendix is provided of the derivation and interrelation of equations of interest.

Abstract No. 1316.

Van Dyne, G. M. 1969. A plea for fewer but more significant digits. J. Range Manage. 22:52-53.

Using data from this journal, the author shows how considerable savings can be made in space and in reading time by rounding tabulated data.

Abstract No. 1317.

Van Dyne, G. M. 1969. Some mathematical models of grasslands ecosystems, p. 3-26. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

A diagrammatic representation of an ecosystem is outlined and a mathematical notation showing interrelationships of components is presented. The mathematical notation is developed step by step to build a compartment model. General differential equations describe quantitatively the simultaneous transfer of materials or energy among interrelated components within this theoretical model. Analog, digital, and hybrid analog-digital computers make possible the solution of realistically complex models necessary for accurate descriptions of biological systems. Two studies, one dealing with intraseasonal vegetation change (herbage dynamics) and one with interseasonal change (secondary succession on old fields), illustrate applications of models. Some cautions and considerations about modelling are: (1) successive revisions of a model are essential in order to approach a realistic simulation, and no model is perfect; (2) a model that approximates a system fairly accurately provides not merely a graphic representation, but, more importantly, a predictive instrument for manipulating a system and describing changes under natural and artificial stress; and (3) development of realistic mathematical models of grassland ecosystems will not be trivial and will not be done by a single man, but, rather, they will be a product of team effort requiring constant feedback and communication among investigators in the field, the laboratory, and the armchair.

Abstract No. 1318.

Van Dyne, G. M. 1970-1971. Organization and management of integrated ecological research. Invited lectures at: Amer. Ass. Advance. Sci., Chicago, 1970; Australian National Univ., 1970; Congressional Hearings, 1970; Senate Hearings, 1970; Univ. Afghanistan, Kabul, 1970; Univ. New South Wales, Armidale, 1970; British Ecol. Soc. Annu. Meeting, 1971; Cornell Univ., 1971; Hebrew Univ. Jerusalem, Israel, 1971; Oklahoma State Univ., 1971; Univ. North Dakota, 1971; Univ. Wyoming, 1971.

This paper reviews a large-scale, long-term, interdisciplinary, integrated ecological research program. I attempt to not only discuss the development of the U.S. IBP Grassland Biome study, but also to search out principles and problems common also to the other biome programs comprising the Analysis of Ecosystems study. The magnitude of these studies is indicated by the example that the grassland study now has more than 90 senior scientists involved, representing about 30 academic institutions and federal agency groups, and an annual budget of about $1.8 million is spent in field, laboratory, and armchair research.

Abstract No. 1319.

Van Dyne, G. M. 1970. A systems approach to grasslands, p. A131-A143. *In* 11th Int. Grasslands Congr., Proc. Univ. Queensland Press, Australia.

This paper focuses on the role of mathematical modelling and analysis in grasslands research, management, and training. Examples are given of intraseasonal and interseasonal dynamics models of herbage biomass and of a total system energetics model. A generalized, computer-compatible notation is provided for modelling ecosystems. The complexity of grassland ecosystems imposes an interdisciplinary team approach for research and management. This complexity also imposes a modelling and systems analysis approach which requires a new approach in training. We now must train many grassland scientists and managers to work in interdisciplinary teams.

Abstract No. 1320.

Van Dyne, G. M. 1970. Systems ecology. CHIASMA 8: 59-61. Rural Sci. Undergraduates' Soc., Univ. New England, Armidale, New South Wales, Australia.

An ecosystem is a system resulting from the integration of all living and nonliving factors of an environment. Application of the ecosystem concept has no limit in size and complexity. Its boundaries are delineated chiefly for convenience in study. Therefore, an ecosystem considers interrelationships between components and their environment, not one specific entity. The process of progressive succession is the recovery of a damaged ecosystem to a stable state known as the climax where energy into a system equals energy transported out. Equilibrium, however, is a climax only if it is reached naturally. Intervention, i.e., by man and maintenance of a disclimax is the essence of renewable resource management. Man is the most vital part of the ecosystems, as part of and manipulator of them. His needs required that he produce a removable product for his sustenance by diverting the energy flow within a climax ecosystem. He may induce instability or encounter difficulties by trying to return an ecosystem to its native state. Systems ecology provides an answer to the understanding of long-term effects of ecosystem manipulation. This confronts the entire complexity as a whole. The conceptual medium of systems ecology is the use of models for mathematically abstracting a real world situation. Once data has been transported into mathematical models, it is then capable of being analyzed by digital computers. Computers play a large role in the future of systems ecology.

Abstract No. 1321.

Van Dyne, G. M. 1971. Aspects of quantitative training in the natural resource sciences, p. 440-454. *In* G. P. Patil, E. C. Pielou, and W. E. Waters [ed.] Statistical ecology, Vol. 3: Many species populations, ecosystems, and systems analysis. Pennsylvania State Univ. Press, University Park, Pennsylvania.

Man must manipulate the environment to produce the food, fiber, metals, and power he needs for his existence. But often he has not had adequate understanding of the long-term consequences of his manipulations. As he increasingly takes an ecological viewpoint, however, and as he increasingly uses quantitative approaches, he will be able to optimize his multiple uses of natural resources. With growing populations and with dwindling resources, there is a critical need to assemble and activate interdisciplinary teams concerned with research and management of our natural resources and their optimal use. I am concerned here with the training procedures and philosophies to equip multidisciplinarians for these interdisciplinary teams who have the quantitative skills to make significant contributions toward the solution of relevant resource problems.

Much must be done to reshape training programs in natural resource sciences, and some aspects of revisions and improvements are discussed here. The emphasis here concerns terrestrial ecosystems; the concepts are extendable to freshwater and marine systems. The curricula I propose below do not exist, with the exception of some graduate programs approximating those outlined. The examples I show are not considered final, the best, or the only approach. But they are a point of departure.

Abstract No. 1322.

Van Dyne, G. M. 1971. Prairie ecosystem, p. 652-654. *In* McGraw Hill Encyclopedia of Science and Technology, McGraw Hill Book Co., New York.

Prairies (grasslands) are inhabited by large numbers of animals throughout the year. Many of these animal groups have been able to survive in prairies by developing protective mechanisms against the rigorous climate; they developed specific grazing habits and complement each other in ecosystem functioning. Some species migrate to escape the winter; others move below ground and thus serve a vital role in reducing plants to a decomposable form for nutrient release and also in churning and modifying the soil to allow new plants to grow.

Abstract No. 1323.

Van Dyne, G. M. 1971. A review of *Wildflowers of the United States* (H. W. Ricket. Vol. III. McGraw-Hill Book Co., New York. 553 p.) J. Range Manage. 24:79-80.

Volume 3 of the series "Wild Flowers of the United States" has been published by the New York Botanical Garden and McGraw-Hill Book Company. This series is compiled and edited by Dr. H. W. Rickett of the New York Botanical Garden. A review of volumes 1 and 2 of this series was published in this journal (21:271-272).

Volume 3 of the series deals exclusively with the wild flowers of Texas. This volume has the same high quality of photography and construction as the preceding volumes. Of the more than 4000 flowering plants in Texas (including grasses, sedges, trees, cacti), some 2700 herbaceous wild flowers are considered in this volume. More than 1000 color plates are presented in this two-book volume selling for $44.50. Book 1 has 274 pages plus xii and book 2 has 279 plus v, and the two books fit into a sturdy case.

Plans are for Volume 4 of the series to cover the Southwest (New Mexico, Arizona, and southern California), Volume 5 the Pacific Northwest, and Volume 6 the Rocky Mountains and Great Plains. A complete index for all volumes will be published last.

Abstract No. 1324.

Van Dyne, G. M. 1971. The U.S. IBP grassland biome study--an overview, p. 1-9. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

The Grassland Biome study was originated as part of an Analysis of Ecosystems (AOE) program in the United States' contribution to the International Biological Program (IBP). In the AOE there were desert, tundra, and deciduous, coniferous, and tropical forests. The basic concept in the AOE study was that a few, carefully-selected large-scale systems were to be examined. Each of these systems is far larger than has been comprehensively studied previously. In each case many scientists work together cooperatively in carefully defined team structures attacking problems pertinent to the "man-environment-ecology" interrelationship. Obviously, these studies also are coordinated with similar programs as part of the IBP around the world.

The overall purpose of the IBP is to examine "the biological basis of productivity in human welfare." Internationally, a major objective is to study organic production on a world-wide basis. The global objectives will not only include the acquisition of information necessary for the development and testing of ecological theory, but also that such theory will eventually have usefulness to man and his understanding of aspects of ecosystems such as energy flow, nutrient cycling, trophic structure, spatial patterns, interspecies relations, and species diversity. Further goals include the understanding of ecosystem processes by which observed characteristics of flow, cycling, density, diversity, etc., are achieved and maintained.

The focal point in much of the AOE research, and particularly in our Grassland Biome study, is to improve our understanding of entire systems. No matter how narrow or detailed a single given project may be, the relationship to the whole system will be the dominant theme. Thus, there must be a mechanism of synthesizing this information into a whole as the program progresses. We are finding mathematical models useful to us here.

Abstract No. 1325.

Van Dyne, G. M., W. G. Vogel, and H. G. Fisser. 1963. Influence of plot size and shape on range herbage production. Ecology 44:746-759.

Different sizes and shapes of plots were evaluated for measuring herbage production on southwestern Montana foothill bunchgrass ranges. Plots were restricted to those which could be conveniently located in cage exclosures. Statistical analyses were made of species or plant-group yield, total herbage yield, clipping time, and number and frequency of species. Yield estimates derived from different sizes and shapes of plots on these foothill grasslands varied. In general, less variable data per unit area were found with circular than with rectangular, square, or strip plots. Larger plots gave more uniform estimates than smaller plots. A circular, 2-sq-ft plot and a 1 × 4-ft plot, respectively, were the most efficient for estimating herbage production of two bunchgrass ranges based on minimizing yield variance and clipping time. The distribution of the species influenced yield estimates. Scattered shrubs or aggregated clusters of large bunchgrass clumps caused an abnormally high variation in yield from plot to plot, indicating that different species or groups of species require different shapes, sizes, and numbers of plots for equally efficient estimates. Smaller plants, which occurred at a greater density, required fewer or smaller plots to obtain the same efficiency of estimate as compared to the aggregated clusters of large plants. Plot shape appeared to have no influence on the number of species encountered. Percentage frequency was not different for 1- and 2-sq-ft plots, but was different for 2-, 4-, and 6-sq-ft plots. Differences in plot yields for different shape plots of a given area may possibly be explained by the ratio of plot perimeter to area. More subjective decisions must be made in harvesting individual plants or plant parts as the ratio of the perimeter to the area becomes larger. Workers harvesting range vegetation probably tend to take more vegetation than is necessary when a subjective decision must be made. In general, the estimates of yield increased as the ratio of plot perimeter to area increased. There was a heterogeneity of variance among different rectangular plot sizes for forbs and for bunchgrasses on grazed sites and for all shrubs and half-shrubs on ungrazed sites. The effects of grazing and of mean yield are discussed in relation to heterogeneity of variance. Since common statistical tests are not completely valid if the assumption of homogeneity of variance cannot be accepted, such a relation is of obvious importance.

Abstract No. 1326.

Van Dyne, G. M., O. O. Thomas, and J. L. Van Horn. 1964. Diet of cattle and sheep grazing on winter range. Western Sect. Amer. Soc. Anim. Sci., Proc., 14(61):1-6.

Esophageal fistulated heifers and ewes were grazed in adjacent pastures under herd and band conditions, respectively, on a foothill bunchgrass range in south-central Montana in 1959 and 1960. There were no significant differences in dietary composition between morning and afternoon grazing by sheep. Analysis of data from selected periods when several animals were used for sampling failed to show significant differences among animals. Significant differences were found among dates for dietary chemical components for both cattle and sheep, which suggests the importance of climatic variations on grazing performance.

Percent dietary composition for sheep in 1959 was based on 117 samples collected from 11 ewes used at various times during the winter. Means for all animals with coefficients of variation (in parentheses) and minimum and maximum values were: crude protein 7.2 (26), 4.2 to 13.7; lignin 16.9 (15), 11.4 to 25.4; and chromogen .0006 (50), .0002 to .0016.

Results for 1960 based on 79 samples collected from four heifers and 260 samples collected from seven ewes were as follows: crude protein for cattle 4.3 (30), 1.7 to 8.1 and for sheep 7.0 (36), 3.5 to 16.0; ether extract for cattle 2.8 (29), 1.0 to 4.9, and for sheep 3.1 (19), 1.6 to 4.5; lignin for cattle 14.2 (18), 5.3 to 22.9; and for sheep 14.8 (12), 9.1 to 24.0; and cellulose for cattle 42.6 (11), 14.9 to 49.0 and for sheep 41.6 (10), 25.0 to 51.8.

Abstract No. 1327.

Van Dyne, G. M., G. F. Payne, and O. O. Thomas. 1965. Chemical composition of individual range plants from the U.S. Range Station, Miles City, Montana, from 1955 to 1960. Oak Ridge Nat. Lab. TM-1279. 21 p.

In developing and testing complex simulation models for macroecosystems, many data will be needed on chemical constituents in and digestibility of diets consumed by domestic and wild animals. Individual data will be required in order to assess the precision of estimates. The individual data presented herein are previously unpublished information on chemical composition of some important native plants of the northern Great Plains. Methods of sample collection, preparation, and chemical analyses are described. Chemical constituents reported include crude protein, ether extract, lignin, crude fiber, carotene, total ash, silica, calcium, phosphorus, and nitrogen-free extract. The data are identified by the Latin name of the plant, phenological stage at which the plant was sampled, and the date of sampling. Data are presented for 459 samples of the entire current year's growth and for 94 samples collected to represent only the portion of the plant which was grazed by cattle. Graphs are presented in which between-year and within-year variations in chemical constituents are reported separately for grasses and grasslike plants and for shrubby plants.

Abstract No. 1328.

Van Dyne, G. M., and J. L. Van Horn. 1965. Distance grazed by sheep on winter range. Western Sect. Amer. Soc. Animal Sci., Proc. 16(74):1-6.

Distance traveled by a band of sheep grazing on a foothill range of about 1620 ha in south-central Montana was measured in the winter of 1960. The band's travel route during 31 days was plotted on aerial photographs. The distance traveled by three wethers in the band was measured for 41 sheep-days with metering devices harnessed to the sheep. The average distance traveled by individual sheep was 1.6 times that measured from aerial photographs for band travel. Wind movement, temperature, and relative humidity were measured winterlong. The calculated distance traveled by sheep in the band averaged winterlong was 7.6 km. Elevation climbed each day, determined from 12.2 m interval contour maps, varied from 85 to 280 m. Energy expenditure for grazing, calculated using Blaxter's constants of .030 and .322 kcal/m, respectively, for horizontal and vertical movement for a 50 kg sheep, varied from 137 to 406 kcal/day per sheep. The average energy expenditure for grazing, 235 ± 62 kcal/day of which less than 3% was expended for climbing, represents about 20% of the basal metabolic requirement. Dietary samples collected from seven esophageal fistulated ewes grazing in the band were analyzed for crude protein, ether extract, lignin, and cellulose which averaged, respectively, 7.0, 3.1, 14.8, and 41.6% during the winter.

Wind movement was the most important climatic variable affecting energy expenditure by the grazing sheep. There was no apparent lag influence of climate on energy expenditure for grazing.

Abstract No. 1329.

Van Dyne, G. M., and I. Thorsteinsson. 1966. Intraseasonal changes in height growth of plants in response to nitrogen and phosphorous. Int. Grassland Congr., Proc., 10:924-929.

The residual influences of nitrogen and phosphorus fertilizers on plant heights in early spring, maximum rate of growth, plant heights at the time of maximum growth rate, and maximum plant height were examined. Height growth of *Agropyron spicatum*, *Stipa comata*, and *Oxtropis serecia* were related to the effects of fertilizers on production and basal cover and to soil moisture content. As compared to no fertilizer, N, but not P, caused grasses to attain their greatest growth rates while they were shorter, which was earlier in the spring when there was a high soil moisture content.

Abstract No. 1330.

Van Dyne, G. M., and W. G. Vogel. 1967. Relation of *selaginella densa* to site, grazing, and climate. Ecology 48:438-444.

Selaginella densa, small clubmoss, is an important component of central Montana foothill grasslands. In an area where it occupied 10 to 20% of the soil surface, aboveground biomass was 42 to 101 g/m^2. Soils growing *S. densa* were shallower, more rocky or gravelly, but less sandy, than soils without this species. High levels of fertility, shading, and mulch reduced, but additional water increased its cover. Contrary to other reports, we found a greater decrease in cover on areas grazed intensively than on areas protected for 4 years. Cover on moderately grazed sites or on adjacent protected areas did not change.

Abstract No. 1331.

Van Dyne, G. M., W. E. Frayer, and L. J. Bledsoe. 1970. Some optimization techniques and problems in the natural resource sciences, p. 95-124. *In* Society for industrial and applied mathematics. Studies in optimization I: Symposium on optimization. Philadelphia, Pennsylvania.

The main objective of this paper is to review briefly and present examples of some of the kinds of optimization techniques used in the natural resource sciences. No attempt is made, however, for exhaustive coverage; only typical studies are reported. As a secondary objective, we introduce to analysts some of the important unsolved problems in the natural resource fields. Perhaps some of these problems have been solved, but have escaped our attention. If so, we would appreciate learning of pertinent references.

The following optimization topics will be considered in this paper: (i) mathematical programming including linear, nonlinear, and dynamic programming; (ii) special problems in regression analyses such as those involving discontinuities; (iii) network and graph theory as they may relate to structuring optimization problems in resource biology; (iv) optimization problems related to sampling allocation; (v) a class of problems which can be considered optimum association problems; (vi) compartmental model analyses, especially those models for total ecosystems for energy and nutrient flow involving nonlinearities and probabilistic forcing functions; and (vii) inverse estimation problems in population dynamics analyses involving time lags.

Abstract No. 1332.

Van Dyne, G. M., G. Innis, and G. L. Swartzman. 1971. Some analytical and operational approaches to developing dynamic models of ecological systems. Annu. Meeting Inst. Environmental Sci., April 26-30, Los Angeles, California.

The first part of this paper briefly reviews the literature of simulation models of ecological systems as contrasted with models of individual processes such as photosynthesis. It compares modelling approaches for different levels of resolution and includes studies based on Markov chains, difference equations, and differential equations. The development of such large scale models requires the cooperation and coordination of scientists and technicians with widely different backgrounds and interests. The second part of this paper addresses the challenges which management faces in achieving the necessary cooperation among a group as diverse as that needed to develop ecosystem models. The existing and proposed organizational structure for accomplishing the modelling work associated with the United States' participation in the International Biological Program (IBP) will be presented.

Well-managed ecosystem modelling efforts have the potential of providing a framework for quantifying a great deal of descriptive ecology, providing a basis for the generation of an ecological theory, and eventually providing the foundation and leadership for a new level of natural resource management. These integrated programs are having a world-wide impact on developing research studies.

Abstract No. 1333.

Van Haveren, B. P. 1971. Measurement of the energy status of water in a grassland ecosystem. U.S. IBP Grassland Biome Tech. Rep. No. 76. Colorado State Univ., Fort Collins. 21 p.

The concept of the free energy status of water in soil and plant systems is discussed together with the theory, instrumentation, and techniques involved in the measurement of water potentials. Preliminary soil water potential data collected on the Pawnee Site are included.

Abstract No. 1334.

Van Haveren, B. P. 1971. Measurements of vapor pressure in snow with thermocouple psychrometers. Symp. Thermocouple Psychrometers, March 17-19, Utah State Univ., Logan, Utah.

The process of snow metamorphism is highly dependent upon the existence of negative vapor pressure gradients within the snowpack. Strong negative gradients result in a transfer of water vapor and redistribution of mass from warmer to colder regions of the snowpack. Thermocouple psychrometers were placed in a mountain snowpack to measure vapor concentrations of the void air. Preliminary results indicate slight undersaturation of the void air in the middle regions of the profile and greater undersaturation in the top 20 cm. The significance and possible causes of undersaturated void air in seasonal snowpacks is considered. In addition, the use and calibration of thermocouple psychrometers in temperatures below 0 degrees C is discussed.

Abstract No. 1335.

Van Haveren, B. P. 1971. Psychrometry in water relations research: A review. U.S. IBP Grassland Biome Tech. Rep. No. 132. Colorado State Univ., Fort Collins. 43 p.

The Symposium on Thermocouple Psychrometers: Theory and Applications to Water Relations Research was held at Utah State University on March 17, 18, and 19, 1971. The Symposium was co-sponsored by the U.S. International Biological Program, Grassland and Desert Biomes, and the Intermountain Forest and Range Experiment Station, U.S. Department of Agriculture, Forest Service. The general themes of the Symposium were the theory and techniques involved in the use of psychrometric instrumentation in water relations research. Some 33 technical papers were presented at the three-day meeting. The proceedings have been accepted for publication by the Utah Agricultural Experiment Station and will be available late in 1971. The Symposium was dedicated in memory of the late Dr. Sterling A. Taylor, Professor of Soil Physics, Utah State University.

Abstract No. 1336.

Van Haveren, B. P., and A. F. Galbraith. 1971. Some hydrologic and physical properties of the major soil types on the Pawnee Intensive Site. U.S. IBP Grassland Biome Tech. Rep. No. 115. Colorado State Univ., Fort Collins. 46 p.

Experimental design of the soil water transect study is discussed in some detail. Soil bulk density, texture, and water retention data for the soil water transects and irrigation plots are presented. Preliminary water content data collected at the end of the 1970 growing season are also shown and discussed. Observations on snow accumulation and associated soil water recharge are introduced and discussed briefly. Results of the textural analysis, pore space distribution, and water desorption characteristics of the microwatershed soils are presented. The calibration results for the neutron probe are also given.

Abstract No. 1337.

Van Horn, D. H. 1969. Dry weight biomass data for four abundant grasshopper species of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 19. Colorado State Univ., Fort Collins. 6 p.

Data are presented for the oven-dry weights of adults and juvenile instars of each sex for four species of acridid grasshoppers on the Pawnee Site: *Opeia obscura* Thomas, *Psolessa texana* Scudder, *Xanthippus corallipes* Haldeman, and *Melanoplus gladstoni* Scudder.

Abstract No. 1338.

Van Horn, D. H. 1970. Population density and biomass for a grassland Orthopteran community. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

Drop-cage samples of orthopteroid insects have been accumulated from *Bouteloua-Buchloe* grassland sites on the Pawnee National Grassland, Weld County, Colorado, at intervals during 1969 as a part of the International Biological Program (IBP) Grassland Biome Project. Oven-dry weights for both sexes and adult and nymphal stages were ascertained for 10 of the most abundant or common species. These data suggest that there is a second early fall peak involving six species as the major components. This second peak involves both a higher population density and a higher biomass. During winter months nymphs (mainly third instar) of three species are active on warm, calm days, and thus this local orthopteran population probably functions as a part of the primary consumer trophic level all through the year.

Abstract No. 1339.

Van Horn, D. H. 1971. Grasshopper population numbers and biomass dynamics on grazed shortgrass plains in northeastern Colorado from 1968 through 1970. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

Grasshopper populations have been sampled from summer 1968 through the end of 1970 on pastures of varying grazing intensity of the Pawnee National Grassland in northeastern Colorado. A 2-m^2 drop cage was extensively used for quantitative estimations of population size. In both 1969 and 1970 there was an early (May-June) peak of adult grasshoppers comprised of four species and a late peak (September) of much higher density involving mainly six species. Total biomass of grasshoppers showed a peak period corresponding with the fall peak of adult populations. There was not a definite indication of an early summer peak in biomass.

Abstract No. 1340.

Van Horn, D. H., and R. M. Hansen. 1971. Orthopteran density and biomass studies on the Pawnee Site, 1970 (With an appendage on Orthopteran stomach analysis). U.S. IBP Grassland Biome Tech. Rep. No. 124. Colorado State Univ., Fort Collins. 15 p.

At least 38 species of leafhoppers have been identified from the Osage Comprehensive Network Site. Evidence, obtained through comparative collecting methods and "escape tests," is presented to show that collecting methods need alteration. Information is presented to show that collecting methods need alteration. Information is presented on biomass and numbers of leafhoppers; an annotated list of species is included and recommendations for future research are given. Additional information on parasitism and other general ecological information is included.

Abstract No. 1341.

Van Wyk, J. J. P. 1972. A preliminary report on new separation techniques for live-dead aboveground grass herbage and roots from dry soil cores. U.S. IBP Grassland Biome Tech. Rep. No. 144. Colorado State Univ., Fort Collins. 16 p.

Separation of live from dead herbage and roots from soil can be expensive and time consuming operations. Equipment has been designed to greatly assist in each of these operations. The live-dead herbage separation operates on the principle of aerodynamic differences between live and dead herbage in an airstream. The root-soil device is a dry crusher-separator which is particularly well suited for obtaining non-washed roots for chemical analyses.

Abstract No. 1342.

Vass, A. F., and H. Pearson. 1935. Profitable systems of farm and ranch organizations for certain areas in Wyoming. Wyoming Agr. Ext. Service Circ. 60. 8 p.

The irrigated lands of the state can be made to yield a satisfactory labor income if good farm management is followed in adjusting the cropping and livestock enterprises to the size of the farm, as well as following good production practices. A 40-acre tract of irrigated cropland may constitute a well balanced organization in those areas where there is a satisfactory market for truck crops, poultry, and dairy products.

A well balanced irrigated general farm producing sugar beets and feed crops should contain from 80 to 120 acres of cropland in order to permit a well balanced crop rotation and at the same time enable the operator to make efficient use of equipment and labor.

A livestock enterprise of some kind should be an important part of the irrigated farm organization. The kind of livestock enterprise should be the one that will make the most efficient use of feed and labor as measured by farm profit.

Abstract No. 1343.

Vaughan, H. W. 1942. Types and market classes of livestock. College Book Co., Columbus, Ohio. 608 p.

These pages aim to familiarize the reader with the types of farm animals, market demands, and market classes of livestock, such knowledge being fundamental in all livestock work and study and valuable not only to breeders and feeders but to all persons who buy and use animals.

Abstract No. 1344.

Vaughan, T. A. 1967. Food habits of the northern pocket gopher on shortgrass prairie. Amer. Midland Natur. 77:176-189.

The food habits of *Thomomys talpoides* were studied in shortgrass prairie in north central Colorado. The following six plants comprised 88% of the yearly diet: *Opuntia polyacantha* (49.9%), *Stipa comata* (12.1%), *Sphaeralcea coccinea* (10.3%), *Agropyron smithii* (10.1%), *Bouteloua gracilis* (3%), *Atriplex canescens* (2.5%). The yearly diet consisted of approximately 67% forbs, 30% grasses, and 3% shrubs; approximately 70% of the material eaten was aboveground parts of plants (stems and leaves). *Opuntia* was by far the most important food. It was eaten in all seasons, but was utilized most heavily in midwinter, when it comprised 79% of the diet and probably served most importantly as a source of water. In laboratory experiments *T. talpoides* thrived, using *Opuntia* as the only source of water. Certain ecological relationships resulting from the dependence on *Opuntia* by pocket gophers are discussed.

Abstract No. 1345.

Vavra, M. 1972. Diet and intake of yearling cattle on different grazing intensities of shortgrass ranges. Ph.D. Diss. Univ. Wyoming, Laramie. (Advisor: Richard Rice).

Studies were conducted during the summers of 1969 and 1970 and January of 1970 to determine the botanical and chemical composition and digestibility of the diet of yearling cattle on different grazing intensities of shortgrass range. Intake and gain were also measured. Esophageal fistulated cattle were used to make diet and total fecal collections. In 1969, heavy, moderate and light intensities were studied and in January 1970 and the summer of 1970 the light and heavy use pastures were studied. Blue grama (*Bouteloua gracilis* H.B.K. Lag. ex Steud.) was the principal forage species. Western wheatgrass (*Agropyron smithii* Rydb.) and sun sedge (*Carex heliophila* Mackenz.) were also consumed but availability limited the amount. Red threeawn (*Aristida longiseta* Steud.) was consumed on the heavy and moderate use pastures especially in June but little was consumed on the light use pasture. Scarlet globemallow (*Sphaeralcea coccinea* (Pursh.) Rydb.) was the only forb that had continued use. Other forbs were eaten during short time periods. Forbs made up a greater part of the diets in 1969 than in 1970. Shrub use was greatest on the heavy and moderate use pastures in 1969. Shrubs were not important diet constituents during the summer of 1970. During January of 1970, shrubs were an important part of the diet on the light use pasture. Crude protein, gross energy, lignin, acid detergent fiber, and cellulose values were quite similar between pastures for all sampling periods. Percent dry matter digestibility was slightly higher on the light use pasture during both summers, while winter values were similar. Intake was greatest on the light use pasture during both summers during July and August. This was reflected in the greater individual gains recorded on the light use pasture. Gain per hectare was highest on the heavy use pasture.

Abstract No. 1346.

Vavra, M., R. W. Rice, and R. M. Hansen. 1970. Esophageal vs. fecal sampling for the botanical determination of steer diets. J. Anim. Sci. 30: 1036.

Esophageal fistulae and fecal samples were used to determine the botanical composition of the diets of steers grazing shortgrass range in eastern Colorado. Samples were collected in June, July, and August of 1969 and January of 1970. The summer samples were drawn from 12 steers; four each on heavy, medium, and light grazed pastures. The winter samples were taken from six steers; three each on heavy and light use pastures only. The esophageal fistulae and fecal samples were mixed with water in a Waring Blender and strained on a five mesh screen. Two microscope slides were made per sample. The occurrence of each species was determined from 20 microscope fields for each of the two slides. Ten species of grasses, 21 species of forbs, and two species of shrubs were observed in the samples. Statistical analysis revealed that over all seasons and pastures significant differences ($P<.05$) existed between methods for percent incidence of grasses and forbs but not for shrubs. A significant season × method interaction occurred only in the forbs. Of the principal grass species utilized, significant differences ($P<.05$) between percent occurrence due to technique were noted for *Aristida longiseta*, *Bouteloua gracilis*, and *Buchloe dactyloides*, but not for *Agropyron smithii* nor for the sedge, *Carex heliophila*. Of the principal forbs consumed, differences occurred for *Cirsium undulatum*, *Kochia scoparia*, and *Eriogonum effusum*, but not for *Sphaeralcea coccinea*. *Artemisia frigida*, the only shrub consumed in any quantity did not vary in percent occurrence between methods.

Abstract No. 1347.

Vavra, M., R. W. Rice, and R. M. Hansen. 1971. Botanical species of plants consumed and intake of steers grazing light, medium, and heavy shortgrass pastures. 24th Annu. Meeting Soc. Range Manage., February 14-18, Reno, Nevada.

Esophageal fistulated heifers were used to obtain samples of the diets of light and heavy use pastures. Esophageal fistulated heifers and sheep were used to collect dietary samples on the herbivore diet pastures. Grasses made up a major portion of the diet in 1970. They were relatively more important than in 1969. This was probably due to a reduced availability of forbs because of 1970 precipitation. Blue grama (*Bouteloua gracilis*) was the most important grass eaten. Other grasses of importance were western wheatgrass (*Agropyron smithii*), red threeawn (*Aristida longiseta*), and needle-and-thread (*Stipa comata*). The sedge, *Carex heliophila*, was also important. Forbs were less prominant in the diets of cattle on the light use pasture in 1970 than in 1969. Environmental limitations due to precipitation may have reduced the availability of forbs to cattle. Scarlet globemallow (*Sphaeralcea coccinea*) was again the most important forb and was apparently a preferred forb. Many other forbs were noticed in the diet, but were not of continued individual importance. Shrubs were a very minor component of the diet. Dietary crude protein was adequate throughout the summer. Dry matter digestibility declined through the season and was lower in July and August on the heavy use pasture. Dry matter intake and digestible energy intake increased seasonally. The intake per animal was lower in the heavy use pasture. Winter samples were collected in December of 1969. These indicate that winter diets include a much greater proportion of the half shrub fringed sagewort (*Artemisia frigida*) in the light use treatment, whereas shrubby plants on the heavy use pasture were not nearly as important. The thistle (*Cirsium undulatum*) was evidently eaten in unusual quantity in the heavy use pasture at the time winter samples were obtained.

Abstract No. 1348.

Vestal, A. G. 1914. Prairie vegetation of a mountain-front area in Colorado. Bot. Gaz. 58:377-400.

This account is based on a study, during the past three seasons, of plant associations in the Great Plains region and of their modifications along the mountain-front. These are caused by climatic, physiographic, and vegetational differences which are of influence immediately adjoining the foothills, and to a less degree within a "mesa" belt extending eastward for several miles from the mountains. The study was carried on chiefly in the neighborhood of Boulder, Colorado.

Abstract No. 1349.

Vinke, L., and W. F. Dickson. 1933. Maintenance of beef cows for calf production. Montana Agr. Exp. Sta. Bull. 275. 35 p.

This publication presents a summary of the results obtained from experimental work with beef cows at the Northern Montana Branch Station, near Havre, from 1921 to 1932, a period of 11 years. During this period various winter feeds and rations were tested for economy in wintering cows and for their effects upon the calves produced. Factors influencing the weights of calves at birth and weaning time were studied.

Abstract No. 1350.

Visher, S. S. 1912. The biology of south-central South Dakota. South Dakota State Geol. and Natur. Hist. Surv. Bull. 5:61-130.

Mellette, Bennett, Todd, and Washabaugh Counties located in southwestern South Dakota are being opened for settlement. The first two were opened in 1911; Todd County in 1912, and Washabaugh will probably be opened in 1913. About one-fourth of this would be classed as rough land, about one-fourth as smooth, and the rest as rolling. The soils vary, but most of the region has an excellent loam soil. In regard to rainfall these counties probably fare better than nearby ones, except to the east. However the rainfall is periodically deficient. The Indians have selected much of the choicest land, but here and there an excellent piece has been left vacant. Even the less desirable areas are good mixed farming or grazing land. Indian lands can be rented at a reasonable rate. In a few years much of their land can be purchased. At present these counties are not very accessible to railroads, but extensions of the Northwestern railroad are expected soon.

The agricultural success of the eastern part of the old Rosebud Reservation (Gregory and Tripp counties) has been phenomenal. These counties increased 600 percent in population in the last decade. We expect a prosperous future for these four counties.

Abstract No. 1351.

Visher, S. S. 1914. Plants of the South Dakota sand hills. Amer. Bot. 19(3):91-94.

Very few realize that the Nebraska sandhill formation reaches into the Pine Ridge Reservation of south-central South Dakota. Since no botanist had collected in the South Dakota sandhills it was believed that a considerable number of species could be added to the flora of the state by a study of that region, and in consequence I visited the area for the State Geological and Biological Survey in August 1911 and added about fifty species to the state flora.

Abstract No. 1352.

Visher, S. S. 1916. The biogeography of the northern Great Plains. Geogr. Rev. 2:89-115.

The Northern Great Plains region displays a rather monotonous and uninviting aspect. The characteristic vegetation of millions of acres is short grass, low herbs, and stunted shrubs, nearly all of which appear dead during more than half the year. Animal life, too, is rarely conspicuous and in general seems almost wanting. The signs of human occupation are few and not uncommonly of a doleful sort, unattractive shacks, stunted crops, or poorly constructed barbed-wire fences.

The region is far more attractive to the geographer who appreciates that it contains many evident and important responses to geographic conditions. The fairly high latitude, location to the leeward of a lofty mountain range, the irregular and meager precipitation, and the rather uneventful geologic history of the region combine to produce the more direct influences: the amount of moisture and heat content of the soil, subsoil, and air, the compactness of soil and subsoil, the exposure of the surface to sun and wind, and the drainage. These factors are few in number and fairly uniform over large areas. They have acted as the chief selective agents in barring most of the many species which, for topographic reasons, have found it easy to attempt to establish themselves on the steppe.

Because of the comparatively simple geographic conditions, the paucity of species, the simplicity of structure of the plants, the unusual opportunities for field work and the many striking "adaptations" in plants and animals, this region appears especially suitable for a study in biogeography.

Abstract No. 1353.

Visher, S. S. 1936. Maps of regional contrasts in non-average temperatures and precipitation. Ann. Ass. Amer. Geogr. 26:85-87.

Plants and animals are affected by the actual atmospheric conditions, not by averages. Since life is fairly well adjusted to normal conditions, abnormal departures are especially important, and extremes impose barriers which must be overcome. The present study was made partly to discover and disclose the significance of unusual temperature and rainfall conditions. The area selected is conspicuous for the general desirability of its climate, and is a small state with little contrast in latitude, longitude, altitude, or nearness to the ocean or to other striking climatic limits.

Fifty maps dealing with temperature and precipitation in Indiana have been prepared and have revealed many significant conditions not disclosed by the conventional maps of average annual temperature and precipitation. Ten of the disclosures of the study may be summarized here.

Abstract No. 1354.

Visher, S. S. 1949. American dry seasons: Their intensity and frequency. Ecology 30(3):365-370.

For each of the four seasons, maps show (1) how much precipitation occurs in a relatively dry season (one so dry that only one in five is drier); (2) the least precipitation received in 52 years; (3) the approximate percent of the seasons which receiva less than 3 inches; and (4) the percent which receive a seasonal total of less than 1 inch. Some correlations are noted as to biologic conditions and exceptional dryness for each of the seasons. Examples are: the often extreme aridity in spring in the southwest correlates with fewer spring flowers than in California and the Middle Rockies. The frequent dry springs in the southeast hasten the maturing of early vegetables and fruits. The much greater rainfall in summer in New Mexico even in an exceptionally dry summer than in Nevada and California helps to explain the greater corn production there. Dry autumns, normal in the Great Plains, convert much grass to natural hay and help explain the importance of the ranching. Dry autumns in forested areas correlate with forest fires. The occasional arid autumns in the southeast correlates with the distribution there on sandy soil of the relatively drouth-resisting southern hard pine forest. The scanty winter precipitation of the Dakotas helps explain why spring rather than winter wheat is grown there.

Abstract No. 1355.

Vogel, W. G. 1965. Stem growth and apical meristem elevation related to grazing resistance of three prairie grasses. Int. Grassland Congr., Proc., 9:345-348.

Stem growth and apical meristem elevation of *Andropogon scoparius*, *Andropogon gerardi*, and *Sorghastrum nutans* were studied in a lithosolic prairie grassland in southwest Missouri, U.S.A. By early summer (June 15) when apical meristems begin elevating, leaf growth nearly stops even on stems that do not become fertile. Most vegetative (indeterminate) apices of *A. scoparius* and *S. nutans* do not elevate enough to be removed by grazing but those of *A. gerardi* do elevate. Although low or delayed apex elevation contributes to the persistence of these grasses to grazing, it may not be the primary factor for grazing management of these grasses in the region studied. More important is relating time and amount of defoliation with available soil moisture.

Abstract No. 1356.

Vogel, W. G., and G. M. Van Dyne. 1966. Vegetation responses to grazing management on a foothill sheep range. J. Range Manage 19:80-85.

Measurements were made of cover, yield, and vigor of plants at five locations in fenced exclosures and on adjacent range moderately grazed by sheep in fall through spring. Under the conditions of this study, four years of either deferment or moderate grazing did not cause major changes in vegetation cover, but there were improvements in the yield composition and vigor of climax-dominant perennial grasses.

Abstract No. 1357.

Voigt, J. W., and J. E. Weaver. 1951. Range condition classes of native midwestern pasture: An ecological analysis. Ecol. Monogr. 21(1):39-60.

Degenerating true prairie results in four range condition classes. The excellent class consists almost entirely of native prairie plants. A good class results when about half of the native species, mostly decreasers, have waned and died and are replaced by bluegrass (*Poa pratensis*). Further overuse of the vegetation exterminates nearly all prairie species and the resulting fair class is nearly all bluegrass, but it has an increasing number of invading weedy grasses and forbs. Further degeneration results in a poor class of pasture with patches of bluegrass, weeds, and bare soil. Vegetational composition was compared on 12 native pastures near Lincoln, Nebraska, three in each range condition class. Each pasture of 50 to 80 acres was sampled in 150 square-foot areas. *Andropogon furcatus*, *A. scoparius*, *Sporobolus heterolepis*, and *S. asper* were the chief decreasers. The first species furnished 24.8, 14.6, 2.8, and 1.7% of the forage, respectively, in excellent to poor range condition class. Grass decreasers as a group furnished 66.6% of the vegetation in the excellent class, 34.2 in the good one, 3.9 in the fair class, but only 1.9% in the poor class. *Poa pratensis*, the chief increaser, furnished only 16.2% of the vegetation in excellent range, 40.2 in good range, 78.1% in fair range condition, and 23.3 in the poor class. Total increasers averaged 30.5, 60.6, 88.0, and 31.7% in the several classes of range conditions. Invading grasses were few in excellent and good (2.1 to 3.1%) and were extremely abundant (47.5%) in poor ones. Percentage composition of vegetation furnished by forbs averaged 0.9, 2.0, 2.0, and 18.9, respectively. Thus, as pastures degenerate the best forage grasses (the decreasers) are replaced by the second best (the increasers). Finally these give way, mostly to annual grasses and weeds. The average amount of grasses left unconsumed at the time of clipping in June, July, and August was ascertained. In excellent and good pastures where warm season grasses were abundant it was highest in July and August. In fair pastures, where bluegrass dominated, it was highest in June and decreased greatly in August. In poor pastures, amount of unconsumed grasses was uniformly low. Total amounts of grass stubble in excellent to poor pastures were .86, .47, .40, and .24 tons per acre, but in poor pastures .45 ton of various forbs also occurred.

Abstract No. 1358.

Vorhies, C. T., and W. P. Taylor. 1933. The life histories and ecology of jackrabbits, *Lepus alleni* and *Lepus californicus* spp., in relation to grazing in Arizona. Arizona Agr. Exp. Sta. Tech. Bull. 49. 117 p.

This detailed study of jackrabbits (hares) centered about the Santa Rita Exp. Range in southern Arizona. There is a long breeding season and an indicated correlation of the limited number of young with amount of precipitation. Mesquite and grass are the most important sources of food; the relative amounts consumed by each species are given. The percentage of potential production of grass on the range consumed by jackrabbits is estimated. Enumeration of jackrabbits was made by several methods, and an estimate of their combined weight is compared with the total weight of cattle on the range. Pellet counts showed the hares to be less abundant on the best grass than on weed areas. Caution against complete removal of either jackrabbits or their predatory enemies on the range is urged; the possible value of rabbits is discussed critically.

Abstract No. 1359.

Wade, O. 1927. Breeding habits and early life on the thirteen-striped ground squirrel, *Citellus tridecemoineatus* (Mitchell). J. Mammal.8:269-276.

1. In the region of Lincoln, Nebraska, the rutting season of *Citellus tridecemlineatus* extends over a period of about a month and corresponds roughly to the month of April, breeding activities being at their height the last two weeks of the month.

2. The rutting impulse of the males occurs only in the spring some three or four weeks following emergence from hibernation and lasts for a period of two or four weeks, more commonly for the shorter time. At this time the testes are much inflamed and swollen.

3. After having produced a litter, females are not known to breed a second time the same season. In all cases observed females have refused to mate after having given birth to young.

4. The rutting impulse of the female appears to last for a longer time than it does in the male provided the female does not become pregnant in the meantime.

5. The gestation period is practically a lunar month--between 27 and 28 days.

6. The characteristic stripes are distinct, and the anterior portion of the body, at least, is clothed in downy hair when the young are 12 days old.

7. At 12 days of age the young make the typical ground squirrel "call" or "trill" when disturbed. The fore legs can also be used at this time for locomotion but the hind legs can not and the posterior part of the body is simply dragged along.

8. When 20 days old the hind legs are strong enough to support the hind parts and the young squirrels can walk.

9. The eyes begin to open when the young are 26 days old and are fully open by the 28th day.

10. The young squirrels can take care of themselves when about six weeks old.

Abstract No. 1360.

Waisel, Y. 1958. Dew absorption by plants of arid zones. Israel J. Bot. 6D:180-186.

1. A series of plants was examined for dew absorption, for which purpose the V-method was adapted. By this method dew absorption can be calculated from differences in water content or water saturation deficit of dew-exposed as against dew-protected arms of a V-shaped branch not detached from the plant.

2. On the basis of their capacity to absorb dew, the plants were divided into two groups, pronounced absorbers and non-absorbers.

3. So far no difference was found in the intensity of dew absorption between Mediterranean and desert plants.

4. Soil humidity affects dew absorption; the latter is considerably higher under dry soil conditions than under irrigation.

5. The recorded amounts of dew absorbed by the plants seem to be of little value in balancing their daily water output.

Abstract No. 1361.

Waksman, S. A. 1916. Soil fungi and their activities. Soil Sci. 2:103-156.

The fungi of the soil represent a numerous group of organisms found in all the soils studied in numbers large enough to warrant a conclusion that they probably play an important part in the fertility of the soil.

There does not seem to be any distinct difference between the species of fungi found in cultivated soils and those in uncultivated soils, though each soil seems to have a more or less characteristic fungus flora.

The numbers of fungi decrease rapidly with depth.

Over 100 distinct species of fungi were isolated from the soil, belonging to 31 genera, many of the species being isolated from several of the different soils.

Many pathogenic fungi have been isolated from the soil, a fact which leads one to think that they pass certain stages of their life history in the soil, or are able to live saprophytically in the soil, and perhaps play a part in its fertility.

The study of the physiological activities of the fungi pointed out the fact that they do not play a very great, if any, part in the fixation of atmospheric nitrogen, but they do prove to be able to decompose organic matter rapidly and liberate ammonia, under laboratory conditions. Many of them prove to be strong decomposers of cellulose, though fewer of them hydrolize starch.

Abstract No. 1362.

Wallace, J. D. 1969. Nutritive value of forage selected by cattle on sandhill range. Ph.D. Thesis. Colorado State Univ., Fort Collins. 224 p.

Grazed-forage was collected over five days in each of June, July, September, and December from eight esophageal-fistulated steers on sandhill range. About 55 kg of grazed-forage was collected in each season.

Dietary botanical composition approximated that of total range herbage. Actual cattle diets and those simulated from hand-clipped plants were similar in chemical composition and nylon bag dry matter digestibility. June cattle diets were 4% higher, 4.5% lower, and 2.2% lower in protein, fiber and lignin, respectively, than total herbage. Such differences became progressively smaller with advancing plant maturity. By December, diets and total herbage were similar chemically.

Salivary contamination of grazed-forage caused a significant increase in the ash component, but did not change other chemical constituents when expressed on an organic matter basis. The increase in the ash attributed to the saliva varied with species of plants and season of the year.

Cattle-grazed forage collected during each season was successfully fed to four sheep housed in metabolism crates. This method is a new approach to range nutrition studies. Major nutrient digestion coefficients, metabolizable energy values, and nitrogen balance data for the cattle diets were established in the sheep trials. Cattle diets became deficient in digestible protein and marginal in metabolizable energy in September. By December, the diet was grossly deficient in both of these items. Nitrogen, in the June diet, was poorly utilized due to excessive urinary nitrogen loss.

Fecal energy losses ranged from 30% on the June diet up to 58% on the December diet. Combined losses of urinary and methane energy, expressed as a percent of gross energy intake, decreased from about 10% on the June diet to 7.4% on the December diet. Urinary and methane energy could be predicted from dietary percentages of protein and digestible energy.

Dietary protein percentage, urinary nitrogen loss and blood urea nitrogen were closely related to nitrogen utilization. Metabolic fecal nitrogen and endogenous urinary nitrogen were calculated by regression analyses as 0.50 g per 100 g dry matter intake and 1.2 g per day, respectively. True digestibility of protein in the cattle diets was calculated as 93%.

Fecal nitrogen: digestibility regression equations (established from results of the sheep trials) were used with steer fecal nitrogen data to estimate digestibility of various components by steers on pasture. Except for protein digestion, these values were in close agreement with those found with sheep.

The lignin ratio method gave invalid digestibility results; but good results were obtained by correcting fecal lignin data for apparent digestibility of lignin as found in the sheep trials. Apparent lignin digestion was 46, 42, 29, and 4% on the June, July, September, and December diets, respectively. More steers were required to sample fecal lignin than fecal nitrogen. Digestibility estimated by the fecal nitrogen index method was generally closer to conventional results than were values derived by the adjusted lignin ratio.

Abstract No. 1363.

Wallace, J. D., and A. H. Denham. 1970. The digestion by sheep of range forage collected by esophageal fistulated cattle. J. Anim. Sci. 30: 605-607.

Grazed forage was collected twice daily from eight esophageal-fistulated steers on sandhill range over 5-day periods in mid-June, late July, early September, and mid-December. About 55 kg was collected in each period. Digestibility was determined by feeding the cattle-grazed forage to caged sheep in conventional digestion trials. This method offers a new approach for range and pasture nutrition studies. Proposed uses for the method are discussed.

Abstract No. 1364.

Wallace, J. D., K. L. Knox, and D. N. Hyder. 1970. The energy and nitrogen value of sandhill range forage selected by cattle. J. Anim. Sci. 31: 398-403.

Forage was collected from esophageal-fistulated cattle grazing sandhill range in eastern Colorado during mid-June, late July, early September, and mid-December. Metabolizable energy values and N balance data for the cattle diets selected during each period were established by feeding the grazed forages to sheep. Cattle diets became deficient in digestible protein and marginal in metabolizable energy in September according to N.R.C. standards (1963). By December, the diet was grossly deficient in both. Nitrogen in the June diet was poorly utilized as shown by excessive urinary N loss.

Fecal energy losses ranged from 30% on the June diet up to 58% on the December diet. Combined losses of urinary and methane energy decreased from about 10% on the June diet to 7.4% on the December diet when expressed as a percent of gross energy intake. Urinary and methane energy could be predicted from dietary percentages of protein and digestible energy.

Dietary protein percentage, urinary N loss (g/day), and blood urea N were closely related to several measures of N utilization in the sheep trials. Blood urea N was useful as an index to N intake and digestibility. Metabolic fecal N and endogenous urinary N were calculated by regression analysis as 0.50 g per 100 g dry matter intake and 1.2 g per day, respectively. True digestibility of protein in cattle diets was calculated as 93%.

Abstract No. 1365.

Wallace, J. D., and G. M. Van Dyne. 1970. Precision of indirect methods for estimating digestibility of forage consumed by grazing cattle. J. Range Manage. 23(6):424-430.

Comparisons were made of the lignin ratio and the fecal nitrogen index methods of estimating digestibility of diets of grazing animals. Special attention was given to sources of error and variability in these estimates. Evaluation of indirect methods of estimating digestibility of grazed forage were made by sampling forage from the range with esophageally-fistulated steers and later feeding it to sheep in conventional digestion trials. Regression equations for predicting diet digestibility from fecal nitrogen and factors for correcting for lignin digestibility were obtained from the digestion trials with sheep. These equations and correction factors were used with composition data for fecal and forage samples from steers on the range to calculate digestibility under grazing conditions.

Abstract No. 1366.

Wallwork, J. A. 1970. Ecology of soil animals. McGraw-Hill, New York. 283 p.

The purpose of this symposium is to consider the influence of the quantity, quality, and availability of food on the processes regulating animal populations. Food is often difficult to define because animals feed selectively; several papers emphasize this point. The effects of nutrition on reproduction, survival, and numbers are not necessarily direct: food is sometimes not a proximate influence. The symposium therefore considers the role of social behavior as an important intermediary and also sometimes as a direct influence on numbers independently of food. Factual reports of progress in current research are presented against a background of more general reviews. Papers are included from agriculturalists, nutritionists, and behaviorists as well as from ecologists since each can contribute towards a better understanding of the role of food in influencing population processes. The symposium is partly intended to promote a fuller appreciation among ecologists of recent advances in these other fields.

Abstract No. 1367.

Walton, K. 1969. The arid zones. Aldine Publ., Chicago. 175 p.

Many factors may lead to aridity of large areas of the earth's surface. Latitude and longitude cannot, by themselves, explain the location and size of the components of the arid world; neither can continentality nor the distribution of high- and low-pressure cells, nor the upwelling of cold ocean waters. To these must be added factors originating far back in geological time--the formation of the continents and the ocean basins. On these must be superimposed the more recent cycles of orogenic activity which created geosynclines and uplifted the much modified sedimentary structures. The areas of high relief created by isostatic uplift have been worn down and later uplifted into platforms and plateaux by differential earth movements to create an architecture of isolated topographic basins in the rainshadow of the adjacent hill masses. When the western Cordillera of North America were uplifted at the end of the Cretaceous period they were dislocated into more humid fault blocks margining drier intervening rift valleys and fault-angle depressions. One of the youngest arid areas of the world is also tectonically the most recent rift valley; Death Valley in California dates only from the Pleistocene and its landscapes reflect its recent origin. It is perhaps significant that almost all the world's arid lands are dominated by adjacent high relief or have high mountains in their midst. This fact directs attention to tectonics, erosion, and sedimentation with the concomitant lightening and overloading of the crust compensated by uplift and depression. Since changes in altitude are linked with the amount of precipitation received, the importance of tectonic movements cannot be overestimated. Conversely, the zones of sedimentation have, for many reasons, proved attractive to the inhabitants of the arid lands since there accumulate the deposits on which crops can be grown and on which there may be sufficient vegetation for animals to graze. These too are the zones where the rivers drain into interior basins providing water for irrigation or for stock. To them man has been drawn since the dawn of prehistory and repeatedly failed to conserve the moisture which was available. In more extreme cases he has, in the process of establishing himself, even extended the area of the arid lands and thus himself become responsible for causing aridity. At this stage it becomes essential to look more closely at the characteristics of the climates of the arid lands to understand the natural processes behind the environment which man is now attempting to develop.

Abstract No. 1368.

Ward, R. T. 1969. The nature and significance of eco-genetic variations in ecosystems, p. 148-152. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

The importance of genetically fixed eco-physiologic variability within species has been recognized since the early work of Turesson. Much of the research in this country has been concerned with dominant grasses of the central grassland of North America. Broad climatic patterns of phenologic and morphologic ecotypic variability have been demonstrated for most of the species studied. Northern populations, in contrast to those of the south, are earlier in development and shorter in stature. Ecotypes in relation to edaphic and biotic factors have also been demonstrated. Studies of the physiological attributes of ecotypes have indicated differences but little consistent patterning. It is evident to extend the information and hypotheses drawn from a few study sites to the broad landscape of the grasslands will require a thorough knowledge of intraspecific, genetically-fixed physiological-ecological variation in the component species.

Abstract No. 1369.

Wardlaw, J. I. 1970. The early stages of grain development in wheat: response to light and temperature in a single variety. Australian J. Biol. Sci. 23(4):765-774.

For wheat plants (cv. Gabo) grown under natural daylight at a temperature of 21/16°C, increase in dry weight of the stem exceeded that of the ear for the first 10 days following anthesis. Higher temperatures (27/22°C) resulted in a greater rate of grain development, with a corresponding increase in the rate of cell division in the endosperm tissue and a shortening of the stem growth period. Despite initial differences in the rates of cell division with variation in temperature, the final number of cells formed in an endosperm did not vary significantly between temperature treatments. Dry weight accumulation in the stem was, in contrast to the grain, highest at lower temperatures (15/10°C).

Low light intensity (17.5% of daylight) reduced dry weight accumulation by both the stem and ear and resulted in a reduction in the final number of endosperm cells formed in the grain. Both dry weight analyses and studies of the distribution of ^{14}C-labeled photosynthate from the flag leaf indicated that the top internode of this variety, which elongated a further 12 to 16 cm after anthesis, competed with the grain for assimilates under light-limiting conditions.

Grain set was maximal when temperatures were low, and light intensity high from the time of anthesis, and ranged from 28 grains per ear at 27/22°C under 17.5% sunlight to 49 grains per ear at 15/10°C under full sunlight.

A comparison was made of temperature and light variations during the first 10 days after anthesis with similar treatments during the stage of starch deposition 15 to 25 days after anthesis. High temperature during either period reduced grain yield per ear at maturity with the greater effect during starch deposition. However, low yield which resulted from high temperature during the early period was caused by a reduction in seed set, which was partially compensated by increased grain size. In contrast high temperatures during the later stages reduced the weight of individual grains. Low light at both stages of development significantly reduced grain weight per ear at maturity.

Abstract No. 1370.

Wasser, C. H. 1944. Reseed range land to increase grazing capacity and produce more beef per acre. Colorado Exp. Sta. Farm Bull. 6(5):12-14.

It is estimated that during the past three years Colorado ranchers have annually reseeded from 50 to 75 thousand acres to grass. There are several million acres of abandoned cropland, depleted rangeland, and dense sagebrush lands which may be improved by artificial reseeding. Results of reseeding have not always been wholly satisfactory. Therefore, results from experimental seeding work at Fort Collins, the Cheyenne Wells Substation, Middle Park, and Great Divide, Colorado, are represented to guide future reseeding work in the state and make it more successful.

Abstract No. 1371.

Watkins, W. E. 1933. Digestion and mineral balance trials on range cattle with native New Mexico range hay, cottonseed meal, and mineral supplements. New Mexico State Univ., Agr. Exp. Sta. Bull. 212. 31 p.

The object of this investigation was to determine if there exists a deficiency of calcium and phosphorus in some of the range grasses in this region and also to determine what minerals will correct this condition most efficiently, if such a deficiency exists.

Abstract No. 1372.

Watkins, W. E. 1937. The calcium and phosphorus contents of important New Mexico range forages. New Mexico State Univ., Agr. Exp. Sta. Bull. 246. 75 p.

There were 12 counties in New Mexico in which the average phosphorus content of the range grasses in the fall of 1932 was insufficient for normal growth and reproduction of range cattle. That year was slightly above normal with respect to precipitation.

There were three counties in 1932 in which the average calcium content of the grasses was insufficient for cattle. The calcium was low in parts of several other counties.

During an average year, so far as precipitation is concerned, there seems to be a greater deficiency of phosphorus than of calcium in the range grasses of this state.

According to analyses of samples of grasses obtained in nine counties in northern New Mexico, in September and October, 1934, and in the late winter and spring of 1935, the losses by leaching are very great. Approximately 75% of the phosphorus and 25% of the calcium were lost from the grasses during the winter months.

The analyses made of samples of grasses collected in the spring of 1935 indicated that there is a period of several months just before the beginning of the growing season during which the phosphorus levels of the grasses are low. This suggests a special need for providing minerals or mineral-rich feeds during this period.

Results from a recent experiment conducted by this station indicate that in New Mexico the calcium and phosphorus requirements of sheep are slightly higher than for cattle; therefore, the need for a mineral supplement containing available calcium and phosphorus appears to be more urgent for sheep than for cattle.

The samples of browse collected were more than three times as high in calcium and 61% higher in phosphorus than the samples of range grass collected in the fall.

Abstract No. 1373.

Watkins, W. E. 1943. Composition of range grasses and browse plants at varying stages of maturity. New Mexico State Univ., Agr. Exp. Sta. Bull. 311. 43 p.

Fourteen different species of range forage plants were studied by analyses and evaluation of 712 samples from the plants.

In the cases of some of the principal range grasses on the College ranch in southern New Mexico it was found that protein losses of from 37 to 73% occurred between October and March. There was one winter with the protein level satisfactory for nonlactating cows, three winters with slight protein deficiencies, and one with a pronounced and extended deficiency.

Reference to the phosphorus content of the grasses analyzed indicates that, except for a short period at the peak of the growing season, phosphorus requirements for cattle were not met. Phosphorus losses of from 49 to 83% were found between October and March, depending upon the amount of late fall and winter losses and leaching.

The losses of calcium were not large, but increased when excessive weathering and leaching occurred during the late fall or winter. The three principal grasses on the College ranch lost an average of 23% of calcium between October and March, while excessive leaching increased this percentage to 44.

During four of the five years in which carotene percentages of black grama were determined, the winter carotene levels were sufficient for beef cows, even during the gestation and lactation periods. During the other winter, the black grama contained only 55% of the amount of carotene needed. Mesa dropseed grass lost all of its carotene soon after the end of the growing season and was of no value as a source of winter carotene.

Chamiza (*Atriplex canescens*) and sand sagebrush (*Artemisia filifolia*), valuable browse plants, had rather high contents of protein, calcium, and phosphorus.

There is a relationship between available soil phosphates and the phosphorus of the forage.

The quantity of amido protein present is suggested as a measure of the wintertime plant activity of black grama grass.

Abstract No. 1374.

Watkins, W. E. 1947. Nonprotein and carotene as an index of plant activity in range forage. J. Agr. Res. 75:63-69.

The percentages of nonprotein in various New Mexico range forages are presented. Some of the range grasses and browse plants have continuous plant activity throughout the winter, though the rate of activity in certain species is much reduced. The percentages of nonprotein for black grama and mesa dropseed grasses are closely correlated with the carotene level. Analyses of the nonprotein, as well as of the crude protein and carotene values when these were available, together with field observations, formed the basis for estimating the plant activity of these forages.

Abstract No. 1375.

Watkins, W. E. 1955. Digestibility of range grasses and grass-legume mixtures. New Mexico State Univ., Agr. Exp. Sta. Bull. 400. 22 p.

The feeding values of four native range grasses, three introduced grasses, and four grass-legume mixtures were determined in 22 metabolism trials with wethers.

Abstract No. 1376.

Watson, A. [Ed.]. 1970. Animal populations in relation to their food resources. British Ecol. Soc. Symp. No. 10, Blackwell Sci. Publ., England. 477 p.

This book provides a basic text on the ecology of soil animals assuming little previous knowledge on the part of the reader. After the introduction of the soil as a habitat for animal life, each group of the soil fauna is considered in turn and reviews are given, where appropriate, of the modern knowledge of macro- and micro-distribution patterns and the factors which govern these, reproductive biology and population dynamics, feeding habits, and ecological status. Information widely scattered in the literature is brought together to identify the factors regulating the size of population in the soil, and the structural and functional characteristics of the soil community are described in terms of trophic relationships and the efficiency of energy utilization and transfer. The reader is also introduced to modern techniques for collecting soil animals.

The basic approach adopted reflects the changing pattern of ecological studies, and particular emphasis is placed on the synthesis of quantitative information. The soil community is considered as a dynamic entity which can be most meaningfully understood in terms of energetic relationships. Where possible, the treatment is in the form of critical appraisal, and broad generalizations are avoided. Thus the book will prove informative to undergraduates and stimulating to postgraduates and research workers.

Abstract No. 1377.

Watson, D. J. 1956. Leaf growth in relation to crop yield, p. 178-191. *In* J. Milthorpe [ed.] The growth of leaves. Butterworths, London.

The leaves are the chief organs of photosynthesis, and the area of a leaf is usually assumed to be the size-attribute that best measures its capacity for photosynthesis; at least there is some evidence that leaf area is more appropriate for this purpose than leaf weight. So the sum of the areas of all the leaf laminae per unit area of land, both areas being expressed in the same units--the *leaf area index (L)*--can be taken as a measure of the size of the photosynthetic system. It is not a perfect measure because parts of the plant other than the leaf laminae are capable of photosynthesis and may sometimes account for an appreciable fraction of the total dry matter production.

The total annual photosynthesis by a crop depends not only on the size of the photosynthetic system but also on its efficiency and the length of time during which it is active. In assessing the relative importance of leaf area as a determinant of yield and the possibility of increasing yield by influencing leaf growth, we must therefore consider to what extent yield varies or can be made to vary by change in the rate of photosynthesis or in the length of the growth period.

Abstract No. 1378.

Watson, D. J. 1958. The dependence of net assimilation rate on leaf area index. Ann. Bot. N.S. 22: 37-54.

The leaf-area index (leaf area per unit area of land, L) of field crops of kale and sugar-beet was varied experimentally by removing different fractions of the plant population distributed uniformly through the crop. The net assimilation rate (E) was determined in subsequent periods of 10 to 14 days.

For kale, E decreased nearly linearly with increase of L throughout the range from 1 to 5. E of sugar-beet was less affected by change in L and was apparently not decreased until L rose above about 3.

Because of this dependence of E on L, the rate of dry-matter production per unit area of land, or crop growth-rate ($C = EL$), showed a curved relation to L; for kale it increased to a maximum when L was between 3 and 4 and fell again at higher values of L. Maximal C for sugar-beet occurred beyond the range of L tested, probably between $L = 6$ and $L = 9$. This optimal L for dry-matter production by sugar-beet crops probably lies near the upper limit of the current agricultural range, so there is little, if any, scope for increasing the dry-matter yield by further increase in L. For heavy kale crops L is already far in excess of the optimum, and it may be possible to increase the total dry-matter yield of kale by repeated thinning or defoliation to hold L near the optimum.

Abstract No. 1379.

Watson, D. J., and A. G. Norman. 1939. Photosynthesis in the ear of barley and movement of nitrogen into the ear. J. Agr. Sci. 29:321-346.

Experiments were made in 1936 and 1937 on barley plants grown in pot culture to determine the effect of shading the ear or the shoot after emergence on dry weight and nitrogen content.

Abstract No. 1380.

Watson, K. K. 1965. A statistical treatment of the factors affecting the infiltration capacity of a field soil. J. Hydrol. 3:58-65.

A series of sprinkling infiltrometer experiments on small field plots is analyzed statistically to determine the relative importance of such factors as antecedent moisture content, simulated rainfall intensity and sub-surface cracking on the infiltration capacity.

Abstract No. 1381.

Watts, J. G. 1963. Insects associated with black grama grass, *Bouteloua eripoda*. Ann. Entomol. Soc. Amer. 56(3):374-379.

Collections from black grama grass, *Bouteloua eriopoda* Torrey, were made throughout the year by a variety of techniques on a ranch in southern New Mexico; and 9 orders, 55 families, 109 genera, and 120 species of insects were taken. They included grass feeders, parasites and predators, and casual visitors. Four species of Thysanoptera accounted for considerably more than 50% of the total insect population and 97% of the thrips were *Chirothrips falsus* Hood. Insect populations were manipulated by use of broad-spectrum insecticides. The reduction of the *C. falsus* population by 80% or more resulted in a consistent and substantial increase in seed set which, in a few cases, increased six or seven times. Other insects were at such low levels that no significant change in their numbers could be measured.

Abstract No. 1382.

Watts, J. G. 1965. *Chirothrips falsus* on black grama grass. New Mexico Agr. Exp. Sta. Bull. 499. 19 p.

This study was undertaken to determine the biology and ecology of *Chirothrips falsus* Priesner and its relationship to the typically poor seed set of black grama. The work was conducted on native range, principally at the University Ranch near Las Cruces, and on irrigated plots at the Middle Rio Grande Branch Station near Los Lunas.

Some 136 species of insects were collected from black grama, but *Chirothrips falsus* was the principal species limiting seed production.

Abstract No. 1383.

Weakly, H. E. 1940. Tree-ings as a record of precipitation in western Nebraska. Tree-Ring Bull. 6:18-19.

The material used in this study is entirely Eastern red cedar, *Juniperus virginiana*, from Lincoln County, Nebraska. For tree-ring study, this species leaves much to be desired. Perhaps one cross-section in four is of sufficient symmetry to be usable. This is the only softwood available; hardwoods have thus far proved of little value.

Numerous sections of logs which had been used in some of the buildings at Fort McPherson and also a number of specimens from old log houses erected by some of the early settlers of this territory have been studied. Also, some specimens have been uncovered in old fills in the bottoms of a number of canyons. Some of this old buried material has given very readable ring sequences, but as yet it has been impossible to assign actual dates.

The larger trees cut by the early settlers ran from about 175 years to over 200 years old. The buried trees predate these by many years, as in some cases they have been found beneath a substantial fill in old gully or canyon floors with the stumps of 200-year-old trees in place in the soil many feet above them. At the level of the tops of these old buried trees there is a 3- to 6-inch layer of charcoal, and all those observed by the writer or reported to him show evidence of having been burned off at the old level of the earth fill about them. This charcoal bed is present in practically all the canyons in this vicinity and lies at depths varying from one to as much as six or even more feet below the surface. The material below it is largely aeolian in nature, whereas that above is both colluvial and alluvial in its general aspect.

The amount of wind-blown material in the lower portion of these canyon fills would indicate a drought period of considerable duration and severity. The annual rings on the buried wood from these localities indicate a period of over 30 years with deficient moisture. Apparently this drought period contributed very largely to the death of these trees.

The correlation coefficient between ring width and the annual rainfall for 63 years at North Platte is 0.63 ± 0.05. An occasional lag effect is observed.

The recorded droughts of 1856 to 1860, 1869 to 1873, 1893 to 1894, and the one culminating in 1910 are all reflected in tree growth very faithfully. The periods of 1676-84, 1765-70, 1795-1800, 1820-24, and 1839-43 were also apparently deficient in precipitation. The period from 1820 to 1824 is of special interest because of the apparently extreme severity of the drought and the fact that it was extraordinarily widespread, being a matter of record in the diaries of several persons in the New England States and showing in the growth of trees studied by Douglass at Flagstaff, Arizona.

The above study has been in progress for about five years; a complete report on it is in preparation.

Abstract No. 1384.

Weakly, H. E. 1943. A tree-ring record of precipitation in western Nebraska. J. Forest. 41:816-819.

A study of tree rings in carefully selected specimens of red cedar and ponderosa pine from various parts of western Nebraska shows that for the last 400 years there have been frequent dry years or short periods of dry years, with less frequent droughts lasting for 5 years or more. The latter have averaged 12.85 years in length, and the period between them 20.58 years. The correlation between annual ring growth and annual rainfall as recorded by the Weather Bureau indicates a high degree of statistical significance. The data do not show precipitation cycles of sufficient regularity to be of value in the exact forecasting of future droughts.

Abstract No. 1385.

Weaver, J. E. 1915. A study of the root systems of prairie plants of southeastern Washington. Plant World 18:227-248, 273-292.

While carrying on a study of the plant formations and associations of semi-arid southeastern Washington in 1912-1914, it soon became apparent that for a proper understanding of the development and structure of these associations a knowledge of the root-systems of the more important prairie species was imperative. Consequently, during the fall, winter, and spring of 1913-1914, more than 350 root-systems of 25 of the most important ecological species were examined. This paper contains descriptions of these, together with a discussion of the conditions under which the plants grow.

Abstract No. 1386.

Weaver, J. E. 1919. The ecological relations of roots. Carnegie Inst. Washington, Pub. 286. 128 p.

This study was undertaken to determine the root habits of dominant and subdominant plants growing under a wide range of climatic and edaphic conditions, to find the root relations of the plant communities as units of vegetation, and to determine the root distribution and root competition of the individual species in their relation to other species in the community. Other aims were to determine the relation between the root habits of plants in various communities and their successional sequence and to obtain a more definite knowledge of the indicator value and the significance of various species used in classifying lands for grazing or for agriculture, as well as to aid the forester in selecting sites for afforestation or reforestation.

Abstract No. 1387.

Weaver, J. E. 1920. Root development in the grassland formation. Carnegie Inst. Washington, Publ. 292. 151 p.

The grasslands are considered under three subdivisions of true prairie, mixed prairie, and shortgrass plains. The true prairie is characterized by tall sod-forming grasses in soil of rather abundant water content, with greater moisture in the subsoil. On the basis of root development, three general classes may be recognized in grassland vegetation. In the first the "working depth," or average depth reached by a large number of roots is about 1.5 ft, with a maximum of about 6 ft; while in the third class the working depth of the roots is usually 5 to 8 ft and the maximum penetration 8 to 12 ft, with a few species reaching an extreme of 15 to 20 ft. Examples of the three classes are (1) *Aristida oligantha*, *Elymus canadensis*, and *Koeleria cristata*; (2) *Andropogon scoparius*, *Bouteloua gracilis*, *Grindelia squarrosa*; and (3) *Andropogon furcatus*, *Aster multiflorus*, and *Panicum virgatum*. The deeper rooted species have few roots in the surface layers of the soil, showing a grouping of roots into more or less definite layers, thus reducing competition and permitting the growth of a larger number of species. In the shortgrass plains practically all plants have root systems well adapted for water absorption from surface soils. Two have roots with a working depth of less than 2 ft, three have working depths of 2 to 4 ft, and three have a range of 4 to 7 ft. Examples of the three classes are *Opuntia polyacantha*, *Bulbilis dactyloides*, and *Psoralea tenuifolia*, respectively. Here the water supply is much more limited, especially in the subsoil. The soil and moisture conditions as well as the vegetation in the mixed prairie are intermediate between the true prairie and the shortgrass plains. Compared with the true prairie, the plants are not as deeply rooted, but have usually developed a very efficient and widely spreading absorbing system in the surface soil. The root systems of cereal crops grown at many stations in true and mixed prairie and shortgrass plains were also examined. The comparative amount of root development of cereals in each seems to be in true prairie 100%, in mixed prairie 80 to 95%, and in shortgrass plains 51 to 79%. The experimental data are given in the form of tables, drawings, and photographs, all of excellent quality. It is recognized that variations in root development are caused by various factors, such as the chemical and physical character of soils and the evaporating power of the air. The soil factors are most effective through water content and aeration. The water relations of the various habitats were examined by Weaver using atmometers and soil moisture determinations, the latter being interpreted by means of the wilting coefficient and the hygroscopic coefficient. He calls attention to the recognized fact that many plants are able to continue to absorb water below the limits of the wilting coefficient. In fact, it is in the responses of different plants to the use of soil moisture lying between the limits of the wilting and the hygroscopic coefficients that differences appear which might be used with advantage for a most significant classification.

Abstract No. 1388.

Weaver, J. E. 1925. Investigations on the root habits of plants. Amer. J. Bot. 12:502-509.

Investigations in several states showed that extensive root systems are the rule among grassland species. The great extent of roots in relation to aboveground parts is often very striking. Nor is the great extent of roots in comparison to tops confined to native species. The rapidity of root growth is quite as remarkable as root extent. A growth rate of over half an inch a day is not unusual among native grasses. That large amounts of both water and nutrients are absorbed by these deeply penetrating roots has been repeatedly demonstrated. By means of wax seals placed at various depths in filling large containers, soil layers of known water and nutrient content have been effectually isolated from the layers above and below. Through these seals roots penetrate readily and develop normally. Variations in root habit under different climatic conditions are often very pronounced. Continued examination of the smaller cereals in fertile silt-loam soils under a wide range of precipitation and soil moisture shows that the root habit varies widely. Variations under local environments are also very great. Root-stratification due to soil texture is not infrequent. In these layers of greater nutrient content densely branched roots run horizontally in great profusion, contrasting in a striking manner with more poorly branched parts of the root system above and below. Pronounced differences in root-development in the same field may also be induced by competition. Considerable progress has been made in a study of the relation of absorbing area to transpiring surface. Methods have been devised by means of which it has been found possible to secure root systems several feet in extent quite in their entirety from the soil in which they grew. Adaption of crop plants to new environments whether by selection or by breeding, like so many other problems in plant-production, warrants careful study of root relations.

Abstract No. 1389.

Weaver, J. E. 1930. Underground plant development in its relation to grazing. Ecology 11:543-557.

Underground plant parts play a role of major importance in the starting of plant populations. Natural grasslands are relatively dry lands; rapid germination and elongation of the primary absorbing system are requisite to successful establishment. Water is the major limiting factor to growth, hence the amount of forage produced depends in a large measure upon the extent and efficiency of the root system. The production of tillers is successful only when the secondary root system penetrates into the moist soil and meets the increased demands for water. Seedlings weakened by too severe grazing are liable to succumb, especially if the soil is compacted by trampling or eroded as a result of the disturbance of the plant cover.

Persistence of the vegetation through the arid summer, and through the drought and cold of winter, is directly related to the development of underground plant parts. Among grasses of prairie and plains, those of uplands and arid soils usually have roots that are more extensive in proportion to tops and possess finer and more numerous branches than those of lowlands and less arid soils. Plants with poorly established root systems and little food stored therein are less resistant to winterkilling. More rapid and earlier growth of long-lived grasses and other herbs results from abundant food accumulations in underground parts. Overgrazing results in poorer root growth, and permits of little food accumulation; the plants are more apt to die of drought and cold.

Underground plant development permits of an increase in territory and of resistance to invaders. The bunch and sod habits, resulting from tillering and rhizome production, increase the plant cover, even when conditions are unfavorable for the establishment of seedlings. Erosion is decreased, and invading annuals are at great disadvantage unless the cover is broken by overgrazing. Rhizomes persist even when all the aboveground parts are eaten and the soil trampled bare. An efficient absorbing system frequently outweighs the advantage of greater stature. Vigor of growth and the amount and viability of seed are directly related to the food supply available in underground parts. Poor seed may result in slow germination and poor establishment.

Abstract No. 1390.

Weaver, J. E. 1942. Competition of western wheat grass with relict vegetation of prairie. Amer. J. Bot. 29:366-372.

Agropyron smithii is a common sod-forming, perennial, forage grass of midwestern prairies. It is so successful a competitor for the meager supply of soil moisture that it often causes the death of more mesic grasses and forbs of the true prairie. It renews growth in early spring, produces abundant foliage which normally reaches a height of 1.5 to 2 ft in June and is overtopped by flower stalks 1.5 to 2 ft taller. Seed is produced in abundance, and migration is rapid by means of long, slender, much branched rhizomes. Formerly occurring sparingly in the eastern portions of Nebraska and Kansas, western wheat grass spread rapidly and widely following the great deterioration of grassland due to drought.

The early luxuriant growth, when water was available, resulted in greatly reducing the amount of soil moisture for use by other species, most of which began development four or more weeks later. Lack of much débris under western wheat grass permitted rain to loosen the surface soil and roil the water that entered it. This resulted in decreased infiltration and greater runoff than on soil covered with bluestems.

Competition for water resulted in great dwarfing and often in wilting and death of most other prairie grasses and forbs. Numbers of species and numbers of stems of perennial forbs were greatly decreased.

Abstract No. 1391.

Weaver, J. E. 1943. Replacement of true prairie by mixed prairie in eastern Nebraska and Kansas. Ecology 24:421-434.

The replacement of true prairie by mixed prairie has occurred as a result of drought in an area 100 to 150 miles in width in central Kansas, eastern Nebraska, and eastern South Dakota. The change of plant populations and structure of vegetation is described in detail as it occurred in three widely separated representative native prairies. Predrought vegetation consisted mostly of little and big bluestem with only small amounts of western wheatgrass, side-oats grama, and the short grasses--blue grama and buffalo grass.

The chief dominant, little bluestem, mostly or entirely succumbed to drought in 1934 and 1936. Big bluestem was greatly damaged. It finally nearly disappeared in 1940. Western wheatgrass rapidly increased each year. In 1939 it was held in check by an enormous spread and excellent development of side-oats grama. This competitor, however, suffered great losses the following year and wheatgrass occupied most of the area. A steady increase and wide distribution of the very xeric blue grama, and, in a smaller degree, buffalo grass occurred syncronously with the rise of wheatgrass. By mutual invasions of the mid grass and short grasses, typical mixed prairie became clearly apparent in 1938. By 1941, these grasslands were almost entirely transformed into mixed prairie.

Where native true prairie had been weakened by grazing and trampling, or where it had degenerated to shortgrass pasture, wheatgrass usually gained even earlier entrance and spread with great rapidity, often resulting in a wheatgrass-shortgrass mixed prairie type.

Abstract No. 1392.

Weaver, J. E. 1947. Rate of decomposition of roots and rhizomes of certain range grasses in undisturbed prairie soil. Ecology 28:221-240.

Rate of decomposition of underground parts of 12 range grasses was ascertained at Lincoln, Nebraska.

Plants of big bluestem, little bluestem, and blue grama growing in prairie on silt loam soil were killed and left to decay in undisturbed soil. Columns of soil were excavated. They were separated into horizontal layers including the upper 6 inches, second 6 inches, and the second foot, respectively, one column with each species of grass being examined at the end of each of three years of decay.

Decrease of erosion in soil, which has produced several crops of grass, even after it is again cultivated may be due in part to the undecayed roots and in part to the effects of decomposing roots upon promoting soil aggregates or retaining aggregates already formed.

Abstract No. 1393.

Weaver, J. E. 1950. Effects of different intensities of grazing on depth and quantity of roots of grasses. J. Range Manage. 3:100-113.

This paper is concerned with a new quantitative method of studying root-soil relations and particularly its application to the effects on the underground plant parts brought about by grazing. The method of obtaining a sample of the entire root system from the soil surface to the deepest root tips is a modification of the direct or trench method. It consists in the digging of a trench to the desired depth in a particular soil and the obtaining of a single soil block (monolith) extending from the surface to a depth of 3 to 6 ft. The monolith is of such dimensions, 2.5 ft wide and 3 inches thick, that it can be removed from the trench and taken to the laboratory without special equipment.

The monolith is marked out on the vertical trench wall directly beneath a representative bunch or sod of grass to be studied. With appropriate knives and spades the soil at the sides and beneath the monolith is removed to such a distance into the wall that the column of soil protrudes at least 3 inches into the trench. The monolith is tightly incased in a special open box or frame before it is cut from the trench wall and taken to the laboratory. This prevents cracking of the soil column and breaking of the roots. The soil is removed from the box by a process of repeated soaking, often for several days, and gentle washing, mostly under water. This is accomplished even when the soil is extremely compact or contains a claypan. During this process one may study the intimate relations of soil and roots. Roots remain unharmed and in their natural position in the water after the soil has been washed away. They are mounted on black felt cloth and photographed. They may then be sectioned in such a manner that the dry weight of the root-mass at 0 to 6 inches, 1 to 2 ft, or at any other soil depth may be ascertained.

Abstract No. 1394.

Weaver, J. E. 1950. Stabilization of midwestern grassland. Ecol. Monogr. 20:251-270.

During the three years (1941-1943) following the seven years of devastating drought, the true prairie of the midwest had succeeded in repopulating most of the bared soil. But a series of changes in the vegetation seemed inevitable before predrought stability could be attained.

These changes included an increase in the former dominants, suppression of drought dominants under the wetter phase of the climatic cycle, disappearance or suppression to normal numbers of other relict drought populations, and an increase of drought-depleted forbs. Other necessary changes were a new development of societies, reduction in height-growth with the return of increased competition, reestablishment of the understory, and the building of a soil mulch. These phenomena have been studied during a period of five years very favorable for stabilization.

Abstract No. 1395.

Weaver, J. E. 1954. North American Prairie. Johnsen Publ. Co., Lincoln, Nebraska. 348 p.

More than 40 summers have now been spent by the author in a study of the annual renewal of growth, development, and fruition of North American grassland. This included the direction of numerous graduate students who became interested in some of the countless problems presented by vegetation. It has been my practice to write the story of the prairie and the studies made therein at the time the field work was under way. The intimate acquaintance one makes with plants by living with them month after month must be recorded completely and at once, lest it fade from memory with the passing of time. One cannot well descri be a root system he excavated many years ago, any more than he can vividly relate the terrible life and death struggle of vegetation during severe drought, a long time after it has occurred. Moreover, the many observations, experiments, and findings made and recorded in the past must be correlated and judged in the light of other findings to the present day.

It has long been the desire of the author to write a simple, coherent story of the prairie, scientifically accurate, but in nontechnical language for the general reader. It is the reader's right and heritage to share the wonders and the beauty of the living prairie landscape. A secondary purpose is the bringing together, so far as is possible, the findings of other workers--a record of accomplishment that is widely scattered through the literature. This could best be done by consulting and abstracting materials from various publications.

Abstract No. 1396.

Weaver, J. E. 1954. A seventeen-year study of plant succession in prairie. Amer. J. Bot. 41:31-38.

Plant succession was studied in an old bluestem pasture under complete protection at Lincoln, Nebraska, from 1937 to 1953. About half of the vegetation was Kentucky bluegrass. The pasture adjoined a large area of True Prairie. Three years of drought had reduced the bluestems to 10% of the cover; bluegrass and invading sand dropseed composed 56 and 26%, respectively. All but 3% of bluegrass died by the end of the great drought, 1940; sand dropseed had increased enormously and, with the xeric side-oats grama, almost completely dominated. But many less xeric prairie grasses were scattered throughout and indicated the return of prairie. Big bluestem on lower, more moist slopes and, later, little bluestem on upper hillsides slowly increased, following the drought, over a period of 13 years. Succession was greatly retarded by the presence of the drought population and later by a sod of bluegrass which was rapidly established. Upper slopes are now clothed with about 60% little bluestem, 30% big bluestem, and only 3% bluegrass. Lowland now supports extensive pure stands of big bluestem or alternate areas of big bluestem and bluegrass. Forbs were at first largely represented by a few prairie species which increased greatly, and by numerous annual weeds. Most prairie forbs were exterminated by grazing or by drought. Many have returned only slowly; some are now represented by a few plants; numerous others have not yet reentered the area. This is also true of various grasses. The regenerated prairie is approaching a dynamic equilibrium not greatly unlike the adjacent climax.

Abstract No. 1397.

Weaver, J. E. 1958. Classification of root systems of forbs of grassland and a consideration of their significance. Ecology 39:393-401.

Root systems of several plants of each of 80 species of forbs were examined and classified. Some 65 grew among the grasses in true prairie of western Iowa and eastern Nebraska and in the hard lands or sand in mixed prairie of Kansas, Nebraska, and Colorado.

The root systems were of four types.

When a root system is assigned to its type, and depth and lateral spread are stated, a fair conception of its appearance may be had with little further description.

The great depth of water penetration in plains soil is considered. Root habits and response of forbs to great drought are discussed.

Abstract No. 1398.

Weaver, J. E. 1958. Native grassland of southwestern Iowa. Ecology 39:733-750.

The vegetation on a 200-acre tract of native grassland in southwestern Iowa and the environment in which it grew have been described. The study began in 1928, continued throughout the great drought of 1933-40, and intermittently since that time. It describes typical, annually-mowed prairie under a precipitation in excess of 30 inches on the border line between the more mesic prairies eastward and southward and the more xeric ones westward. This grassland was scarcely affected by the drought. It was the last large area of natural vegetation found in southwestern Iowa, and has now been plowed or pastured.

Abstract No. 1399.

Weaver, J. E. 1958. Summary and interpretation of underground development in natural grassland communities. Ecol. Monogr. 228:55-78.

Underground development in western Iowa, Nebraska, Kansas, and eastern Colorado has been studied for a period of 40 years. The earlier work (1916-1927) dealt largely with the root systems of a large number of individual species in relation to soil and climate. In further intensive studies of the structure of prairie vegetation this background was employed in defining the root habits of various plant communities on fully developed and stabilized soils. Both soil and aerial environment determining root development were used in interpreting community root habits.

Studies of the effects of extreme drought, recovery from drought, and removal of herbage on root development have aided greatly in the interpretation. They also emphasized the value of a knowledge of the usual community root habit.

Abstract No. 1400.

Weaver, J. E. 1968. Prairie plants and their environment. Univ. Nebraska Press, Lincoln. 276 p.

From 1916 until his death in 1966, John E. Weaver studied the grasslands of the central United States and the ecology of their component species with a single-mindedness of purpose few biologists can match. Two weeks before his death at the age of 82 he submitted to the University of Nebraska Press the manuscript of a book which was to be, he said, the final statement drawn from a lifetime of ecological research. The present book is that statement.

The original manuscript has not been altered except to change minor grammatical errors. The structure and content of the book are Professor Weaver's. He summarizes the purposes of his investigations: "to clarify some of the many problems presented by this vast natural unit of vegetation, to better understand the importance and significance of grassland and its utilization, and to furnish a permanent record of a rapidly vanishing vegetation." His research did, indeed, meet his objectives. Throughout the pages of this book the skill and zeal of this pioneer plant ecologist are revealed. His entire life was devoted to, as he himself says, "a most interesting and fascinating task."

Some 42 students completed Ph.D. degrees under his direction and about 50 students did their master's thesis work with him in the Department of Botany at the University of Nebraska.

The following bibliography of his published work was compiled by Professor Weaver some months before his death and is believed to be a complete listing of his works, exclusive of reviews, abstracts, yearbook reports, and the like.

Abstract No. 1401.

Weaver, J. E., F. C. Jean, and J. W. Crist. 1922. Development and activities of roots of crop plants. Carnegie Inst. Washington, Pub. 316. 117 p.

This book may be considered a continuation of "Root Development in the Grassland Formation." The investigations here recorded were carried out during the growing-seasons of 1919 to 1921. Stations were selected at Peru and Lincoln, Nebraska, at Phillipsburg, Kansas, and at Burlington, Colorado. These stations have a mean annual precipitation of about 33, 28, 23, and 17 inches, respectively. The differences in climate are clearly expressed in the type of natural vegetation. The true prairies at Lincoln give way southeastward along the Missouri near Peru to the subclimax prairie, which is potentially chaparral or woodland, the grasses having possession only because of such disturbances as grazing, fire, mowing, etc. At Burlington, in eastern Colorado, a typical expression of the shortgrass plains is found, while in north-central Kansas at Phillipsburg short grasses intermingle with the taller ones and constitute mixed prairie. Crops were grown at the several stations under measured environmental conditions for the purpose of determining not only the nature of the root system, but especially also its distribution and extent at various stages of growth. The work was conducted under field-crop conditions and methods of tillage in order that the results might faithfully portray the root relations of crops as grown under usual farm practice. Moreover, extensive experiments have been conducted both in the greenhouse and under field conditions to determine the active working-level of the roots of cereals and other crop plants as regards the absorption of water and nutrients at various stages in their growth.

Abstract No. 1402.

Weaver, J. E. and J. W. Crist. 1924. Direct measurement of water loss from vegetation without disturbing the normal structure of the soil. Ecology 5:153-170.

A method has been devised for determining the water losses from square-foot areas of native grassland and cultivated crops without disturbing the soil structure. It consists in excavating soil columns a square foot in cross-sectional area and three feet deep and forcing galvanized iron cylinders over these tightly as they are formed. The columns are then smoothly cut off and bottoms sealed to the cylinders, which, after weighing, are replaced in trenches of appropriate width and depth so that after refilling the interspaces between the cylinders in the trench the vegetation in the containers is completely surrounded by undisturbed grassland or a crop similar to that enclosed in the soil column. The containers are covered during rain and water added to the soil as needed for a 15-day period after which they are reweighed and the losses calculated. Direct losses from the soil and from soil covered with dead plants are determined by control soil columns.

Experiments were conducted in the shortgrass plains of Colorado, in mixed prairie in north-central Kansas, and in true prairie in eastern Nebraska.

Abstract No. 1403.

Weaver, J. E., and T. J. Fitzpatrick. 1932. Ecology and relative importance of the dominants of tallgrass prairie. Bot. Gaz. 93:113-150.

A study of the tallgrass prairie from southern South Dakota to northern Kansas and eastward into Iowa reveals several patterns or types of vegetation. The big bluestem type is the most extensive and the most important of those found on the lowlands. It is characterized by the single species, *Andropogon furcatus*, which alone often constitutes 80 or more percent of the vegetation. *Sorghastrum nutans* is a close ecological equivalent which associates with it, but it is in general much less important.

All of the dominant grasses have excellent forage value, especially if they are grazed or cut for hay before the coarse flower stalks of the late-blooming species become hard and fibrous.

Abstract No. 1404.

Weaver, J. E., and J. Kramer. 1932. Root system of *Quercus macrocarpa* in relation to the invasion of prairie. Bot. Gaz. 94:51-85.

The western border of the deciduous forest, extending along the Missouri River, meets the prairie in south-eastern Nebraska. The mean annual precipitation is about 32 inches; the humidity is relatively low, average day ranging between 50 to 80% in years of greater rainfall, but falling to 40 to 50% during drier years. Average night humidity is frequently 20% higher. Evaporation is usually 20 to 30 cc daily during the growing season; wind movement is relatively high. The silt loam soils are many feet in depth but during drought contain only a small amount of water available for growth. Hence competition for water is great between the grasses and the shrubs and trees, which are invading since the cessation of prairie fires about 60 to 70 years ago. *Quercus macrocarpa* is the most xeric forest tree and invades the grasses either directly or in the wake of certain shrubs, chiefly *Rhus glabra*, *Symphoricarpos vulgaris*, and *Corylus americana*. Invasion occurs on well drained lowlands where *Andropogon furcatus*, *Sorghastrum nutans*, and other grasses 6 to 10 ft tall and of similar depth dominate. It also occurs on uplands where *Andropogon scoparius*, *A. furcatus*, *Poa pratensis*, etc., are 0.5 to 4 ft tall and 3 to 6 ft deep. The shrubs advance largely by means of rhizomes into the grassland. Their roots often extend outward and then upward under the grasses. Some are so finely branched and abundant as to successfully compete with those of the prairie grasses. Bur oak develops a taproot about 9 inches deep before the leaves are unfolded above ground. The strong, finely branched taproot extends into moist soil 3 to 5 ft the first summer. Mature trees 50 to 65 years old were 35 to 40 ft tall, 12 to 18 inches in basal diameter and grew 10 to 40 ft apart in a pure stand. The taproot gave rise to 30 or more large main branches, most of which arose in the first 2 ft of soil. It tapered rapidly and extended to a depth of 14 ft. Most of the main branches, which were 1 to 7 inches in diameter, extended widely (20 to 60 ft) before turning downward. Some grew even deeper than the taproot. All branched repeatedly, and together they occupied a very large volume of soil. Many branches of the main roots grew vertically downward 8 to 15 ft, resembling the taproot system of an oak sapling. Others extended obliquely or vertically upward and filled the surface soil with a mat of absorbing rootlets. Ropelike roots 0.5 inches or less in diameter extended many feet without much change in thickness. A cordlike type, 3 to 5 mm thick, was also abundant. A third type consisting of fine, much branched rootlets clothed the widely extending skeletal framework and furnished the bulk of the absorbing surface. Mycorhizal mats were abundant. The weight of the roots equaled that of the tops; the volume of the roots was about 1/10 less than that of the parts above ground. Low water content of soil is compensated by a widely spreading, well branched root system. This may account for the wide spacing of the oak trees and the open forest canopy. They do not obtain moisture from the water table but depend upon the direct supply furnished by rainfall.

Abstract No. 1405.

Weaver, J. E., and T. J. Fitzpatrick. 1934. The prairie. Ecol. Monogr. 4:109-295.

Some 135 selected areas of tallgrass prairie were studied during a period of five years. They were representative of the vegetation of the eastern one-third of Nebraska, the western one-third of Iowa, and adjacent areas in Kansas, Missouri, South Dakota, and Minnesota. They varied in size from 20 to 360 acres and were rather uniformly distributed throughout an area of 60,000 square miles.

The study was made to determine the structure, development, and continuity of the prairie; to better understand the importance, significance, and utilization of grassland; and to furnish a permanent record of a rapidly vanishing vegetation.

Abstract No. 1406.

Weaver, J. E., and E. L. Flory. 1934. Stability of climax prairie and some environmental changes resulting from breaking. Ecology 15:333-347.

With few exceptions, undisturbed native prairie has been successful in resisting invasion, although the number of possible invaders is as large as that of the more important prairie species. Control of the area is exerted partly through competition for light and especially for the water supply. Stability is increased by the long span of life of many prairie species; few are annuals. It changes slowly under the impact of judicious grazing. With the breaking of prairie and the growth of cultivated crops, the environment is profoundly modified. Relative energy relations as expressed in light and heat are greatly increased, temperatures at or within 4 inches of the soil surface being sometimes 11 to 38°F higher. Humidity is greatly decreased among and above the plants, and wind movement is accelerated. Evaporation is increased 27 to 106%, and transpiration per unit leaf area 20 to 89%. Pore space of soil is rapidly decreased under cultivation and run-off and erosion greatly augmented, the former sometimes being 38 to 80% greater. Demands for water in prairie are gradual and at all soil depths; among crops they are less so and often localized at different depths during the growing season. Various ways in which the balance of nature has been upset are discussed.

Abstract No. 1407.

Weaver, J. E., V. H. Houghen, and M. D. Weldon. 1935. Relation of root distribution to organic matter in prairie soil. Bot. Gaz. 96:389-420.

A typical square meter of vegetation was selected in the upland, *Andropogon scoparius* prairie on Lancaster loam soil, near Lincoln, Nebraska, and another in the lowland, *A. furcatus* prairie on the Wabash clay loam soil of the floodplain of the Missouri River.

The surface soil was removed in 6-inch layers and the deeper soil in foot sections to the depth of root penetration; the roots and rhizomes were carefully removed by washing, and their dry weights, nitrogen contents, and organic contents determined.

Water content of soil and atmospheric factors affecting plant development were measured and rate of growth of the vegetation was determined. Root habits of the plants excavated were noted.

Except in the surface 6 inches of soil, there is an approximately linear relation between the amount of root material and the amount of soil organic matter in the various soil horizons.

In the surface soil the presence of a large amount of living rhizome and root material and the favorable conditions for the decomposition of dead organic matter increase the proportion of roots and rhizomes to soil organic matter.

Abstract No. 1408.

Weaver, J. E., L. A. Stoddart, and W. Noll. 1935. Response of the prairie to the great drought of 1934. Ecology 16:612-629.

The most severe drought ever recorded in the prairies of eastern Nebraska occurred during 1934. Water content of the upland was gradually depleted, and by July 30 no water to a depth of 4 ft was available for growth. During July the average maximum daily temperature varied from 98° to 111°F and the average minimum daily humidity from 15 to 22%.

Blossoms of deeply rooted plants marked the vernal and estival aspects. Flowering often began 2 to 3 weeks earlier than normal and was of shorter duration. *Poa pratensis*, *Koeleria cristata*, *Antennaria campestris*, and other shallowly rooted species dried in May, developing osmotic pressures of only 18 to 27 atmospheres. *Andropogon scoparius* in the dry upland soils withered early in June; *A. furcatus*, because of its deeper root system, persisted a longer time. *Stipa spartea* and *Bouteloua gracilis* were more resistant, rolling their leaves and assuming a condition of drought-dormancy.

Among the forbs, resistance to drought was closely correlated with root extent. Species with root systems penetrating 8 to 20 ft into the moist subsoil were little affected. Water content of tissues decreased but little with the progress of drought and increase in osmotic pressure was slight. Where the root systems were shallow and less efficient, decrease in water content of tissues was pronounced, and increase in osmotic pressures was 8 to 38*A*. Many species wilted and dried.

Drought swept from hilltops down the slopes into mesic and hydric ravines. Wilting and drying were not due alone to high temperatures and low humidities but primarily to low water content of soil, since plants in watered areas thrived.

Abstract No. 1409.

Weaver, J. E., and F. W. Albertson. 1936. Effects of the great drought on the prairies of Iowa, Nebraska, and Kansas. Ecology 17:567-639.

Following the most severe drought ever recorded in the prairies of Iowa, Nebraska, and Kansas, studied were made to determine the effects upon the vegetation.

The 30 or more prairies examined in Iowa, Nebraska, and east-central Kansas had each been fully studied before the drought so that changes were readily determined. Prairies on the deep loess soil of southwestern Iowa as well as some northeastward on the glacial soils had not been harmed. Others had suffered a loss of 20 to 50% of certain grasses on the most exposed slopes.

Lists of native grasses that entirely or almost entirely disappeared and native forbs that increased in abundance are given. Weeds sowed widely by the wind and growing in such abundance as to give native grassland the appearance of abandoned fields are also listed.

Abstract No. 1410.

Weaver, J. E., and F. E. Clements. 1938. Plant ecology, 2nd ed. McGraw Hill Book Co., New York. 601 p.

The new conception of the vast importance of climate and vegetation in soil development has now been generally adopted. The enormous importance of a plant cover in stabilizing soil against erosion by wind and water is more fully realized. Studies of conservation of wild life have been shown to hinge upon an understanding of the vegetation which furnishes food, cover, and shelter for animal life. The heavy toll exacted by erosion on tilled lands must be overcome in the main by farming systems that are in harmony with the environment--the normal climatic and vegetational processes. A fairly comprehensive understanding of Nature's principles and methods has now been attained as regards the processes of plant succession, stabilization of climax vegetation, and the use of plants and plant communities as indicators of what has happened in the past, what is taking place today, and what can be made to happen in the future.

The purpose of the revised edition is to furnish a comprehensive textbook in accord with present-day ecological progress and a guide to workers in the numerous related fields where an intimate knowledge of plants and plant environments, whether natural or modified by man, is fundamental to progress.

Abstract No. 1411.

Weaver, J. E., and F. W. Albertson. 1939. Major changes in grassland as a result of continued drought. Bot. Gaz. 100:576-591.

Degree of deterioration of native grassland from western Iowa, through eastern Nebraska and Kansas, to western Kansas in 1939; water content of soil to 6-ft depth (monthly); and rate of growth of vegetation and density of cover, were determined, as well as the distribution of grasses and other plants. The Iowa prairies had been scarcely affected by the great drought. At one Nebraska-Kansas group of bluestem prairies (*Andropogon scoparius* and *A. furcatus*) still prevailed; at the other they had died and been replaced by western wheatgrass (*Agropyron smithii*). Blue grama grass (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) were the chief grasses of the western Kansas prairies. Soils throughout were deep, fertile, silt loam. Water was plentiful at all depths in the bluestem prairies of Iowa; those of Nebraska and Kansas had only a low supply after early spring and were repeatedly threatened with drought. In the wheatgrass group, available deep-soil moisture was the exception, and repeated exhaustion of surface soil moisture occurred. Water was available only in the surface soil at the shortgrass station and at only 2 or 3 periods. There was 50 to 100% more evaporation and 2 to 3 times as much wind movement in western Kansas as in eastern Nebraska. No previous deterioration of vegetation had occurred in Iowa. The basal area was only one-half to two-thirds normal in the drought-depleted bluestem prairies westward. Drought and dust had destroyed most of the former plant cover of the third group of prairies, which were now dominated by an open growth of western wheatgrass which permitted a continuous pattern of bare soil. In western Kansas, the 85% basal cover of short grasses had been reduced by continued drought, burial by dust, and injury by grasshoppers to 10 to 15%. The remaining soil was bare. Grasses dried after midsummer and failed to flower in eastern Nebraska. Wheatgrass dried very early and burned readily in July. The short grasses in west-central Kansas were dormant during most of the summer but grew to a height of 3 inches when revived by late summer showers. In Iowa, 15 species of grasses and sedges occurred at the sampling stations, but 19 at the western, bluestem station-group. There were but 9 at the wheatgrass stations, and only 4 in the shortgrass areas. Native forbs similarly decreased from 65 to 33 species, then to 21, and finally to 11.

Abstract No. 1412.

Weaver, J. E., and W. W. Hansen. 1939. Increase of *Sporobolus cryptandrus* in pastures of eastern Nebraska. Ecology 20:374-381.

Sand dropseed, *Sporobolus cryptandrus*, occurred only rarely and sparingly in native pastures of eastern

Nebraska before the great drought of 1934. It has since increased so rapidly that it is now one of the most abundant and important pasture grasses. This species, of wide distribution westward, renews growth in early spring, develops rapidly, and is not readily injured by close grazing. It is a prolific seeder and under proper grazing soon reclaims pastures where bluegrass and little bluestem have died. Its resistance to drought is due in part to an excellent root system. In eastern Nebraska, it is of good palatability, produces much forage, and is efficient in protecting the soil against loss by erosion.

Abstract No. 1413.

Weaver, J. E., and V. H. Hougen. 1939. Effect of frequent clipping on plant production in prairie and pasture. Amer. Midland Natur. 21:396-414.

The rate of degeneration of native bluestem (*Andropogon*) prairies in eastern Nebraska and decrease in forage production when they degenerate into shortgrass or bluegrass pastures have been studied. The clip quadrat method was employed, a total of 190-meter quadrats being used at 6 stations. Total yields of prairie quadrats cut at frequent intervals during the first year exceeded those clipped only at the end of the season by 11 to 26%. An exception occurred in the *Andropogon furcatus* type, because of the heavy flower-stalk production of the controls. Quadrats closely clipped for two seasons always gave lower total yields than a single clipping of the controls. In little bluestem (*A. scoparius*) the yield averaged 46 to 49% less, in big bluestem (*A. furcatus*) 28% less, and in mixed little and big bluestem 43 to 52% less than the controls. Yields from quadrats frequently clipped during two years were likewise much lower than from those similarly clipped for only a single year. In the preceding order of species the yields were 60, 37, and 51% less. When clipping was continued in the same quadrats for 3 years, yields of little bluestem were 68% and mixed bluestems 56% less than the controls, and 42 and 23% less than from similar quadrats clipped for 2 years. This rapid decrease in yield following too close utilization of the forage resulted also in deterioration of underground plant parts. Decrease in dry weight of the plant materials in the surface 4 inches varied from 33 to 41% after 2 years of close clipping, and was 57 to 59% by midsummer of the third year, but these decreases were partly due to severe drought. Where upland prairie degenerated into the shortgrass (*Bouteloua gracilis*) type, the yield of clipped quadrats was reduced to about one-half of that of similarly clipped prairie. Where lowland prairie degenerated into the *Bouteloua gracilis-Buchloe dactyloides* type or bluegrass (*Poa pratensis*) type, the former prairie yield was reduced to 68%. Because of drought, these data are based upon yields of a single year.

Abstract No. 1414.

Weaver, J. E., and F. W. Albertson. 1940. Deterioration of grassland from stability to denudation with decrease in soil moisture. Bot. Gaz. 101 (3):598-624.

As a result of the great drought in Nebraska (1934-1937) many perennial grasses have decreased greatly in abundance. Little bluestem (*Andropogon scoparius*), formerly one of the most important dominants, has suffered great depletion, disappearing from some prairies. Bluegrass (*Poa pratensis*), big bluestem (*Andropogon furcatus*), and Indian grass (*Sorghastrum nutans*) have all become much less abundant on uplands. Certain shallowly rooted species of non-grasses or forbs have almost entirely disappeared, a few have greatly increased in numbers, but general losses have been approximated at one-half to two-thirds. The annual *Festuca octoflora*, *Bromus secalinus*, and *Hordeum pusillum* were especially abundant during the early years of drought but much less so during 1938. The scourge of the ruderal, *Lepidium virginicum*, so serious in 1936-37, has disappeared. Other annual weeds were extremely abundant in prairie only during one or two seasons. *Aster multiflorus*, a perennial with rhizomes, spread so widely in drought ravaged areas as to ruin many prairies for production of hay and resulted in breaking. *Erigeron ramosus* was almost equally widespread. Numerous forbs with fleshy storage organs--*Oxalis violacea*, *Allium mutobile*, *Tradescantia bracteata* et al.--increased remarkably in abundance. Western wheatgrass (*Agropyron smithii*) occurred sparingly at the beginning of the drought but has spread so widely as to occupy one-half to three-fourths of many former bluestem prairies. Numerous native grasses and especially *Stipa spartea*, *Sporobolus heterolepis*, and *Bouteloua curtipendula* have become far more abundant and important. The short grasses (*B. gracilis* and *Buchloe dactyloides*) have greatly increased. Drought has reduced the basal cover in true prairie 50 to 66%. The lower layer of grasses and forbs has been almost destroyed and grassland types have been much modified.

Abstract No. 1415.

Weaver, J. E., and F. W. Albertson. 1940. Deterioration of midwestern ranges. Ecology 21(2):216-236.

A survey was made in the summer of 1939 of 88 ranges selected as representative of grazing lands in western Kansas and Nebraska, portions of southwestern South Dakota, eastern Wyoming and Colorado, and the Panhandle of Oklahoma.

Severe drought, overgrazing, burial by dust, and damage by grasshoppers have resulted in greatly reducing the cover of range grasses.

This portion of the mixed prairie has almost completely lost its upper story of mid grasses on the non-sandy lands. The short grasses and sedges have undergone a process of thinning which has resulted in only the most vigorous plants remaining alive. Many of the less xeric forbs have practically disappeared and only six or eight of the most xeric native forbs are regularly represented by much dwarfed and widely spaced individuals.

Extremely poor conditions varied with the better ones throughout. The bare soil during periods with moisture is populated with annual weeds, chief of which is Russian thistle. In many places it is only with difficulty that one can distinguish denuded pastures from weedy, tilled land. Cacti have increased greatly almost everywhere and constitute a serious problem.

Because of the low precipitation of 1939, most ranges have lost any gains made during favorable periods since 1934, and further reduction in vegetation seems certain if the winter also is dry.

Abstract No. 1416.

Weaver, J. E., J. H. Robertson, and R. L. Fowler. 1940. Changes in true-prairie vegetation during drought as determined by list quadrats. Ecology 21:357-362.

A study in nine widely spaced prairies in southeastern Nebraska and north-central Kansas was made by the list, or census, method over the period 1936 to 1939, inclusive. Percentage change in abundance and relative stability of important species were calculated from data obtained from 75 plots. A decrease of 20% in perennial grasses and 28% in perennial forbs occurred following the severe drought of 1936.

Abstract No. 1417.

Weaver, J. E., and W. W. Hansen. 1941. Native midwestern pastures: Their origin, composition and degeneration. Univ. Nebraska Conserv. Surv. Div., Nebraska Conserv. Bull. 22:1-93.

Extensive areas of unbroken prairie land still occur in eastern Nebraska, South Dakota, and Kansas, and in western Iowa, and adjacent portions of Minnesota and Missouri. These support the original prairie vegetation in part, but on most of them the prairie has deteriorated into various types of pastures.

The native grasses and forbs of these midwestern prairies and pastures have been studied over a period of 12 years and the process of degeneration to pastures analyzed.

Five stages have been determined in degeneration of prairie to low-grade pastures; very large pastures or ranges may include more than one stage.

Examples of each pasture type are described.

According to their response to grazing, plants of prairie and pasture have been placed into six groups.

Prairie grasses that decrease under grazing include 10 of the most important native species. Each is discussed separately.

Abstract No. 1418.

Weaver, J. E., and W. W. Hansen. 1941. Regeneration of native midwestern pastures under protection. Univ. Nebraska Conserv., Surv. Div. Bull. 23. 91 p.

The nature and rate of regeneration of a 23-year-old native pasture under complete protection from grazing was studied near Lincoln, Nebraska, during four summers, beginning in 1937.

The pasture was of the little bluestem (*Andropogon scoparius*)--Kentucky bluegrass (*Poa pratensis*) type preceding the great drought of 1934-36, but was dominated by sand dropseed (*Sporobolus cryptandrus*) and side-oats grama (*Bouteloua curtipendula*) following the high mortality of the less xeric grasses.

Abstract No. 1419.

Weaver, J. E., and I. M. Mueller. 1942. Role of seedlings in recovery of midwestern ranges from drought. Ecology 23:275-294.

Square-foot samples of surface soil were collected from 49 drought-damaged ranges and prairies in Nebraska, Kansas, and Colorado, and viable seeds germinated. Seedlings grew at the average rate of 67 per sample. Forty species of forbs occurred, of which more than 96% were annual weeds, mostly *Amaranthus* species and *Salsola pestifer*. There were 26 species of grass seedlings of which 20% were ruderals, mostly *Eragrostis cilianensis*, *Hordeum pusillum*, and *Panicum capillare*.

Several years of good seed production and development of seedlings into mature grasses are necessary for the restoration of midwestern ranges.

Abstract No. 1420.

Weaver, J. E., and F. W. Albertson. 1943. Resurvey of grasses, forbs, and underground plant parts at the end of the great drought. Ecol. Monogr. 13: 63-117.

This survey of midwestern grasslands included the western portion of true prairie in Iowa, eastern Nebraska and Kansas, and mixed prairie, with its short grass disclimax, in western Kansas and Colorado. Five prairies in western Iowa, 12 in true prairie west of the Missouri River, and 12 in mixed prairie in Kansas were studied year by year since the inception of drought in 1933-1934. This is the record of their condition in 1940 near the end of the drought.

Abstract No. 1421.

Weaver, J. E., and R. W. Darland. 1944. Grassland patterns in 1940. Ecology 25:202-215.

A brief statement of the original composition of the vegetation and its degree of destruction is given for prairies at Belleville, Kansas, and Hebron, Nebraska. The temporary possession of the bared soil by a weedy flora among the terribly decimated prairie grasses and its loss with the recovery of the grasses is described. The origin of each community and its development into the late-drought patterns are briefly discussed.

Prairie types at Lincoln and Crete, Nebraska, are pointed out to illustrate their wide variety and general distribution in a prairie cover which represents only a stage in the restoration of climax true prairie.

Abstract No. 1422.

Weaver, J. E., and W. E. Bruner. 1945. A seven-year quantitative study of succession in grassland. Ecol. Monogr. 15:297-319.

The nature and rate of succession in a 23-year-old native pasture under complete protection from grazing was studied quantitatively near Lincoln, Nebraska, during seven growing seasons, 1937 to 1943.

The pasture was of the little bluestem (*Andropogon scoparius*)-Kentucky bluegrass (*Poa pratensis*) type preceding the great drought of 1934-36, but was dominated by sand dropseed (*Sporobolus cryptandrus*) and side-oats grama (*Bouteloua curtipendula*) following the high mortality of the less xeric grasses.

Five groups of permanent, meter quadrats were established in which the increase or decrease of plants of each species was ascertained by stem-counts.

Fourteen species of grasses and sedges, 19 of native forbs, and 13 ruderals, constituted the total vegetation in the 43 quadrats in 1937; the number later increased to 58.

After 8 years, and especially three consecutive good years, climax conditions had almost been attained. Only in a few places was sand dropseed still abundant. The bluestems and side-oats grama dominated except in parts of lowlands where bluegrass formed a dense sod. There was no bare soil. All the weedy annuals had disappeared; aster and goldenrod were also absent or greatly subdued. An understory of various minor prairie grasses, bluegrass, and forbs was rapidly developing. Under the dense stand of prairie grasses there was a good mulch of fallen debris. But the absence of certain species of prairie grasses and forbs, common in adjacent climax prairie, and the lack of various community relationships, indicated that succession was still incomplete.

Abstract No. 1423.

Weaver, J. E., and E. Zink. 1946. Annual increase of underground materials in three range grasses. Ecology 27:115-127.

Separate lots of three range grasses were grown in large steel drums. At the end of each summer the root systems were washed free of soil and photographed, and the dry weights obtained.

The effects of roots of grass in producing a granular soil structure, the time required for the completion of the structure-forming effect, decrease or loss of soil granulation under continuous cropping to cereals, and the restoration of good structure and fertility by growing perennial grasses, are considered.

Abstract No. 1424.

Weaver, J. E., and E. Zink. 1946. Length of life of roots of ten species of perennial range and pasture grasses. Plant Physiol. 21:201-217.

Seeds of 10 species of perennial range and pasture grasses were planted in triplicate lots in loam soil in containers large enough for ample root development. A removable extension at the top of each container was filled with sandy loam soil easily washed away when the extension was removed, thus exposing the roots for examination.

Abstract No. 1425.

Weaver, J. E., and W. E. Bruner. 1948. Prairies and pastures of the dissected Loess Plains of central Nebraska. Ecol. Monogr. 18:508-549.

Lying north of the great southward bend of the Platte River in central Nebraska but southeast of the sandhills, there are several thousand square miles of rugged uplands known as loess bluffs. The excellent cover of grasses and forbs of the mixed prairie, which clothes and protects the highly erosive loess bluffs and furnishes sustenance for thousands of cattle, has thus far not attracted the attention of an ecologist.

This preliminary survey is concerned with soil and aerial environment of the abundant undisturbed native environment of the abundant undisturbed native vegetation, and its composition and behavior in the extensive range lands. It also includes a 3-year study of grazing types, of grazing patterns throughout the season, and of forage yield and forage consumption in experimental pastures.

Abstract No. 1426.

Weaver, J. E., and R. W. Darland. 1948. Changes in vegetation and production of forage resulting from grazing lowland prairie. Ecology 29(1):1-29.

Large areas of lowland prairie in Iowa, Nebraska, and adjacent midwestern states have degenerated into weedy bluegrass or buffalo grass pastures of low productivity, the true-prairie grasses disappearing as a result of long overuse.

Changes in the vegetation and decreased production of forage have been studied in a typical tract of low, level, fertile prairie at Lincoln, Nebraska, over a period of four years. Frequent examination of the species that were being grazed was made and especially the degree to which they were grazed and their response to grazing injury were observed. This was supplemented by means of numerous, large, portable exclosures which protected selected areas from disturbance each month, thus furnishing an excellent criterion of the rate of growth in the prairie and, by clipping, the quantity of forage consumed.

The three types or communities of grass were (1) western wheatgrass (*Agropyron smithii*), which had invaded the native prairie during drought and formed extensive pure stands totaling a third of the entire 50-acre tract, (2) Kentucky bluegrass (*Poa pratensis*) of similar extent, which resulted from previous grazing, and (3) native prairie, mostly of big bluestem (*Andropogon furcatus*) but including other tall, coarse grasses and some little bluestem (*A. scoparius*) and others of mid-grass stature.

Abstract No. 1427.

Weaver, J. E., and R. W. Darland. 1949. Soil-root relationships of certain native grasses in various soil types. Ecol. Monogr. 19(4):303-338.

A new method has been devised by which a complete sample of an entire root system from soil surface to maximum depth of penetration may be taken, separated from the soil without injury to the root or displacement of individual roots from their natural position, and examined in the laboratory in relation to the various horizons of the soil profile. Descriptions have been made of each of 16 soil types from which 11 species of grasses were taken. They include not only the depths of the main soil horizons and the minor subdivisions of each, but also the color, texture, structure, consistence and pH of soil in each subdivision. Some interrelationships of the soil types are given. Monoliths of soil 12 inches wide, 3 inches thick, and from 3 to 5 ft in depth were taken from the walls of trenches made in selected pure stands of each species. The 33 monoliths examined were taken in 3 general areas: in the vicinity of Lincoln near the Prairie soil-Chernozem boundary; 65 to 125 miles southwestward in the Chernozem soil area; and in the loess hills near Kearney in central Nebraska. Roots were obtained from monolith by a system of soaking and gentle washing. A special technique was used in mounting; lighting for photographing was by electro-flash units, and sectioning was done in such a manner as to obtain the oven-dry weight for each 6 inches or foot in depth as well as for each major horizon. Kentucky bluegrass (*Poa pratensis*), blue grama (*Bouteloua gracilis*), and big bluestem (*Andropogon furcatus*) were studied.

Abstract No. 1428.

Weaver, J. E., and G. W. Tomanek. 1951. Ecological studies in a midwestern range: The vegetation and effects of cattle on its composition and distribution. Univ. Nebraska Conserv., Surv. Div. Bull. 31. 82 p.

A study has been made of a mile-long, 290-acre range which, during a period of 47 years, has degenerated from excellent mostly to fair range condition class. The degree of degeneration has been studied in relation to topography, distance from water, and factors affecting the activities of the livestock, especially unequal distribution of grazing.

Factors affecting the distribution of the livestock and the consequent overuse of some areas and underuse of others are discussed. Methods of proper utilization of the forage are suggested. The resulting increase in forage and gains of cattle would quickly repay the investment required for their proper distribution.

Abstract No. 1429.

Weaver, J. E., and N. W. Rowland. 1952. Effects of excessive natural mulch on development, yield and structure of native grassland. Bot. Gaz. 114:1-19.

An upland prairie, undisturbed by mowing, grazing, or burning for 15 years, was studied. About 80% was covered with a nearly pure stand of *Andropogon gerardi*. Similar stands of *Panicum virgatum* and *Sporobolus heterolepis* each occupied about 9%.

Abstract No. 1430.

Weaver, J. E., and W. E. Bruner. 1954. Nature and place of transition from true prairie to mixed prairie. Ecology 35:117-126.

The very gradual changes in vegetation from true to mixed prairie have been described. These occur over a broad ecotone about 50 miles in width. If the place were to be indicated by a single line, one (98° 30'W longitude) extending along the eastern side of Barton County to Smith County in Kansas, and through Hastings, Grand Island, and Greely to O'Neill and Spencer in Nebraska would be representative.

Abstract No. 1431.

Weaver, J. E., and F. W. Albertson. 1956. Grasslands of the Great Plains. Johnsen Publ. Co., Lincoln, Nebraska. 395 p.

This book is the result of a long-felt need by the authors and their students for a comprehensive survey of the numerous studies that have been made on plains grasslands. From southern Texas far into Saskatchewan the mid and short grasses form a magnificent prairie nearly 2,500 miles in length and approximately 400 miles wide. Kinds of communities, their composition, nature, significance and uses are fully described. Such information is of value not only to students, range technicians, and other professional conservationists, but also to ranchers and other land owners--in fact, to anyone interested in the economy of our midwestern grasslands. The damaging effects of drought on forage production in this unstable climate and the restoration of the plant cover are of such great importance that they have been given special attention. Climate, soils, and the proper use of the forage for its sustained production are described.

Abstract No. 1432.

Weaver, R. J. 1941. Water usage of certain native grasses in prairie and pasture. Ecology 22:175-191.

Water losses by transpiration and surface soil evaporation were determined at Lincoln, Nebraska, for seven species of prairie and pasture grasses in closely adjacent prairie and pasture habitats during their period of growth in 1939. The grasses, grown from sections of sod, were *Andropogon furcatus*, *Andropogon scoparius*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Sporobolus cryptandrus*, *Poa pratensis*, and *Agropyron smithii*.

Abstract No. 1433.

Webb, J. 1939. *Festuca octoflora* var. *hirtella*, a new grass for Kansas. Kansas Acad. Sci., Trans., 42:207-208.

Festuca octoflora var. *hirtella* Piper was first found by Dr. F. W. Albertson while he was making ecological studies in the College pasture, two miles west of Hays, Kansas. This was the first record of the grass having been found in Kansas. Previously, this variety had been known only from the Southwest and Pacific Coast, mostly occupying arid or semiarid situations.

Although the variety greatly resembles the species, *Festuca octoflora* Walt., there are contrasting characteristics of the two which are significant. The most marked difference is in height. Obviously this cannot be an ecological change as a result of environmental conditions, because the variety and the species are found growing side by side in the shortgrass habitat.

A study of 100 specimens of each plant from the College pasture shows that the average height of the species is 40 cm, as compared to 25 cm for the variety. The sheaths and blades of *Festuca octoflora hirtella* are finely pubescent. Its inflorescence is a compressed panicle resembling that of *Festuca octoflora*, except that it is even more compact, the secondary branches are shorter, less branched, and the spikelets tend to become arranged on one side of the rachis. The head of the variety contains fewer spikelets and is usually only one-third as long as that of the species. The florets of *F. octoflora hirtella* are bristly with a rough pubescence. The lemmas bear a relatively long awn, and the florets tend to grow in a divaricate manner, presenting a larger angle to the rachilla. In the species, these characteristics are not found, or are greatly altered. It has also been noted that the variety matures several days ahead of the species.

In the plants studied, it was found that there is an average of 7 florets per spikelet in the species as compared to 10 in the variety. The range in number of florets per spikelet seemed to deviate very little from the average. The length and width of the spikelets are identical. However, the average length of the lemma of *F. octoflora* is 4 mm, while that of the variety is 3 mm, but it has in addition an awn 2 mm long. The species is awnless or nearly so. The presence of the awns makes the spikelets of the variety look larger.

Abstract No. 1434.

Webb, J. 1940. Identification of rodents and rabbits by their fecal pellets. Kansas Acad. Sci., Trans., 43:479-481.

During the fall and winter of 1939 a study was made of the fecal pellets of several rodents and rabbits to determine whether or not they were as distinct in form and size as the animals themselves. Accordingly, samples of excreta from known species were collected and compared. A total of 13 samples from as many species of animals were obtained. Each sample represented a separate genus. All collecting was done near Hays, Kansas. These pellets were labeled, photographed, measured, and given careful study by means of a low-power binocular microscope.

Observations show that the feces from these species are probably as distinct as the animals themselves. Without exception, each species' sample differs from the others in one or more of the following respects: size, shape, color. These characteristics were so distinct that the author was able to construct an artificial key to the animal feces included here. It is the purpose of this paper to present some of the facts observed together with a presentation of further possibilities in this type of study.

Abstract No. 1435.

Webb, J. J., Jr. 1941. The life history of buffalo grass. Kansas Acad. Sci., Trans. 44:58-75.

Studies of the life history of buffalo grass were conducted at Hays, Kansas, during the growing season of 1939. Plants for making these determinations were grown in sandy loam soil occupied originally by a grass nursery. There was an average number of three caryopses per bur. The seed produced during 1939 was as viable as that produced during previous years. Buffalo grass seed germinated three days after being planted. The coleoptile reached the surface of the ground four days after being planted. Tiller production ranged from two to six tillers per week per plant during the first three months of growth. The seminal root grew at the rate of 1 cm per day, and became functionless when secondary roots became established. The secondary roots grew at an average rate of 1 cm per day throughout the growing season, and penetrated to a depth of 4 ft 8 inches. Stolon roots grew at the rate of 2.5 cm per day during the first three weeks after growth began. Stolons were produced when the plants were from 30 to 40 days old. Stolon growth was responsible for the rapid manner in which buffalo grass covered the ground. Stolons grew from .5 cm to 5 cm per day. Several stolons averaged 1.6 cm per day. One plant produced 650 ft of stolons at the age of 84 days. Both sexes of plants originated from the seeds of a single bur. Considerable variations in growth forms and habits were found.

Abstract No. 1436.

Webb, W. P. 1931. The Great Plains. Ginn Publ. Co., Boston. 525 p.

The Great Plains comprise a much greater area than is usually designated-an area which may best be defined in terms of topography, vegetation, and rainfall.

A plains environment, such as that found in the western United States, presents three distinguishing characteritstics:

1. It exhibits a comparatively level surface of great extent.

2. It is a treeless land, an unforested area.

3. It is a region where rainfall is insufficient for the ordinary intensive agriculture common to lands of a humid climate. The climate is sub-humid.

The purpose of this book is to show how this area, with its three dominant characteristics, affected the various peoples, nations as well as individuals, who came to take and occupy it, and was affected by them; for this land, with the unity given it by its three dominant characteristics, has from the beginning worked its inexorable effect upon nature's children. The historical truth that becomes apparent in the end is that the Great Plains have bent and molded Anglo-American life, have destroyed traditions, and have influenced institutions in a most singular manner.

Abstract No. 1437.

Webster, J. 1956. Succession of fungi on decaying cocksfoot culms. I. J. Ecol. 44:517-544.

Although the decomposition of organic remains in soils and composts has been extensively studied, we have little information about the succession of organisms which bring about the decay of plant remains above ground, apart from descriptions of the succession of fungi on rotting timber. In the present paper, the succession of fungi collected on decaying cocksfoot stems during a 2-year period following flowering is described, and the distribution of the more common species discussed.

Abstract No. 1438.

Webster, J. 1957. Succession of fungi on decaying cocksfoot culms. II. J. Ecol. 45:1-30.

There is need for descriptive work on the succession of fungi on decaying plant remains above ground. In this paper the succession fungi collected on stems of *Dactylis glomerata* during a 2-year period following flowering is described.

Anatomical, physiological, and physical variations within the tussock are discussed. The upper internodes frequently have a water content of less than 15 whilst the lower internodes maintain a consistently higher water content. The capacity of the stems to hold water declines with age.

Cocksfoot stems were removed at monthly intervals from three different localities, and the distribution of fruit bodies of fungi recorded.

Analysis of the distribution of the more common fungi shows a number of distinct patterns of distribution.

Abstract No. 1439.

Webster, J., and N. J. Dix. 1957. Succession of fungi on decaying cocksfoot culms. III. British Mycol. Soc., Trans., 43:85-99.

The frequency of fruiting colonies of some primary saprophytic fungi on decaying stems, leaf blades and leaf sheaths of *Dactylis glomerata* is compared for standing and uprooted culms. Comparative studies of spore germination on glass slides and mycelial growth on ground sterilized grass at various relative humidity values have shown that the primary colonizers often show more rapid spore germination, more rapid growth, and a better ability to grow at lower relative humidity values than secondary colonizers with which they were compared. Nutritional differences between grass tissues collected from upper and lower internodes throughout the year have been compared by testing the growth rate of the primary colonizers on a medium composed of 3% dried grass in 2% tap-water agar. Evidence is presented that upper internodes may attain a higher nutritional status than lower internodes during the early period of colonization, but this situation may be reversed later. These findings are discussed in relation to the senescence of host tissues and a hypothesis is presented to explain the observed pattern of fruiting of primary saprophytes on decaying grass stems.

Abstract No. 1440.

Webster, J. E., G. D. Shyrock, and E. H. McIlvain. 1959. Seasonal variations in the carbohydrate composition of two species of grama grass. Plant Physiol. 34(Suppl.):VII.

Detailed carbohydrate analysis will be presented for two species, covering six stages of growth. Little difference was noted in the chemical composition of the two grasses except during May and June when blue grama was distinctly higher in crude fiber. Less than 0.2% of fructosans were present at any stage of growth and lignin percentages ranged from 4 to 8%. Crude holocellulose percentages ranged from 60% in the spring to 77% in mid-winter, and hemicellulose percentages during the same period varied from 22 to 29%. Chromatographic analysis indicated that the hemicellulose were composed chiefly of xylose and arabinose with a small amount of glucose. Traces were also found of unidentified uronic acids.

Abstract No. 1441.

Weddle, J. P., and H. A. Wright. 1970. An evaluation of five methods to retreat sprayed mesquite. J. Range Manage. 23(6):411-414.

Based on mortality, chaining is the most economical method for retreating mesquite trees that are greater than 5 inches in diameter. For smaller trees, basal spray with diesel oil is most economical. Foliar spray with a mixture 2,4,5-T and Picloram is least economical.

Abstract No. 1442.

Wedel, W. R. 1947. Prehistory and environment in the central Great Plains. Kansas Acad. Sci., Trans., 50:1-18.

A few general observations on vegetation.

Abstract No. 1443.

Wedel, W. R. 1953. Some aspects of human ecology in the central plains. Amer. Anthropol. 55(4):499-514.

There are several avenues of approach to a clearer understanding of the fascinating but still vexing problem of man versus nature in the Central Plains. For one thing, we need a careful analysis of community patterns, economic practices, size of population groups, and relative emphasis on food-collecting as against food-producing on the part of the historic Village Indians. Of equal importance is a thoroughgoing ethnographical and ethnohistoric synthesis and interpretation of western Plains Indian culture as it must have been in pre-wite and pre-horse days. Ethnography is in a good position to contribute much useful information along these and other lines.

Similar analytical studies will have to be made of the earlier populations, communities, and their subsistence bases, as the results of intensive excavation programs become available. This will involve closer attention to the floral, faunal, and other geographical associations involved, which means, in turn, more help from specialists in other disciplines.

Abstract No. 1444.

Wedel, W. R. 1957. The central North American grassland: Man-made or natural?, p. 39-69. *In* Pan Amer. Union, Div. Sci. Development, Washington, D.C. Soc. Sci. Monogr. No. 3.

The origin and history of the grassland of central North America would seem to be properly a problem for specialists in ecology, botany, geology, climatology, pedology, and related fields--for a whole set of scholars, in short, in whose company there should be only a minor role for the anthropologist. Certain recently expressed views, however, allot to man a fundamental role, perhaps indeed the primary one, in the origin of the grassland. It is somewhat surprising to find that these views seem to have gained some following, perhaps because they appear to offer a simple explanation for what is actually an exceedingly complicated problem. This fact is perhaps justification enough for reviewing the problem before an anthropologically-oriented group.

Abstract No. 1445.

Wedel, W. R. 1961. Prehistoric man on the Great Plains. Univ. Oklahoma Press, Norman. 355 p.

This book has been written with two primary objectives in mind. It undertakes, first, a review of the human prehistory of the North American Plains, as this has been revealed by some three decades of systematic and sustained archaeological research. Obviously, any attempt to condense into a few hundred pages the story of some 10,000 years or more of human activities in more than 800,000 square miles of valley and plain has necessarily involved the slighting of some important facts and the omission of a great wealth of detail.

A second objective is that of presenting the story in a manner which will not deter or repel the non-specialist, but without sacrifice of clarity and accuracy. For this I have sought to avoid the overuse of technical terms and specialized expressions.

Abstract No. 1446.

Wedel, W. R. 1963. The high plains and their utilization by the Indian. Amer. Antiquity 29:1-15.

This paper reexamines the thesis, which still persists in some quarters, that limited surface-water supplies, scarcity of through-flowing streams, a generally harsh environment, and shortage of wood for tipi poles, stakes, and fuel, because they precluded year-round occupation of the High Plains, would also have made regular seasonal residence and through-travel by pedestrians extremely difficult or impossible. A review of historic Indian occupation and natural resources, notably distribution and nature of the water supplies, suggests that seasonal residence patterns were entirely feasible for pre-horse Indians, and that travel in and through the region, except in times of severe drought or winter storms, would have been practicable for experienced plainsmen, even on foot. The potential significance to archaeology of the larger perennial springs in and around the shortgrass country is noted.

Abstract No. 1447.

Weese, A. O. 1939. The effect of overgrazing on insect population. Oklahoma Acad. Sci., Proc. 19:95-99. [As quoted by Graham 1944, Natural Principles of Land Use. p. 158].

Data from quantitative collections from normal and overgrazed grassland in the Wichita Mountain Wild Life Refuge indicate that there is a striking qualitative and quantitative difference in the populations in the two areas during the aestival period. The total population in the overgrazed grassland is, on the average, approximately four times as great as in the normal prairie. Of the ten species most abundant in the normal community only one is as numerous as the least frequent of the first ten in the overgrazed community. An important factor in the distribution of grasshoppers, and perhaps of other insects, is the presence of younger and more tender plants in the area in which the vegetation is kept down by the combination of grazing pressure and insect pressure. In the closed community of the *Andropogon* grassland, plants are larger and more vigorous and better able to withstand the attacks of insects. The presence of bare areas which serve for places of oviposition of grasshoppers is also a factor in their abundance during the "hopper" stage when migration is not extensive. The net result is that excessive grazing makes possible further degradation of the plant cover of an area by favoring the presence of destructive insects.

Abstract No. 1448.

Weinmann, H. 1940. Seasonal chemical changes in the roots of some South African highveld grasses. J. South African Bot. 6(3):131-145.

Roots of *Trachypogon plumosus*, *Tristachy hispida*, and *Digitaria tricholaenoides* were collected from unfertilized and fertilized camps at different times of the season. The percentages of nitrogen, phosphorus, and of total sugars decreased in the roots during the growing period and increased in autumn and winter. Starch occurred in larger amounts only in the roots of *Tristachya hispida* where it also increased in autumn and winter. Fertilizer treatment increased the nitrogen and phosphorus content of the roots and in *Tristachya hispida* roots also the starch content.

Abstract No. 1449.

Weinmann, H. 1940. Storage of root reserves in Rhodes grass. Plant Physiol. 15:467-484.

Chloris gayana Kunth, Rhodes grass, was grown under controlled conditions in pots receiving different fertilizer treatments and was harvested at three different stages of maturity.

In the well fertilized plants significant increases of the root system occurred after the time of flowering and during the formation of seeds, when growth of the aerial parts had already ceased.

During this period considerable amounts of sugars, hydrolyzable carbohydrates, nitrogen, phosphorus, and potassium were lost from the shoots and were largely recovered in the roots.

In addition to translocation from the shoots, nitrogen and mineral elements also accumulated in the roots to a certain extent by simultaneous absorption from the soil. The duration of the absorption period varied, however, for different elements; it also varied for plants grown under different nutritional conditions and hence reaching different stages of physiological maturation.

The relative amounts of dry matter and constituents present in the roots (expressed as percentages of the total amounts present in the whole plant) increased, in most cases, considerably during autumn, indicating a continuous storage of these substances in the roots with the approach of maturity.

Abnormally developed and immature remaining deficiency plants showed in part a correspondingly abnormal behavior with regard to root storage and absorption.

Abstract No. 1450.

Weinmann, H. 1942. On the autumnal remigration of nitrogen and phosphorus in *Trachypogon plumosus*. J. South African Bot. 8(2):179-196.

Plants from fertilized and unfertilized plots were analyzed for total nitrogen and phosphorus and for water-soluble fractions. An increase occurs in roots and a decrease in shoots. In the colder weather the water-soluble fraction increases relatively to the total.

Abstract No. 1451.

Welch, H., and H. E. Morris. 1952. Range plants poisonous to livestock in Montana. Montana Agr. Exp. Sta. Circ. 197. 35 p.

The vast areas of mountains, foothills, and uncultivated plains that constitute summer range for livestock are not utilized to their full capacity because of the presence of poisonous plants. However, considering the wide distribution of some of these plants and the large number of sheep and cattle pastured on summer range, the actual loss is not large. The mere presence of poisonous plants on a certain range does not mean that losses will necessarily follow. With few exceptions, the known dangerous plants are not palatable to stock, and, from observations made in connection with losses, it becomes evident that faulty management of both the livestock and the range contribute to these losses.

This circular has been prepared to assist Montana stockmen to recognize the dangerous plants, to learn the conditions under which losses may occur, and to take the necessary precautions to minimize the losses of livestock that these plants may cause. Some of these plants are found in many western states, but many plants dangerous to livestock in other western states are not found in Montana.

Abstract No. 1452.

Welch, W. R. 1970. A numerical analysis of grassland faunal resemblances. U.S. IBP Grassland Biome Tech. Rep. No. 60. Colorado State Univ., Fort Collins. 22 p.

Species lists of small mammals at eight grassland sites were compiled. Coefficients of Community among the sites were computed and subjected to cluster analysis. The resulting relationships are discussed and suggestions are made for additional and expanded study.

Abstract No. 1453.

Welkie, G. W., and M. Caldwell. 1970. Leaf anatomy of species in some dicotyledon families as related to the C_3 and C_4 pathways of carbon fixation. Canadian J. Bot. 48:2135-2146.

Species in the families Amaranthaceae, Aizoaceae, Chenopodiaceae, Convolvulaceae, Euphorbiaceae, Nyctaginaceae, Portulacaceae, and Zygophyllaceae were examined for leaf anatomy typical of plants having the C_4 type photosynthetic carbon fixation pathway. They are assembled by families into three groups: genera in which all species possess the specialization, and genera in which no species possess the specialization. The specialization in leaf anatomy was noted in species of 24 genera. Its presence is highly correlated with a habitat of limited water availability and (or) with a tropical origin. The carbon dioxide compensation points of nine species in the Chenopodiaceae family were measured. Low values were obtained only for those species that possess a form of specialized leaf anatomy (*Atriplex confertifolia* (Torr. & Frem.) Wats., *A. falcata* (M. E. Jones) Standl., *Halogeton glomeratus* (Bieb.) Meyer, *Salsola kali* L. var. *tenuiflora* Tausch.). The latter two species, having centric leaves, do not possess the more typical differential bundle sheath chlorenchyma but do possess two, individually distinct, single-cell layers of chlorenchyma, adjacent and external to the peripheral veins.

Abstract No. 1454.

Wells, P. V. 1965. Scarp woodlands, transported grassland soils, and concept of grassland climate in the Great Plains region. Science 148:246-250.

Nonriparian woodlands occur on escarpments and other topographic breaks throughout the grassland province of central North America. Grassland vegetation is mainly correlated with gently sloping or flat terrain mantled by deep, transported soils of Pleistocene or younger age. Paleobotanical evidence suggests that extensive treeless grasslands may be a relatively recent development on the plains. Interaction of topography, wind, and fire may partly account for the observed distribution of vegetation.

Abstract No. 1455.

Wells, P. V. 1970. Postglacial vegetational history of the Great Plains. Science 167:1574-1582.

Radiocarbon-dated macrofossil and pollen records from the Plains region of central North America indicate that areas now occupied by grassland or desert vegetation were wooded during the Wisconsin glacial. But there is no indication that *treeless grassland* shifted southward into what is now the arid Chihuahuan Desert during the Wisconsin glacial, when much of the Great Plains south of the ice sheet was occupied by coniferous forest, woodland, or possibly parkland.

At most of the fossil pollen sites in the Plains region there is a dramatic decrease in coniferous pollens in the postglacial sediments. This is usually interpreted as a climatically induced shift to more xerophytic, nonarboreal vegetation similar to the prairies of today.

The presence of woodland on the now arid floor of the southwestern corner of the Laramie Basin during much of the latter half of postglacial time has major implications for the history of climate and potential vegetation on the Great Plains, only 48 kilometers to the east. At the same latitude, the Plains are now decidedly less arid than parts of the Laramie Basin, and precipitation increases progressively toward the east. Correspondingly, a significant feature of the existing vegetation of the Great Plains is the wide distribution of upland, nonriparian forests and woodlands in the vicinity of escarpments and other major topographic breaks. At the time of settlement, grasslands occupied most of the smooth topography--the flat or rolling plains and gentle slopes.

A rational explanation of these phenomena is that scarp-restriction of forest or woodland vegetation throughout the region of grassy plains in the central part of the continent originated as a consequence of regional forest and prairie fires. Climate is a factor, but so are the regional flatness and continuity of the physiography, the fuel-producing, annual dieback of grasses characteristic of the herbaceous way of life, and fire.

Abstract No. 1456.

Wenger, L. E. 1939-1940. Improvement of buffalo grass in Kansas. Kansas State Board Agr. 32nd Bien. Rep. 211-224.

An intensive program of buffalo grass improvement has been inaugurated only within the last few years. Although merely in its infancy, this program has already demonstrated results and possibilities far beyond earlier expectation.

The need for continued rapid-fire research on improved strains and methods is portrayed in the thousands of acres of land in the Great Plains region that are at present denuded, unproductive, and suffering from severe erosion.

Buffalo grass, together with blue grama and a few other native grasses have demonstrated conclusively their superiority for revegetating this vast acreage of problem-land.

Buffalo grass, aside from fulfilling the requirements of an ideal pasture grass for this territory, is unexcelled for use as a lawn or turf grass, particularly on the heavier, less sandy soils where dense shade is not encountered.

Selection, as one of the methods of improvement, has already exhibited its ability to increase the height of seed production as well as the yields of seed and forage.

Abstract No. 1457.

Went, F. W. 1938. Specific factors other than auxin affecting growth and root formation. Plant Physiol. 13:55-80.

A study of sweetgum was made to determine (a) the time of least vigorous sprouting during the growing season in terms of phenological development, (b) the sprouting vigor in relation to the size of the parent tree, (c) the effect on sprouting vigor of the destruction of successive generations of sprouts during the same growing season, and (d) the sprouting vigor in relation to carbohydrate reserves.

Abstract No. 1458.

Wesley, D. E. 1971. Energy and water flux in pronghorn antelope (*Antilocapra americana*). Ph.D. Diss. Colorado State Univ., Fort Collins. 84 p. (Advisor: Julius Nagy).

Four trials conducted at 21°C with female pronghorn (*Antilocapra americana*) aged 1 month to 12 months showed that average body water content decreased from 71.5 to 61.3% during this period. Water intake, flux, and turnover rate values for 1-month-old pronghorn were significantly higher ($P<0.01$) while $T\frac{1}{2}$ was significantly lower ($P<0.01$) than for metabolically mature animals.

Two-month-old pronghorn exposed to 32°C significantly ($P<0.01$) increased water intake, flux, and turnover rates and significantly ($P<0.01$) decreased $T\frac{1}{2}$ when compared to 21°C exposure. Water intake, flux, and turnover rates for mature pronghorn exposed to -12°C were 53, 50, and 45% lower, respectively, while $T\frac{1}{2}$ was 79% greater than when these animals encountered 21°C temperature.

Energy metabolism trials conducted at 21°C with pronghorn at four ages from 2 months to 18 months, indicated that 2-month-old animals showed higher energy intake, apparent digestible energy, metabolizable energy (N-corrected), energy retention, total heat production, and fasting metabolic rates than animals above 7½ months of age. Mature animals at 21°C voluntarily consumed an average of 218 kcal/$kg^{0.75}$/day each and retained approximately 14% of this amount. Apparent digestible energy averaged 74% and metabolizable energy accounted for 69% of gross energy intake in metabolically mature animals. Total and fasting heat production averaged 119 and 76 kcal/$kg^{0.75}$/day, respectively.

Lower critical temperature for fasting pronghorn was determined to be near 0°C. Below this temperature, fasting heat production increased 1.7 kcal/$kg^{0.75}$/day for each degree (C) decrease in ambient temperature. Critical temperature for one animal on feed was found to exist between -12°C and -23°C. With the exception of fasting metabolic rate at -12°C, no change in energy partitioning was noted in mature pronghorn when exposed to 21°C, 10°C, 01°C, and -12°C. Total and fasting heat production increased 9 and 6%, respectively, in young animals upon exposure to 32°C, when compared to 21°C exposure.

Restricted activity increased total heat production by approximately 38% while moderate activity increased heat production by 58%.

Change in barometric pressure and artificial light stimulus (on-off) showed no measurable effect on food intake/metabolic body size.

Abstract No. 1459.

Wesley, D. E., K. L. Knox, and J. G. Nagy. 1969. Water kinetics in pronghorn antelope. J. Anim. Sci. 28(6):866. (Abstr.).

Since the pronghorn (*Antilocapra americana*) has evolved in an arid environment, certain adaptations to regulate its water metabolism may have been necessary. The insufficiency of information about the water kinetics of pronghorn must be corrected if we are to gain the physiological information to properly manage for this unique animal.

Abstract No. 1460.

Wesley, D. E., K. L. Knox, and J. G. Nagy. 1970. Energy flux and water kinetics in young pronghorn antelope. J. Wildlife Manage. 34:908-912.

Energy flow trials with four pronghorn antelope (*Antilocapra americana*) ranging from 108 to 182 days of age, produced results similar to those described for other ruminants with the possible exceptions of total heat production and fasting metabolic rate. The comparatively high heat production may be related to the higher metabolism of younger animals. Fasting metabolic rates were above the interspecies mean of 70 kcal/kg$^{0.75}$/24 hr; similar results have occurred with other wild ruminants. Pronghorn antelope, under the conditions tested, had a slightly higher content of body water than reported for other ruminants. This is feasible since pronghorn probably have a lower fat content than do most domestic or laboratory animals. Water flux in antelope is similar to that in domestic sheep and mule deer (*Odocoileus hemionus*). Noticeable differences existed between water kinetics of male and female pronghorn.

Abstract No. 1461.

Wesley, D. E., K. L. Knox, and J. G. Nagy. 1971. International Biological Program: Metabolic studies on pronghorn antelope. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 21-24, Tucson, Arizona.

Six young female antelope were trained to accept metabolic chambers which were constructed to permit temperature regulation. Metabolic response of fasting antelope to age followed a pattern similar to that of other ruminants. Metabolic rate dropped rapidly prior to seven months of age and became relatively stable thereafter. The mean fasting metabolic rate of mature pronghorn is approximately 75 kcal/kg$^{0.75}$/day. The thermoneutral area for fasting antelope ranged from approximately 32°C to a point just above 0°C. Digestible energy for pronghorn on a mixed concentrate and leafy alfalfa diet was not different from domestic ruminants. Pronghorn, however, metabolized a greater percentage of its digested energy than reported for their domestic counterparts.

Abstract No. 1462.

West, N. E., and R. W. Wein. 1971. A plant phenological index technique. BioScience 21(3):116-117.

Although plant ecologists have long recognized the importance of describing phenological patterns, such studies have generally lacked quantification. Comparatively more progress has been made with field crops and horticultural plants as meteorological indicators than for native species. The problem is compounded if one wishes to study populations of native perennials *in situ*. Age of perennials, site differences, interspecific competition, and, perhaps, genetic differences increase variability and make quantification more difficult in wildland situations.

Plant phenological patterns have usually been described by only a few stages. Descriptions such as "full flower" or "seed shatter" have limited value, however. Numerical ratings of more closely defined phenological stages would permit the data to be used in statistical tests for different sites or treatments.

This paper outlines such a technique and gives an example of its application. Members of a Western Regional Research Committee from Arizona, Nevada, New Mexico, Utah, and Wyoming are using the indexes for an autecological study of *Hilaria jamesii* (Torr.) Benth. The technique has also worked well for Utah State University studies of eight shrub, half-shrub, forb, and grass species in various desert and mountain areas of Utah. The approach taken may find general application in other situations as well.

Abstract No. 1463.

Western Regional Soil Survey Work Group. 1964. Soils of the western United States (exclusive of Hawaii and Alaska). Washington State Univ., Pullman. 69 p.

This publication reports on the occurrence and distribution of soils in the 11 western states of Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming. It consists of a generalized soil association map and an explanatory text.

The text describes 36 great soil groups and eight miscellaneous land types which occur in the Western Region. Their occurrence and distribution and their relationships to physiography, climate, and vegetation are discussed.

The soil association map is organized at two levels of generalization. At the higher level, 13 subregions are shown by color separations on the map. Within each subregion the dominant great soil groups are closely related.

At the lower level, associations of great soil groups and land types are identified by letter and number symbols on the map. This level shows the patterns of great soil groups as they intermingle one with another on the landscape.

The map units of both of these levels of generalization are described and discussed in detail in the report. Genesis and morphology of soils and relationships between soil occurrence and other landscape features are treated for the soil regions. Kinds of soils, their proportionate area, associated physical characteristics of the landscape, and climate are described for each soil association. Information about location of soils, land use, and management is also offered for the soil associations.

The report provides information about occurrence and distribution of soils in the western United States and is the first document to show distribution of soils for the entire Western Region. It includes the first complete description for those great soil group recognized as occurring in the western United States. In addition, several important and extensive miscellaneous land types, significant to western soil and water management, are described and located on the map. The map and report should have several widespread uses.

Abstract No. 1464.

Wexler, H., and J. Namias. 1938. Mean monthly isentropic charts and their relation to departures of summer rainfall. Amer. Geophys. Union, Trans., 19:164-170.

The authors constructed mean monthly charts on isentropic surfaces which show flow-pattern dry and moist tongues. This form of analysis allows a better correlation between rainfall-patterns with upper-air phenomena and also throws new light on the maintenance of these anticyclonic eddies.

The monthly mean isentropic charts are drawn from the data published in the Monthly Weather Review for August, 1934-1937.

A few general remarks can be made about these charts. First these eddies are difficult to explain as purely thermal phenomena since they are regions of convergence rather than divergence as one should expect from the classical thermal explanation. Also, it does not seem likely that they are caused by motion around solenoids since a closed circuit in an isentropic surface contains no solenoids.

Because of lack of data this analysis cannot now be extended to other regions, but it would appear that such anticyclonic eddies necessarily must exist to the south of the westerlies around the Earth. There seems to be a certain stability in position of the main moist and dry tongues of these eddies. The main moist tongue enters the country from Mexico. Originally it is brought to Mexico by the subtropical easterlies, but on climbing the high Mexican Plateau convection ensues which brings warmth and moisture to high levels. At the Plateau the deep moist current is deflected northward, then eastward, and finally southward over the United States. The dry tongues enter the country mostly from the eastern Great Lakes Region.

Abstract No. 1465.

Wheeler, R. O., and R. J. McConnen. 1961. Organization, cost, and returns of commercial, family operated cattle ranches. Montana Agr. Exp. Sta. Bull. 557. 19 p.

A study was made of the organizational characteristics, cost and returns to three sizes of commercial family-operated cattle ranches in the northern Great Plains. The size classes were defined by the number of animal units on hand January 1, 1959. The major source of data was a survey of ranch operators in the area in 1959. The data were used in establishing the organization characteristics and most of the values for a budget analysis of a typical ranch unit within each size class presented.

Abstract No. 1466.

Whitehouse, E. 1933. Plant succession on central Texas granite. Ecology 14:391-405.

The climax vegetation of the coarse granite rocks of the central mineral region of Texas is attained through four types of succession; namely, the rock surface, the crevice, the gravel, and the rock pool. The first three belong to the xerosere and the last to the hydrosere.

The vegetation of the granitic wash plains, not discussed in this paper, differs from that of the slopes in that post oak, *Quercus stellata*, replaces the live oak, *Q. virginiana*.

Successional changes on the granite are shown.

Abstract No. 1467.

Whitfield, C. J., J. H. Jones, and J. P. Baker. 1949. Grazing studies on the Amarillo Conservation Experiment Station. Texas Agr. Exp. Sta. Bull. 717. 21 p.

This bulletin gives a summary of the grazing studies made on the Amarillo Conservation Experiment Station from 1943 through 1949.

Investigations have been made of the grazing values of: (1) native blue grama-buffalo grass pasturage; (2) seeded cool-season grasses, such as crested wheatgrass and western wheatgrass; and (3) temporary pasture crops, such as Sudan grass and winter wheat. Tables show the gains made from these various types of pasturage.

Forage production and the chemical composition during different seasons of the year for the important plants studied are also presented.

With favorable rainfall, a well balanced, year-round, green grazing program for this section of the southern Great Plains may be had from a combination of the following pasturage: *winter*--winter wheat, crested wheatgrass, and western wheatgrass; *spring*--crested wheatgrass, western wheatgrass, little barley, and early weeds; *summer*--blue grama, buffalo grass, Sudan grass, and late weeds; and *fall*--crested wheatgrass, western wheatgrass, and winter wheat.

Abstract No. 1468.

Whitman, W. C. 1954. Yield characteristics of native grass ranges. North Dakota Acad. Sci., Proc., 8: 14-19.

A study of the yield characteristics of native grass ranges in the vicinity of the Dickinson Experiment Station in southwestern North Dakota has shown that almost 60% of the total yield is produced by western wheatgrass and needle-and-thread. These two grasses comprise slightly less than 16% of the vegetative cover. The upland sedges and blue grama grass produce about 23% of the total yield, but together make up over 67% of the vegetative cover.

Weeds during the period of the study have been relatively unimportant in terms of forage production and ground cover.

Variability in forage production is high from year to year on these native grass ranges. The coefficient of variability for yield based on eight years observation is 56%. Forage production shows greater variability than would be anticipated on the basis of variability in amount and distribution of precipitation.

Detailed clipping studies have shown that on the average about 80% of the forage yield is produced by June 30. Only one species, blue grama grass, had made a substantial part of its production after July 1. Precipitation in August and September has had only a slight effect in stimulating additional forage production during the latter part of the season.

Abstract No. 1469.

Whitman, W. C. 1969. Microclimate and its importance in grassland ecosystems, p. 40-64. *In* R. L. Dix and R. G. Beidleman [ed.] The grassland ecosystem: A preliminary synthesis. Range Sci. Dep. Sci. Ser. No. 2. Colorado State Univ., Fort Collins.

Microclimatic investigations have been concerned with the prevailing atmospheric conditions within the plant canopy and immediately above the canopy. These are the conditions determining the effective climate within which the grassland plants go through their diurnal, seasonal, and life cycles. The most obvious feature of the microclimate above a grass sod is the gradient in environmental factors which exists at nearly all times. The nature of the gradients in temperature, wind movement, atmospheric moisture, and evaporation above mixed-grass prairie has been found to result in a generally more rigorous climatic situation closer to the surface of the earth than that which exists above the vegetation canopy.

Soil moisture perhaps cannot be considered as a microclimatic factor, but its overwhelming importance in the functioning of the grassland ecosystem makes consideration of this factor essential in any discussion of microclimatic influences. High atmospheric evaporative potential and shortage of soil moisture are characteristic features of the microenvironment of the mixed-grass prairie. The direct influence of these features on plant activities is just beginning to come under intensive analytical study, especially in the field of water stress.

Energy balance studies in the grassland microenvironment have been few in number, but the development of precise mathematical formulations of plant-energy environment relations, so essential to successful grassland ecosystem modeling, is dependent on the acquisition of information from such studies. The work which has been done provides guidelines and examples for the development of precise expressions of such relations, but the qualifying conditions of the microclimate under which these expressions will have validity in the grassland ecosystem remain to be worked out.

Abstract No. 1470.

Whitman, W. C. 1970. Comprehensive Network Site description, DICKINSON. U.S. IBP Grassland Biome Tech. Rep. No. 40. Colorado State Univ., Fort Collins. 15 p.

The Dickinson Site is located on the Dickinson Experiment Station near the city of Dickinson in the southwestern part of North Dakota. The land on which the site is located is owned by the state of North Dakota and is formally constituted as part of the Dickinson Experiment Station. The Dickinson station is a branch station of the North Dakota Agricultural Experiment Station, which, in turn, is part of North Dakota State University at Fargo, North Dakota. The Dickinson station is on the northwestern edge of the city of Dickinson. The city of Dickinson is in southwestern North Dakota about 60 miles east of the Montana border and 65 miles north of the South Dakota border. The specific study area consists of a 4-acre enclosure within a 27-acre tract of native grass. The enclosure has been in place since 1961, and thus there has been no grazing in the enclosed area for 9 years. The grassland outside the enclosure has been grazed heavily in late fall for the past 12 years.

Abstract No. 1471.

Whitman, W. C. 1971. Primary productivity and abiotic studies at the Dickinson Site, 1970 season. U.S. IBP Grassland Biome Tech. Rep. No. 116. Colorado State Univ., Fort Collins. 100 p.

This report describes the methods used in the study of primary productivity and abiotic influences on grazed and ungrazed treatments at the Dickinson Site in the 1970 season and gives a summary of the data obtained in the field during the study period. The general abiotic data provided include precipitation, soil moisture, soil and air temperatures, net radiation, soil heat flux, wind movement, and relative humidity on both treatments. The primary productivity data include data from vegetation clippings made at essentially 2-week intervals throughout the growing season from May 25 through August 18, supplemented with clippings on September 17 and October 17. Underground biomass data were obtained from core samples taken to a depth of 1 m at the same time that clippings were made. Results obtained show the grazed site to have warmer soil and air temperatures, greater wind movement, slightly less favorable soil moisture conditions, less energy utilization, and nearly equal atmospheric moisture conditions as compared to the ungrazed site. The maximum standing crop on the ungrazed area was over 50% larger than on the grazed area. Standing dead material on the grazed area was only less than one-third that on the ungrazed areas. Belowground biomass was greater under the grazed treatment than under the ungrazed, averaging 53% greater dry weight for the season.

Abstract No. 1472.

Whitman, W. C., and O. A. Stevens. 1941. Grass. North Dakota Agr. Exp. Sta. Bull. 300. 108 p.

North Dakota is a grassland state. Today about 29%, or 12,000,000 acres, of the total land area of 44,917,210 acres is in grass, either as farm pasture or as rangeland. Dependent to a considerable extent on the forage produced on these 12,000,000 acres, North Dakota has 1,337,000 head of cattle and 767,000 head of sheep having a combined total value of approximately 59½ million dollars. Since 1936 the income to the North Dakota farmer from the sale of livestock and livestock products has consistently exceeded the income from the sale of farm crops.

These figures serve to indicate the important position that grass now occupies in the agricultural economy of this state. As the basic feed for North Dakota's livestock, it can be expected to become even more important in the future, when a stable livestock and farming economy is developed.

Abstract No. 1473.

Whitman, W. C., H. C. Hanson, and R. Peterson. 1943. Relation of drought and grazing to North Dakota range lands. North Dakota Agr. Exp. Sta. Bull. 320. 29 p.

The changes in the grassland vegetation on grazed ranges in western North Dakota have been determined by use of permanent meter-square quadrats during the 10-year period 1932 to 1941 inclusive. During the first half of this period the grassland deteriorated, primarily because of severe drought, but partly because of heavy grazing. In the last half, the grassland vegetation showed continued improvement. Cessation of the drought with return to favorable moisture conditions and a decrease in grazing intensity because of the removal of large numbers of livestock from the region were responsible for the improvement in the range vegetation.

Abstract No. 1474.

Whitman, W. C., H. T. Hanson, and G. Loder. 1943. Natural revegetation of abandoned fields in western North Dakota. North Dakota Agr. Exp. Sta. Bull. 321. 18 p.

The process of natural revegetation of abandoned fields was studied in western North Dakota during the summer seasons of 1939, 1940, and 1941. A fairly good cover of native grasses had developed on such fields within 8 to 10 years after they were abandoned. This cover is characterized by low total density and dominance of three mid-grasses, western wheatgrass, needle-and-thread, and feather bunchgrass. Such a cover produces a relatively high yield of good quality forage, and the fields are especially valuable as hay land.

The mid-grasses continue to dominate the cover 25 to 30 years or more after the field is abandoned. However, by this time, the trend toward the dominance of blue grama, a short grass, is evident. As the proportion of blue grama increases, the density of the cover on the field increases, and the proportion of mid-grasses declines.

No abandoned fields were found on which the vegetation had developed to the point that it was similar to the climax vegetation of the native grassland. Most of the abandoned fields in the area studied are less than 30 years old. On the basis of the vegetation on the fields studied, it appears that 40 to 60 years or even more may be needed for the development of true climax vegetation by the process of natural revegetation.

The process of natural revegetation is benefitted to some extent by protection from grazing. However, the spread of blue grama grass on clay soils seems to be furthered by moderate grazing. The vegetation in the late mid-grass stage has greater density on sandy soils than on clay soils indicating that revegetation takes place somewhat faster on sandy soils.

Abstract No. 1475.

Whitman, W. C., and E. A. Helgeson. 1946. Range vegetation studies. North Dakota Agr. Exp. Sta. Bull. 340. 43 p.

Three points of major interest are shown by the results of the clipping treatments on the yield and density of all vegetation in the quadrats. The principal point of interest is that in the needle-and-thread-grama-sedge type the total yield of all vegetation showed a decrease over the 7-year period of the clipping experiment at all heights and frequencies of clipping. At the same time the total yield of all vegetation was greater in the quadrats in the grama-wheatgrass type in the final year of clipping than it was in the initial year of the experiment.

The decreases in total yields of vegetation under the various clipping treatments in the needle-and-thread-grama-sedge type are the result of decreases in the yields of grasses accompanied by only small or no increases in forb yields on the quadrats. The principal reason for the decrease in yields of grasses from the quadrats in this type is the effect that the clipping treatments had in decreasing the yield and basal area of needle-and-thread.

In the grama-wheatgrass type the increase in yield of total vegetation is the result of the maintenance of fairly high yields of grasses in the quadrats and the tremendous increases in forb yields under all clipping treatments.

This large increase in yield of forbs in the grama-wheatgrass type is the second point of major interest. In this vegetation type the weakening influence of the clipping treatments on the grasses tended to stimulate the production of forbs.

The third point of major interest is that the total density of the vegetation in the quadrats in both the needle-and-thread-grama-sedge type and the grama-wheatgrass type decreased under all clipping treatments. For the most part these decreases in percent density were not large, and they occurred mainly after 1942, the fourth year of clipping. Except at the ½-inch level in the grama-wheatgrass type clipping twice during the season did not seem to have a much greater effect in producing a decrease in density than did single clipping. For the most part the results showed no consistent relation between height of clipping and decrease in percent density.

Abstract No. 1476.

Whitman, W. C., D. W. Bolin, E. W. Klosterman, H. J. Klosterman, K. D. Ford, L. Moomaw, D. G. Hoag, and M. L. Buchanan. 1951. Carotene, protein, and phosphorus in grasses of western North Dakota. North Dakota Agr. Exp. Sta. Bull. 370. 55 p.

Field moisture, carotene, protein, and phosphorus were determined in 11 native range grasses, two tame grasses, and some miscellaneous forages at the livestock farm of the Dickinson Experiment Station during the 1946 and 1947 growing seasons. The native grass pasture at the livestock unit, from which samples of native grasses for analysis were taken, is a typical piece of mixed prairie with needle-and-thread, western wheatgrass, blue grama grass, threadleaf sedge, plains reedgrass, prairie Junegrass, and prairie sandgrass as the principal species. A small area along a water course in the pasture supports a tall grass type containing such species as big bluestem, little bluestem, and Kentucky bluegrass.

The grasses were high in moisture, carotene, protein, and phosphorus in the spring and early summer when they were in a young, actively growing condition, and relatively low in these constituents when they were mature and dry in late summer and fall.

Abstract No. 1477.

Whitman, W. C., L. Langford, R. J. Douglas, and T. J. Conlon. 1963. Crested wheatgrass and crested wheatgrass-alfalfa pastures for early-season grazing. North Dakota Agr. Exp. Sta. Bull. 442. 24 p.

A 7-year, early-season grazing trial with yearling steers on crested wheatgrass and crested wheatgrass-alfalfa pastures was conducted at the Dickinson Experiment Station over the period 1955-1961.

The steers grazed the pastures for an average seasonal period of 56 days with the average dates of the pasture season being May 7 to July 1. Throughout the 7-year period of the trial the crested wheatgrass-alfalfa pastures were superior to the crested wheatgrass pastures in forage and beef production.

Abstract No. 1478.

Whitman, W. C., and G. Wolters. 1963. A field installation for the study of grassland microclimate. North Dakota Acad. Sci., Proc. 17:106.

A meteorological station for the observation of gradients in microclimatic factors was set up in mixed-grass prairie vegetation at the Dickinson Experiment Station in the spring of 1962. Instruments were installed on a 15° south-facing slope, a 15° north-facing slope, and in undisturbed native grass on the small ridge between the two sloping sites.

Air temperatures, soil temperatures, and relative humidity readings are taken hourly, day and night throughout the growing season, and are recorded in a centrally located instrument shelter by means of recording potentiometers. Miles of wind are counted and recorded in the instrument shelter by means of industrial counters. Evaporation at each site is measured daily using black and white Livingston atmometer bulbs. Soil moisture is determined at weekly intervals by means of Coleman fiberglass-sandwich units and by gravimetric methods. Precipitation is determined with standard Weather Bureau rain gauges.

Instrumentation for the automatic recording of net radiation data on each site will be installed in the 1963 season.

Details of installation assemblies, recording operations, and calibration and maintenance procedures were described.

Detailed phenological studies of native grass and developing stands of seeded native grass are being made on each of the slope sites. Microclimatological data are being entered on punch cards and readied for machine analysis and correlation with plant growth information.

Abstract No. 1479.

Whittington, W. J. [Ed.]. 1969. Root growth. Butterworths, London. 450 p.

Plant roots have been investigated less extensively than shoots or reproductive organs because they are rarely of direct use to man and are difficult to study in their natural state. Yet, the root, by providing water, nutrients, and growth substances, is essential for the growth of the plant as a whole. It is now apparent that there is an increasing interest in the study of root systems and this has, at least partly, been due to the development of new techniques. There is little doubt, therefore, that the topic of "Root Growth" for the 15th Easter School was appropriately timed, not because definitive statements can now be made on the subject, but because the earlier descriptive phase of study is being rapidly replaced by experimental investigation using the newer methods.

The purpose of the meeting was to give an account of the present state of knowledge on a wide variety of subjects related to the growth of roots. There was no attempt at a comprehensive description of the root as an organ nor did every topic concerning root growth receive attention. Instead, accounts were given of recent investigations seeking to elucidate the development and functioning of root systems in various environments and the relation of these to the growth of the plant as a whole. From the knowledge thus gained comes an increasing awareness of the conditions required to produce a root population providing the maximum crop yield rather than merely excessive root growth.

This volume includes the papers presented at the meeting together with an edited account of the discussion which followed each paper. A detailed description of the Underground Laboratory at East Malling Research Station is also given as are accounts of the demonstrations which were exhibited. It is hoped that this book will provide students and research workers with the inspiration and techniques required to design experiments yielding the information still urgently required on many aspects of root growth.

Abstract No. 1480.

Wiant, H. V., Jr. 1967. Contribution of roots to forest "soil respiration." Advance. Frontiers Plant Sci. 18:163-167.

Field studies indicate the CO_2 produced by the respiration of roots may comprise a significant portion of the total amount of the gas evolved from forest soil.

This study was made to obtain some estimate of the contribution of roots to forest soil respiration.

Abstract No. 1481.

Wiegert, R. G., and F. C. Evans. 1964. Primary production and the disappearance of dead vegetation on an old field in southeastern Michigan. Ecology 45(1):49-63.

During the period 1949-1960 the flora of a long-abandoned field in southeastern Michigan showed little change. The peak standing crop of vegetation remained relatively constant from year to year, but during this period grasses decreased in importance from more than 90% of the standing crop biomass to less than 50%.

Because of the diverse perennial flora of the Old Field, the peak standing crop was not a good indication of annual net production. Instead, the annual disappearance of dead material was equated with the net annual growth, exclusive of herbivore consumption.

Dead material in place on the field disappeared at rates of from 8.4 to 1.3 mg/g per day on the upland and 13.6 to 1.8 mg/g per day on the swales, depending on time of year. Material placed in mesh bags did not disappear as fast as undisturbed material, even after being on the field 6 months. But the mesh-bag experiments showed that the rate of disappearance did differ with species of plant during the first 2 months after placement, but not thereafter.

The rates of disappearance of dead material, combined with data on green and dead standing crops, were used to calculate net production of the aboveground plant parts and its seasonal distribution in 1959 and 1960. In 1959, shoot production on the Old Field was: upland, 1,328 kcal/m^2; swale, 4,102 kcal/m^2. In 1960 the corresponding values were: upland, 1,392 kcal/m^2 and swale, 4,629. The net annual production of root biomass in 1960 was minimally estimated as 631 kcal/m^2 on upland and 1,573 kcal/m^2 on the swales.

Net production of the vegetation in 1969 (exclusive of herbivore consumption but including root production) thus was estimated as 2,023 kcal/m^2 on upland and 6,202 kcal/m^2 on the swales.

Because of the greater quantitative importance of root growth as compared to the amount of herbivore consumption, lack of detailed information about the latter is less an obstacle to the correct estimation of annual net production of vegetation than is the present ignorance of the dynamic processes associated with the subterranean parts of the plant community.

Abstract No. 1482.

Wiegert, R. G., D. C. Coleman, and E. P. Odum. 1970. Energetics of the litter-soil subsystem, p. 93-97. *In* J. Phillipson [ed.] Method of study in soil ecology. IBP/UNESCO Symp., Paris.

It is our objective in this paper to review and assess our knowledge of the energetics of the litter-soil subsystem. We propose to: (a) delimit the generalized and subsystem to provide a frame of reference for discussion; (b) consider, through a further discussion of trophic models, the position of the soil populations in the context of total terrestrial ecosystem energetics; (c) briefly review current knowledge of the population energetics and trophic relations of some soil-litter groups; and (d) suggest some methods useful for the study of components of the litter-soil subsystem in a quantitative fashion.

Abstract No. 1483.

Wiens, J. A. 1970. Avian populations and patterns of habitat occupancy at the Pawnee Site, 1968-1969. U.S. IBP Grassland Biome Tech. Rep. No. 63. Colorado State Univ., Fort Collins. 47 p.

This report analyzes the ecological relations of breeding birds on two 10.6-ha plots subjected to different grazing regimes at the Pawnee Site. Emphasis is given to the relation of various population parameters (species diversity, density, interspecific spatial overlap, biomass) to vegetational heterogeneity, and the position of the Pawnee results in relation to a spectrum of grassland-shrubsteppe samples from other areas. In addition, characteristics of vegetation structure in areas occupied and not occupied by each of the breeding species are analyzed and are discussed in the context of interspecific differences, year-t-year changes, and responses to grazing treatment.

Abstract No. 1484.

Wiens, J. A. 1970. Habitat heterogeneity and the structure of avian communities in grasslands. Ecol. Soc. Amer. Bull. 51(2):29. (Abstr.).

Avian breeding populations and habitat characteristics were measured at 15 study sites in grassland and shrubsteppe habitats in central and western United States from 1967-1969. These sites include a broad range of climatic and productivity conditions. Measures of vertical and horizontal vegetation patchiness for the study plots were related to variations in avifaunal diversity, population density, standing crop biomass, territory sizes, and the extent of interspecific spatial overlap. The effects of habitat patchiness on the ecology of several selected bird species were further analyzed through detailed comparisons of features of the areas occupied by the species with those of areas not utilized.

Abstract No. 1485.

Wiens, J. A. 1970. Habitat structure and spatial relationships among grassland birds. Joint Annu. Meeting Cooper Ornithol. Soc. and Wilson Ornithol. Soc., June 19, Fort Collins, Colorado.

The extent of spatial overlap between species co-occupying an area has important effects on their ecological and behavioral relationships. In grasslands, unlike forests, these spatial relations are compressed into a single vertical plane, and are thus relatively accessible to study. An examination of the spatial relations among the species breeding in 12 grassland and 3 shrubsteppe sites in the United States has shown that the degree of overlap between the 3 to 6 species occupying any one site varies considerably. These sites represent a gradient of rainfall conditions, grass coverage and height, heterogeneity, and productivity, but interspecific overlap is unrelated to any single factor. Stepwise regression analysis indicates that bird species diversity, avian density, the density of vegetation within 10 cm of the ground surface, grass coverage, litter depth, and forb density are all related to overlap. This complexity is further indicated by the positive association in some areas of species pairs (such as Dickcissel-Grasshopper Sparrow or Horned Lark-Grasshopper Sparrow) which in other areas have negatively correlated occupancy patterns. These varying relationships are probably associated with variations in the ecological amplitudes and habitat response patterns of the different species and the functions served by the areas they occupy. Some indication of this may be derived from the manners in which territory size of different species vary in association with various habitat conditions.

Abstract No. 1486.

Wiens, J. A. 1971. Avian ecology and distribution in the Comprehensive Network, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 77. Colorado State Univ., Fort Collins. 49 p.

This report presents a summarization and preliminary analysis of data obtained on breeding bird populations at six IBP Grassland Biome Comprehensive Network sites and two plots at the Pawnee Site during the spring and summer of 1970. These data were obtained from roadside counts made in the general vicinity of the sites, from 8.4 to 10.6 ha intensive study plots located in grazing treatment areas at each site and from specimens collected near the study plots. This report considers these data in terms of: (i) species presence and distributions, (ii) population densities, (iii) standing crop biomass, (iv) individual weights, (v) diversity, (vi) ecological structure of the breeding avifaunas, and (vii) general migratory tendencies of the breeding populations.

Abstract No. 1487.

Wiens, J. A. 1971. Pattern and process in grassland bird communities, p. 147-211. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Data collected during 1969 and 1970 in the U.S. IBP Grassland Biome Program are synthesized to examine patterns and processes characterizing breeding bird populations and communities in grasslands, with the overall intent of clarifying the role of birds as consumers in grassland ecosystems.

In analyzing pattern, primary attention is given to variation in species abundances and distributions and features of avifaunal and community organization at regional, local, and within-plot scales of resolution. At the regional level patterns were generally not distinct, although low rainfall sites tended to support fewer individuals and less biomass than more mesic sites. The dominant bird species were generally widely distributed, but 70% of all species recorded were present at only one of the seven sites. Local plot-to-plot differences associated with grazing regimes to varying degrees, were considerably more important than the regional differences. Vegetational and avifaunal relationships of plots were determined by similarity-cluster analysis and by examination of features of vegetation structure. The ranking of plots from tallgrass through shortgrass to desert was unrelated to variations in the number of breeding bird species, bird species diversity, or equitability, but standing crop biomass generally decreased along this plot gradient. Grazing had variable effects on bird populations: at some sites (Pantex) treatment plots were avifaunistically quite similar, while at others (Cottonwood) differences were considerable. At Pawnee grazing season seemed to have a greater effect than grazing intensity. Patterns of variation were much more pronounced when single species rather than breeding faunas were considered. Within sample plots, patterns of territorial overlap, territory size, habitat occupancy, and vegetational characteristics of nest sites are discussed.

Temporal variations in bird populations were also considered as patterns. Data are available only from Pawnee, but these are sufficient to demonstrate seasonal and annual alterations in species abundances.

Discussion of processes is centered upon trophic dynamics and production. Preliminary results of food habits analyses from the Comprehensive Network Sites are presented, as are more detailed summarizations of Horned Lark and Lark Bunting diets at Pawnee. The Pawnee data indicated considerable temporal variation in the proportions of seeds and arthropods in the diets of these two species, and in the consumption of prey taxa within these broad categories. Difficulties in relating these dietary data to measures of prey availability are discussed.

Information on raptors was obtained only at Pawnee. Diurnal raptors were widely dispersed, occurring at densities and standing crops substantially less than those of small passerine populations. Owls at Pawnee preyed chiefly upon small mammals and insects, but there were significant differences between the four owl species studied.

The bioenergetic demands of the breeding bird populations at Pantex, Osage, and Cottonwood are estimated from metabolic functions and information on population dynamics. The estimated energy intake of the breeding bird populations from April through August ranged from 1.01 to 2.33 kcal/m^2; thus, the energy flux through avian consumers in grasslands is apparently very small. Coupled with food habits data, these estimates suggested a general decrease in the importance of seeds as energy sources and an increase in the importance of arthropods, with a progression from shortgrass through mixed-grass to tallgrass plots. Production was estimated for six treatment plots at Pawnee; values ranged from 3.6 to 6.7×10^{-3} g/m^2.

Concluding speculations compare birds and small mammals in grasslands and consider the role of birds as consumers in the dynamics of grassland ecosystems. The suggestion is offered that birds may act as controllers of other elements of system function, or may not be closely evolved into the functional framework of the ecosystem at all, existing off "excesses" in production.

Abstract No. 1488.

Wilhelm, D. E., Jr. 1966. Some population characteristics of *Peromyscus maniculatus*, *Perognathus hispidus*, and *Onychomys leucogaster*. M.S. Thesis, Fort Hays Kansas State College, Hays.

There was no significant difference in male and female home ranges for *Peromyscus hispidus* and *P. maniculatus*, but there was a significant difference for *Onychomys leucogaster*.

Some evidences of territoriality were present for deer mice, but there were few indications that territoriality existed in the other two species investigated.

Definite habitat preferences were evident for grasshopper mice and hispid pocket mice, but deer mice occupied a variety of habitats. The home ranges of grasshopper mice increased in size as the mulch decreased; home ranges of hispid pocket mice and deer mice increased in size as vegetative production increased.

All three species were near random distribution within those communities in which they occurred.

Grasshopper mice were associated in primarily male-female pairs, while deer mice and hispid pocket mice displayed no pairing.

Abstract No. 1489.

Will, G. F. 1946. Tree ring studies in North Dakota. North Dakota Agr. Exp. Sta. Bull. 338. 24 p.

A number of years ago, Dr. A. E. Douglass, a professor of Astronomy and Research Fellow of the Carnegie Institution first made public a method of reading weather data from tree rings in sequoias. This was followed by his work with ponderosa pine, principally on the Colorado plateau. This latter phase of his work led to the dating of old Pueblos and Cliff dwellings by comparison of the rings in old house timbers with those of already known dates in the series worked out in meteorological studies. In the continuation of that work a definite calendar of building dates for many of the old ruins has been worked out for a period of nearly two thousand years.

Abstract No. 1490.

Williams, B. C. 1960. Fertility status of fifteen New Mexico soil types. New Mexico State Univ., Agr. Exp. Sta. Bull. 445. 18 p.

Fertility status studies were made on 15 soil types under controlled conditions using Romaine lettuce and German millet as indicator crops.

The data showed: (1) Definite need for nitrogen and phosphorus combinations to give high crop yields. This supports field information that New Mexico soils are not adequately supplied with these elements to fully supply crop needs. (2) Acutely limited phosphorus supply for crop growth in soils from the Plains area of eastern New Mexico. Other areas show less response to phosphorus alone. This may be important in partially explaining the erratic response of crops to nitrogen fertilizers applied to these soils without phosphorus. (3) Adequate potassium supplying power of New Mexico soils. Use of this element, however, must be considered for special crops and especially on sandy soils where the potassium content is low or possibly when the soils are high in lime. (4) Increased uptake of nutrients by plants with application of the elements to the soil. (5) That presence of lime obscures the relationship between crop yield and chemically determined nitrogen and phosphorus in the soil and factors such as pH and organic matter content which in part govern availability of these nutrients to the plant. (6) Application of these results for general predictions of crop response in the field can be made, although yield prediction equations must await completion of studies on more soil types over the state.

Abstract No. 1491.

Williams, G. J. III. 1971. Producer function on the Intensive and Comprehensive Sites, p. 125-131. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

The IBP study of grassland ecosystems in the United States has included an extensive study of producer function. This study has been focused on the areas of photosynthesis, respiration, translocation, and growth of grassland species. In 1970 studies it was found that sods in which *Bouteloua gracilis* predominated had CO_2 fixation rates of 652 mg/m^2/hr (corrected for dark respiration). Studies of laboratory grown seedlings of *Bouteloua gracilis*, *B. hirsuta*, *B. curtipendula*, *Andropogon saccharoides*, *A. scoparius*, *A. gerardi*, *Panicum virgatum*, and *Sorghastrum nutans* had CO_2 fixation rates that varied from 16.42 mg CO_2/g dry weight/hr to 4.71 mg CO_2/g dry weight/hr (corrected for dark respiration). These rates did not fit a pattern correlated to tall-, mid-, or shortgrass types; and all eight of the species had CO_2 compensation points that placed them into the C_4 pathway. Growth temperature curves for *Bouteloua gracilis*, *Agropyron smithii*, and *Buchloe dactyloides* seedlings grown under controlled conditions coupled with data indicating the pathway type of these species indicate that pathway type (C_3-C_4) can be useful to predict the temperature growth relationship of a species. Measurements of abiotic parameters have also been useful in interpreting producer function. Sunlight interception measurements of herbage plants have been correlated with diurnal rhythms in photosynthesis as the time of lowest photosynthesis is the same as least intercept of incoming radiation (midday). The data produced in 1970 have not only been useful in adding to the knowledge of producer function but have shown the advantage of integrating the research of multidisciplinary groups.

Abstract No. 1492.

Williams, T. A. 1896. Renewing of worn-out native prairie pastures. U.S. Dep. Agr. Div. Agrostol. Circ. 4. 4 p.

Throughout the prairie regions of the West one frequently sees native pastures nearly devoid of grass and often grown up to weeds of various kinds.

Such a condition of things is usually due to two causes, drought and overstocking. While the farmer may have no control over the drought itself, he can, by a little care and foresight, put the pasture in condition to withstand it in a great measure, and he certainly can prevent the pasture from being overstocked.

The native grasses are hardy and are adapted to the natural conditions which prevail on the prairies. Some species stand grazing much better than others, and after a pasture has been used for several years it will be found that the weaker grasses are giving way to the stronger ones.

As a rule, the forage obtained from the average prairie pasture is furnished by a comparatively small number of species. In the more thickly settled portions of the great prairie states big blue-stem, bushy blue-stem, the wheatgrasses, switch grass, prairie June grass, wild rye, blue joint, and the various species of *Stipa*, *Poa*, and *Bouteloua* furnish most of the native pasturage.

Abstract No. 1493.

Wills, D. L. 1968. Observation of Swainson's Hawk near New Raymer, Colorado. Colorado Field Ornithol. 4:15.

On September 15, 1968, five miles west of New Raymer, Colorado, I observed an estimated 100 to 150 Swainson's Hawks (*Buteo swainsoni*) of all color phases. They were resting on a green winter wheat field. As I stopped to observe, several began to fly, circling until they would catch a convection current. Riding it upward, they gradually moved off to the southwest.

Abstract No. 1494.

Wilm, H. G. 1941. Methods for the measurement of infiltration. Amer. Geophys. Union, Trans., 22(3):678-686.

By means of the group of studies which has been described and analyzed, it is hoped that several useful facts have been demonstrated.

In the first place, infiltration rates are characteristically variable. Judging from the relative magnitudes of measured variances of adjusted averages, the largest part of this variation occurs between sites in a single plant-type, and a smaller amount of variation may be charged to errors of instruments and technique.

As to the instruments themselves, any of the four infiltrometers can be expected to give only relative estimates of true infiltration. For some reason, perhaps associated with differences in distribution of applied water, the type-F instrument gave results higher than rates obtained with the three smaller instruments, which agreed relatively well among themselves. It is believed, however, that any of these four infiltrometers should give satisfactory estimates of relative infiltration rates.

Perhaps the result of greatest consequence in this investigation is its demonstration of the reduction of experimental errors by the measurement and analysis of important concomitant factors. In this particular environment and of all the factors measured, rainfall-intensity appeared to exert the greatest influence upon infiltration. In other regions, other factors may be found important; in any case, it is imperative that measurements be taken of all significant variables in every study or survey of infiltration. By a relatively small amount of additional field work on each plot, the errors of individual measurements may be so greatly reduced that actually less plots may be needed for the whole survey than would otherwise be required; and the results will actually exhibit a materially greater degree of reliability.

Abstract No. 1495.

Wilm, H. G. 1943. The application and measurement of artificial rainfall on types FA and F infiltrometers. Amer. Geophys. Union, Trans., 24(2): 480-484.

In field-use of the types FA and F infiltrometers, some difficulties have been experienced in the consistent and uniform application and accurate measurement of artificial precipitation. Because consequent inaccuracies in computed infiltration rates seemed undesirably large, it was considered desirable to work out improvements in existing equipment and to test a number of methods for measuring rates of water applied with the improved instruments. Accordingly, studies were organized to accomplish three main objectives:

1. To review all practical suggestions for the improvement of both instruments and to incorporate them into the existing infiltrometers so as to provide instruments as free as possible of ordinary inaccuracies in water-application.

2. To test the shape and stability of rainfall-patterns applied with the improved equipment and to estimate the effect of variations in plot-slope and rainfall-rate upon shape and stability of patterns.

3. To evaluate the merits and accuracy of several methods of measuring rates of rainfall and to show how the accuracy of selected methods is affected by variations in plot-slope, rainfall-rate, and other factors.

Abstract No. 1496.

Wilson, C. C., W. R. Boggess, and P. J. Kramer. 1953. Diurnal fluctuations in the moisture content of some herbaceous plants. Amer. J. Bot. 40:97-100.

A study was made of the diurnal fluctuations in the moisture content of the roots, stems, and leaves of sunflower and amaranthus plants. The moisture content of the leaves reached a minimum during the afternoon and attained a maximum between 12 and 4 AM. The appearance of the maxima between midnight and 4 AM is possibly a result of changes in dry weight upon which the moisture content was based, rather than a change in the absolute amount of water in the tissues. The moisture content of the roots and stems reached a maximum between 6 and 10 AM and during the remainder of the day paralleled fairly closely the water content of the leaves. Root pressure possibly is a significant factor in supplying the roots and stems with water during the early morning, but is considered to be a negligible factor when tensions are developed in the plant.

Abstract No. 1497.

Wilson, C. P. 1931. The artificial reseeding of New Mexico ranges. New Mexico Agr. Exp. Sta. Bull. 189:3-37.

Where there is control of the range many of the New Mexico ranges can be improved by artificial reseeding.

The results so far accomplished indicate that chamiza (*Atriplex canescens*), blue grama grass (*Bouteloua gracilis*), and in the colder sections smooth brome grass (*Bromus inermis*) are among the most promising species for artificial reseeding in this state.

As a rule, artificial reseeding in this state, especially where there is much vegetation already on the land, requires plowing or similar preparation of the soil before planting. At least one or two cultivations may also be essential during the fore part of the growing season for weed control. Plot tests and the experience of stockmen indicate that some of the New Mexico ranges can be materially improved, however, merely by broadcasting chamiza or blue grama grass seed with little or no soil preparation.

The seeds of many New Mexico range forage plants germinate considerably better than generally supposed.

During the rainy season, a stand of some of the most valuable species can usually be obtained with little difficulty, but at the lower altitudes of southern New Mexico all of the young plants generally die during the drouth of the following spring or early summer. The seeds of chamiza and winter fat germinate during fall and winter and many of the seedlings, especially of the chamiza, if on suitable soil, survive such drouths.

The depredations of rabbits and several other species of rodents often interfere seriously with reseeding of badly overgrazed ranges. This is especially true when attempts are made to reseed small areas.

Abstract No. 1498.

Witkamp, M. 1971. Soils as components of ecosystems. *In* R. F. Johnston [ed.] Annu. Rev. Ecol. Syst. 2: 85-110.

In the following pages I will present results of the last few years of study of the mechanisms, the ecology, and the analysis of mineral flow through soils. Forest ecosystems are emphasized because their mineral cycles are usually more closed than those found outside the forest. Particularly in mature stands there is great year-to-year continuity. Thus forests offer excellent sites for cycling studies. In addition, understanding and subsequent maintenance or enhancement of mineral turnover in forests is of more importance than in most other "production" ecosystems, such as grasslands and fishponds, where fertilizer amendments are commonly used to raise productivity and compensate for harvest outputs.

Emphasis will be on nutrient supply because productivity is more often checked by mineral availability than by lack of energy input. In many natural ecosystems, especially in forests, mineral supply depends on remineralization of chemical elements that are returned to the soil in organic plant and animal debris. Therefore much of the discussion will center around recent additions to our knowledge of litter decomposition and nutrient remineralization.

There exist three main approaches to the study of mineral transfer in soils. The approach of soil chemistry focuses on chemical and colloid chemical reactions between mineral elements and the soil with its adsorbtion complex. The emphasis is on the chemical state and availability of the elements for subsequent plant uptake. This approach is very much at the molecular and soil particle level. At the other end of the scale is the hydrological approach which sees water as the principal mover of soil nutrients. Studies are preferably at the landscape and watershed level. Many of the mineral transfers between the various forms of input and output are treated as mass transport by flow, diffusion, and assorted black boxes for root uptake, weathering of rock, and biological remineralization. Root uptake of minerals is well documented in plant physiological literature, whereas weathering of rock has a place in geochemistry. Biological remineralization, on the other hand, has been studied in a variety of disciplines such as forestry, agriculture, microbiology, entomology, ecology, and pedology. Usually certain segments of the complex sequence have been studied separately, and few results of integrated studies of the entire "biological remineralization" black box have been published thus far. The main processes connected with biological remineralization are nutrient input, fragmentation and some transportation by the soil fauna, chemical decomposition and remineralization by the soil microflora, and output via root uptake. This edaphic segment of the biological cycle continuously interacts with aspects of soil chemistry and the hydrologic cycle. Space and the adsorbtion complex function primarily as a rather static storage pool for minerals, whereas the hydrologic cycle tends to move minerals and bypass biological compartments. This report will mention some of the recent findings on compartments and transfer pathways in the edaphic part of the mineral cycle.

Abstract No. 1499.

Woestemeyer, I. F., and J. M. Gambrill. 1939. The westward movement. Appleton-Century Co., Inc., New York. 500 p.

The subject of this book is the long-continued flow of population toward the frontiers of settlement, the influences that lured people there, and the progress of changing frontiers of culture. The nature of this interesting and important social process is illustrated in many of its aspects by a varied collection of contemporary writings and pictures, supplemented by a few secondary narratives of special value. These materials are selected from biography and autobiography, exploration and travel, several types of historical narrative, legal documents and official correspondence, gazetteers and directories, handbooks and guides, fiction and verse, legends and folk-lore, and personal letters. They are drawn from books, periodicals, newspapers, pamphlets, and the collections of learned societies, many of them long out of print, while some are from manuscripts hitherto unpublished.

These materials have been grouped in three main divisions: the first to exhibit the various attractions that lured men to the frontiers of settlement, the second to tell the story of the continuous spread of population that filled the continent, and a third to picture the chief aspects of the economic and social development which accompanied this movement and the shifting center of population.

Abstract No. 1500.

Wohlrab, G., R. W. Tuveson, and C. E. Olmsted. 1963. Fungal populations from early stages of succession in Indiana dune sand. Ecology 44(4):734-740.

The most common pattern of succession observed in the most recently active dunes along the southern shore of Lake Michigan is the formation and stabilization of dunes by *Ammophila breviligulata*, its decline after stabilization, and its eventual replacement by *Andropogon scoparius* var. *septentrionalis*. The distribution of fungi in two adjacent communities which represent these two stages has been recorded. A relatively rich fungal flora was found, but it contained few species that appeared to be confined to the dune habitat. Significant differences in the composition of the fungal flora were found to exist in the two communities. This suggests that a succession of species, comparable to that of higher plants, occurs in the fungal populations of these areas. In addition, many species were isolated from only a single sample. Their activity in the sand is not known.

Abstract No. 1501.

Wolff, D. N. 1970. Grassland infiltration phenomena. U.S. IBP Grassland Biome Tech. Rep. No. 54. Colorado State Univ., Fort Collins. 125 p.

The infiltration of precipitation into grassland sites, especially rangelands, is a critical factor in maintaining vigor of the plant cover. Infiltration rates on grassland sites are affected by numerous interacting phenomena of the soil, atmospheric, and vegetation systems. A review of infiltration literature including the processes involved, factors affecting it, and methods of measurement is presented. Infiltration data collected on a wide variety of grassland sites is summarized by geographic region, range condition, and soil index and is represented in tabular form.

On the typical grassland areas range condition exhibits a greater control over infiltration values than does soil influences. However, the reverse situation occurs in semi-arid regions where vegetation is characteristically sparse. The average (P = 0.5) 1-hr storm is capable of being infiltrated on practically all range sites studies. Good and excellent condition ranges can generally accommodate the average (P = 0.5) 10-minute duration storm without producing too much runoff.

Abstract No. 1502.

Wolters, G. 1967. Characteristics of the growing-season microclimate of mixed grass prairie in western North Dakota. Ph.D. Thesis, North Dakota State Univ., Fargo. 160 p.

The study was conducted to secure quantitative microenvironmental data from the mixed-grass prairie of southwestern North Dakota and to characterize the microenvironment associated with this prairie.

Data was collected within a 9-ft profile, from 5 ft above the soil surface to 4 ft below the soil surface, from early June to mid-September during 1962, 1963, and 1964. Microenvironmental factors measured include air temperatures, soil temperatures, and relative humidity readings taken at hourly intervals, air movement from 0800 to 1800 hours and from 1800 to 0800 hours daily, daily evaporation from black and white atmometer bulbs, soil moisture at weekly intervals, and precipitation after each occurrence.

Temperature was determined at 1, 3, 6, 12, 24, 36, 48, and 60 inches above the soil and at 0.5, 1, 3, 6, 12, 24, 36, and 48 inches below the soil surface. Anemometers were positioned at 6-, 12-, 36-, and 60-inch heights. Evaporation was measured at 6, 12, 24, 36, 48, and 60 inches, and soil moisture was determined at 0 to 6, 6 to 12, 12 to 18, 18 to 24, 24 to 36, and 36 to 48 inches below the soil surface.

Phenological measurements of the dominant grasses were made at weekly intervals during the study and forage production, basal cover, and relative cover were determined in August annually.

The following comparisons were made by statistical analysis: differences in average, maximum, and minimum air temperature, soil temperature, and relative humidity due to distance above or below the soil surface, hour of day, period of summer, and year; differences in air movement due to height above the soil surface, period of day, period of summer, and year; differences in evaporation due to height above the soil surface, atmometer bulb color, period of summer, and year; difference in available soil water due to week and year; and difference in forage production due to year.

The degree of association between all possible combinations of air temperature, soil temperature, relative humidity, air movement, and evaporation was determined.

Fluctuations in air temperature, soil temperature, relative humidity, air movement, evaporation, and available soil moisture by weekly intervals are described.

Growth of vegetation determined at weekly intervals is discussed. Changes in basal cover and relative cover of vegetation are described.

Abstract No. 1503.

Wood, T. G. 1966. The fauna of grassland soils with special reference to Acarina and Collembola. New Zealand Ecol. Soc., Proc., 13:79-85.

Soil animals may be classified into various categories depending on size, degree of dependence on the soil, mode of locomotion, or life form. The first is the most widely used and a simple division is into micro-fauna (0.001 mm to 1 mm), meio--or meso--fauna (0.1 mm to 10 mm), and macro-fauna (over 10 mm). The micro-fauna includes protozoa, nematodes, tardigrades; the meso-fauna, mites, collemboles, enchytraeids; and the macro-fauna, earthworms, molluscs and many insects, myriapods and spiders. This classification is obviously arbitrary, and some groups (e.g., spiders) have representatives in more than one category.

Grassland soils contain many individuals and many species from each of these groups. Acari and Collembola are generally the most abundant arthropods, and in this paper their ecology will be considered with particular reference to their population density, communities, and role in certain soil processes.

Abstract No. 1504.

Woodmansee, R. G., and L. D. Potter. 1971. Natural reproduction of winterfat (*Eurotia lanata*) in New Mexico. J. Range Manage. 24(1):24-30.

In situ ecological factors influencing the natural reproduction of the important Western browse species winterfat (*Eurotia lanata*) were investigated in central and west-central New Mexico from summer 1967 to spring 1969. Seed of winterfat germinated in late winter and early spring on all slopes and in soils varying widely in origin and texture. Survival was greatest on disturbed soils which supported low vegetation that afforded some shelter but little shading for seedlings. The disturbed soils indicated greater moisture availability. Seedlings were tolerant to competition and were often found in living clumps of grass. A comparison of vegetation on heavily grazed and protected ranges indicated winterfat was susceptible to heavy grazing and reproduced when on protected or lightly grazed range dominated by low-growing grasses.

Abstract No. 1505.

Woodruff, N. P., and A. W. Zingg. 1952. Wind-tunnel studies of fundamental problems related to windbreaks. U.S. Soil Conserv. Service Tech. Paper 112. 25 p.

Wind-tunnel tests were conducted to obtain fundamental information on problems related to windbreaks.

Three known geometrical shapes of barriers and a model tree windbreak were utilized to evaluate the effect of shape on flow patterns. Wind-tunnel data are presented on the effect of barrier shape on flow patterns, similarity of flow patterns, and the zone of influence of single barriers of different shape. These results are also extended to atmospheric conditions. Pitot-tube measurements of horizontal velocity, velocity-profile maps, streamlines of flow, and shear patterns are employed to describe the flow about the objects.

Abstract No. 1506.

Woodruff, N. P., and A. W. Zingg. 1955. A comparative analysis of wind tunnel and atmospheric air flow patterns about single and successive barriers. Amer. Geophys. Union, Trans., 36(2):203-208.

Atmospheric wind velocities were measured aft of a single and a series of three successive snow fences and compared to velocities measured aft of models of the fences placed in a wind tunnel. Results indicate the wind-tunnel approach gives a reasonable estimate of the effectiveness of full-scale surface barriers under atmospheric conditions. It is also shown that a series of three successive barriers is not enough to obtain a beneficial accumulative ground effect. A general lessening of velocity with distance traveled over the successive barriers indicates, however, that an accumulative effect might be obtained in a system containing a larger number of successive barriers extending for a great length. The barriers are shown to increase the velocity fluctuations of the wind from two to nine times at different locations aft of a single barrier. Maximum fluctuations in a series of successive barriers were found to occur at the 0.5-ft elevation aft of the second barrier.

Abstract No. 1507.

Woolfolk, E. J. 1945. Some observations of Lark Buntings and their nests in eastern Montana. Condor 47:1-128.

The Lark Bunting (*Calamospiza melanocorys*) is one of the most common summer birds in eastern Montana. The males arrive first each spring in the vicinity of Miles City. They come early in May and the females appear in numbers a few days later. Large flocks are maintained for a short time, usually until late May, when the birds disperse preparatory to nesting. The fall migration from this vicinity begins in early September. Small groups composed of both sexes and all ages gather for a few days, then disappear until the next spring.

During the summer of 1944, 18 nests were found and observed on the pastures at the United States Range Livestock Experiment Station near Miles City. All these nests were located on the ground near or under sagebrush. The three species of *Artemisia* most common to eastern Montana were sought as nesting sites. Ten nests were in the shelter of big sagebrush, *A. tridentata*, five were near bushes of silver sagebrush, *A. cana*, and three were protected by fringed sagebrush, *A frigida*. Even though several other browse species were common on the area, nests were found only in the protection of sagebrush plants.

Abstract No. 1508.

Woolfolk, E. J. 1949. Stocking northern Great Plains sheep range for sustained high production. U.S. Dep. Agr. Circ. 804. 40 p.

The northern Great Plains constitute one of the most important range areas in the United States for the production of wool, feeder lambs, and replacement breeding ewes. In this region, the major range problem confronting sheep ranchers is how to stock their range (1) to get the greatest possible production year after year without deteriorating the forage and soil and (2) to permit recovery from drought within a reasonable time.

To obtain guides to proper stocking of northern Great Plains range, the Northern Rocky Mountain Forest and Range Experiment Station, in cooperation with the Bureau of Animal Industry and the Montana State Agricultural Experiment Station conducted a study of sheep grazing near Miles City, Montana, from 1936 to 1941. Three range pastures, having areas of 332, 476, and 847 acres, were established and stocked each year with equal numbers of yearling Rambouillet ewes to maintain three relative intensities of grazing. Studies of density, composition, and herbage production of the vegetation, plus surveys of utilization, periodic weights of the sheep, and observations of their grazing habits formed a basis for evaluating the three rates of stocking.

Abstract No. 1509.

Woolfolk, E. J., and B. Knapp, Jr. 1949. Weight and gain of range calves as affected by rate of stocking. Montana Agr. Exp. Sta. Bull. 463. 26 p.

A range stocking experiment with Hereford breeding cows was conducted cooperatively by the United States Forest Service, the Bureau of Animal Industry, and the Montana Agricultural Experiment Station from 1937 through 1945 at the United States Range Livestock Experiment Station near Miles City, Montana.

This experiment, designed to determine the effects of three rates of range stocking on native shortgrass range vegetation and on Hereford breeding cows and their calves, provided the basis for this publication. The record of calf weights from birth to weaning on range stocked heavily, moderately, and lightly, during the first winter in dry wintering lots and during the second summer on lightly stocked native range, has been analyzed and reported.

Abstract No. 1510.

Wooster, L. D. 1931. The present status of certain mammals in western Kansas. Kansas Acad. Sci., Trans., 34:112-113.

This paper makes note of the present numerical status of certain mammals in western Kansas. The data presented have been gathered from personal observation, county-wide round-ups, bounty records, and a few other sources indicated in connection with the items concerned.

Questions as to whether certain mammals are on the increase or decrease, or are holding their own, are of both biological and economic interest. The data herewith presented will at least show something of the present trends of animal population.

Abstract No. 1511.

Wooster, L. D. 1935. Notes on the effects of drought on animal populations in western Kansas. Kansas Acad. Sci., Trans., 38:351-352.

The drought of the past two summers has had varying effects on animal life--effects not always foreseen. It is the purpose of this report to record effects on vertebrate animals as observed in the western half of Kansas during the summers of 1933 and 1934. Two species on which the effects have been opposite are discussed particularly.

First of all, the drought has had the rather surprising effect of increasing the number of black-tailed jackrabbits, *Lepus californicus melanotis* (Mearns).

The most marked decrease in numbers observed in any mammal has been that of the meadow mouse, *Microtus haydeni* (Baird).

Abstract No. 1512.

Wooster, L. D. 1935. Rabbit drives in Kansas. Turtox News 13(5):49-50.

Western Kansas, during the winter of 1934-35 has been besieged by an army of jackrabbits. So great have been the numbers of these animals that farmers, already stricken by the depression and drouth, have feared for what little feed remained and for coming crops. As a consequence, and as the only practical way in which the thing could be done, "drives," large and small, by the score, have been held over the western third of the state through the winter, and on into the spring. Tens of thousands of jackrabbits have been killed and a few thousand have been shipped out alive to other states (to Ohio, for instance) at the request of state game commissioners.

The species which has caused all this uproar in western Kansas is *Lepus californicus melanotis* (Mearns), commonly known as the "black-tailed jackrabbit."

Why are these animals so much more numerous this year than for a number of years previously? Two reasons have been suggested, for neither of which is there absolute proof, but both of which have probably had their effect. These two reasons or causes are: first, migration from other regions; and second, low mortality of young due to two dry, warm years.

The drives have served several purposes: First, they have reduced the numbers of rabbits below what they otherwise would have been; second, the killed rabbits are all carried away and used as food for hogs and chickens which otherwise could not be maintained; third, the drives have really served as recreation for communities over a large area, where life has been rather hard and austere through the past two or three years; and fourth, they have furnished a few biologists with opportunities for observations of most interesting animal behavior, which would have been available in no other way.

Abstract No. 1513.

Wooster, L. D. 1936. The contents of owl pellets as indicators of habitat preferences of small mammals. Kansas Acad. Sci., Trans., 39:395-397.

In studies of the habitat preferences of small mammals it has been found that an analysis of the contents of owl pellets is of some significance.

During the last six years (1930-1936) the writer has carried on considerable trapping for small mammals on mixed prairie, along streams, in sandy areas, on short grass, and on tall grass areas, to determine habitat preferences. Of course, owls in their hunt for food make no sharp distinctions in habitats. Their hunting and collecting of food is done over definite habitats only, broadly speaking. But by finding owl nests in areas predominantly of one general, environmental character, helpful information has been obtained.

As is well known, owls swallow their small mammal food whole; then the indigestible portions are formed into pellets in the stomach and regurgitated. These pellets are composed largely of hair and bones. And by means of these materials the owl food can be determined.

In the present study the pellets of barn owls (*Tyto alba pratincola*) were gathered from four nests from widely scattered areas and quite different environments.

Abstract No. 1514.

Wooster, L. D. 1938. An attempt at an ecological evaluation of predators on a mixed prairie area in western Kansas. Kansas Acad. Sci., Trans., 41:387-394.

The present study is an attempt to evaluate certain animals in terms of their importance to the general animal community on a mixed prairie area in midwestern Kansas. Such a study has both biological and economic values.

The problems of conservation, game management, predator control, and rodent control can be solved with any degree of satisfaction only as we gain as full an understanding as possible of the biological, and, especially, ecological status of animal and plant life on any given area.

At the same time, such a study is of importance to our understanding of certain phases of life and its relations to environment. With these problems, both economic and biological, in mind a study has been and is being made of the ecological place of certain mammals and birds on a mixed prairie area involving particularly the relations of predatory mammals and birds to the mammals which are commonly preyed upon. This paper is a report of that part of the study which deals with the predators.

Abstract No. 1515.

Wooster, L. D. 1939. An ecological evaluation of predatees on a mixed prairie area in western Kansas. Kansas Acad. Sci., Trans., 42:515-517.

By using the three factors, number of individuals per square mile, average weight, and part of day and year available, the ecological evaluation of predatees in the mixed prairie association in Kansas gave most importance to the jackrabbit (*Lepus californicus melanotis* (Mearns)) following which in order were the meadow mouse (*Microtus haydeni* (Baird)), 13-lined ground squirrel (*Citellus tridecemlineatus pallidus* (Allen)), cottontail (*Sylvilagus floridanus mearnsi* (Allen)), and whitefooted mouse (*Peromyscus maniculatus nebrascensis* (Coues)), etc.

Abstract No. 1516.

Wooster, L. D. 1939. The effects of drouth on rodent population. Turtox News 17(1):26-27.

Investigations along various lines, such as the study of tree rings, sun-spots, and fur company records are contributing toward our understanding of fluctuations in animal numbers. The following notes may be of interest as indicating the effects of weather cycles on animal population in western Kansas as shown by census-taking methods.

During the years 1928 to 1932, inclusive, the annual rainfall at Hays, Kansas, was never less than 25 inches. The 64-year average is 22.95 inches. But in 1933 the total year's rainfall dropped to 16.26 inches and for the four succeeding years was, in effect, equally subnormal in amount.

Abstract No. 1517.

Wooton, E. O. 1916. Carrying capacity of grazing ranges in southern Arizona. U.S. Dep. Agr. Bull. 367. 40 p.

When these experiments were begun in 1903 the problems which presented themselves for solution were as follows: (1) To demonstrate that under proper treatment run-down and overstocked ranges will recover, a statement of fact that was very much doubted by stockmen when the experiments were begun; (2) to ascertain how long a time is necessary to get appreciable and complete recovery and what methods of management will produce such results; (3) to carry on reseeding and introduction experiments in the hope of increasing the total quantity of feed; and (4) to measure as accurately as possible the carrying capacity of a known representative area.

Results have already been published relating to the first three of these questions. The present bulletin presents the data on carrying capacity which have been obtained so far. The methods of making collections originally established have been continued. Hay-cutting operations have been carried on for five years, and records of the number of "animal-days" feed used on measured areas of the reserve have been obtained by recording the number of stock on given areas for a period of seven years. From the hay-cutting records and the estimates based upon the collections an estimate of the carrying capacity is made, and this is compared with the actual results obtained from the pasturing records. Some additional miscellaneous observations relating to the project are included.

Abstract No. 1518.

Wright, J. C., and E. A. Wright. 1948. Grassland types of south central Montana. Ecology 29: 449-460.

The preceding study presents the results of analyses of the vegetation in ten relict grassland communities in south central Montana. The rough and broken topography of this section results in an alternation and intermingling of the bunch grass prairie extending into the region from the northwest and the shortgrass prairie of the Great Plains.

The vegetation of these areas was classified into five types: (1) *Festuca idahoensis* type, (2) *Agropyron spicatum* type, (3) *Agropyron spicatum-Carex filifolia-Bouteloua gracilis* type, (4) *Bouteloua gracilis-Stipa comata-Koeleria cristata* type, and (5) *Bouteloua gracilis-Stipa comata* type, arranged in order from the most mesophytic to the most zerophytic.

Abstract No. 1519.

Wright, R. G., Jr. 1970. Automatic picture processing of chart quadrat maps. Southwestern and Rocky Mountain Div. Amer. Ass. Advance. Sci., April 22-23, Las Vegas, New Mexico.

This paper describes a method for digitizing the information contained on chart quadrat maps from grassland vegetation. 35-mm pictures of the data maps are processed through a flying-spot-scanner at Argonne National Laboratory. Scanner generated tapes are then used to calculate the area, center of mass, and seven moment invariants which effectively describe each vegetative shape charted. Approximately 5000 year-quadrat mappings taken on the Jornada Experimental Range have been processed in this way.

The data is then recoded with species-specific information, e.g., species, percent standing dead, through the aid of CRT plotting output to provide a digital record for each year-quadrat map. The recoded data have thus far been used only in preliminary analyses. A search program has been developed to scan each record and calculate plant life-spans and distributions. An example of these analyses and the biologic and mechanical difficulties encountered in using this type of information are presented along with plans for future analyses.

Abstract No. 1520.

Wright, R. G. [Compiler]. 1970. Scientific personnel participating in the Grassland Biome study, June 1968 through January 1970. U.S. IBP Grassland Biome Tech. Rep. No. 24. Colorado State Univ., Fort Collins. 278 p.

This report is intended to serve as a directory of all participants active in the Grassland Biome Program between June 1968 and January 1970 and those participants joining the program in January 1970. The basic entries in this report are divided into sections, each in alphabetical order, first for the senior level investigators, and then for the graduate students. All entries are written in a comparable format and contain background information on academic training and professional experience, major interest, professional activities, and all publications and technical reports. Naturally, those entries for the senior level investigators will tend to be much longer than those given for the graduate students.

Abstract No. 1521.

Wright, R. G. [Compiler]. 1971. Curriculum vitae of scientists to participate in the U.S. IBP Grassland Biome studies proposed for 1972 and 1973. U.S. IBP Grassland Biome Tech. Rep. No. 125. Colorado State Univ., Fort Collins. 266 p.

This report is intended to serve as a directory of all participants for the proposed U.S. IBP Grassland Biome studies in 1972 and 1973. All entries in this report are in alphabetical order and are written in a comparable format and contain background information on academic training and professional experience, major interests, professional activities, and all publications and technical reports. Preceding the individual vitae is an overall list of all participants contained herein, together with their formal organizational affiliation.

Abstract No. 1522.

Wright, R. G., and F. M. Smith. 1970. Grassland Biome graduate student symposium--A review. U.S. IBP Grassland Biome Tech. Rep. No. 59. Colorado State Univ., Fort Collins. 40 p.

This paper reports on the organization and results of a 2-day meeting involving 83 graduate students and technicians from the intensive and comprehensive sites of the Grassland Biome Program, U.S. IBP. The considerations and hang-ups of small group (interest area) discussions are included along with a summary of the individual critiques and evaluations submitted by the participants.

Abstract No. 1523.

Wright, R. G., and G. M. Van Dyne [Ed.]. 1970. Simulation and analysis of dynamics of a semi-desert grassland: An interdisciplinary workshop program toward evaluating the potential ecological impact of weather modification. Range Sci. Dep. Sci. Ser. No. 6. Colorado State Univ., Fort Collins. 359 p.

Ecology has long been recognized as a multidisciplinary and integrative science. It has recently been recognized that the ecosystem is a fundamental unit of study in basic ecology and that the management of renewable resources should be undertaken in an ecosystem framework. The techniques of systems ecology will be applied to solving tomorrows' resource management problems. However, such a new resource management is limited by the number of available qualified practitioners having ability to condense and synthesize a body of information about a resource problem and present it in an analytical framework useful in decision making. One of the major goals of this project was to develop, as an experiment, a workshop focusing on an ecological problem of real-life complexity and relevance and utilizing the workshop format as an educational approach. The broad overall problem selected was that of examining the ecological impact of weather modification on a semi-desert grassland range.

Generally, it was regarded that the two-week workshop, with the preparatory activities listed, was insufficient time to develop a highly mechanistic, completely valid systems model. However, a top-echelon model was developed and did run although the output reflects a great need for evaluation and adjustment of coefficients in the differential equations composing the model. The model was not developed in time and to the stage to allow detailed evaluation of potential ecological impact of weather modification by varying the climatic forcing functions within the model and examining output such as plant and animal biomass or plant cover changes. The workshop was regarded as highly successful from the standpoint of the training goals.

Abstract No. 1524.

Wright, R. G., and G. M. Van Dyne. 1971. Comparative analytical studies of site factor equations, p. 59-95. *In* G. P. Patil, E. C. Pielou, and W. E. Waters [ed.] Statistical ecology, Vol. 3: Many species populations, ecosystems, and systems analysis. Pennsylvania State Univ. Press, University Park.

This paper examines the models used for predicting forest productivity as measured by site index or tree height. These models normally take the form of multiple regression equations that relate various attributes of the site to direct measurements of productivity. A portion of the existing published equations are examined and conclusions are drawn as to the accuracy and relevance of these equations. New equations are developed and tested on original data to provide better estimates of productivity. The use of linear programming in determining the optimum site is explored and an application of this method is described. The problem of accurately recording original data is examined, and the use of forms of available data to provide assessments of site productivity is covered with a case example.

Abstract No. 1525.

Wurster, M. J., J. K. Lewis, L. D. Kamstra, and W. K. Bjorklund. 1968. Studies on the chemical composition and *in vitro* digestibility of western wheatgrass. South Dakota Agr. Exp. Sta., A.S. Ser. 68-15:77-81.

Studies were conducted at the Cottonwood Range Field Station to evaluate the effect of range condition, emergence date, plant height, and age of tissue on the *in vitro* digestibility and chemical composition of western wheatgrass.

In 1967 no significant differences were found in *in vitro* dry matter digestibility of western wheatgrass from pastures in poor range condition and in good range condition although such differences were found in previous years. Plants emerging in early spring (prior to April 15) were slightly less digestible than later emerging plants when sampled at the same date. Early emerging plants also contained more cellulose and acid-detergent fiber than later emerging plants although the difference was not significant. The effect of emergence date was not as large as expected. Apparently early emerging plants grew and matured slower than later emerging plants and therefore were only slightly digestible. In all instances digestibility declined with later sampling date.

Within the heights studied plant height did not affect digestibility of western wheatgrass plants to any great extent. Tall plants contained slightly more cellulose and acid-detergent fiber than short plants. However, the differences were not significant. Short plants contained a larger percentage of leaf tissue throughout the summer.

The first two leaves to emerge on a plant were significantly less digestible than the third and fourth leaves.

Abstract No. 1526.

Wurster, M. J., L. D. Kamstra, and J. G. Ross. 1971. Evaluation of cool season grass species and varieties using in vivo and in vitro techniques. Agron. J. 63:241-245.

Digestibility of the cool season grass species, smooth bromegrass (*Bromus inermis* Leyss), intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.) and the crested wheatgrass complex (*Agropyron sibericum* (Willd.) Beauv. and *Agropyron desertorum* (Fisch.) Shult.) was measured at heading and 2 weeks after by *in vivo* and *in vitro* techniques. In addition, plant fraction percentages and digestibilities were determined throughout the season for two varieties within each of the above species, "Manchar" and "Sac" bromegrass, "Greenar" and "Oahe" intermediate wheatgrass, and "P-27" Siberian wheatgrass and "Nordan" crested wheatgrass. Both *in vivo* and *in vitro* criteria, as well as chemical analyses, indicated that intermediate wheatgrass was lower in digestibility than the other two species. Bromegrass and crested wheatgrass differed very little; bromegrass was slightly superior under *in vivo* test, while crested wheatgrass was slightly but significantly superior when *in vitro* techniques were used. A high correlation ($r = 0.89$) was found between *in vitro* and *in vivo* dry matter digestibility.

At heading and 2 weeks after, *in vitro* dry matter digestibility indicated that Greenar was significantly superior to Oahe. No significant difference was found between the varieties of the other species. When entire plant and plant fractions were sampled over the growing season, Sac bromegrass was significantly superior to Manchar, Greenar intermediate wheatgrass to Oahe, and Nordan crested wheatgrass to Siberian. These results indicate the possibility of selecting for more highly digestible stems and sheaths to produce a variety for utilization at the time of maximum dry matter yield. For grazing purposes, however, selection at an early stage for whole plant digestibility would seem desirable.

Abstract No. 1527.

Wynne-Edwards, V. C. 1965. Self-regulating systems in populations of animals. Science 147(3665): 1543-1548.

Self-regulating systems in populations of animals. A new hypothesis illuminates aspects of animal behavior that have hitherto seemed unexplainable (Pisces, Aves, Mammalia).

Abstract No. 1528

Yater, W. M. 1971. An automatic recording field station for collecting environmental data. BioScience 21(1):11-15.

In the course of the forest ecology and soil water study being conducted by Richard L. Phipps and Clark P. Baker of the U.S. Geological Survey, Arlington, Va., it was necessary to measure soil water, rainfall, temperature, and microchanges in tree radius in several different habitats (hilltop, stream valley, etc.) of an upland deciduous forest every few hours over a period of several years. A preliminary study has shown that this data-gathering problem can be solved most economically with an automated system that records data on punched paper tape which can then be transcribed to magnetic tape for high speed computer use. As this kind of data-gathering problem is common to many other ecological and agricultural field studies, other researchers may benefit from the technique developed for this study.

To simplify instrumentation and still maintain precision, we selected or built all of the sensors so that their electrical resistance would vary over all or part of a 0 to 41,000 ohm range. This range is used because it is large enough to include the most useful part of the resistance ranges of the Bouycucos soil water blocks and Colman soil water cells, to be described later, and small enough to match the impedances in the measuring circuit closely enough for good precision. This matching of the resistance ranges of the sensors to the measuring circuit permits the same Wheatstone bridge circuit to measure all of the sensors. This is the key to the economy of the system.

Abstract No. 1529

Yemm, E. W. 1965. The respiration of plants and their organs, p. 231-310. *In* F. C. Steward [ed.] Plant physiology: A treatise. Vol. 4A. Academic Press, New York. 731 p.

In this account of plant respiration attention has been focused particularly on the changes in respiratory metabolism that accompany growth and development in plants.

There is now much direct and indirect evidence which indicates that endogenous regulatory mechanisms play an important part in the control of respiratory metabolism. High rates of respiration in young growing organs and tissues are in all probability maintained by the extensive diversion of energy and metabolites into biosynthetic reactions by way of oxidation-reduction and phosphorylation. From this standpoint, oxidative assimilation and anabolism may be regarded as closely coupled with, and as important parts of, respiratory metabolism.

Our present knowledge of respiratory metabolism in plants is in many respects incomplete both at cellular and at higher levels of organization. Many of the catabolic pathways have been effectively explored by modern biochemical and biophysical methods, but relatively little can yet be said in quantitative terms of their overall contribution to the respiratory processes. A deeper understanding of the significance of respiration in the metabolism and energy economy of plants will require quantitative information, not only of the catabolic mechanisms, but also of the anabolic systems with which they may be coupled. The unique and versatile biosynthetic mechanisms of autotrophic plants depend primarily upon their respiratory and photosynthetic metabolism. Much common ground between these metabolic systems has been revealed in the oxidation-reduction, phosphorylation, and substrate reactions of plant cells. A better understanding of the relationship between respiratory and photosynthetic processes is, therefore, an important objective in the study of plant metabolism.

Abstract No. 1530

Yeoh, H. T., H. R. Bungay, and N. R. Krieg. 1968. A microbial interaction involving combined mutualism and inhibition. Canadian J. Microbiol. 14:491-492.

A defined medium deficient in both niacin and biotin supported neither *Proteus vulgaris* nor *Bacillus polymyxa* in pure culture, but a mixed culture grew well. Presumably each can supply a vitamin requirement for the other. Continuous flow cultivation of mixed cultures exhibited oscillatory population levels of each species. *P. vulgaris* produced an inhibitor which accumulated to inhibit growth of *B. polymyxa*, and the vitamin interdependency caused the former to also cease growing. After continued pumping diluted the inhibitor, growth resumed. The inhibitor seems to be a protein, because proteolytic enzymes added to the culture gave higher, non-oscillatory population levels.

Abstract No. 1531

Yoakum, J. 1958. Season food habits of the Oregon pronghorn antelope (*Antilocapra americana oregona* Bailey). Annu. Interstate Antelope Conf., September 17-18, Sheldon Nat. Wildlife Refuge, Nevada. p. 47-59.

Data pertaining to 189 antelope rumen samples collected from 1939 to 1956 was analysed as to seasonal forage utilization. Only stomach content information from the pronghorn antelope (*Antilocapra americana oregona* Bailey) will be discussed. Bailey listed the common name of this subspecies as the Oregon pronghorn; consequently, this common name will be used in conjunction with its synonym Oregon antelope.

This study combines the findings of seven different collections, and represents a complete calculation of all known data pertaining to the Oregon pronghorn's diet. Its main objectives are to tabulate figures of seasonal forage utilization, provide a complete list of plant species eaten, and express vegetation consumption in volume percent and frequency of occurrence in percent.

Abstract No. 1532

Young, S. E., and G. K. Hulett. 1968. Emergence and growth of six mixed prairie grasses under the influence of *Yucca glauca* extract. Kansas Acad. Sci. Trans. 71:136-144.

The study investigated the effect of soapweed on emergence germination, and growth of six native grass species.

Soils treated with *Yucca* mulch and Yucca seed, and soils from around *Yucca* plants were seeded to buffalo grass, blue grama, switchgrass, big bluestem, little bluestem, and sideoats grama. Soils were collected from a common site and the grass species used, except for sideoats grama and little bluestem in the *Yucca* soil.

Data on the possible effect of steaming on inhibitory action were collected. Emergence rates indicated that steaming may lessen the inhibitory effect of *Yucca* soil.

Germination of the six grass species was determined under various leachate treatments. No germination inhibition was found under the treatments used. It was concluded that under the conditions of this study leachates of soapweed leaves do not inhibit germination of the grasses.

The length of the epicotyl and radicle of germinated big bluestem seeds, under leachate treatments ranging from 10 to 35 g of ground *Yucca* leaves per 100 ml of distilled water, was measured. Results of radicle measurement indicated that a strong retardation of growth begins at the 15 g level and remains roughly the same through the 35 g level. Results from epicotyl measurement indicate some retardation from the 20 g treatments. Conclusive evidence on this same inhibition of growth in side-oats grama and little bluestem has not been obtained, however, it is possible that a similar mechanism may account for the emergence inhibition of the latter species in soil taken from beneath *Yucca* plants.

Abstract No. 1533

Young, T. R., and G. Swartzman. 1972. Public opinion, tradition, and information of half-life. U.S. IBP Preprint No. 37. Colorado State Univ., Fort Collins. 30 p. (Submitted to Gen. Syst. J.)

The information needs of a complex society are not met by an information-flow technology invented and developed in traditional societies. This article provides a theoretical framework derived from modern systems theory by which to understand the technology of public opinion policy formation in guidance operations of a complex society. Qualitative models of information flow systems are presented together with a discussion of the kind of society each information flow technology produces. Three are considered: Tradition-based information-flow societies, managed information-flow societies (Utopian and elitist), and cybernetic issue-based information-flow societies.

Abstract No. 1534

Yount, V. A. 1971. Food habits of selected insects in the Pawnee Grassland. M.S. Thesis. Colorado State Univ., Fort Collins. 95 p.

The diets of prevalent phytophagous insects other than orthopterans were studied on the light and no grazing pastures at the IBP Pawnee Site eight miles northeast of Nunn, Colorado, during the summer of 1970.

The methods used were those of visual observation and microscopic analysis of the contents of beetle stomachs. Computer analysis in the form of plant-insect matrices were used for interpretation of the results of observations. The relative percent dry weight of the species of plants in the insect diets' and indices of preference were calculated for those beetles whose diets were studied by the microscopic technique.

Eleodes obsoleta fed primarily on *Psoralea tenuiflora* and *Oenothera coronopifolia*. *E. fusiformis* chose *Bouteloua gracilis* and *Carex heliophila* consistently. *E. extricata* had *O. coronopifolia* and *C. heliophila* as major foods. *E. hispilabris* selected *B gracilis* and *O. coronopifolia* predominantly. *E. tricostata* ate chiefly *Thelesperma megapotamicum* and *P. tenuiflora*. *Edrotes* sp. ate primarily *B. gracilis*, while *Epicauta parva* chose chiefly *Oxytropis sericea*. *Lytta* sp. selected *Sophora sericea* primarily. *Cratacanthus dubius* fed on *B. gracilis* and *Agropyron smithii*, while *Moneilema annulata* ate chiefly *Opuntia polyacantha*.

The family of insects most commonly observed feeding was Aphididae, followed by Cicadellidae, Chrysomelidae, Membracidae, and Meloidae. Cicadellidae was the insect family observed feeding in the greatest numbers on the most species of plants, followed by Chrysomelidae, Meloidae, and Formicidae. *Gutierrezia sarothrae* was the species of plant occurring in the largest proportions in the greatest number of insect diets.

Cuerna costalis was the most observed species of insect, followed by *Campylenchia latipes*, *Carpohilus pallipennis*, *Epicauta stuarti*, *Nodonota puncticollis*, and *Chauliognathus limbiocollis*. *G. sarothrae* was the species of plant occurring in the greatest number of diets of insect species, followed by *Chrysothamnus nauseosus* and *Cirsium undulatum*.

Abstract No. 1535

Yount, V. A., and T. O. Thatcher. 1972. Plant/insect interactions of selected insects at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 142. Colorado State Univ., Fort Collins. 34 p.

The diets of prevalent phytophagous insects other than orthopterans were studied on the light and no grazing pastures at the IBP Pawnee Site eight miles northeast of Nunn, Colorado, during the summer of 1970.

The methods used were those of visual observation and microscopic analysis of the contents of beetle stomachs. Plant/insect matrices were used for interpretation of the results of observations. The relative percent dry weight of the species of plants in the insect diets and indices of preference were calculated for those beetles whose diets were studied by the microscopic technique.

Abstract No. 1536

Zavesky, L. D. 1967. Soil-vegetation relationships of a blue shale-limy upland range site in Ellis County, Kansas. Fort Hays Stud. Ser. No. 7. 42 p.

The blue shale-limy upland range site is comprised of five soils, with three soils being developed from Blue Hill shale, one soil being developed from colluvial-alluvial sediments and one soil being developed from calcareous outwash materials. The soils occurred intermixed in such small areas; therefore, for practical aspects of management, they were grouped into a soil complex.

Soil 1 and 2 were dark colored regosolic soils which developed from Blue Hill shale and occurred on south and north exposures, respectively. Soil 3 was a dark colored regosolic soil which developed from outwash material while soil 4 was a dark colored lithosolic soil which developed from Blue Hill shale. Soil 5 was a dark colored soil which developed from colluvial-alluvial sediments from the shale and outwash material.

Profile descriptions were written for each soil and compared with respect to depth, color, texture, and structure.

Abstract No. 1537

Zaylskie, J., and W. C. Hicking. 1963. Protect trees from rabbits. North Dakota State Univ. Agr. Ext. Service Circ. A-410. 6 p.

Trees and shrubs in North Dakota serve effectively to protect farms and homes from wind, to control drifting snow, to beautify the country, and to provide food, shade, and shelter.

Rabbits are among the animals that are a real hazard to successful tree growth. This circular deals with the protection of trees from rabbits.

Rabbits feed on almost any variety of tree and shrub, and under starvation conditions hardly any plant escapes them. The damage to trees is of three kinds: (1) cutting down of small trees, (2) girdling of trees up to 3 inches in diameter, (3) pruning of twig ends.

Rabbit damage can be prevented by either reduction of rabbit numbers; protecting individual trees with mechanical barriers; or by the use of repellents.

Abstract No. 1538

Zeller, Deane H. 1963. Certain mulch and soil characteristics of major range sites in western North Dakota as related to range condition. M.S. Thesis, North Dakota State Univ., Fargo. (Unnumbered pages)

Fresh mulch, humic mulch, soil organic matter content, bulk density, and infiltration data were collected for 26 study areas in the mixed-grass prairie of western North Dakota during the summers of 1961 and 1962. These 26 areas represented the following seven major soil types of the region: (1) Bainville silt loam found on steep upland hillsides, (2) Farland silt loam developed on terraces, (3) Havre silt loam, an alluvial soil found along watercourses, (4) Morton silt loam, a normal soil of rolling uplands, (5) Flasher loamy fine sand developed from sedimentary sandstones and common on hilltops, (6) Patant-Moline clay loam (Solonetz) characterized by pan spots and found on gently sloping terrain, and (7) Vebar fine sandy loam, an intermediate soil between Flasher loamy fine sand and Morton silt loam. Duplicate ungrazed and grazed study areas were used for each soil type. Vegetation on all areas was in either the excellent or good condition class.

Abstract No. 1539

Zingg, A. W. 1949. A study of the movement of surface wind. Agr. Eng. 30(1):11-13, 19.

The purpose of this paper is to develop and present methods of approach to the analysis of records of wind movement with a view to obtaining a better understanding of the characteristics of the natural force encountered in soil erosion by wind. Records of wind movement obtained at Dodge City, Kansas, during a 74-year period were used for the purpose. Certain adjustments in these data were made in an attempt to make them representative of the present location of the gage.

Adjusted monthly averages of wind velocity were found to be amenable to study by probability methods.

Wind intensity-duration curves were developed for wind movement occurring during the month of April for selected years. The general pattern of these curves was found to be similar.

An average dimensionless pattern of windstorms was derived from storms occurring during the month of April, 1935. The peak of storm intensity was found to be at the midpoint of storm duration.

The results of the study indicate that the problem of soil erosion by wind may be approached analytically by methods similar to those employed in the fields of hydrology and flood control.

Abstract No. 1540

Zingg, A. W. 1950. The intensity-frequency of Kansas winds. U.S. Soil Conserv. Service Tech. Paper SCS-TP-88. 19 p.

The basic nature of problems common to the dynamic action of fluids on the land surface is cited. Studies of the phenomenon of soil erosion by wind initiated at the Manhattan, Kansas, headquarters are outlined briefly.

Experiences with the soil-blowing tunnel are discussed. Some of the aerodynamic characteristics of the tunnel developed at the Manhattan laboratory are given.

Formulas which have been applied to the description of surface wind movement are presented. Demonstrated, also, are problems common to the application of these relationships to the phenomenon of wind movement above field surfaces.

The types of soil movement and forms of erosion caused by wind are summarized, and some of the physical characteristics of several soil materials blown about and drifted into small dunes in the spring of 1948 are presented.

Abstract No. 1541

Zingg, A. W. 1953. Speculations on climate as a factor in the wind erosion problem of the Great Plains. Kansas Acad. Sci., Trans. 56(3):371-377.

The most important feature of this limited study is demonstration of the fact that the level of atmospheric wind movement tends to be high. It is doubtful, however, that the relative values of the arbitrary "index" offer more than a qualitative approach to the subject.

Studies of the recurrence interval of wind erosion indices for the Dodge City, Kansas, location show that conditions of the 30's were extremely adverse and, on the average, are to be expected at a frequency of approximately once per hundred years. Conversely, conditions of the 12-year period starting in 1941 have presented an extremely low hazard from the standpoint of wind erosion and crop production. During this period the index of wind erosion average only 78% of normal, while the level of wheat yields was approximately 37% above the long-time average.

In reviewing the record one is impressed with the fact that combinations of adverse climate come about in a short period. In both the 1890's and the 1930's the change from normal to extremely adverse conditions occurred in 1 year's time.

Abstract No. 1542

Zingg, A. W., and W. S. Chepil. 1950. Aerodynamics of wind erosion. Agr. Eng. 31:279-282, 284.

The basic nature of problems common to the dynamic action of fluids on the land surface is cited. Studies of the phenomenon of soil erosion by wind initiated at the Manhattan, Kansas, headquarters are outlined briefly.

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SUBJECT INDEX

This subject index was compiled by selecting key words from each abstract title. This method allowed cross-referencing a title in as many areas as possible. The key words were then categorized in as general a subject area as possible, while still attempting to maintain the greatest degree of utility as research tools. Therefore, in the effort to keep this index useful, yet not too specific, scientific names for plants and animals were listed in their common form only.

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