T H E S I S

FORAGE VALUE OF CHAPARRAL

- - - - - - -

submitted by

Melvin S. Morris

for the Degree of Master of Science

Colorado Agricultural College

Fort Collins, Colorado

May 1, 1932

COLORADO AGRICULTURAL COLLEGE

- - -

GRADUATE WORK

May 17, 1932

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY MELVIN S. MORRIS

ENTITLED "FORAGE VALUE OF CHAPARRAL"

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

CREDITS Twenty

In Charge of Thesis

Head of Department

Recommendation concurred in

Committee on Final Examination

Approved by

Committee on Advanced Degrees

This is to certify that Mr. Melvin S. Morris has translated for me assigned passages of technical French bearing upon his graduate Botanical work.

Head of Department of
Modern Language

ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks to Dr. Herbert C. Hanson, who suggested the problem and guided the author during the experiment.

The interest and timely suggestions of Dr. L.W. Durrell during the experiment and development of the manuscript also proved valuable.

Professor E. C. Smith carefully criticised the manuscript in preparation. Thanks are also due to the staff of the Botany Department, Professor Bodine, Dr. Howe, and Professor Kreutzer, for their assistance and cooperation in the histological and microchemical studies.

TABLE OF CONTENTS

FORAGE VALUE OF CHAPARRAL

INTRODUCTION

In Colorado there is a large acreage of woody shrubs generally termed chaparral. The foothills region of the front range of mountains which extends from Wyoming to New Mexico and extensive areas in southern and western portions of the state are covered with this type of vegetation. The value of this chaparral for forage and plant cover in areas where it occurs is scarcely appreciated. These plants have a feeding value which is an important item in the management of large range areas of the state.

The management and utilization of this type of pasture and the palatability of the different species is scarcely understood for our conditions. It is the purpose of this thesis to discuss the results of a study on the management, utilization, and palatability of the forage produced on such an area.

As the utilization and management are so closely interrelated with factors governing plant communities, the various ecological phases involved will be dealt with in order to have a fundamental basis for the economic study.

LITERATURE REVIEW

Chaparral

For uniformity with accepted nomenclature, the word chaparral is used to describe the type of vegetation in this study. It is used universally by range investigators. Chaparral refers to that group of plants which are low trees or shrubs, evergreen or deciduous. Cooper (13) states that chaparral is derived from the Spanish word "Chaparra" meaning scrub oak. In his California studies he uses it for "a shrub community or a single ecological type ---- the leaf of which is small, thick, heavily cutinized and evergreen." The deciduous shrubs are referred to as deciduous thicket. This is a distinction not made by most workers. Clements(11), (12), Vestal (55), and Ramaley (38), (39), (40), (41), have used the term to include both evergreens and deciduous shrubs. In the classification of shrub communities Weaver and Clements (60) have considered both as chaparral:

"Scrub Climax
Petran chaparral: Cercocarpus-Quercus association
Coastal chaparral: Adenostoma-Ceanothus association"

The type of vegetation to be considered is related to the Petran chaparral association. In the discussion to follow, chaparral and shrubs will be considered as

meaning the same kind of vegetation. When grazing is associated with this type of vegetation the term browse is commonly employed.

Dayton (16), in discussing important western browse plants uses the term to mean, "shoots or sprouts, especially of tender twigs and stems of woody plants, with their leaves as cropped (browsed) more or less by domestic and wild animals. Browse is also a generic term, applied to shrubby woody vine, or small tree vegetation whether palatable or not, forming one of the four main groups into which range vegetation is popularly divided, the others being grasses, grass-like plants (i. e., sedges, rushes, and their allies) and weeds (i. e., non-grass-like herbs)."

Palatability

In measuring the value of various range forage plants the term palatability or forage value is often used and will be here used in measuring the value of the various forage plants.

While it has been recognized that there are many factors involved in the palatability of forage plants, they have been scarcely used because of the difficulty in evaluating them. The most common meaning of the word has been defined (16) as, "the degree to which the herbage within easy reach of the animal is grazed when a range is

properly utilized. The percentage of the readily accessible herbage of a species that is grazed when the range is properly utilized determines the palatability of the species".

In deriving the value of the various members of the area under study, the following factors are used because of their general acceptance as indices of value. The forage plant should be: palatable, nutritious, abundant locally, extensive in its distribution, accessible (i. e., height), abundance of available herbage, resistance to grazing, reproductive ability by seed or vegetative parts, free from objectionable features as barbs, spines, poisonous properties,etc. Other factors little considered but of considerabld importance are successional value (i. e., permanency) and relation to associates.

A summary of palatability values applied to the different browse plants, by other observers, found in the study, as they occur in other sections of the range area are of interest. Those plants which are low in value will be briefly reviewed.

Mountain mahogany, Cercocarpus parvifolius, "is one of the most important species of western browse plants. It is considered to be good or excellent for all classes of livestock. The palatability is somewhat greater for sheep than for cattle and proportionately greater, as a

rule, in the fall and winter than in the summer. The leaves persist until late fall but the twigs furnish palatable feed the year long. Sampson and Malmstem (49) in studies in Utah, find that it and bitterbush, Purshia tridentata, are outstanding browse plants furnishing early spring forage before associated plants start to grow. They state (49) "too, it is unusually resistant to frost and retains its food values and palatability until late in the fall."

Mountain mahogany is rated as excellent forage for all classes of stock. With a palatability value of 40 for cattle and 60 for sheep (U. S. F. S.) it ranks second to range grasses in southwestern Utah.

Aldous and Shantz (2) state that the carrying capacity of range, where mountain mahogany predominates, is 20 to 40 head per section per grazing season.

Skunk bush, Rhus trilobata, one of the common browse plants of the region has been observed by various workers to be only slightly valuable or worthless. According to Forest Service palatability tables, in this region it is valueless to cattle and sheep.

The value of wax currant, Ribes cereum, and related members of the same genus, is indefinite as field men differ in their estimates of its value. Regional palatability tables show it to be of low value for cattle and

sheep. A value of 10 is given for both classes of stock. However, Sampson (48) from observation in Utah and the west, considers it to be good for cattle and fair for all other classes of livestock. Dayton (16) states that it has been reported to be nutritious and contains a high protein content in Nevada.

Wild rose, Rosa sayi and Rosa fendleri, are considered to be good forage plants but only of local importance. Values given are 20 for cattle and 30 for sheep.

Western chokecherry, Prunus melanocarpa, P. demissa, has received considerable attention by many workers because of its recognized poisonous properties. The Nevada Station (19), (20) and the work of Marsh (37), have made the chief contributions to the knowledge of this plant. It has some grazing value in the fall and winter when danger from poisoning is not great. The leaves of this plant are the first to drop and are gone before intensive grazing begins. By October they have lost their poisonous properties. Fatal poisoning occurs in the spring and it is at this time that poisoning may be a factor in its use. The plant is only rated poor to good as a browse plant.

False raspberry, Bossekia deliciosa, is so local in its distribution that little has been reported of its palatability and general value. Regional palatability

tables of the Forest Service indicate that it is of little value. The following Table, Table 1, is an extract from the regional palatability tables for these plants and is used in determining the grazing capacity of ranges in the region. Two common range grasses are included as a basis for comparison. The more valuable shrubs are nearly as palatable as the range grasses which would again indicate the high value of this class of forage.

Table 1.--Excerpt from U. S. Forest Service Region 2 Palatability Table.

	Palatability	
	Cattle	Sheep
Service berry, Amelanchier alnifolia	20	30
False raspberry, Bossekia deliciosa	0	0
Mountain mahogany, Cercocarpus parvifolius	40	60
Ninebark, Physocarpus ramaleyi	10	10
Chokecherry, Prunus melanocarpa	5	10
Antelope bush, Purshia tridentata	40	40
Skunk bush, Rhus trilobata	0	0
Wax currant, Ribes cereum	10	10
Rose, Rosa spp.	20	30
Buckbrush, Symphoricarpos oreophilus	20	40
Western wheat grass, Agropyron smithii	60	40
Blue grama , Bouteloua gracilis	80	80

Utilization and Management

Studies made on the utilization of deciduous browse vegetation has been very limited and quite recent. Chapline (10) and Hatton (29) working in western United States have observed in general the value and utilization of such vegetation. Chapline recognizes the importance of this vegetation as forage for various classes of stock. Hatton devoted his attention to the eradica-

tion of evergreen chaparral by goats and found that such practices are uneconomical though possible. Ingram (30) working in the Douglas fir region of the Pacific coast studied the utilization of different successional seres of which chaparral or shrubs formed a distinct stage. The value and high utilization of the type by sheep was found to be related to the position in the stage of development of the vegetation, i.e., the closer the climax was approached the more valuable the vegetation became. Shrubs do represent a high stage in development of vegetation in that region. Neither of the above men suggest management that had sufficient investigational foundation. Sampson and Malmstem (49) in Utah have found that management of such land must be based upon the development of the plants. They state that "the leaves of mountain mahogany should be three-eighths to one-half inch wide and one-half inch long before grazing begins in the spring. Where this plant dominates the area it would be the basis for management," and in this case indicate the opening of the grazing season on such areas. For the oak-brush type in Utah the following grazing periods (49) are suggested: "Spring to early summer, and late fall; May 20 to June 9, and October 1 to October 15. Forsling and Storm (21), working in south-western Utah, have made the most comprehensive study of grazing value of browse vegetation. Their results were

based on summer grazing by cattle. The vegetation consisted of considerable amounts of unpalatable shrubs species namely the oaks. They observed the preference of stock for grasses and choice weeds to palatable shrubs and unpalatable shrubs. "The trend of preference was from the first named class and in order to the others (21), (1) grasses and certain choice spring weeds; (2) birch leaf mahogany and bitter bush; (3) certain less choice weeds including lupine; (4) oak; (5) miscellaneous shrubs; (6) service berry; (7) quinine bush, and (8) sagebrush." The condition of stock under forage conditions when browse made up the bulk of the forage was good until complete utilization of palatable browse occurred. "The greatest gains by cattle occurred during May. This coincides with the period when good forage, including grasses and choice weeds together with considerable birch leaf mahogany and bitter bush and service berry, made up 67 per cent or more of the ration." They find that management should be based on the important forage plants, to insure the maintainance and vigor of these plants.

METHODS AND MATERIALS

The areas selected for study, of the plant community itself and for the grazing studies, are located in north-central Colorado.

For the extensive community studies observations were made in the chaparral belt which extends along the foothills and front slope of the Rockies in the vicinity west of Fort Collins, Colorado. Observations were made at Virginia Dale which is 40 miles northwest of Fort Collins, at Owl canyon 20 miles in a northwest direction, and at Spring canyon, College pasture and Soldier canon, all about 4 to 8 miles west of Fort Collins.

Detailed grazing studies were made in the college pasture four miles west of Fort Collins, Colorado. The area comprising some 157 acres. The west one-third of this range consists of chaparral and the east two-thirds of mixed prairie grassland (Fig. 1). The grassland occupies a level plain while the chaparral area occupies the adjacent hogbacks, which rise some 150 feet above the plain. The chaparral slope has an angle of 18 to 20 per cent and is interrupted by two north and south escarpments.

The pasture was stocked with Hereford cows and calves to a capacity of 10 acres per animal per year. The whole area was accessible at all times. Supplementary feed was occasionally given during the winter when the weather was

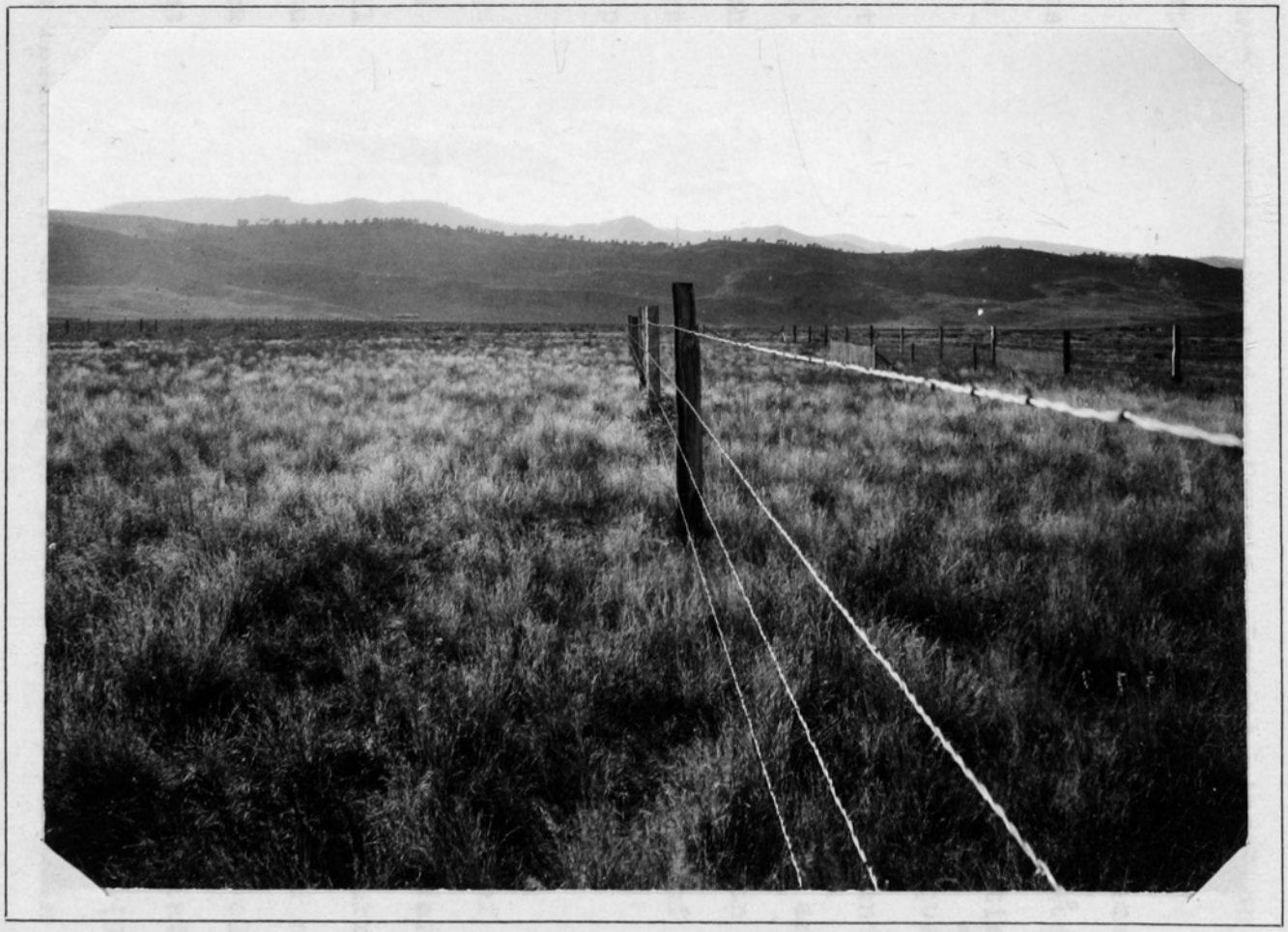


Fig. 1.--View of experimental pasture. Mixed prairie vegetation on plain in foreground. Chaparral pasture on slope of adjacent foothills. Both areas were accessible to stock throughout the year.

severe.

Plane and relief maps were made by standard methods in use by surveyors and engineers. Extent, location and purpose will be mentioned under results.

Transects were used to bring out the various factors considered. Line and belt transects described by Weaver and Clements (60) were employed with some modification.

List, count area list, count list, and chart quadrats of the major size, as described by Weaver and Clements (6), Hanson and Love (27) were used. Measurements and technique were modified by the author. Distribution and number of these sample areas varied with the type of sampling desired.

Data were obtained on the different shrubs at regular intervals in the various areas. Swelling of leaf and flower bud, rate of development of the leaf, leaf fall, full blooming, fruit maturity and dispersal, and current annual growth of stems were obtained on located and non-located plants to obtain trend in development. Development records were also taken in mixed prairie vegetation.

The technic of Eckerson (18) and Chamberlain (9), was followed in the making of free-hand and paraffin sections and chemical tests. Samples of current annual growth of the more important shrubs were selected at intervals during the period of study for examination of

lignin- cellulose relation, starch content and presence of other properties.

Typical sites of various shrubs were selected. Excavations were made and root distribution photographed.

Standard methods (28) were used to gather climatic and soil moisture data at the climatic station in the pasture. Rainfall, evaporation, soil moisture, temperature and relative humidity records were obtained during the growing season.

Geological and soils studies were made directly west of Fort Collins, along one of the extended line transects. Extent of each formation and soil depth and development were obtained by distribution of outcroppings due to natural or artificial causes, erosion and excavation.

Precipitation data were obtained from the records of the Colorado Agricultural Experiment Station (52) at Fort Collins and from Weather Bureau Climatological Data (53) sheets. Evaporation data were obtained from station records and from the Livingston standardized atmometers which were established at the field station in the pasture. Relative humidity and air temperature records were obtained from a Friez recording hygrothermograph.

EXPERIMENTAL DATA

The Structure of the Chaparral Community

The chaparral community occupies a rather extensive portion of western United States, being more marked by its wide distribution than local size.

In Colorado the deciduous chaparral is found occupying the foothill slope between grassland or sagebrush and yellow pine or lodgepole pine forest. The belts thus developed are necessarily narrow except for portions where topography and climate permit its extension.

In northeastern Colorado where the chaparral occurs between grassland and forest the diameter of the type seldom exceeds three to five miles but runs full length of the foothills. In southern and western Colorado it occurs intermediate to grassland and forest of pinon or yellow pine, or intermediate between forest or sage and coniferous woodland.

Distribution of community - In Figure 2 the distribution of the community is seen as it normally occurs in the northern part of the state. In the foreground mixed prairie grassland, Agropyron smithii, Bouteloua gracilis, Stipa viridula and other herbaceous plants are present. The chaparral, of which Cercocarpus characterizes the vegetation, is seen on the hogbacks of the lower hills.

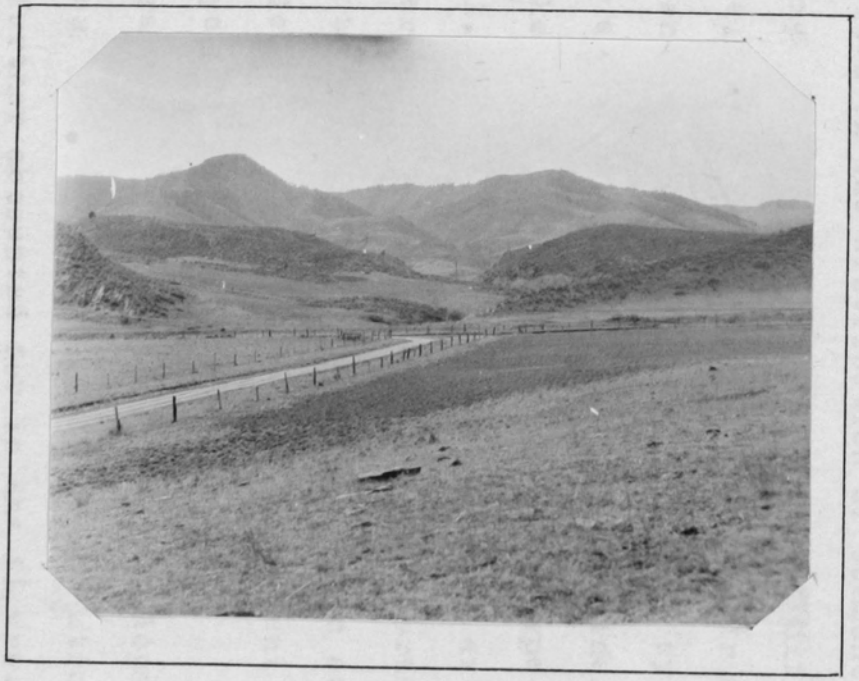


Fig. 2.--View looking west of Fort Collins, Colorado. Mixed prairie grassland occupies the foreground. Chaparral occupies the slopes of hogbacks and lower slopes of higher hills. Coniferous forest of yellow pine and Douglas fir on upper slopes.

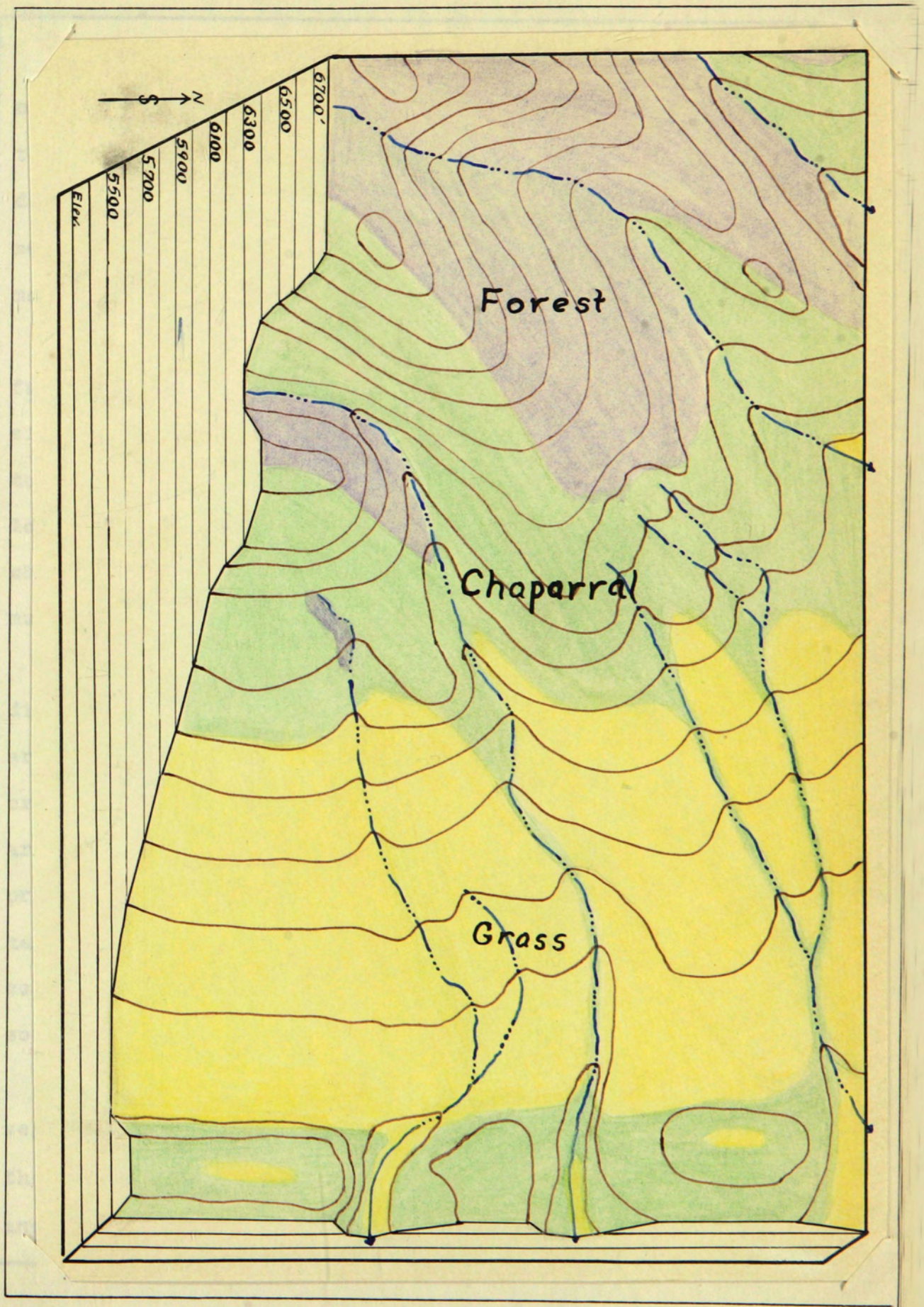
In the background of the upper elevations yellow pine and yellow pine-Douglas fir stands make up the forest cover. This relationship is more clearly seen in Figure 3, where the plant communities are shown in relation to topographic features.

Distribution in relation to topography - The most significance lies in the distribution of communities with relation to exposure rather than elevational differences. At the upper elevations yellow pine-Douglas fir forest predominates and reaches a downward extension by occupying northerly exposures. Yellow pine has a wider range in that it makes up the lower margin of the type.

Chaparral, characterized by Cercocarpus, extends upward on southerly exposures and downward on northerly exposures and along stream courses. Grassland occupies the more gentle south slopes at its upper extent and the more level topography below.

If topography is indicative of soil development as it usually is considered to be, then the distribution of types can be further accounted for in the figure. The upward extension of grassland and its extension on east and west slopes can be attributed to the development of soil surface. This can be more readily seen where chaparral occurs on the lower hills. The occurrence of the shrubs along streams is associated with the presence

Fig. 3.--Topographic map and profile of elevations in relation to the distribution of plant communities.


S
N
Elev.
5500
5700
5900
6100
6300
6500
6700'
Forest
Chaparral
Grass

of gravel and sand. This association is due perhaps to the fact that soil water is more abundant and has a greater degree of penetration. The distribution of types in relation to topographic features is no doubt due to modification of soil, soil moisture and its availability.

The nature of distribution of the community can be further seen in Figure 4. Forest land occupying the upper elevations and grassland the lower. The transition, forest to chaparral is not strongly defined except in a few localities. However, the transition or ecotone between chaparral and grassland is frequently sharply drawn and must be accounted for by soil differences which exist.

The geology of the region lends itself to such soil differences as one might expect to find. The foothills are derived from sedimentary and metamorphic rock outcrops of considerable size. The dip of these structures are various but essentially on a sharp angle. Erosional processes must necessarily result in the development of talus slope which would yield to the development of colluvial soil such as to result in a sharp transition in soil cover.

Regardless of the depth of this soil, herbaceous vegetation will develop on it. In the grassland occupying this colluvium, the soil cover is complete though shallow and maintains a complete cover of such plants as Bouteloua

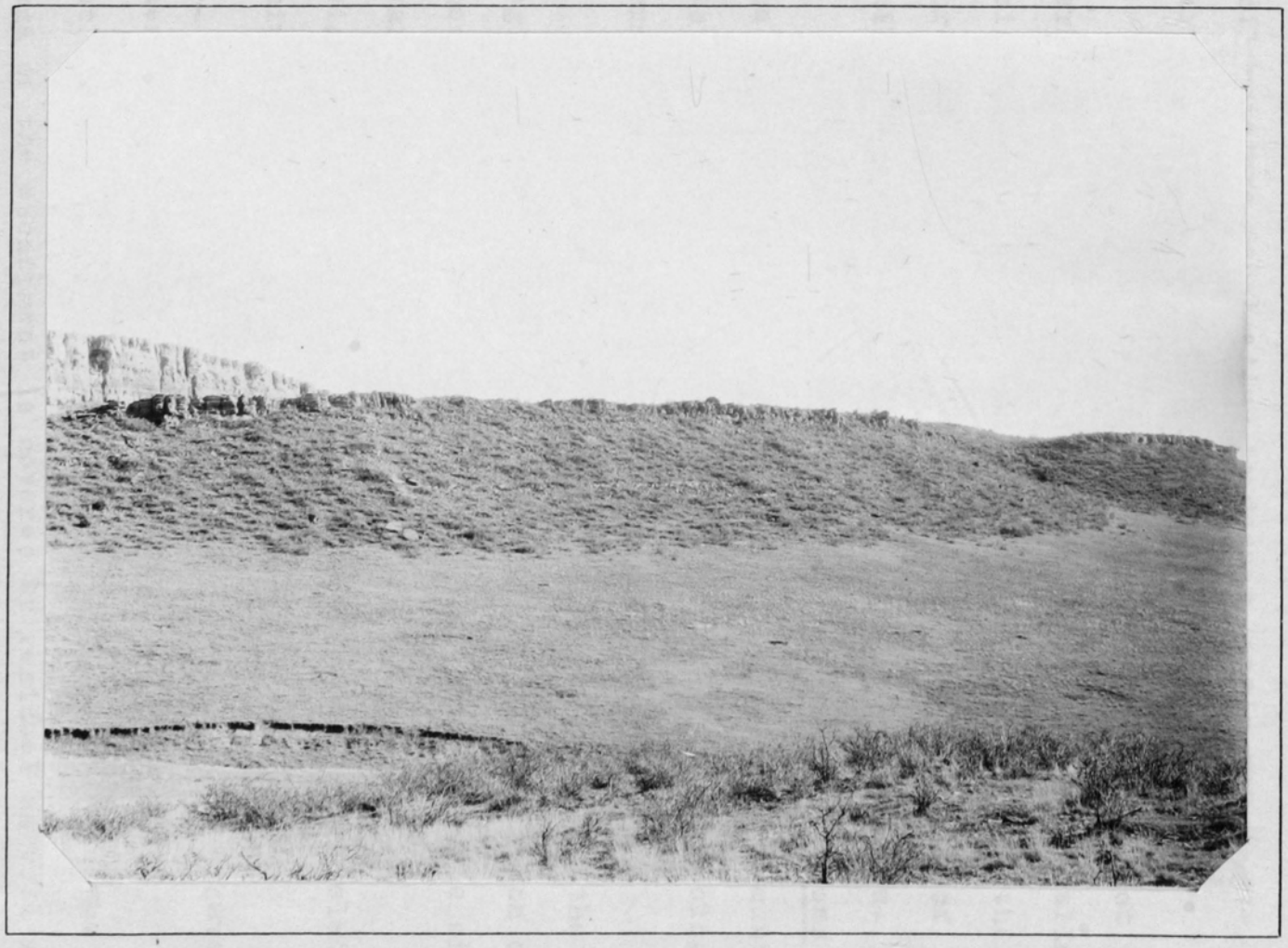


Fig. 4.--Own Canyon region, 25 miles northwest of Fort Collins, Colorado. West slope of hogback. A well defined ecotone is evident.

gracilis, Bulbilis dactyloides and other mixed prairie grasses. Such a cover would naturally prevent the development of deeper rooted plants which depend upon soil moisture penetrating to deeper levels but is retarded by the short grasses.

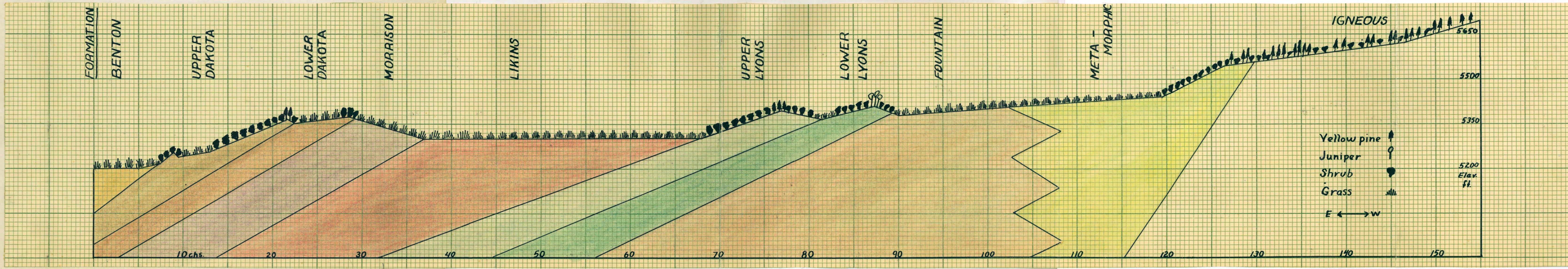
The pockety nature of soil on the slope does not permit the maximum development of grass cover or shallow moisture penetration essential in the exclusion of the shrubs. In many of the illustrations the relation of soil cover to plant distribution can be readily seen.

Distribution in relation to geological formations - The question of soil development as influencing community distribution becomes centered on the role of the geological formations present.

One viewing the geology and the vegetation of the region may become impressed by a supposed association of these two elements. The author has had the pleasure of hearing a report on such a subject by a worker in a neighboring state who affirmatively stated such a relationship.

In Figure 5 the various geological formations have been reproduced and the communities present on each included. The Benton shale is shown on the east. The face of the escarpment is covered by residual as well as colluvial material which has developed into a continuous

Fig. 5.--Distribution of chaparral and associated communities in relation to geological formation. Fort Collins region.


FORMATION
BENTON
UPPER DAKOTA
LOWER DAKOTA
MORRISON
LIKINS
UPPER LYONS
LOWER LYONS
FOUNTAIN
META - MORPHIC
IGNEOUS
5650
5500
5350
5200
Elev. ft.
Yellow pine
Juniper
Shrub
Grass
E ⟷ W
10 chs.
20
30
40
50
60
70
80
90
100
110
120
130
140
150

soil cover. It is therefore covered by the short grasses. The next structures are the Upper and Lower Dakotas, which are composed of sand grains cemented by lime materials, give rise to a limey sandstone. The soil development is pockety where topography does not permit the establishment of derived soils. Shrub vegetation can be seen occupying the dip of the structures and part of the face of upper escarpments. Grassland has developed again where topography has permitted. The face of the Morrison is here covered by colluvial soil which has covered over 90 per cent of the parent sandstone material. Grasses of the true prairie and mixed prairie are present with the exclusion of the chaparral. The Lykins formation being the sofest, has been buried by residual, colluvial and alluvial materials and is thereby covered with grassland.

The Lyons geological formations, Upper and Lower Lyons, are a sandstone with much less lime material than present in the Dakota formations. Here again the chaparral has occupied slopes which have not as yet a great development of soil. The Fountain, next in position, has a modified topographic position. It is sedimentary and can be compared with soils derived from a metamorphic base, namely gneiss and schist. It can be seen from the figure that grassland is present on the described site as one might expect. When the topography permits, on

the metamorphic and granitic structures, chaparral is again present.

If we view the profile as a whole we can readily see that elevation, and geological structure are of indirect importance to topography and subsequent soil development which can be carried to a basic factor, soil moisture.

The distribution of grass and trees illustrates the contrasts in competition for soil moisture. The restriction of forest members to the poorest soils of the ridges is due no doubt, to the greater success of their seedlings in becoming established. Figure 6, a view of a local area, will illustrate more vividly this condition. Note the presence of considerable rock material where the yellow pine occurs and the least evident where the grass is developed.

General composition - The internal structure of the community with regard to species distribution is again based on variation in soil conditions. A view of the type as a whole shows considerable uniformity in the distribution of dominants. Figure 7 illustrates an area on which chaparral reaches its maximum development. However, this uniformity is not so obvious when the community is more closely analyzed.

The composition of the type will be briefly reviewed. High frequency of distribution is confined to only one

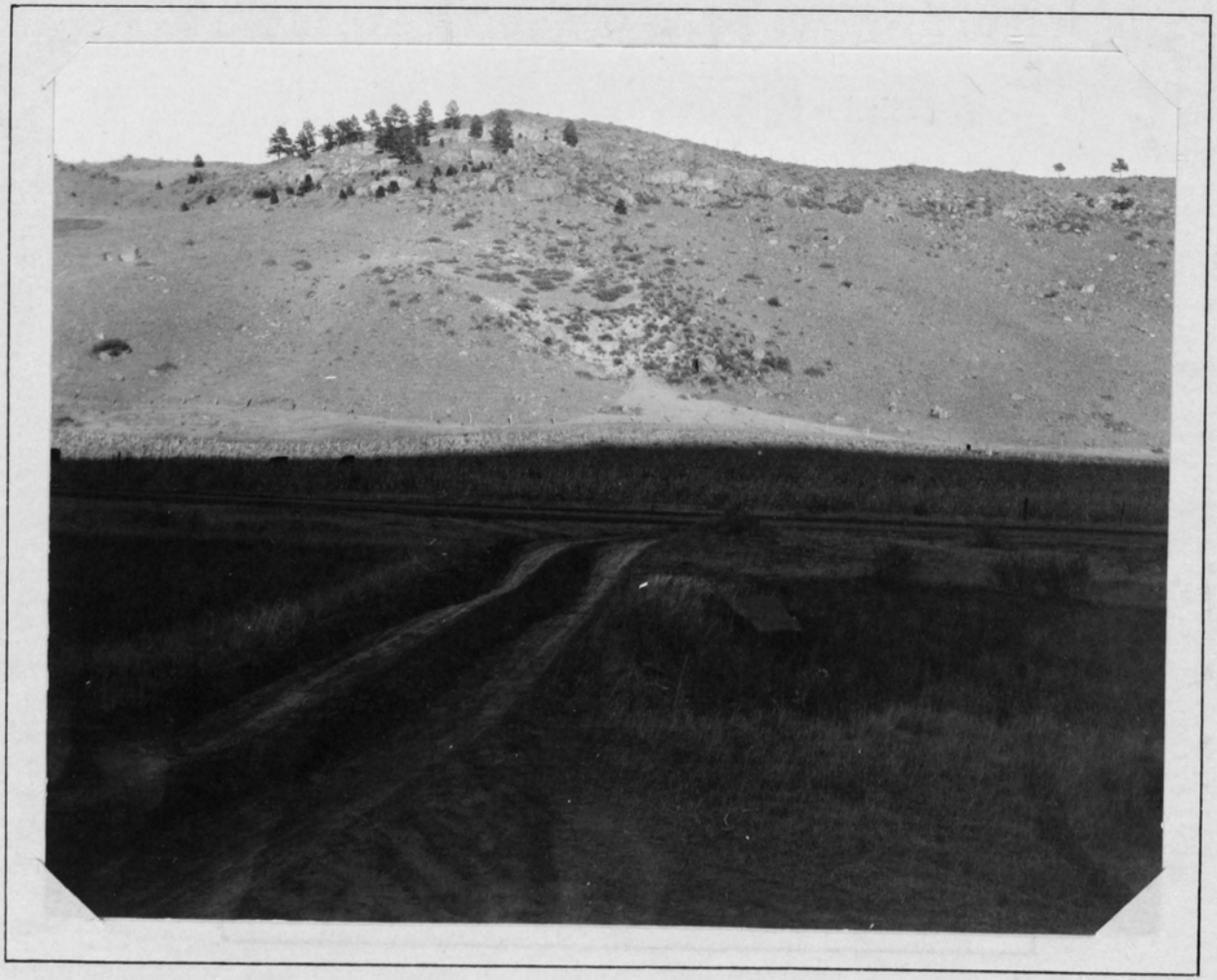


Fig. 6.--East of Empire Mine. Various stages of soil development are seen. Yellow pine occurring where out-croppings are prominent. Shrubs on area where soil cover is partly developed. Grassland dominating slope where soil cover is nearly complete.

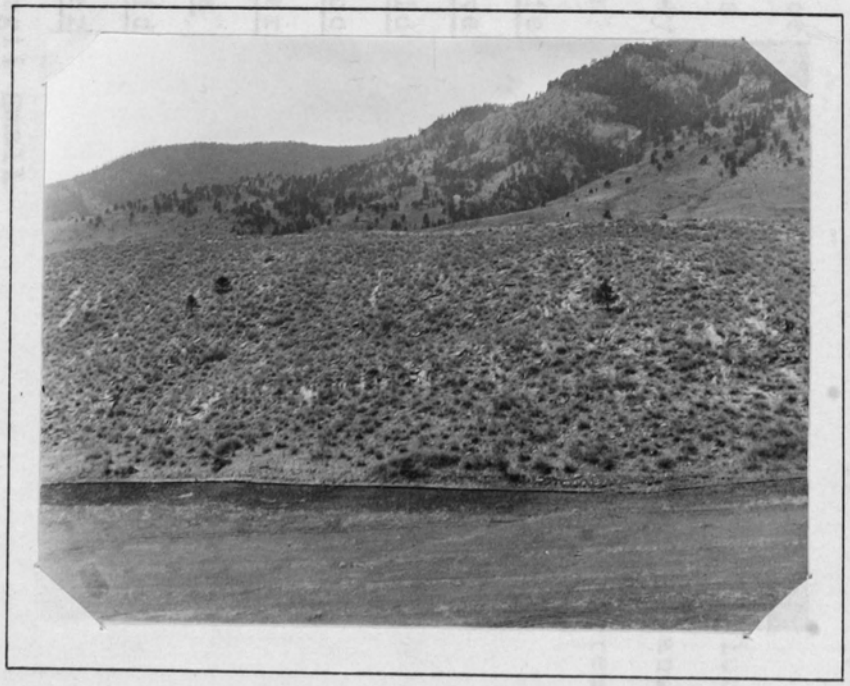


Fig. 7.--Foothills at Fort Collins, Colorado. Chaparral occupying east facing slope. Note the uniform distribution of shrubs which is typical of areas where maximum of type is reached.

species, namely Cercocarpus parvifolius. Rhus is next in frequency value followed by Rosa and Ribes. If frequency of occurrence is indicative of distribution then the chief dominant is Cercocarpus. The frequency values obtained are more illustrative of the character of the vegetation than abundance. Abundance when used supplementary to frequency enhances the latter's value.

All species common to the type were not included in the table as they did not fall in the sample areas. Those not occurring in the table are briefly listed here:

Ceanothus fendleri Gray

Ceanothus velutinus Dougl.

Celtis occidentalis L.

Crataegus occidentalis Brit.

Jamesia americana T. and G.

Physocarpus ramaleyi A. Nels.

Purshia tridentata DC.

Rosa fendleri Crepin

Rhus rydbergii Small

Ribes longiflorum Nutt.

Symphoricarpos oreophilus Gray

Of the members not found in the quadrats, two important ones are: Purshia and Symphoricarpos. They will be only briefly discussed. Purshia occurs above elevations of 7,000 feet in the region where extensive areas

are developed. At Fort Collins this elevation is reached in the yellow pine forest where it occurs as a sub-dominant and is frequently dominant on the dryer canyon slopes of the Montane forest. Cercocarpus is frequently associated with it but requires a better site for maximum development. It is then found on more moist slopes opposite to Purshia areas. In the Virginia Dale area and west Purshia reaches its maximum development for this region. The land area occupied is extensive.

Symphoricarpos is found on the best soils and like Rhus, may invade or be present in the grassland. It forms pure stands in drainage channels in this locality and will be found in the chaparral where soil and soil moisture conditions are highly favorable for plant growth. It never forms large areas in this region.

The nature of distribution of species within the type has been suggested by Table 2, Figure 17, and by the distribution of Symphoricarpos. Cercocarpus, as can be seen in Figures 7 and 8 occurs where soil development is poor. The soil is poorly developed and is confined to depressions in parent material and crevices in the material itself. Root development is well illustrated for this species by Figure 9. The plant was typical of the species in the region. Root development is evidently controlled by the rock structure. Secondary roots reach considerable

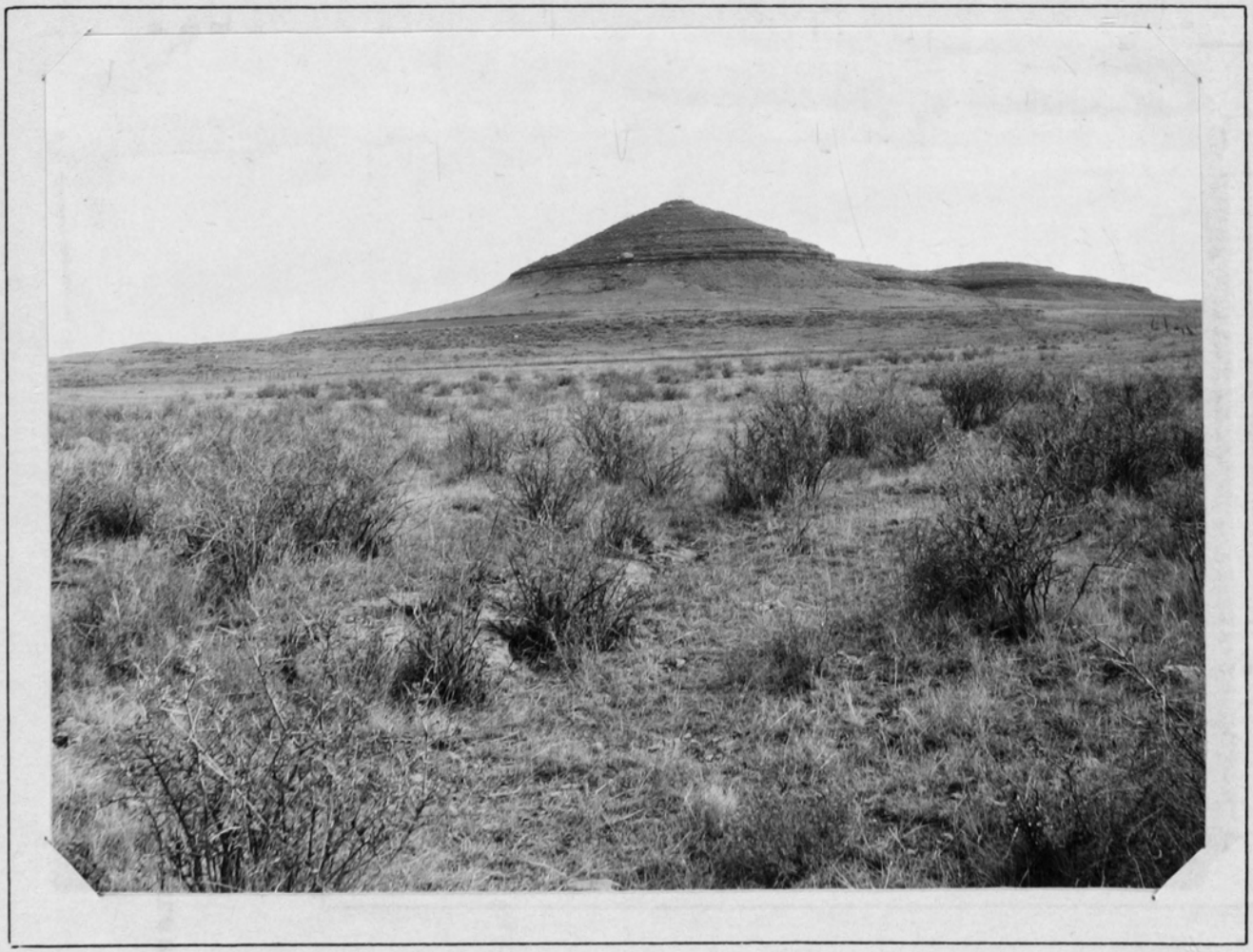


Fig. 8.---Cercocarpus on level plain. Parent material is close to surface. Soil distribution is pockety.

Fig. 9.--*Cercocarpus* on Lyons sandstone. Rock and poor soil development are characteristic of sites occupied by *Cercocarpus*. Note the development of root system following rock fractures.

development and make possible the maintainance of the species.

Such a site is also common to Bossekia, Ribes, and Prunus spp. The latter showing a wider range in site occupation. Rhus, like Symphoricarpos, occupies the best sites in the community. Where soil materials and organic matter has developed, these plants have strongly established themselves. In Figure 10 and Figure 11 the root development of Rhus and Symphoricarpos can be seen. Plant growth must be more suitable under such soil conditions than those occupied by Cercocarpus. Roots of these species have a penetration far exceeding that of the associated grasses. Penetration indicated here must exceed the depths shown by at least two or three feet. In Figure 12 the transition in soil development within the community is shown. The parent material is the Benton shale. Cercocarpus occupies the upper portion of the face where the outcropping is very distinct and surface soil is but superficial. The lower portion of the slope is occupied by Rhus where it can be seen that soil development has reached some maturity. The well defined horizons in the grass area indicate a high degree of maturity, although considerable shale flakes can be seen. The extension of grassland upward in the right of center is, of course, paralleled by the presence of more or less

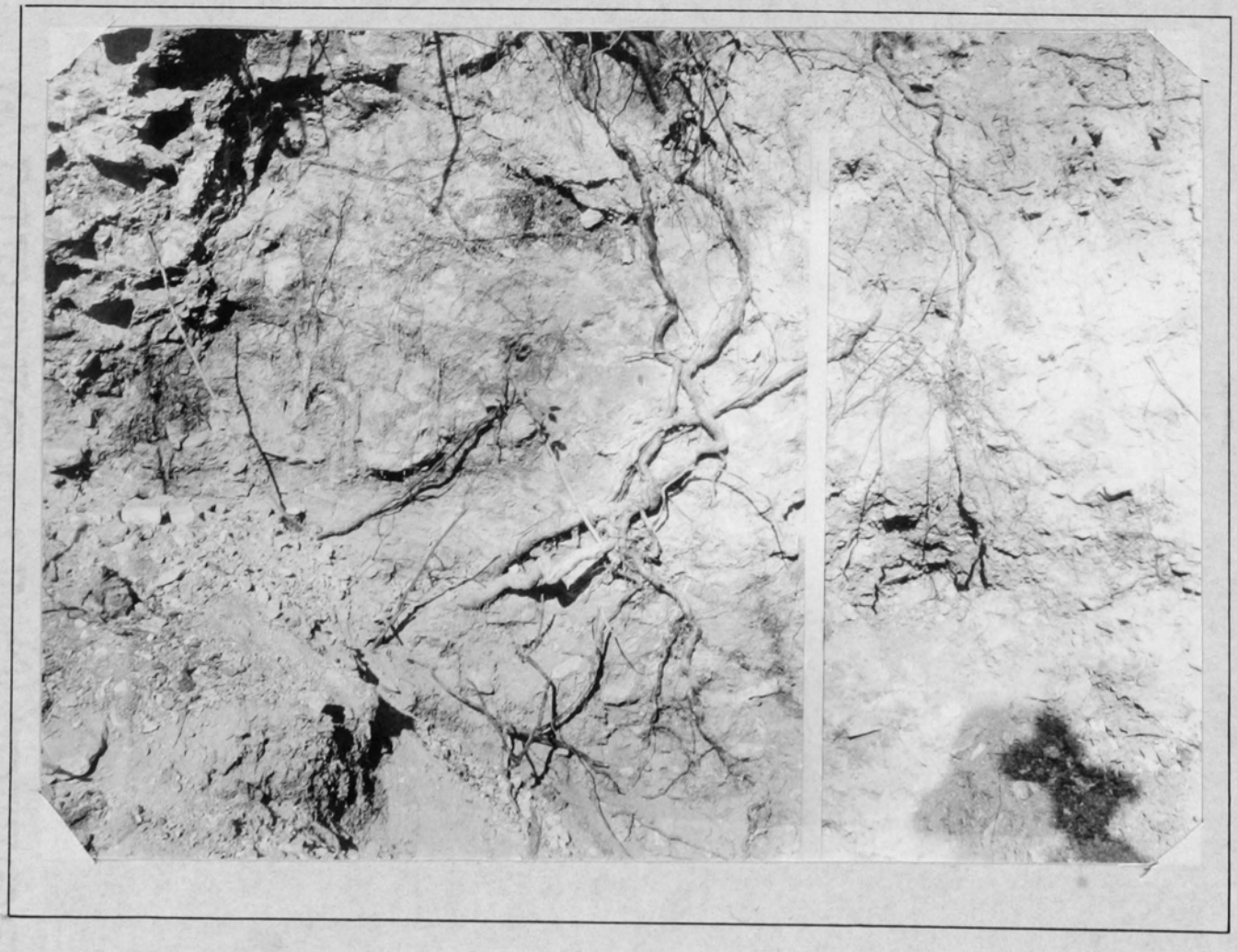


Fig. 10.--Excavation showing root development of Rhus (large roots) and Rosa (small roots). Root systems were carried to the indicated depth.

Fig. 11.--Profile of typical site for Symphoricarpos. Soil development has reached a high stage . Roots here have followed characteristic fracturing of soil.

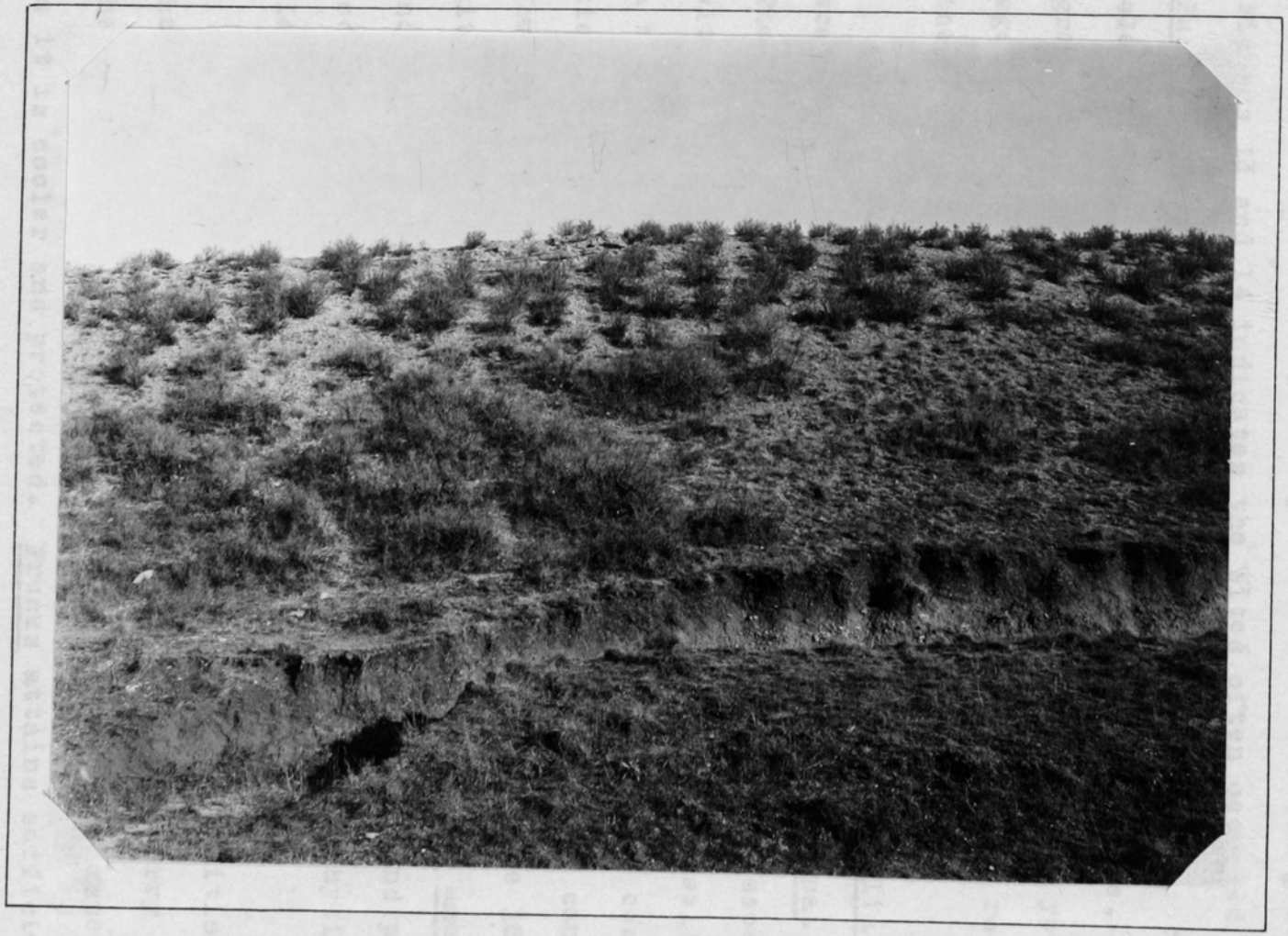


Fig. 12.---Benton shale. The dip of the structure tho not shown is occupied by Cercocarpus. The upper face of the escarpment shown is also occupied by Cercocarpus. The lower slope to the left is covered by Rhus. Mixed prairie grassland is seen in the foreground.

complete cover of soil.

A view of a gravel pit and old railroad grade in Figures 13 and 14 indicates the sites often occupied by Purshia. The high degree of sterility of this site can be clearly seen considering the age of the disturbance. The grade and excavation was established some 30 to 40 years ago. The soil materials are derived from granitic rock of the region.

Prunus melanocarpa and Amelanchier alnifolia are scattered throughout the type as is Prunus americana. Their best development in this region is closely associated with an adequate water supply. This does not necessitate a high development of soil but certain topographic conditions which will provide moisture. This condition can be found along rocky ravines of the region. In Figure 15, a site, nearly typical, for Prunus, is shown. Prunus americana and Amelanchier are also present here. Drainage and protection permit the development of these more mesophytic plants.

It is in such a site and topographic condition that heavy death losses by poisoning from chokecherry occur. Sheep will drift along lines of least resistance, especially as it is cooler and protected. Prunus attains sufficient height to provide shade which further encourages the movement of stock through the area occupied by it.

Fig. 13.--Excavation exposing disintegrated gravel. The invasion and dominance of Purshia on such sites is frequently seen in north-central Colorado.

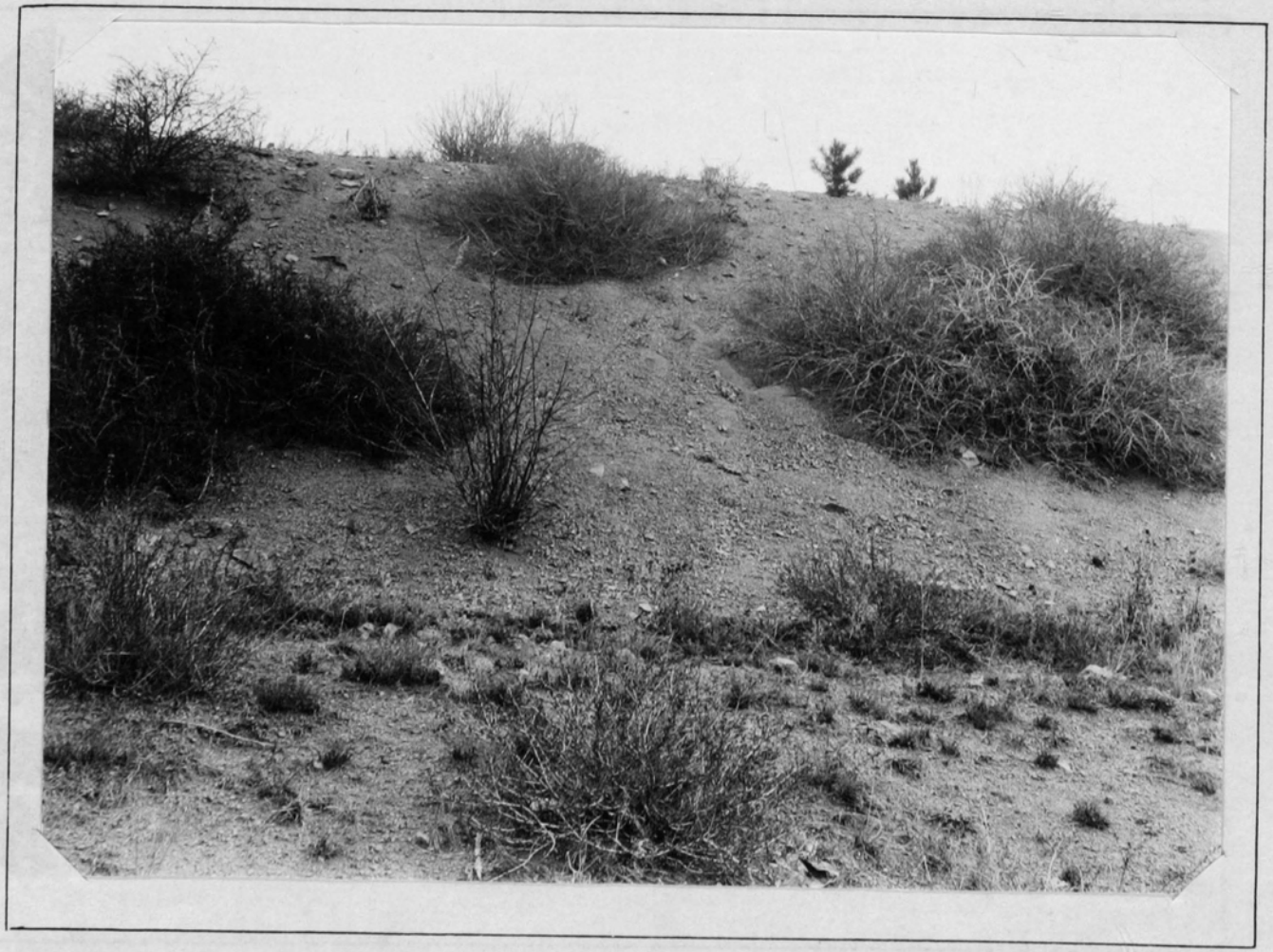


Fig. 14.--An old railroad grade at Virginia Dale, Colorado. The spreading shrub is Purshia, Bossekia occupies the center of the figure, while Ribes is in the upper left portion of the grade. Western yellow pine saplings appear above the crest of the grade.

Fig. 15.--The shrubs which predominate here are Prunus melanocarpa and Amelanchier alnifolia. Sites of this type are favorable for the development of Prunus.

Plant Composition of Experimental Pasture

Before discussing in detail the forage value of the chaparral on which the studies in this thesis were made, specific description of the vegetation is of first consideration. Detailed study of the composition of the forage species was made. In determining the best method to analyze the vegetation any one method did not seem to depict accurately the conditions. Several methods were used, namely the line transect, belt transect, major quadrat, and plane map.

Table 2 illustrates the composition of the chaparral as determined by major quadrats. The frequency values are based on 15 random quadrats aggregating 1,500 sq. meters while the abundance as expressed in area, per cent cover, and plants, was based on 10 major quadrats.

Figure 16 accompanying, shows a representative area of the chaparral used in the present study.

The dominant plant of this foothill type of forage is mountain mahogany, Cercocarpus parvifolius, and occurs on the area with a frequency value of 100, an area cover of 78 per cent, and the highest number of individuals over the whole area.

Rhus, which is considered co-dominant with Cercocarpus, certainly does not occur as such here. It is next highest in frequency and fourth in abundance which

Table 2.--Shrub composition of foothill chaparral in College pasture showing frequency, area cover, individuals, and average height.

Species	Frequency per cent	Area sq. dm.	Per cent cover	Plants	Ave. high, dm.
Cercocarpus parvifolius Nutt.	100	26,351	78.2	976	5
Prunus melanocarpa (A.Nels.) Rydberg	40	440	1.3	119	4
Prunus americana Marsh	20	1,627	4.8	130	6
Prunus besseyi Bailey	6	20	----	26	4
Rhus trilobata Nutt.	66	1,144	3.4	37	5
Bossekia deliciosa (James) A. Nels.	20	252	0.7	4	10
Rosa sayi Schwein.	46	3,268	9.07	2,782	2
Amelanchier alnifolia Nutt.	6	133	0.4	6	
Ribes cereum Dougl.	46	420	1.2	17	10
Totals		33,664	99.7		

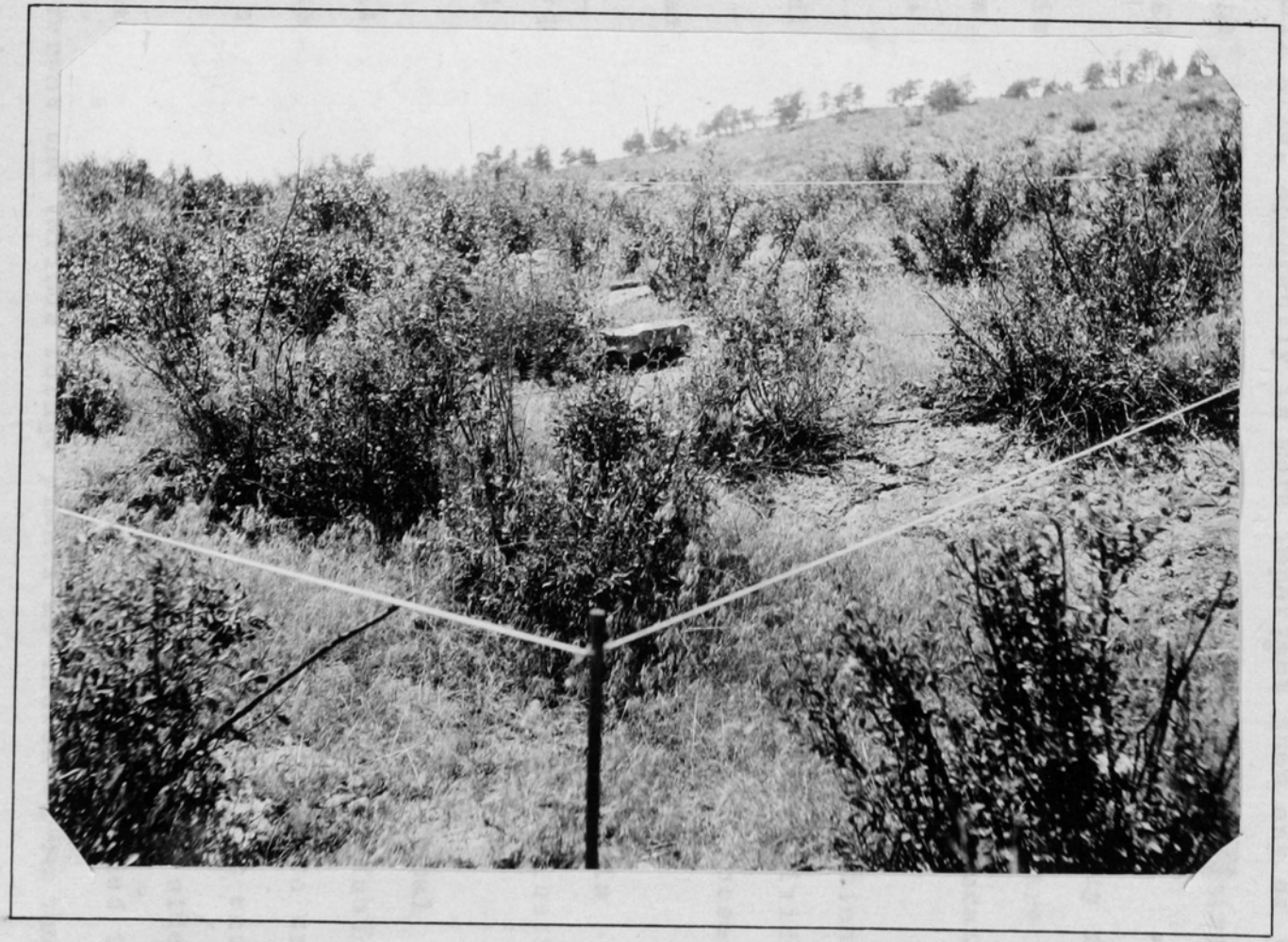


Fig. 16.--Detail of a ten-meter quadrat. Cercocarpus is the principal shrub shown. The understory consists chiefly of Bromus tectorum.

is of interest.

Rosa, which is often obscured because of its small size, apparently is more important than any of the others with the exception of Cercocarpus. It is third highest in frequency but second in abundance.

Prunus melanocarpa and Ribes are moderately distributed but do not occur very abundantly. There are very few individuals of the latter, but these are well scattered.

Prunus americana is local in its distribution as indicated by its frequency value and number of individuals.

Bossekia, next in importance, is only an occasional plant in the area and is well distributed.

Amelanchier and Prunus besseyi, both low in frequency and abundance, are purely local in distribution and insignificant as forage plants on the area.

In Figure 17 is given a diagram of a typical belt transect 160 meters long running through the foothill chaparral from base of foothill adjoining prairie to crest of hill. In this diagram the successive strips fit end to end but for convenience of illustration, are drawn side by side. In this figure the vegetative areas are shaded to represent the various forage plants as indicated in the legend.

While this is not a fair sample of the pasture,

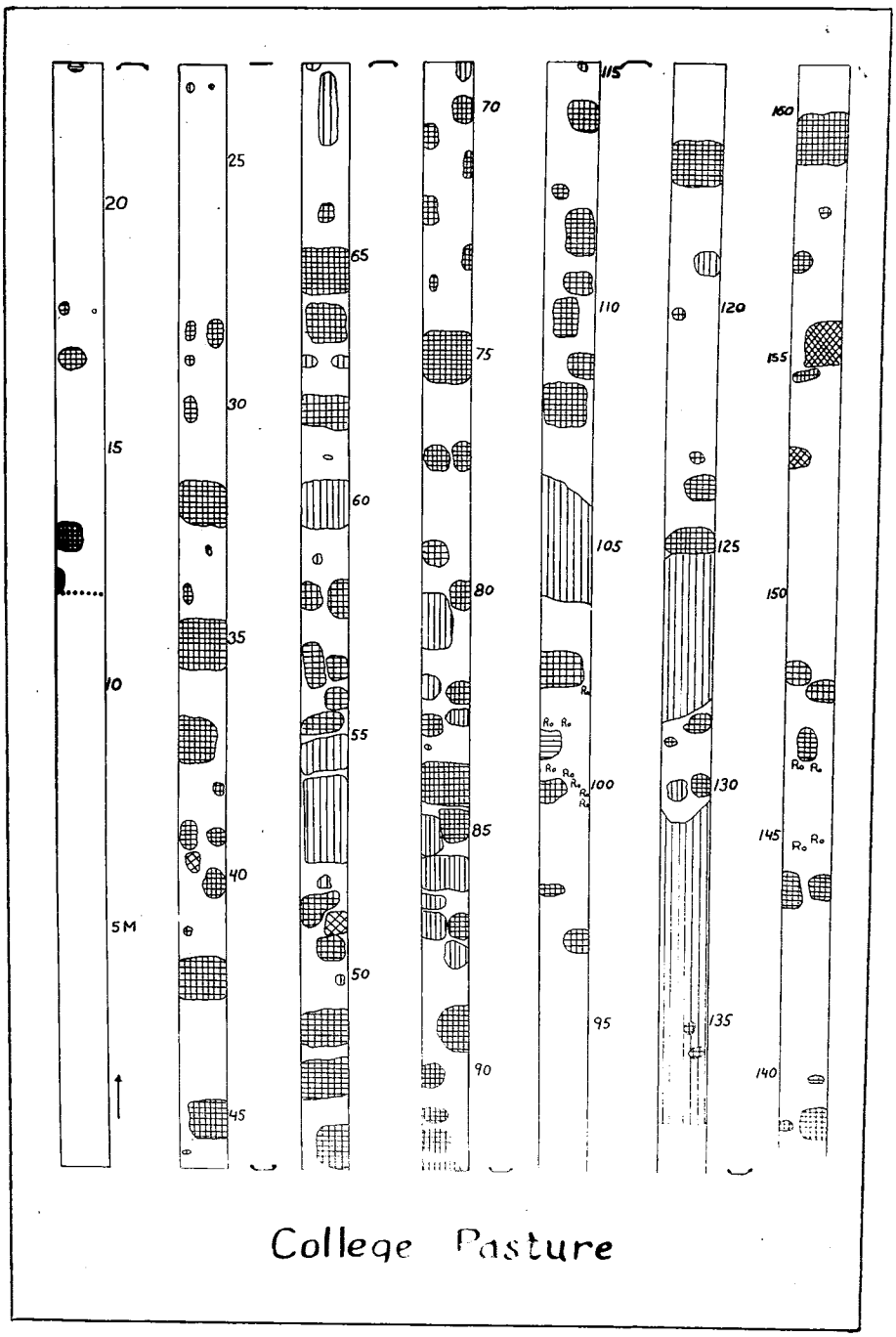


Fig. 17.--A typical transect of 160 meters through chaparral showing kinds of cover from browse to top of foothill slope. First 12 meters in grassland. Square cross hatch, Cercocarpus; vertical hatch, Rhus; diagonal cross hatch, Ribes; Ro, Rosa. Cercocarpus and Rhus predominate. Stand open.

it indicates that Cercocarpus, Rhus, and Rosa are the chief plants. The line transects in Tables 10, 11, and 12 are more illustrative than the belt transect. We can safely say, however, that Cercocarpus occupies 75 per cent or more of the shrub cover.

No detailed study was made of the understory because of the extreme variability of the site. Bromus tectorum, Agropyron spicatum, Poa spp., Bouteloua gracilis, B. curtipendula, Stipa comata, Artemisia frigida, occurred as the most abundant species. The total plant cover not exceeding a density of 55 per cent.

Hanson, Love and Morris (28) comparing the effect of continuous and deferred and rotation grazing on mixed prairie vegetation, studied the grassland adjacent to the pasture in this study. Agropyron smithii, Bouteloua gracilis, Bulbilis dactyloides, Aristida longiseta and various forbs, furnished the bulk of the grazing on this pasture.

The yellow pine forest was not accessible to the stock used in this study, so the relationship of types as affected by the forage in the yellow pine vegetation can not be measured.

Phenology

The phenology of range plants is of utmost importance in the study of range utilization and improve-

ment. This means the consideration of the relation between climate, soil and other factors and the growth and reproduction of the plants.

The basis of range management is the plant. Its change or development is of great value in determining date the grazing season opens, the closing date and the length of the grazing season. This is of importance, not only for the plants grazed but for non-palatable plants and especially those that are poisonous or otherwise injurious.

In the experiments on chaparral, development records were taken throughout the year. Weekly observations were made during the main growing season, at monthly intervals during the fall and winter as well as at various other times. Observations were made in the grassland and in the shrub area. Particular attention was paid to the important grasses of the mixed prairie and the important shrubs in the chaparral. The following data show the periodic development of the important plants in the chaparral areas.

The various shrubs differ somewhat in the time they start growth in the Spring. (See Figure 18.) Ribes cereum is the earliest one to leaf and blossom. Growth starts late in March or early in April and soon reaches full bloom. Leaves persist into late fall and any rise in

temperature at that time will result in the formation of new leaf.

Cercocarpus parvifolius is early in starting. In 1931 leaf buds were open by April 10 and by May 12 the plants were in full leaf and in full bloom. By June 20 the fruit began maturing as indicated by style elongation. Dispersal of seed started during the last week in August. Leaves also started to drop at this time but most of the leafage was retained until early October. New leaves developed during warm periods throughout the winter, others showed continual green color throughout the winter. This would indicate a tendency toward persistant or evergreen leaves. At Virginiadale this plant, as well as other shrubs, was from two to three weeks later in starting and matured about a week later.

Rhus trilobata was the last to start in the spring. The flower buds were first to open. The earliest flowers appeared about May 1, although the flower buds were swelling on April 10. The leaves soon developed after that. Fruit began to mature about June 20 and was ripe in late July. The fruits are quite persistant and many were retained throughout the year. Leafage of Rhus was last to begin to drop and over 50 per centof the leaves were present in late October.

Prunus melanocarpa was early in starting and

reached nearly full development by April 17. Racemes were in evidence soon after and shortly were in full bloom. The leaves of Prunus are early in dropping and by October 15 were almost gone.

Bossekia deliciosa was rather difficult to observe as plants were scattered and varied in development. It appeared to be late in starting but not as slow as Rhus. Like Ribes and Cercocarpus it will develop small new leaves in the fall when air temperatures are favorable.

Rosa was one of the earliest to start. On April 10 many leaf buds were opening while some were completely open. About September 1 the spines became mature and hard. This seemed to be important in the further use of the plant by the grazing animals.

Figure 18 graphically illustrates the seasonal development of the chief shrubs in the chaparral area.

Carex stenophylla, Bromus tectorum, Poa spp., Agropyron spicatum, and Stipa comata, all quite common in the chaparral understory, are very early in starting growth in the spring. In early March Carex had made some three inches of growth and Bromus tectorum was quite green. During the latter half of the month the other plants had from a week to two weeks start on the grasses in the mixed prairie and should produce earlier grazing.

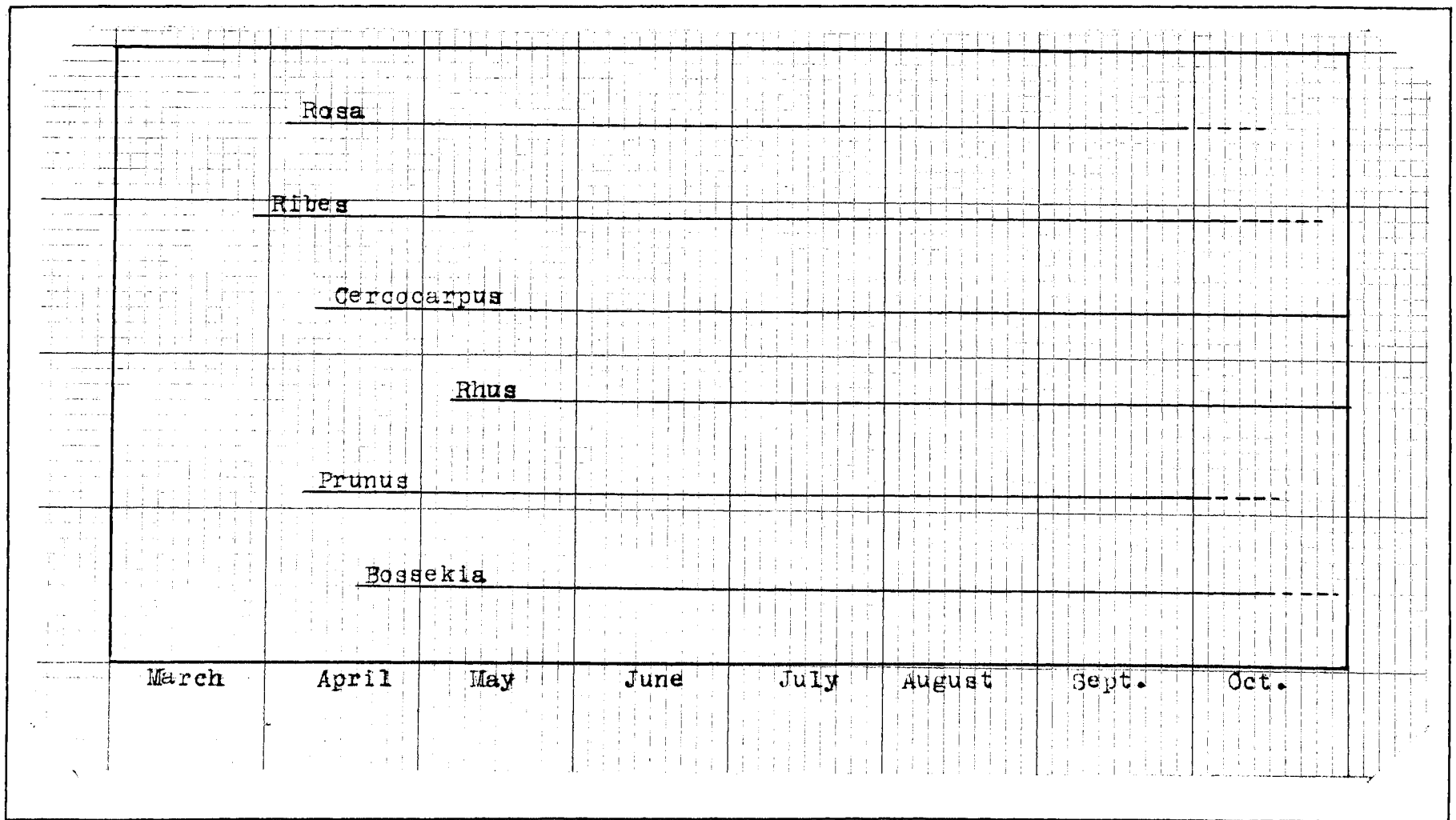


Fig. 18.--Date of initial growth and maturity of six important shrubs in pasture. Broken line approximates close of period when few green leaves remained.

In the chaparral some eight miles north of the pasture studied, larkspur, Delpninium geyeri, and death camas, Zygadenus intermedius, were found. On March 1 these two plants were from one to two inches high. They do not reach full bloom until May and mature in June and July. At Virginia Dale, Delphinium geyeri and D. nelsonii are present in the chaparral. The development of these plants here would be from one to two weeks later but would be an important factor in the management of the pasture.

The importance of adjacent plant communities is not only important from an ecological standpoint but from the grazing angle as well. The seasonal variation in development of species common to both areas and the difference in character of the forage for the same season and for different seasons between the two adjacent types are important factors if full grazing use of range forage is to be obtained.

In the mixed prairie adjacent to the chaparral, Agropyron smithii starts growth about March 15 and is mature by August 1. Stipa viridula and S. comata have somewhat the same growing period. The short grasses, Bouteloua gracilis, Bulbilis dactyloides, Schedonnardus paniculatus, start growth in late April and are mature by July. The moisture content of these plants and the date of maturity would be significant in this study. The effect

on initial grazing is again emphasized. In Figure 19 the moisture content and indirectly the development of the two more important forage plants are shown for part of the growing season.

Environmental Factors

In order to evaluate the importance of environment in relation to growth and utilization of chaparral forage considered in this study, the environmental conditions under which these plants grow and the departure from the normal or average is here presented. In Table 3 the monthly precipitation at Fort Collins is given for the 41-year record of monthly rainfall and for the years 1930 and 1931.

Table 3.--Monthly precipitation at Fort Collins, Colorado.

	41 yr. monthly ave.	1930	1931		41 yr. monthly ave.	1930	1931
Jan.	.45	.45	0	July	1.81	1.00	.10
Feb.	.60	.07	1.26	Aug.	1.24	5.45	.78
Mar.	1.06	.70	.41	Sept.	1.30	.16	.40
April	2.16	.56	1.07	Oct.	1.19	.36	1.00
May	2.81	4.08	2.55	Nov.	.46	.70	.63
June	1.57	1.50	1.50	Dec.	.51	.14	.18

In interpreting these data the years 1930 and 1931 were compared with the normal or average year. To bring out the distribution of rainfall more clearly, rainfall data by weekly periods is given for the years 1930 and 1931 in Table 4.

Fig. 19.--Moisture content of the two principal forage plants in adjacent grass pastures. Based on oven dry weights.

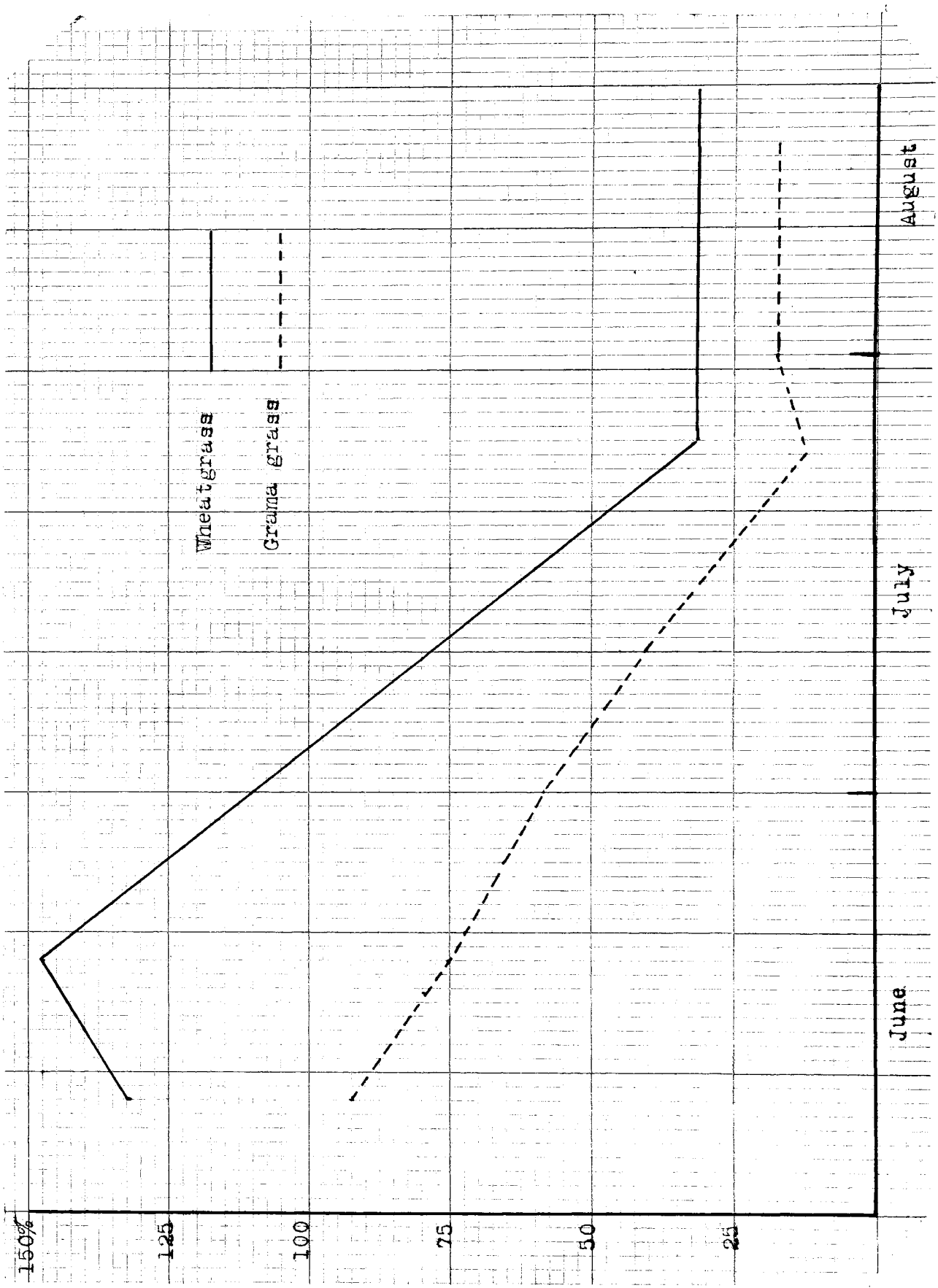

Wheatgrass
Grama grass
150%
125
100
75
50
25
June
July
August

Table 4.--Distribution of precipitation in inches by weekly periods at Fort Collins, Colorado. 1930 and 1931

Week ending	1930	1931	Week ending	1930	1931
January 7	.14	---	July 8	.04	.19
14	.07	---	15	.56	.51
21	.24	---	22	.22	.08
28	---	---	29	.11	---
Total	.45	0	Total	.93	.78
February 4	---	---	August 5	.77	.06
11	---	---	12	2.51	.17
18	.06	.14	19	1.90	----
25	.07	.23	26	---	.07
			September 2	.34	.06
Total	.13	.37	Total	5.52	.36
March 4	.13	.91	September 9	.27	.16
11	---	.10	16	---	----
18	.27	---	23	---	.07
25	.14	.02	30	.08	.11
April 1	.16	.26			
Total	.70	1.29	Total	.35	.34
April 8	---	.22	October 7	.22	.44
15	.18	.01	14	.13	.18
22	.11	.08	21	.02	.38
29	.27	.65	28	---	---
Total	.56	.96	Total	.37	1.00
May 6	.37	1.36	November 4	---	----
13	.38	.07	11	---	----
20	2.96	---	18	.70	----
27	.16	.17	25	---	.62
Total	3.87	1.60	Total	.70	.62
June 3	.23	---	December 2	---	.01
10	1.36	----	9	.09	----
17	---	----	16	.05	----
24	.12	----	23	---	----
July 1	.10	----	31	---	.18
Total	1.71	0	Total	.14	.19
			Annual rainfall	15.43	7.51

As indicated by Tables 3 and 4, 1931 was much drier and the moisture supply was lower than in 1930 or for the normal year. July and August were far below the same period for other years. 1930 was also below the

normal year, particularly so for the growing season with the exception of one month. The early spring periods were more favorable in 1931 than 1930. However, as moisture is not the important controlling factor so early in the growing season that it is later, we find that 1930 was much more favorable later in the season when continued rains aided in maintaining a longer growing season.

The relative intensity of external factors is better expressed by evaporation for the critical growing period than by precipitation. In Table 5 is shown the monthly evaporation rates for growing seasons of the years 1930 and 1931, as compared to the average year.

Table 5.--Monthly evaporation in inches from a free water surface. Average year and for 1930 and 1931.

	Average year	1930	1931		Average year	1930	1931
Jan.	1.41	----	----	July	5.79	6.75	5.42
Feb.	1.56	----	----	August	5.36	4.93	6.54
March	2.62	----	----	Sept.	4.41	4.47	6.32
April	4.27	4.29	4.29	Oct.	3.28	3.34	3.56
May	4.98	4.78	5.51	Nov.	1.61	----	----
June	5.60	7.40	6.78	Dec.	1.30	----	----

These data indicate the variation in demand of the air for moisture from the soil and the plant. It is again indicated that the two years, 1930 and 1931, were dryer and atmospheric conditions more severe. June 1930 and 1931 were very high as was July, 1930 and August, 1931.

To compare the monthly period for each year with the corresponding month of another year is rather difficult, but it would appear that 1930 was much more severe than 1931. This is contrary to the above rainfall summary.

The effective rainfall as well as the effective evaporation can better be measured when the combined rates of evaporation and rainfall are considered. Their combined value is expressed in Tables 6 and 7.

The P/E ratio (precipitation-evaporation) suggested by Livingston and Shreve (35) is used in obtaining the values indicated in Tables 6 and 7.

Table 6.--Efficiency of rainfall as expressed by the precipitation-evaporation ratio.

1930		1931	
Period	P/E	Period	P/E
June 3- 9	.00714	June 6-12	.00040
10- 17	.00000	13-19	.00000
18-24	.00037	20-26	.00000
25-July 1	.00027	27-July 2	.00000
July 2 - 8	.00000	July 3-11	.00000
9 -15	.00180	12-18	.00000
16 -21	.0023	19-25	.00000

In the foregoing table (Table 6) are given the ratios of precipitation over evaporation for weekly periods during the growing season. The evaporation in this case was determined in cubic centimeters by use of Livingston atmometers.

The following data in Table 7, is similar but evaporation in this case was obtained by the use of the

free water surface method.

Table 7.--Efficiency of rainfall as expressed by the precipitation-evaporation ratio. Evaporation based on water loss in inches from a free water surface.

	1930	1931	Average year		1930	1931	Average year
Jan.	----	----	.248	July	.1440	.0180	.303
Feb.	----	----	.334	Aug.	1.1100	.1192	.231
Mar.	----	----	.409	Sept.	.0358	.0632	.295
April	.1305	.2495	.530	Oct.	.1077	.2810	.363
May	.8530	.4630	.557	Nov.	------	-----	.285
June	.2026	.2212	.280	Dec.	------	-----	.392

With the variation in rainfall and evaporation from year to year and from the average in mind, we can safely compare the climatic intensity that existed by the values in Tables 6 and 7.

The main growing season was much severer in 1931 than 1930 as indicated by the P/E values. The corresponding weeks June 10 to 16, and July 2 to 8 were the only weeks in the 1930 season which were as severe as 1931. The values in Table 7 are not as accurate as those in Table 6 which are on a weekly basis, but indicate that the two years were more severe than the average year.

Other environmental factors such as temperature, humidity, wind velocity, and light intensity were much more severe in 1931 than in 1930 or for the average of the five year period. Temperature values were evidently above normal and relative humidity very low. These are

reflected in the evaporation ratios.

Because of the difficulty in obtaining true soil moisture readings in rocky soils, soil moisture values will not be given. However, the trend of moisture content of the soil can be approximated or compared with moisture content of adjacent soils (28). The soil moisture under adjacent mixed-prairie vegetation frequently falls below the hygroscopic coefficient in the upper two feet of soil after the middle of June and is reached later in the lower horizons. From the presence of deep rooted grasses and shrubs, it appears that this condition is reached much later in the shrub community and perhaps not as severe in depletion of soil moisture. Andropogon furcatus, A. scoparius, Poa spp., Agropyron spicatum, and other grasses indicate a more moist site and a longer growing season.

From the above data it is evident that conditions affecting plant growth for these two years were more severe than can be expected for the average year. In applying results obtained for these two years, allowance must be made for the effect of climatic conditions.

It can be expected that rate of development, date of maturity, current annual growth and moisture content of forage will be below normal. This not only applies to the shrubs studied but to other forage plants

associated with them and those which make up the forage in adjacent pastures. It is especially true in determining the initial grazing of the shrubs.

Palatability

One of the chief considerations in estimating the forage value of chaparral is its palatability.

In measuring palatability of a shrub species, it is recognized that many factors are involved and an attempt to measure them must result in obtaining only relative values.

Such factors as the class of stock and its natural preference, the species concerned and their seasonal variation, the abundance and palatability of other nearby species and the difference in climatic conditions from season to season influence the palatability of forage.

In this study cattle will be the class of stock observed and the factors involved in the use of browse by them will be dealt with.

Diameter of stems grazed as a factor - The first observed factor in palatability is that of the stem diameter grazed. The differences between the various species were obtained by random sampling.

Table 8.--The per cent grazed in each diameter class considered. The numbers found in each class are indicated.

Species	Diameter grazed							
	1 mm		2 mm.		3 mm		4 mm.	
	No. measured	Per cent	No. measured	Per cent	No. measured	Per cent	No. measured	Per cent
Cercocarpus	33	24	70	51	27	20	7	6
Rhus	50	45.9	57	51.8	3	2.7	0	0
Prunus	16	44.4	20	55.5	0	0	0	0
Ribes	26	81.1	6	18.8	0	0	0	0
Bossekia	16	61.3	7	26.9	3	11.5	0	0

In Table 8 is indicated the relative frequency of different diameters to which the various shrubs were grazed. Fifty per cent of the measured stems of Cercocarpus were grazed to the average diameter of 2 millimeters. While 20 per cent were grazed to the diameter of 3 millimeters and 5 per cent were grazed to a diameter of 4 millimeters. Four millimeters was the greatest diameter measured. The per cent of each diameter class is fairly well defined and indicates that the average diameter grazed is 2 millimeters. These measurements are graphically illustrated in Figure 20.

The curves not only illustrate the value of the measurements but emphasizes the diameter to which these various shrubs are browsed.

Prunus melanocarpa is grazed to a diameter class very much as that of Rhus, which is between 1 and 2 millimeters. Ribes shows a higher frequency in the 1 mm. class while only 18.8 per cent in the 2 mm. class and none

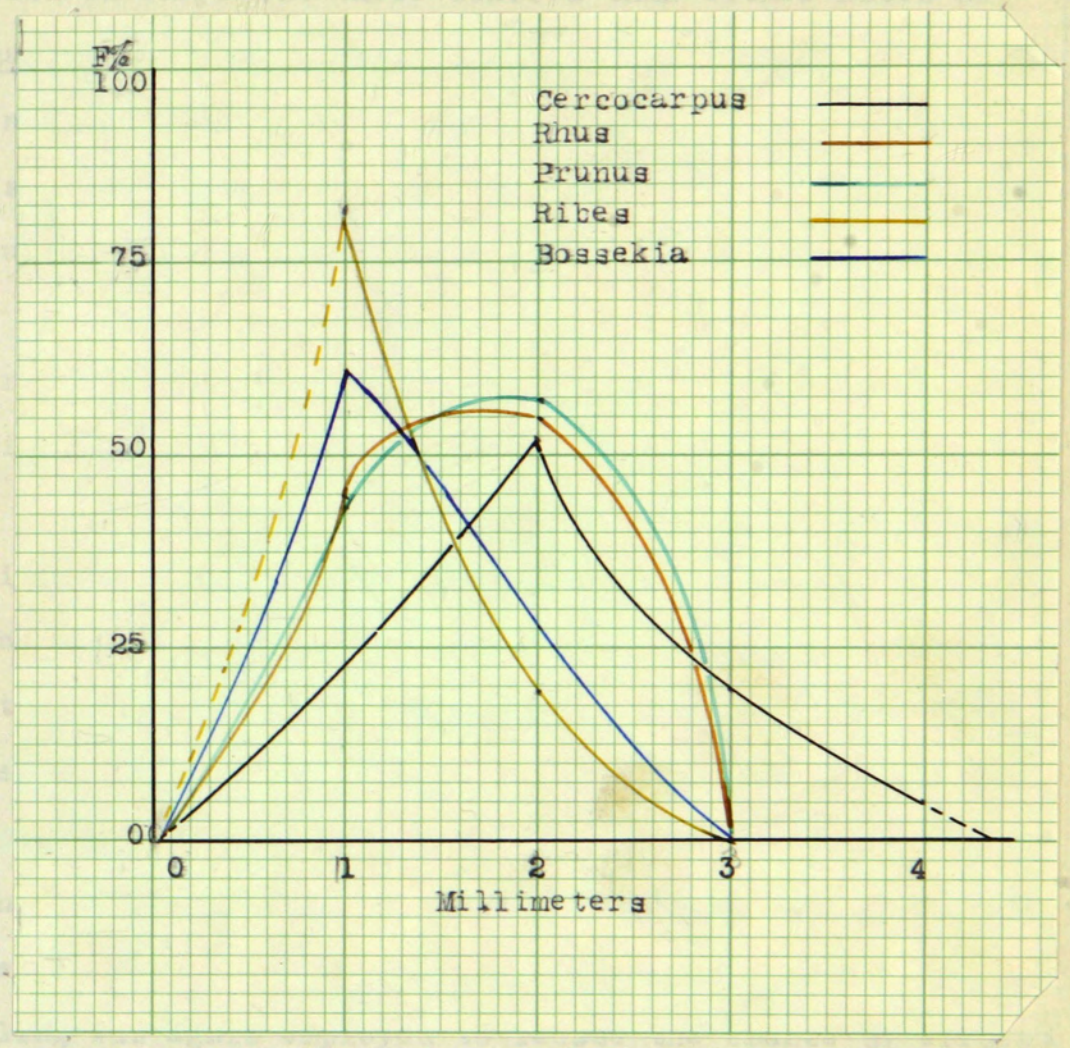


Fig. 20.---Frequency of each diameter class grazed.

in the 3 or 4 mm. class. Bossekia has a greater dispersion in the first three classes than either Ribes or Prunus but not as nigh as Prunus in the 2 mm. class. Rosa was not measured as its palatability value is obvious. It is grazed to a diameter which exceeds any of the five measured and is grazed before any of the above are touched.

The error in sampling was not statistically considered but frequency curves were made to show the dispersion of the values obtained.

These figures suggest that Cercocarpus is more readily eaten than any of the other shrubs as indicated by the diameter to which it is grazed. Prunus is next in palatability with Rhus, Bossekia and Ribes in order of preference.

Length of stems grazed as a factor - The desirability of the various shrubs can also be considered on the basis of actual length of current annual growth grazed. Random sampling was again employed to reduce the chance of error, and the effect of locating plants which might not be grazed. Sample measurements were made in the center of the pasture to exclude the effect of concentration of stock. The observed grazing measured is contained in Table 9.

Table 9.--Current annual growth of several shrubs grazed. Value expressed in palatability per cent.

Species	Current Annual Growth		Amount lost	Palatability per cent
	Ungrazed cm.	Grazed cm.		
Cercocarpus	12.9	7.5	5.4	42.5
Rhus	18.2	9.6	8.6	47.2
Prunus	11.4	4.1	7.3	64.0
Ribes	14.4	11.4	3.0	20.8
Bossekia	27.8	15.8	7.0	25.2

A comparison of ungrazed and grazed current annual growth is shown. This more nearly approaches the Forest Service method (42). Prunus would have the highest palatability while Rhus would be next with only a palatability value of 47.2 per cent, Cercocarpus third with a value of 42.5 per cent. Ribes and Bossekia are nearly of equal value and their relative positions are maintained as compared to palatability based on diameter. Comparison with Forest Service figures are of interest. See Table 1. Cercocarpus is consistent but Rhus and Prunus certainly differ, being considerably higher. The next two are nearly more agreeable, though higher than the Forest Service figures. There is certainly much conflict between these two sets of values. Internal differences between the various species should apparently agree with one or the other of the two methods. It was thought that coarseness and mechanical or chemical difference were probably the cause of the preference shown by cattle for

the different species of shrubs. Microscopic examinations were therefore made of the tissues of the stems eaten.

Histological and microchemical nature as a factor - Microchemical studies were also made to determine the variation in tissue distribution, amount, and presence of various substances as oils, tannins, and stored food. It was thought that these characters would indicate the succulence, palatability, and nutritiousness of the different browse plants. Sections were made just below the tip, at mid length, and the base of the current annual growth as well as at upper end of the previous year's growth. These studies were made throughout the fall and early winter.

Tests for tannin, oils, and sugars did not yield significant differences. Tests for lignin, cellulose and starch were more indicative of differences between the several species.

Because of the volume of material resulting from these studies, only that which is pertinent to discussion will be here considered. From field observations grazing on the average, seldom exceeded 50 per cent of the current annual growth and differences occurring within this grazing limit will be illustrated.

In Figures 21 and 22, camera lucida drawings are shown of sections of the respective shrubs studied. These

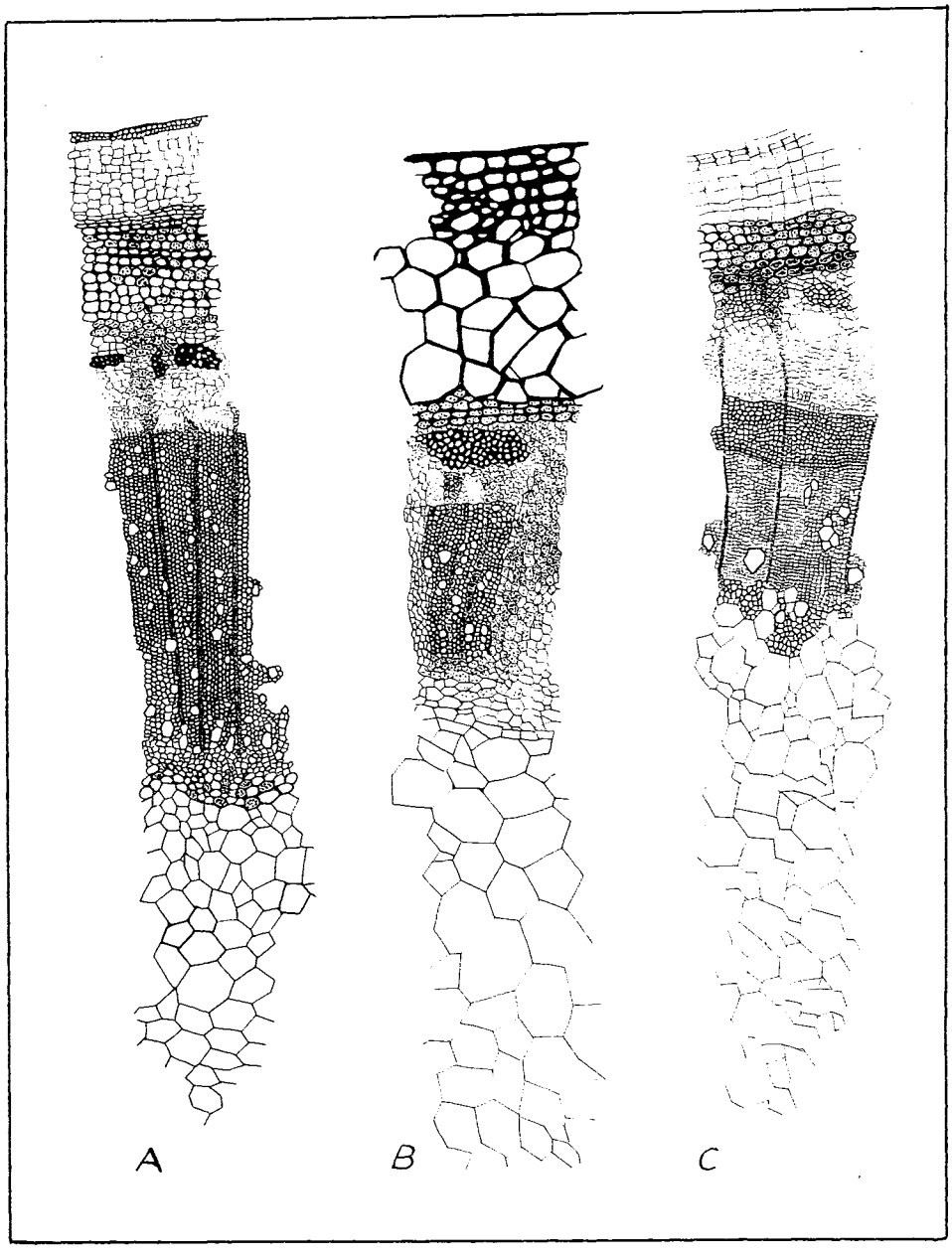


Fig. 21.---Camera lucida drawings of stem sections at mid-length of current annual growth.

A- Prunus melanocarpa
B - Bossekia
C - Rhus

Maximum radius 1.5 mm.

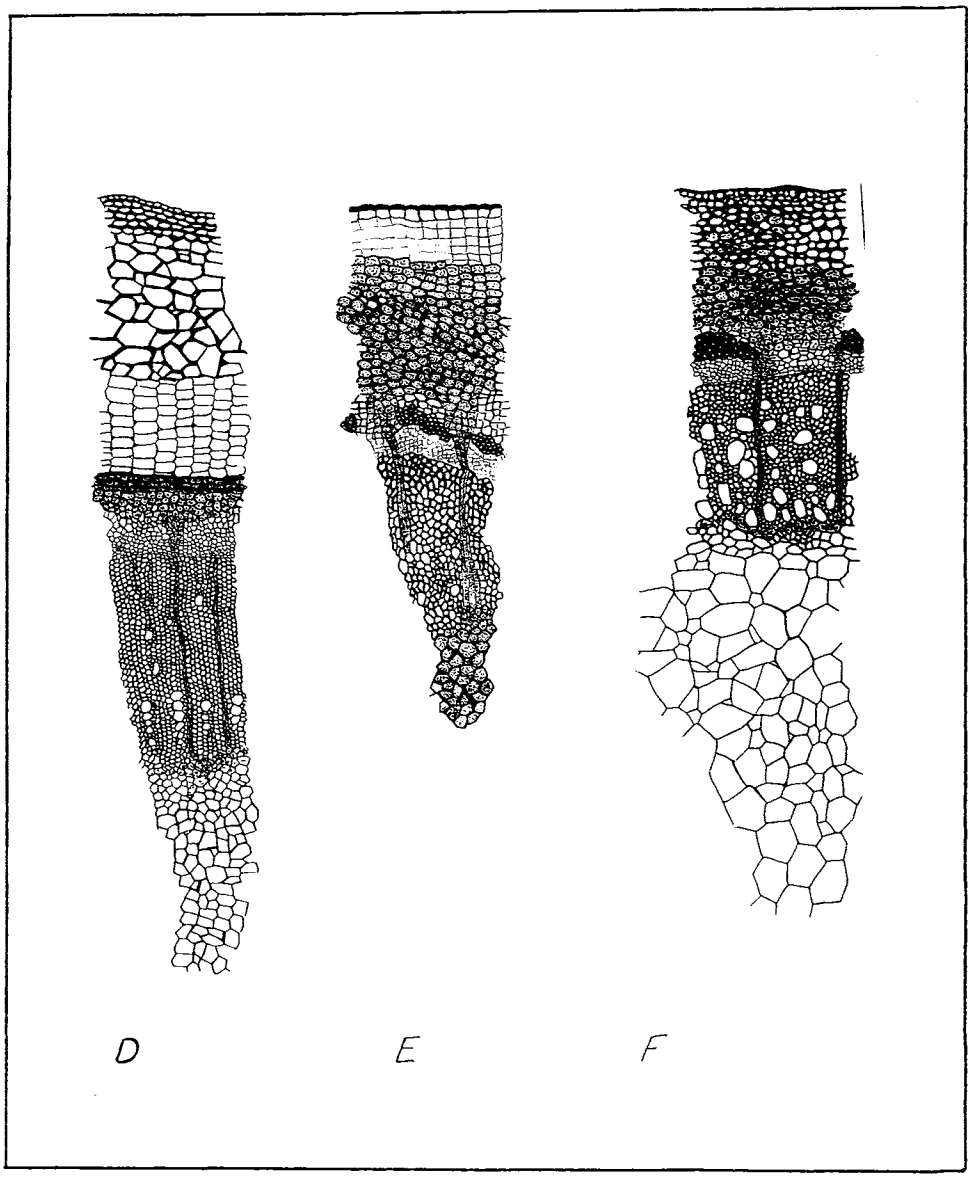


Fig. 22.--Camera lucida drawing of stem sections at mid-length of current annual growth.

D - Ribes
E - Cercocarpus
F - Rosa

Starch grains indicated by stipple marks. Maximum radius 1.5 mm.

sections indicate relationship of the different shrub growths. The amount of lignified or woody tissue and the amount of pith and softer tissue should indicate the succulence and palatability of the plants, while storage areas and stored starch would be a measure of nutritiousness.

Cercocarpus has the highest lignin content with Ribes and Prunus next, in order. Rosa, Bossekia, and Rhus contain much less with Rosa having the least. Bossekia has the most pith. Rosa and Rhus are nearly equal in pith size, while Ribes and Prunus are intermediate. Cercocarpus has comparatively little pith. Phloem tissue is best developed in Rhus and more or less equal in all the others.

Storage tissue is best developed in Cercocarpus as starch was found present in the pith as well as in the cortex. The latter feature is equally true of the others.

The amount of starch was the most uniform significant difference existing between the various plants and was found to agree more nearly with the observed grazing, and follows more nearly the diameter class grazed.

Figures 23 to 30 give a more detailed representation of the internal structure of the shrubs studied. These figures are photomicrographs of stem sections.

In Figures 23,24 and 25, sections of Cercocarpus are shown. Figure 23 is a section taken at the tip. The distribution of tissue is readily seen. The central

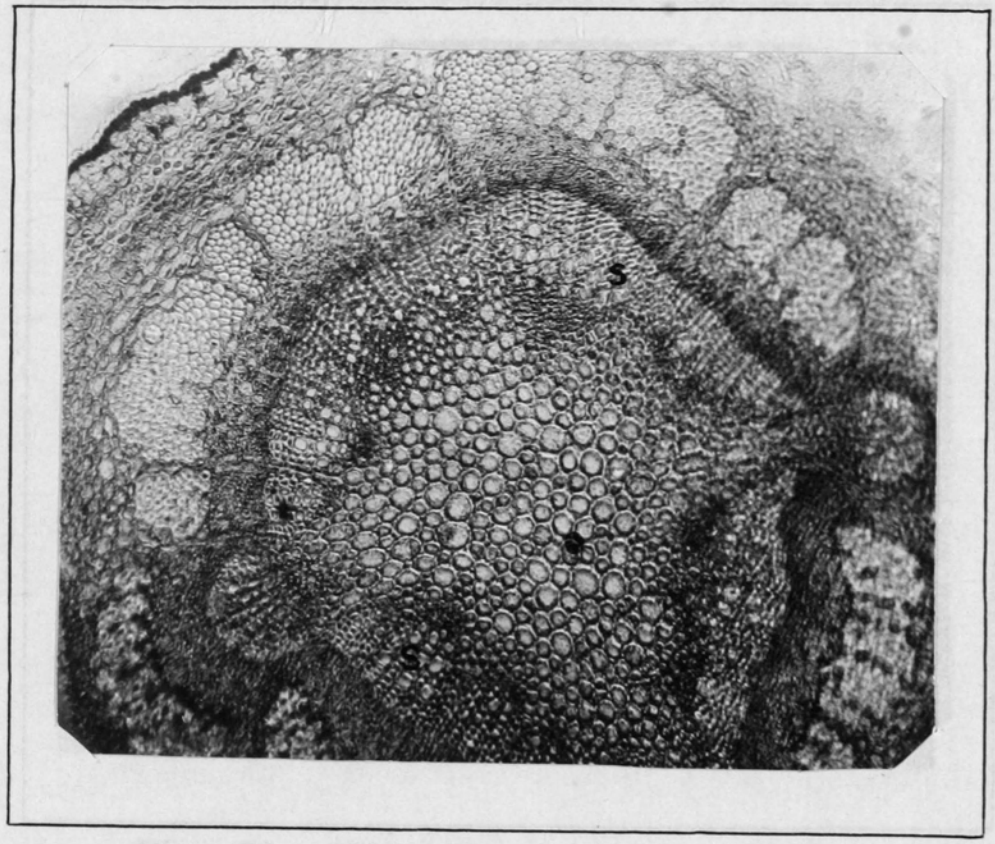


Fig. 23.--Photomicrograph of a section of Cercocarpus. Section made below tip of current growth. Note starch in pith and primary xylem, lignified tissue quite apparent.

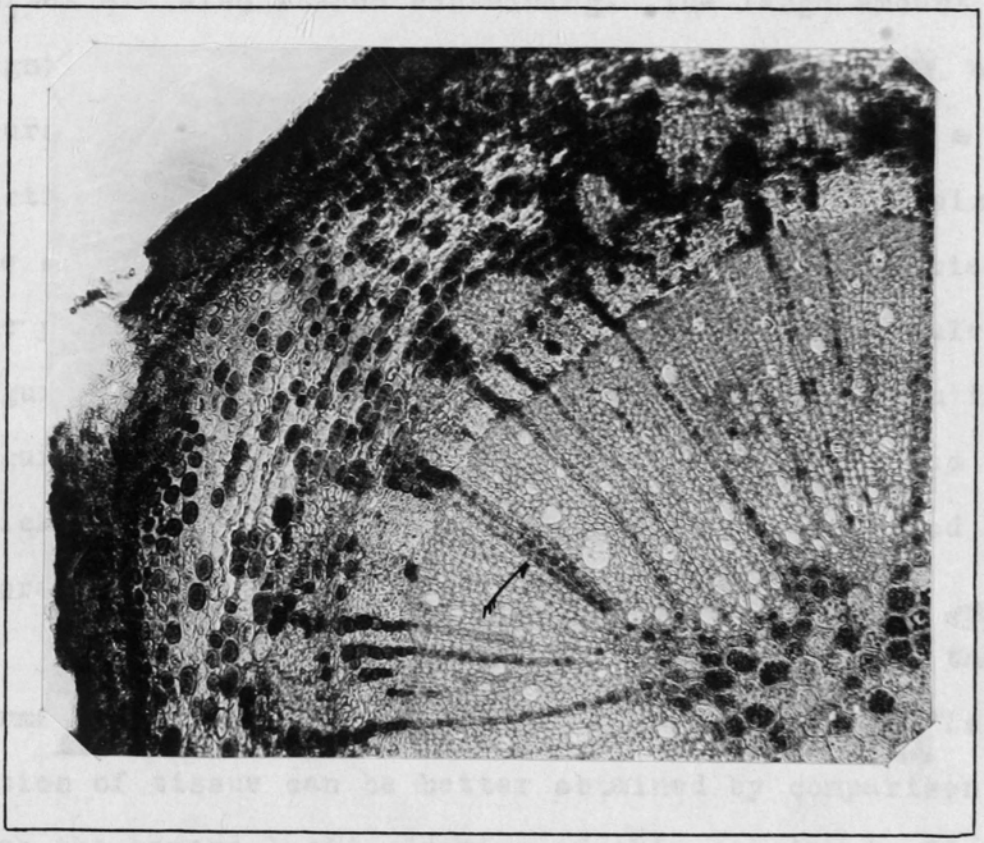


Fig. 24.--Photomicrograph of a section of Cercocarpus. Section made at mid-length of current growth. Note increase starch content in pith, cortex and medullary rays. Increased xylem is also evident.

cells in the pith are lignified as is the xylem and bast fibers. The phloem, medullary rays and cortex, representing the parenchyma tissue. Starch is found in the pith cells. The darkened areas in the phloem rays and inner cortex are also starch containing. The large amount of lignified tissue is great for this position and is, of course, increased in the older growth. Figure 24, a section at mid-length of the current growth, emphasizes the storage tissue present in the stem of this species. The pith, rays, and cortex are full of starch granules. Figure 25 is a greater magnification of the section in Figure 24. The storage material is clearly outlined in the thick walled pith cells which are the center of food storage.

In Figure 26, a section of Rhus, taken at the normally grazed diameter, is shown. The relative distribution of tissue can be better obtained by comparison with the camera lucida drawing of this species in Figure 21.

The greater succulence of this species is much augmented if the amount of parenchyma tissue is an index of succulence. Maximum storage is reached in the parenchyma tissue of the endodermis. The presence or absence of starch seems to be more significant than degree of succulence in accounting for the difference in the grazing

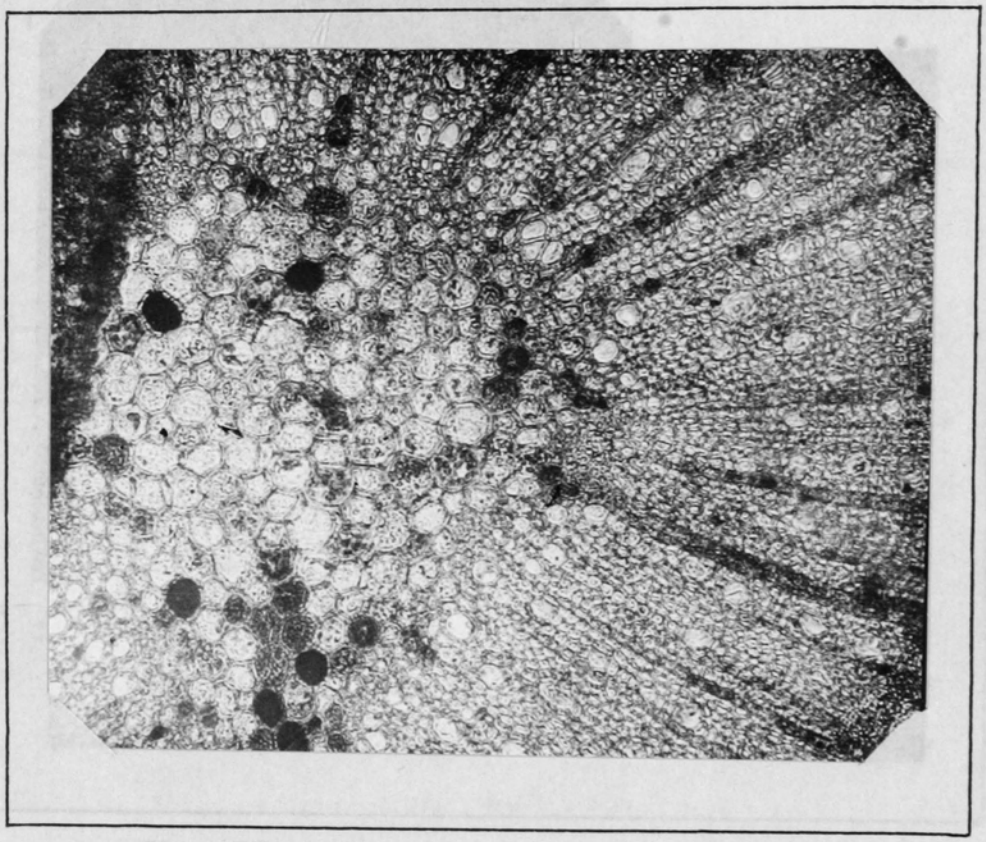


Fig. 25.--Section in Figure 24 magnified. Detail of pith shown. Starch grains are well defined. Note highly lignified pith cells.

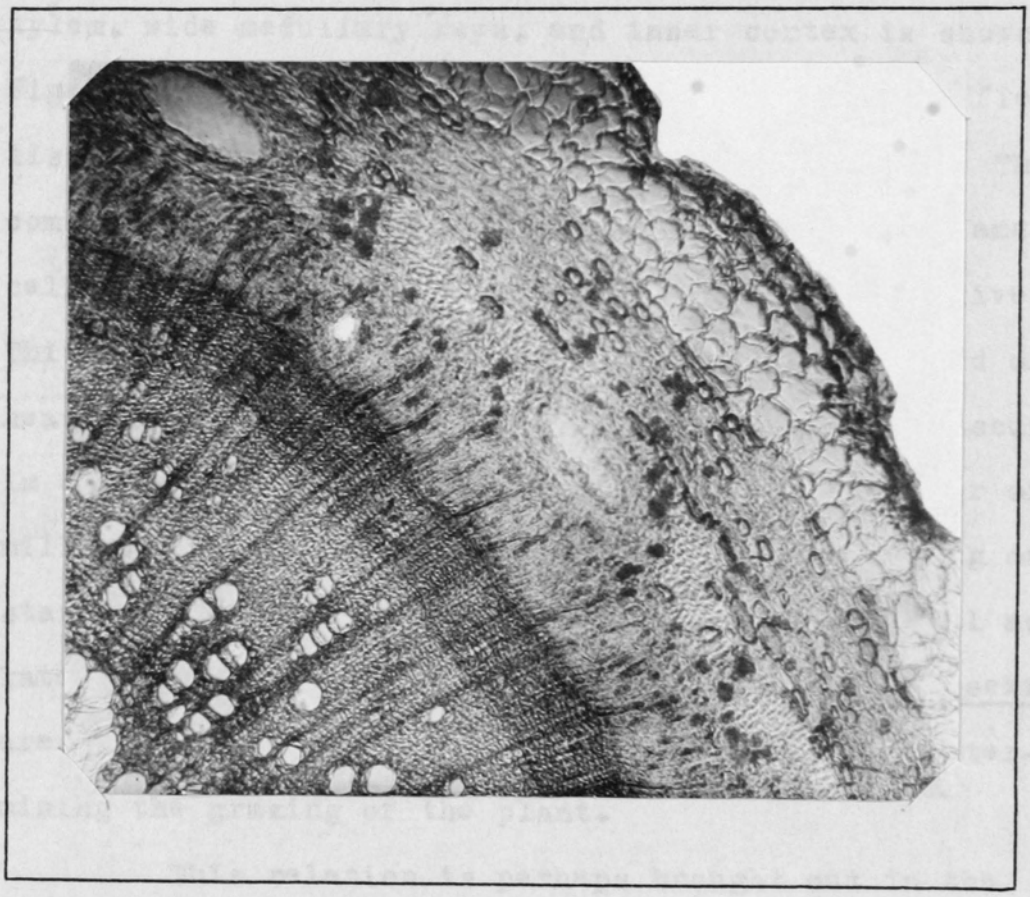


Fig. 26.--Rhus. Section at mid-length. Magnification same as Figures 23 and 24. Comparison with camera lucida drawing shows apparent succulence. Starch storage not evident in pith or greatly developed in cortex.

of the two species.

Bossekia shows again the variation in tissue and food location of shrubs. Starch content in the primary xylem, wide medullary rays, and inner cortex is shown in Figure 27. The ratio of cellulose tissue to lignified tissue is much greater than in the other species. The combination of considerable starch storage tissue and cellulose tissue does not bear out the low value given it. This plant was certainly not the first to be grazed or the heaviest grazed in the pasture. However, shrubs occurring in other areas were frequently grazed to a diameter of 8 millimeters or more. Apparently the greater amoung of starch available and abundance of the plant as well as the later maturity of Cercocarpus as compared with Bossekia are more significant than greater succulence in determining the grazing of the plant.

This relation is perhaps brought out in the section of Rosa in Figure 28. Rosa appears to have a greater starch storage area in the outer cortex and with the same relative ratio of cellulose tissue and lignified tissue.

The amount of lignified or woody tissue and the tannin storage area of Prunus are shown in Figure 29. The amount of starch tissue is less easily defined in this species but seems to be concentrated in cortex and

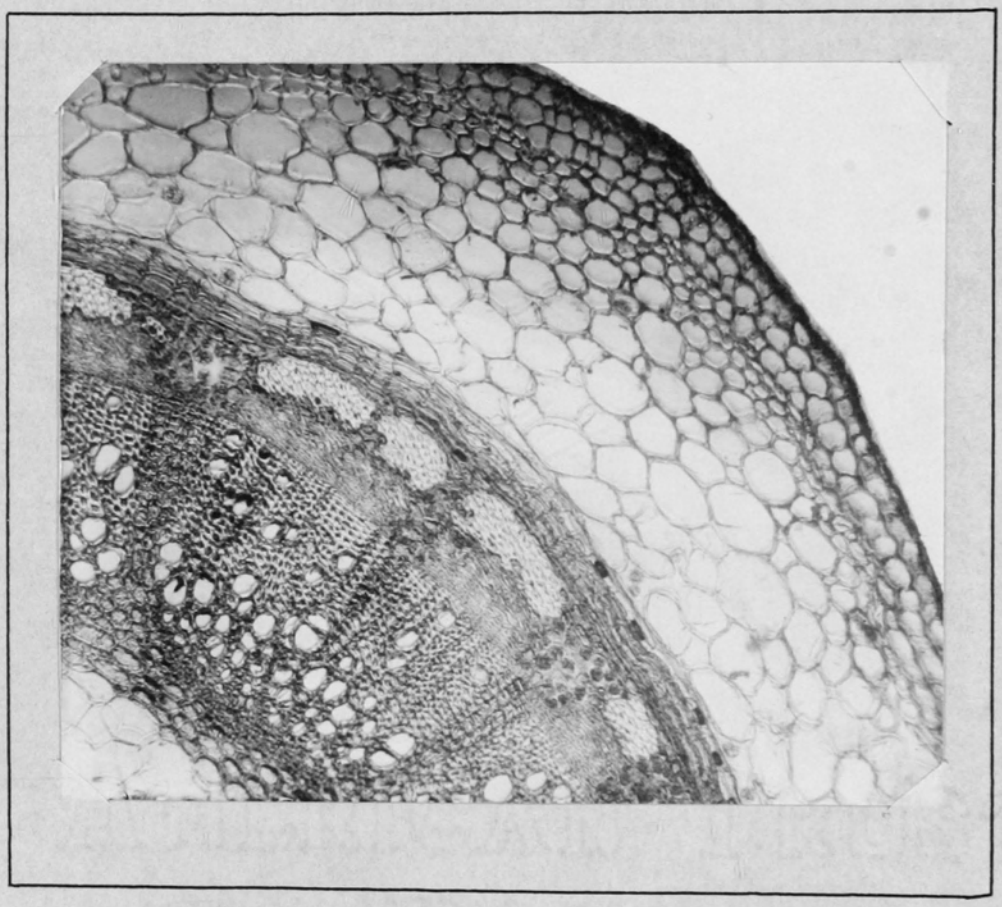


Fig. 27.--Bossekia. Section taken below tip. Only a portion of pith shows. Compare with drawing of same species. Parenchyma tissue is very extensive. Starch storage chiefly in primary xylem and wide medullary rays.

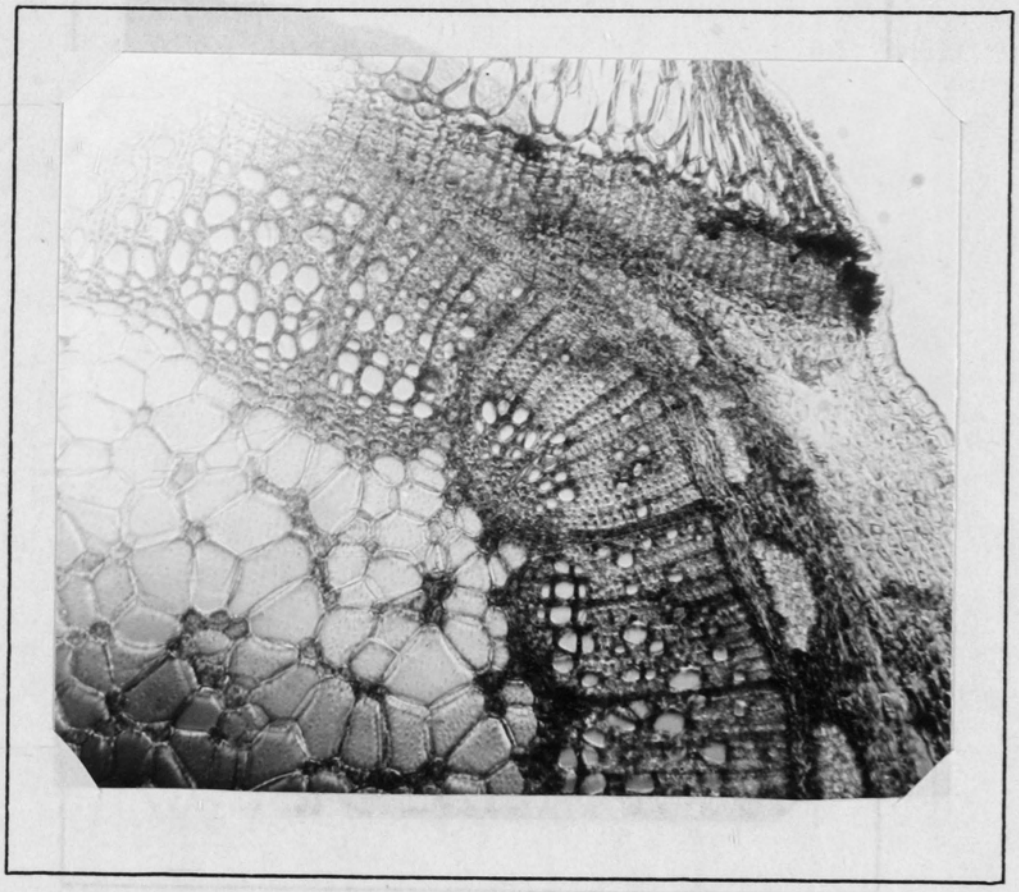


Fig. 28.--Rosa. Taken below point of last grazing. Starch storage well developed. Parenchyma tissue extensive.

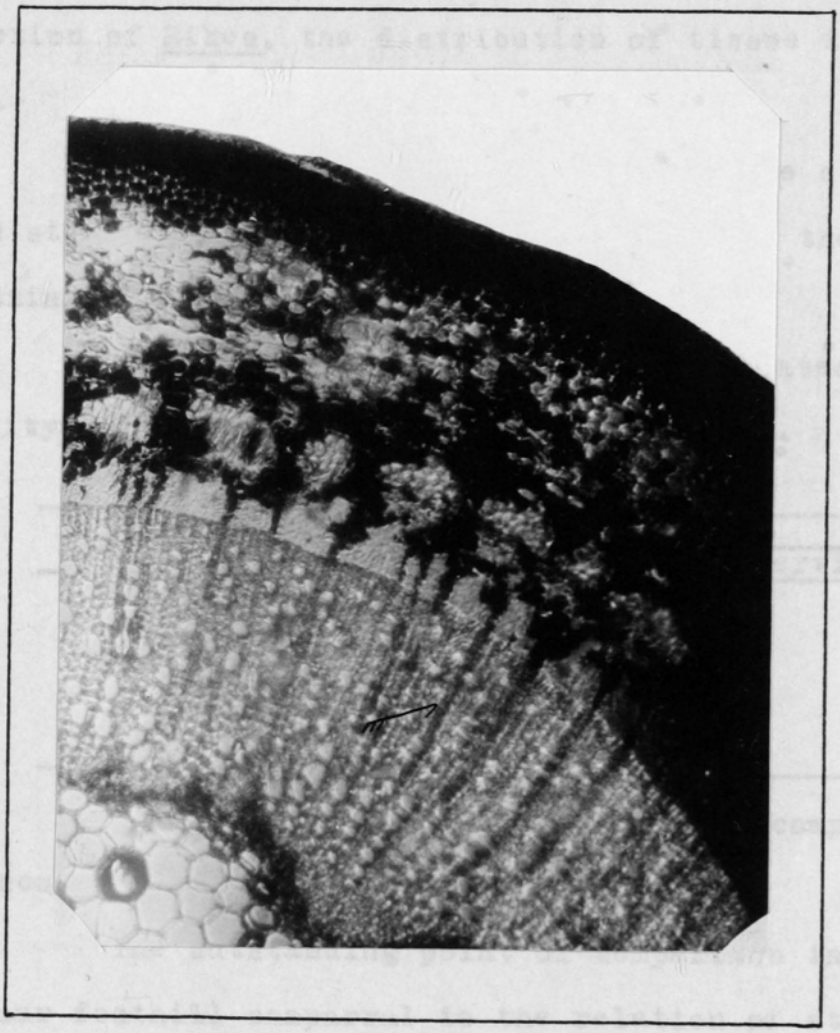


Fig. 29.--*Prunus melanocarpa*. Starch storage shown in primary xylem and phloem rays. Chlorenchyma tissue charged with tannin is indicated by the dark staining.

rays with some in the primary xylem. In Figure 16, a section of Ribes, the distribution of tissue is illustrated.

From the above observation on tissue distribution and storage material, we can again consider the observed grazing values with Forest Service values.

The following list shows the estimated palatability values and the Forest Service values.

Species	Palatability	
	Observed	Forest Service
Rosa	60	20
Cercocarpus	40	40
Bossekia	30	0
Prunus	20	5
Rhus	10	0
Ribes	5	10

This rating will be again seen in comparing the seasonal use of the various species.

The outstanding point of comparison in the shrubs of our foothill chaparral is the relation of stored food to utilization. Apparently succulence and woodiness play little, if any, part in the utilization, but the plants are valued and browsed on the basis of their stored food content.

Utilization

The ultimate measure of vegetation for pasture is its actual use. The carrying capacity, the adjustment

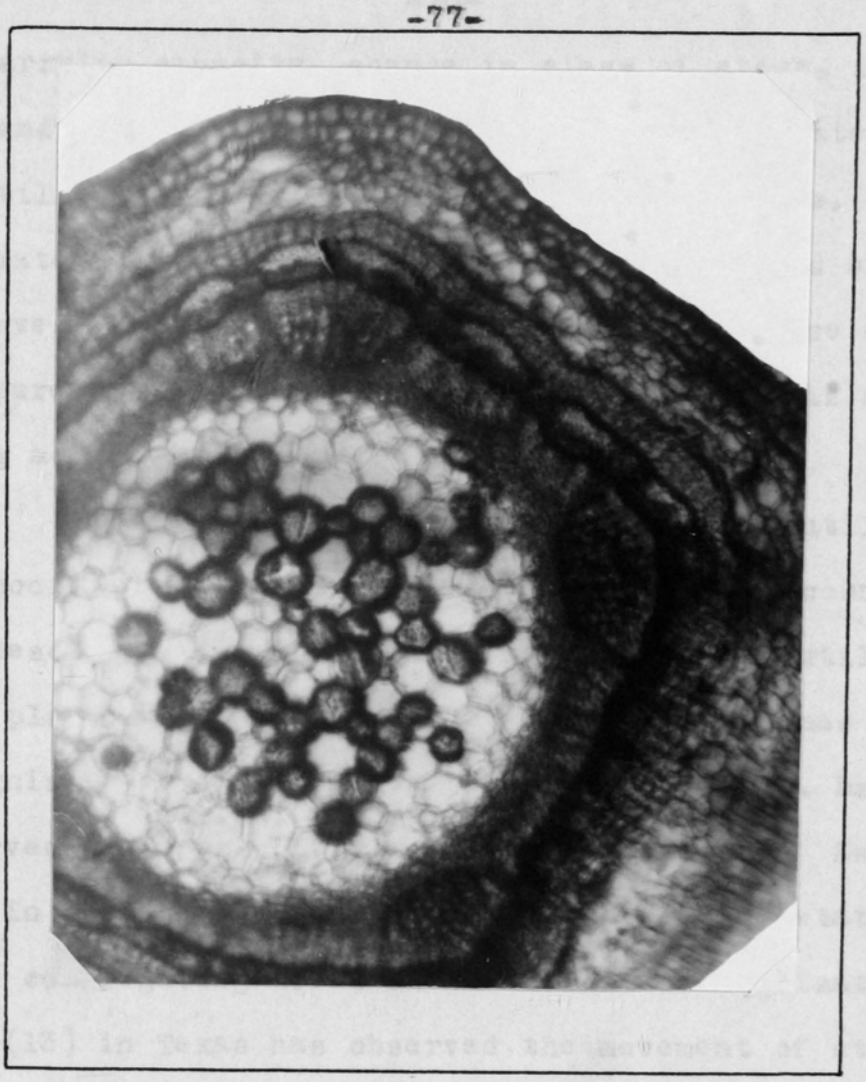


Fig. 30.--Tip or Ribes. Very little development of starch tissue. Resins in tissue tend to obscure detail of structure.

of carrying capacity, change in class of stock, season of use and intensity of use, depend upon an accurate estimate of utilization. The question frequently arises, is the estimate correct? In common field practice and oftimes in investigations estimates of the degree of use obtained, are purely ocular and general. At best it falls short of being accurate when determining full use.

At the present, methods of measuring utilization are poorly developed. The author has never encountered any described method, though the variation in utilization from place to place and from season to season has been recognized by many workers. Ferris in England, has observed the use of different pasture grasses. Sampson (47) in Utah has shown the distribution of vegetation about congregating areas as the result of utilization. Cory (13) in Texas has observed the movement of stock, by means of field glasses, from day to day and during the day. Forsling and Storm (21) in southwestern Utah have shown the degree of utilization of various classes of forage at different seasons of the year. No details of method were given, however.

In measuring utilization of chaparral the problem becomes involved. It does not only become a question of forage preference and use, but of accesibility of the bulk of the forage and of penetration into the

area as well.

In this particular problem utilization involves use as compared to adjacent pasture types, seasonal use of types as a whole, use of secondary plants, effect of slope on distribution and degree of use (accessibility and penetration), and use of different species.

In order to answer the above questions the line transect seemed to be the most suitable method. Three line transects were established in the pasture. The north transect, 100 meters long, extended two-thirds up the slope and contained 51 shrubs. The middle transect, 185 meters long, and containing 75 shrubs, extended the full length of the pasture. The south transect was 200 meters long and contained 88 shrubs.

The shrubs were tagged with metal tags and located on the transect line. Height and average diameter were noted for both years. The condition of the plants was noted, that is, the apparent vigor expressed in new growth and freedom from tip gall caused by an unknown insect.

The transects were visited on the first day of each month or within three days of that date. The grazing of each shrub was recorded. As it was impossible to count each grazed and each ungrazed stem on so many plants, five grazing classes were established which were

sufficiently large to exclude the effect of ocular estimate and still furnish the desirable information. All shrubs which showed less than 25 per cent of all stems grazed were classed as light, 25 to 50 per cent of all stems grazed as moderate, 50 to 75 per cent as heavy, and over 75 per cent as very heavy. Any observation on the character of the vegetation, the difference between one species and another, between individuals, and the chance selection by stock, will indicate that more intensive observation would be beyond the intent and purpose of this investigation.

In the following tables, 10, 11, and 12, are given the records of grazing on the north, south, and middle transect through typical foothill chaparral.

The observations were made during a period of two years during the fall and winter months and indicate the utilization of this type of forage.

The symbols in the tables indicate the following: L indicates low vigor; M, medium; H, high; for degree of grazing N indicates no grazing; L, light; M, moderate; H, heavy; V, very heavy. Symbols for plants are C for Cercocarpus; Rh, Rhus; Ro, Rose; Ri, Ribes; P, Prunus; Bo, Bossekia, Am, Amelanchier.

Table 10.--Records of grazing on north transect through typical foothill chaparral

North Transect													
			Growth					Degree of grazing					
			1930		1931			1930			1931		
Plant	Species	Condition	Height in dm.	Diameter in dm.	Height in dm.	Diameter in dm.	Location	November	December	January	September	October	December
1	C	M	6	3.5	5.7	4.	0	H	H	H	H	V	V
2	C	L	1.5	1.5	---	--	2	M	M	H	M	M	M
3	C	M	8.5	4	7.5	5	4	M	M	H	M	H	H
4	C	L	3	3	3	3.5	5	M	M	M	L	H	H
5	C	M	3	2	3	1.5	6.5	M	M	H	V	V	V
6	C	M	11	10	10	7.5	9	M	M	M	M	H	H
7	C	M	4	4	4	4	11	H	H	H	H	V	V
8	C	L	10	9	11	7	12	V	V	V	M	V	V
9	C	L	1	1	1.5	1.5	13	H	H	H	M	M	M
10	C	L	8	6	8.5	5	16	M	M	M	L	M	M
11	C	L	15	4	16.5	4.5	19	L	M	M	L	L	L
12	C	L	18	16	19	13	20	H	H	H	L	M	M
13	C	L	10	13	12	18	24.5	M	M	M	M	H	H
14	C	M	9	6	9	7	26	H	H	H	V	V	V
15	Pr		20	3	20	3	29	-	-	-	-	-	-
16	Rh		15	10	17.5	10	29	N	N	N	N	L	L
17	Rh		15	15	15	10	31	L	L	L	L	L	L
18	Rh		11	10	13	10	32	L	L	L	V	V	V
19	C	M	8	6	9	9	35	H	H	V	M	M	M
20	C	L	15	8	17.5	10.5	35.5	M	M	M	N	L	L
21	C	L	10	9	11	12	40	M	M	M	N	L	V
22	C	H	2	1.5	5	2	41.3	M	H	H	N	N	N
23	C	M	11	6	11	5	43	H	H	H	L	M	H
24	Rh		6	3	7	4	43.5	N	L	L	N	N	N
25	C	M	9	3	--	--	45	L	M	M	N	N	N
26	C	M	7	5	9	7.5	47.3	M	M	M	M	M	M
27	C	M	7	5	7	5	48.5	H	H	H	N	N	N
28	C	M	10	8	9.5	9.5	55	H	H	H	N	N	N
29	C	M	6	3.5	9	5.5	56	H	H	H	L	H	H
30	C	L	8	4	8.5	7	61	M	M	M	L	M	N
31	C	L	7	3.5	7.5	3	62.5	M	M	M	N	N	N
32	C	M	6	4	8	4.5	63	M	M	M	N	M	M
33	Rh		5	6	6	6	65	N	N	L	N	N	N

Table 10 (continued)

			Growth					Degree of grazing					
			1930		1931			1930			1931		
Plant	Species	Condition	Height in dm.	Diameter in dm.	Height in dm.	Diameter in dm.	Location	November	December	January	September	October	December
34	Rh		6	5	6.5	5	66	L	L	L	N	N	N
35	C	L	6	5	7	5.5	67	N	L	L	N	N	N
36	C	L	5	3	4	1.5	69	N	N	N	N	N	N
37	Rh		8	4	8.5	4	71.5	L	L	L	N	N	N
38	Rh		8	5	10	5	71.3	M	M	M	N	N	N
39	C	L	12	6	11	9	73.5	N	N	N	N	L	L
40	C	L	6	4	7	6	74.5	N	L	L	N	N	N
41	C	M	10	8	10.5	9.5	77	N	N	N	L	L	L
42	C	O	8	7	8	7	79	M	M	M	N	M	M
43	C	L	7	8.5	8	9	82	N	N	N	N	N	M
44	C	L	4	1.5	4	1.5	90	M	M	M	L	L	L
45	C	M	8	6.5	9	9	91.5	L	L	L	N	N	N
46	Rh		6	3	7	3.5	91.7	M	M	N	N	N	N
47	Rh		9	8	10	9	93	L	L	L	N	N	N
48	C	L	8	4	8.5	6	94.3	N	N	N	N	N	N
49	Rh		6	2	8	2	95	N	N	N	N	N	N
50	Rh		6	6	7	6	96	M	M	M	N	L	L
51	Rh		16	11	16	11	100	N	N	N	N	N	N

Table 11.--Record of grazing on middle transect through typical foothill chaparral.

		Growth					Degree of grazing						
		1930			1931		1930				1931		
Plant	Species	Condition	Height in dm.	Diameter in dm.	Height in dm.	Location in meters	November	December	January	August	September	October	December
1	C	H	1.0	2.0		.5	H	H	H	L	L	L	L
2	C	H	1.0	1.5		1.	N	H	V	N	N	N	N
3	C	M	3.0	2.0		1.5	M	M	H	N	N	L	L
4	C	H	2.	2		2.5	M	M	M	M	M	M	M
5	C	H	3	4		3.	M	M	M	M	H	H	H
6	C	H	10	5		5	H	H	M	M	H	H	H
7	C	M	8.5	3.5		8.3	H	H	V	H	V	V	V
8	C	H	8	5		9	H	H	H	M	V	H	H
9	C	M	9	7		11	H	V	V	M	M	M	M
10	C	H	6	5		13	H	H	H	M	H	H	H
11	C	M	5	4		14	L	L	L	L	M	M	M
12	C	M	8	7		16.3	L	M	M	L	L	M	M
13	C	M	7	5		24	M	V	V	L	L	M	M
14	C	M	8	6		26.5	M	V	V	L	L	M	M
15	C	M	7	7		32	H	H	H	L	L	V	V
16	C	M	5	6		34	H	H	H	L	L	H	H
17	C	H	3	1.5		36	M	H	M	L	L	M	H
18	C	H	6	6		38	L	L	L	L	L	M	M
19	C	H	8	9		41	H	H	M	L	M	M	M
20	C	H	5	3		42	H	H	H	L	M	M	M
21	C	H	3	3		44	N	N	N	N	N	N	N
22	C	H	3	2		44.6	N	N	N	N	N	N	N
23	C	H	1	1		46.5	H	H	V	N	N	N	N
24	C	H	6.5	4		48	N	N	N	N	N	N	N
25	C	M	15	11		54.5	L	M	M	N	N	L	L
26	C	M	4.5	5	5.5	56	H	V	V	L	L	L	L
27	C	H	10	10	11.5	59	L	L	L	N	N	V	V
28	C	M	4.5	2	4.5	61	M	M	M	N	L	M	M
29	C	M	18	15	18	62	L	L	L	N	N	M	M
30	C	M	10	10	--	64	H	H	H	L	M	M	V
31	C	H	7	6	8	70	N	N	N	N	N	N	V
32	C	H	2	2	2	71	N	N	N	M	M	M	M
33	C	M	4	3	5	73	M	M	M	L	L	L	L
34	C	M	8	7.5	8	76	N	N	N	N	N	N	N
35	C	M	4	3.5	5	79	H	H	H	N	N	N	N
36	C	H	6	4	7	80	N	N	N	N	N	N	M
37	C	H	7	4	7	80.5	H	H	H	N	N	N	M

Table II (continued)

			Growth				Degree of grazing						
			1930		1931		1930				1931		
Plant	Species	Condition	Height in dm.	Diameter in dm.	Height in dm.	Location in meters	November	December	January	August	September	October	December
38	C	M	5	3	6	85.5	N	L	L	L	L	L	M
39	P	-	9	3	9.5	90	N	N	N	N	N	N	N
40	C	H	5	2	6.5	91	N	N	N	N	N	N	N
41	C	L	3	2	4	93	M	M	M	N	N	N	N
42	C	H	10	1.0	11	96	N	N	N	N	N	L	L
43	C	H	7	12	7	100	L	L	L	L	L	L	M
44	C	L	12	14	12	103	N	N	N	N	N	N	N
45	Ro	-	-	-	-	104.3	-	-	-	-	-	-	-
46	C	-	4.	4		110	N	N	N	N	N	N	L
47	C	M	3.5	2.5	4	117	N	N	N	N	N	N	N
48	C	L	5	6	5	122	N	N	N	N	N	L	L
49	Ri	H	4	4	5.5	123.5	N	N	N	N	N	N	N
50	C	M	5	7	6	126.5	L	L	L	N	N	L	L
51	C	M	6	5	6	130.5	N	N	N	L	L	L	M
52	C	M	10	6.5	11	132.5	M	M	M	L	L	L	M
53	C	H	5	4.5	6	134	N	N	N	M	M	M	M
54	C	M	6	5	8	141	H	H	H	L	L	M	H
55	C	-	5	5	5	142.5	N	N	N	N	N	N	N
56	C	M	9	5	9	144	N	N	N	N	N	L	L
57	Ro	-	2.5	1	--	145	N	-	-	-	-	-	-
58	C	H	10	11	11	148	N	N	N	N	N	L	L
59	C	L	6	7	6	149.5	N	N	N	N	N	L	L
60	Rh	-	7	2.5	8	150	N	L	L	N	N	N	N
61	C	L	5	4	5.5	153	M	M	M	M	M	M	M
62	C	M	3.5	2	4.5	155	L	L	L	N	N	N	N
63	Rh	-	4	6	5.5	157.3	L	L	L	N	N	N	N
64	Rh	-	6	4	7	158.5	M	M	M	N	N	N	N
65	C	L	8	9	8	159	M	M	M	N	N	N	N
66	C	M	5	4	5	160.6	M	M	L	L	L	M	M
67	Am	-	9.5	4	9.5	164	N	N	N	N	N	L	L
68	C	L	9	4	10	164.5	N	N	N	N	N	N	N
69	Am	-	8	4	---	165.5	N	N	N	L	L	L	L
70	C	M	7	4	7	170.5	N	N	N	N	N	N	N
71	C	L	6	3	6	175.	N	N	N	N	N	N	N
72	C	M	9	5	9	176.5	L	L	L	L	L	L	L
73	C	M	2.5	1.5	3.5	178.	H	H	H	M	M	M	M
74	C	M	5	4	5	180.5	M	M	M	L	L	L	M
75	C	M	13	11	14	183.	L	L	L	N	N	N	N

Table 12.--Record of grazing on south transect through typical foothill chaparral

			Growth					Degree of grazing				
			1930		1931			1930		1931		
Plant	Species	Condition	Height in dm.	Diameter in dm.	Height in dm.	Diameter in dm.	Location in meters	December	January	September	October	December
1	C	M	3.5	4	3.5	5	0	N	H	N	N	N
2	C	M	8.	3.5	9	6.5	4.3	H	H	L	L	M
3	C	M	4.5	2	6	4	8	M	H	L	H	H
4	C	D	7	5.5	7	5.5	12	N	N	-	-	-
5	C	M	11	10	13	12	13	M	M	L	M	H
6	C	M	10	10	11	13	25	L	M	L	M	M
7	C	M	2	1	1	1	30	M	M	N	N	N
8	C	M	5	6	5	7.5	35.5	M	M	N	M	M
9	C	M	11	14	11	15	37	L	L	N	L	M
10	C	M	5	4	6	5.5	39.5	L	L	N	N	N
11	C	M	5	12	6	4	40	N	N	N	L	L
12	C	M	10	13	10	14	40.5	N	N	L	L	L
13	C	M	7.5	3	9	3.5	45	M	M	N	L	L
14	C	L	8.	10	8	7	48.5	M	H	M	N	N
15	C	M	7	7	8	7.5	49	N	N	N	N	N
16	C	M	13	13	13	14	50.5	N	N	N	L	L
17	C	M	3.5	3	4	3.5	57	M	M	L	L	L
18	C	M	8.5	6.5	10	7.5	58.5	L	L	N	N	N
19	Ro	-	5	3	--	---	58.5	N	N	N	N	N
20	C	M	4.5	3	4	3	60.5	L	L	V	V	V
21	C	M	7	4	7	5	61.5	N	N	L	L	L
22	C	M	6	6.5	7	7.5	68	M	M	L	L	L
23	C	L	9	7	9.5	8	71	N	N	N	N	L
24	C	M	14	18	13	18	72.5	M	M	N	N	L
25	C	M	7	5	10	6.5	73.5	V	V	N	L	H
26	C	M	5	5	7	7	75	M	H	L	L	L
27	C	M	7	7	9.5	7.5	75.5	N	N	M	N	L
28	C	M	5	5	7	6	79	N	N	N	N	N
29	C	M	10	10	---	---	81	M	M	N	N	N
30	C	M	7	7	7	6.5	86	L	L	N	L	L
31	C	M	3	3	3.5	3.5	87.5	H	V	N	M	M
32	C	M	5.5	7	6.5	7.5	90	L	L	L	H	H
33	C	M	4	3	5	4	92.5	N	N	N	N	N
34	C	M	4	3	4.5	4.5	92.3	L	L	N	N	N
35	C	M	9	7	9	7	94	M	M	L	L	L
36	Ro	-	3	1	---	---	96	-	-	-	-	-
37	Ro	-	4	1	---	---	97.5	-	-	-	-	-
38	C	M	5	5	5.5	5.5	98	L	L	N	N	N
39	C	M	7	5	8.5	6.5	99.5	N	N	N	N	N
40	C	M	9	5	10	7.5	101.5	L	L	N	N	N

Table 12. (continued)

Plant	Species	Condition	Growth 1930 Height in dm.	Growth 1930 Diameter in dm.	Growth 1931 Height in dm.	Growth 1931 Diameter in dm.	Location in meters	Degree of grazing 1930 December	Degree of grazing 1930 January	Degree of grazing 1931 September	Degree of grazing 1931 October	Degree of grazing 1931 December
41	Rh		6	6	7	-	102	L	L	N	N	N
42	Rh		7	12	--	--	103	L	L	N	N	N
43	Rh		5	3	5.5	--	104	L	L	N	N	N
44	C	M	7	9	8	10	110	L	L	N	N	N
45	C	L	7	7	8	5.5	112.6	N	N	N	N	N
46	C	M	7	1.2	8	9.5	119	L	L	N	M	M
47	C	M	2	2	2.5	2	122	H	H	N	N	N
48	C	M	5	5	5.5	6	125	N	N	N	L	L
49	C	M	5.5	3.0	6.5	5	126	H	V	N	N	N
50	C	M	6	8.5	8.5	11	127	H	V	N	M	M
51	C	M	6	6.5	8	11.5	127.5	L	L	N	L	L
52	C	M	7	6	9.5	9	129	L	L	N	N	N
53	C	M	7	7	7.5	8.5	131	L	L	N	N	N
54	C	M	5	6	7	6.5	131.3	L	L	N	N	N
55	Ro	-	2.5	2	---	----	132.	H	H	-	-	-
56	Ro	-	3	2	---	----	135	M	M	-	-	-
57	C	M	10	10	10	12	137	L	L	N	N	L
58	C	M	6	7	7	8	141	N	N	N	N	N
59	C	M	5	5	6	6.5	143.5	N	N	N	N	N
60	Ro	-	4	2	--	----	144	H	H	-	-	-
61	C	M	6.5	4	8	6	146.5	N	N	N	M	M
62	C	M	6	3	7	3	147	N	N	N	L	L
63	C	L	8	3	9.5	4	148	N	N	N	L	V
64	C	M	5	2	7	5.5	149	N	N	N	N	N
65	C	M	6	4	6.5	6	149.5	N	N	N	N	M
66	Rh	-	2	3	4	4.5	152	M	H	N	N	N
67	C	L	5	2	5.0	2.5	153	N	N	N	N	N
68	Rh	-	5	4	---	----	153.5	L	L	N	N	N
69	Rh	-	9.5	11	---	----	154	L	L	N	N	N
70	C	M	6	6	7	6.5	157	N	M	N	M	M
71	C	M	3	3	3	3	160	N	N	N	N	N
72	C	M	5	2	5.5	2.5	161	L	L	N	N	N
73	C	M	5	3	6	4	162.3	L	L	N	N	N
74	C	M	6	6	7	6.5	162.5	M	H	N	L	L
75	C	M	10	5.0	10	5.0	164.5	N	N	N	N	N
76	C	M	6	3	7	4.5	165	N	N	N	N	N
77	C	L	5	2.5	5	3	168	N	N	N	N	N
78	C	M	7	4	7.5	7	172	N	N	N	N	N
79	C	M	6	3	7.5	5	172	L	L	N	N	N
80	C	M	5	2.5	4.5	3.5	173	L	L	N	N	N

Table 12 (continued)

			Growth					Degree of grazing				
			1930		1931			1930		1931		
Plant	Species	Condition	Height in dm.	Diameter in dm.	Height in dm.	Diameter in dm.	Location in meters	December	January	September	October	December
81	C	M	4.5	3	6	4.5	173.5	M	M	N	N	N
82	C	M	8	7.5	9	9	182	L	L	N	N	N
83	C	M	10	10	8.5	10	183	L	L	N	M	M
84	C	M	6.5	3	6.5	4.5	190	L	M	N	N	N
85	C	M	9.0	10	10	12	191	L	M	N	L	L
86	C	M	5.0	2	6.5	3.5	196	--	-	N	L	L
87	C	L	7	7	8	6.5	197	M	M	N	H	H
88	C	M	8	3	9	5	200	L	L	M	N	N

In the above table the utilization of shrubs in typical chaparral is indicated. Several considerations are obviously of value in determining the utilization of foothill chaparral.

Accessibility - In Tables 10, 11, and 12 the heights and diameters of the various species and individuals are given. It is apparent from these observations that the individual plants are for the most part accessible. Very few individuals exceed the height to which cattle can graze. From a view of a small portion of the pasture as shown in Figure 16, one can see that individual plants are accessible. The distribution of plants is remarkably uniform. Density of the stand and height ofvegetation or utilization of this pasture are not factors as may be the case in other types of browse.

The difference between accessibility of mixed-prairie pasture and shrub pasture is merely a question of slope. Trails worn by the stock from the shed, which is directly between the two kinds of pasture, penetrate all parts of the shrub pasture.

Season of Use - The value of shrubs for pasture is readily seen in the study where stock had access to both shrubs and grassland below. The pasture was visited during July and August. Shrubs were not touched except for an occasional plant before August first. Grazing

records were not taken before September first. On that date the grazing was recorded. The results obtained from that time on are contained in the preceding tables, and in Table 13 where the monthly grazing is summarized.

At the end of August, 46 per cent of the shrubs showed some degree of grazing.

The following table (Table 13) gives a summary of the data to illustrate this point.

To explain the marked change in one month we must look to directly related factors, i. e., the condition of the understory and the condition of adjacent pasture.

By August first the vegetation in the mixed prairie had reached maturity as indicated in Figure 19. The forage not only becomes dryer, but also utilization of the most palatable plants must have been nearly complete. As growth continues much later in the chaparral the moisture content of the forage would be higher.

In the understory of the shrubs Bromus tectorum would be matured and uninviting because of awns developed and the high fiber content of the fruit stalk. The other grasses showed at least 90 per cent utilization. They were all cropped to the ground. The maturity and utilization of forage in the mixed-prairie pasture and understory in the shrub pasture are contributing factors in the early

Table 13.--Degree of grazing for monthly periods during fall and winter. Seasons of 1930-1931 and 1931-1932

Degree of grazing	November 1930		December 1930		January 1931		August 1931	
	No. of plants	Per cent of all plants	No. of plants	Per cent of all plants	No. of plants	Per cent of all plants	No. of plants	Per cent of all plants
None	41	33.6	65	30.9	62	29.5	39	53.4
Light	20	16.4	51	24.3	50	23.8	23	31.5
Moderate	33	27.1	51	24.3	49	23.3	10	13.7
Heavy	27	22.1	36	17.1	35	16.7	1	1.4
Very heavy	1	.8	7	3.4	14	6.7	0	0.
Total	122	100.0	210	100.0	210	100.0	73	100.0

Degree of grazing	September 1931		October 1931		December 1931	
	No. of plants	Per cent of all plants	No. of plants	Per cent of all plants	No. of plants	Per cent of all plants
None	133	64.2	96	46.4	82	39.7
Light	43	20.8	51	24.6	45	21.7
Moderate	19	9.2	36	17.4	46	22.2
Heavy	5	2.4	13	6.3	19	9.2
Very heavy	7	3.4	11	5.3	15	7.2
Total	207	100.0	207	100.0	207	100.0

fall use of the browse plants. It is evident that this point would be reached sooner if the adjacent grass pasture and grass in the type furnished less forage. These results are entirely in harmony with the observations of Forsling and Storm (21).

It is certainly evident that the shrubs are less desirable (palatable) to cattle than associated grasses during the growing season.

Monthly Use - In Table 13 the monthly change in utilization and varying intensity of grazing is summarized. The results in Table 13 are graphically shown in Figures 31 and 32. They illustrate the monthly trend for each season. August values in Figures 32 are based on one transect so that use in September does not follow uniformly with the remainder of curve. This is probably due to irregularity in use from one transect to another. However, the trend with the months is readily seen.

Figure 31 shows the trend of grazing for the 1930-1931 season. The increased grazing is rather uniform. The per cent of ungrazed class partly replaced by an increase in the lightly grazed class. The moderate and heavy classes being reduced by an increase in the very heavy class.

In Figure 32 this trend is more clearly shown. The

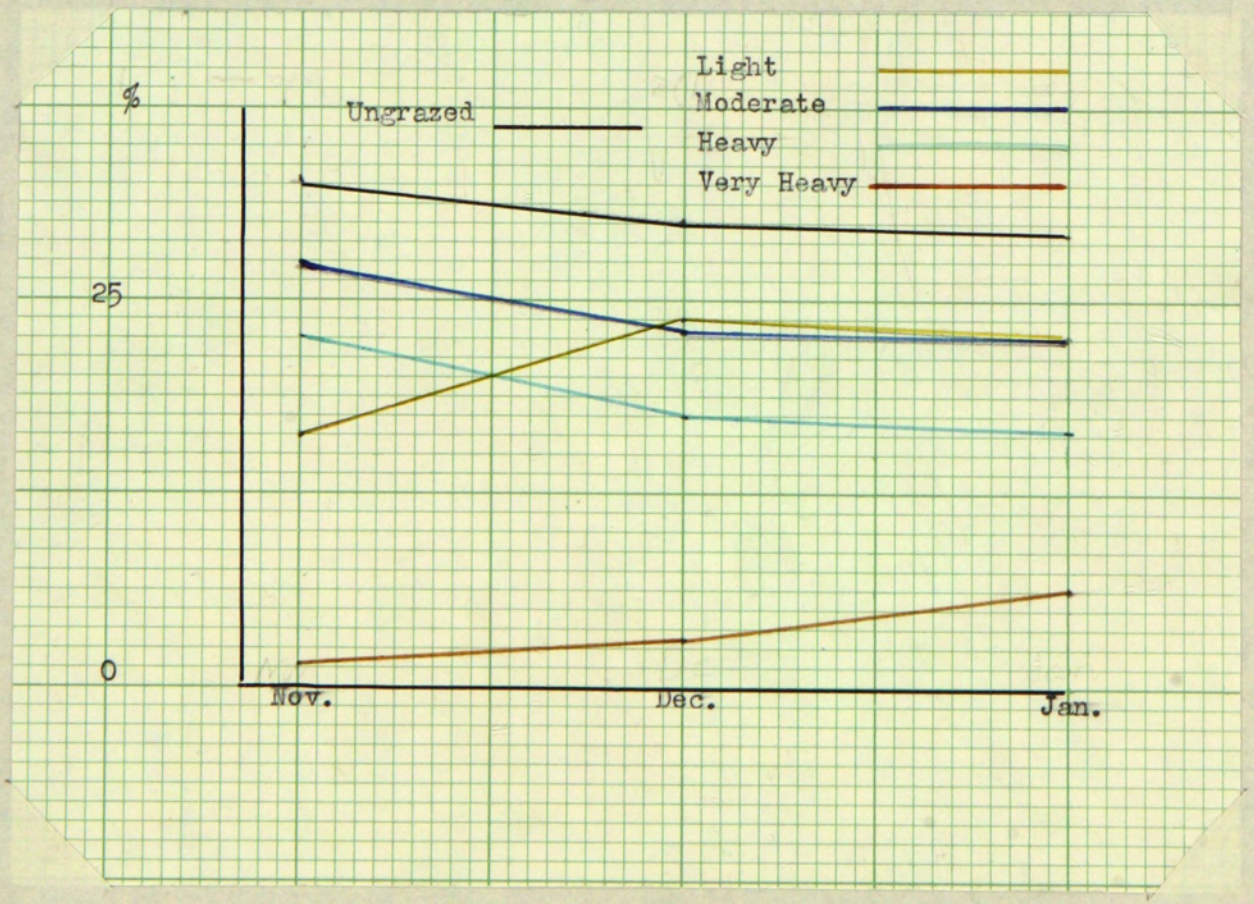


Fig. 31.--Per cent of utilization during observed portion 1930-1931 season, by intensity classes.

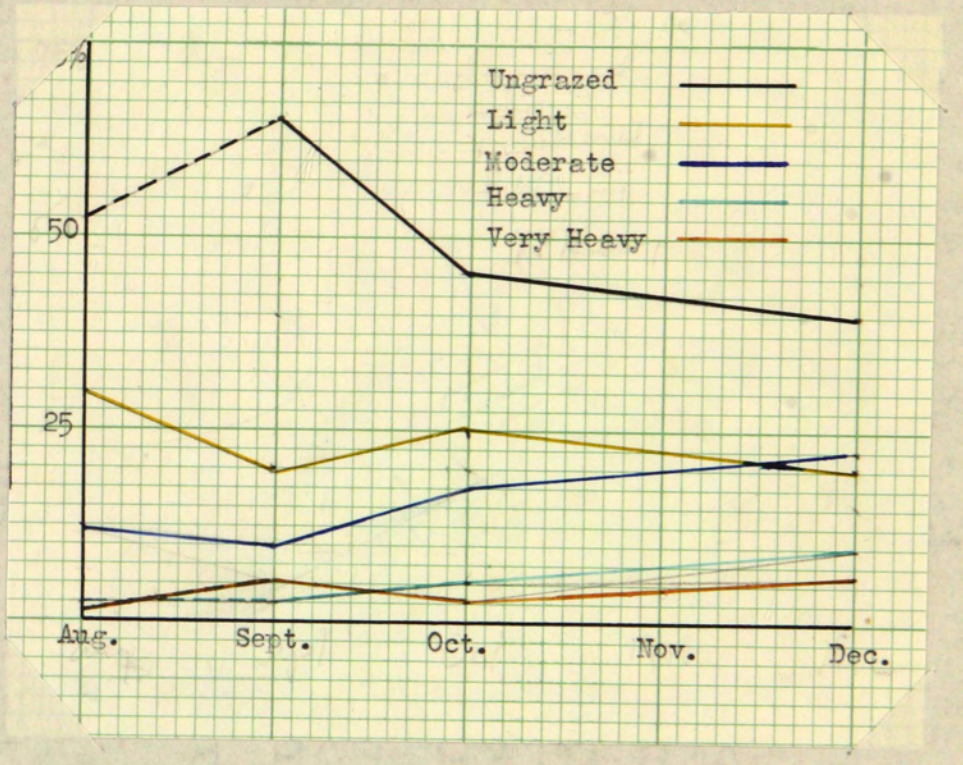


Fig. 32.--Percent of utilization, fall and winter months of 1931, by intensity classes.

The downward trend of the non-grazed class is pronounced after September 30.

The light-grazed class shows an increase of 5 per cent at the end of October, but drops 5 per cent at the end of season to 20 per cent of all classes. The drift of the next three classes shows a more general upward trend replacing the per cent of each succeeding class.

The difference in trend of curves for the two seasons may be explained only in that the maximum degree of grazing was reached later in 1931.

The 1930-1931 season differs from that of the 1931 season in that utilization was much heavier. Utilization reached 70 per cent for total of all degrees of grazing. The pasture could still be utilized to the extent of 100 per cent of the heavy class. In either year the pasture was not grazed more than moderately.

During the 1931 grazing season the transect which gave the August value indicates that over half the shrubs were untouched and those which were grazed heavier than 25 per cent of their stems amounted to 15 per cent. The bulk of the shrubs that were grazed were only lightly grazed . The trend from month to month for the different classes was uniform. The per cent of medium, heavy, and very heavy classes increased to the end of the study, while the per cent of ungrazed and lightly grazed

shrubs decreased. At the end of the 1931 season, 60 per cent were lightly grazed and 22.2 per cent were moderately grazed, 9 per cent heavily grazed and 7 per cent very heavily grazed. The shrubs as a whole were not fully utilized to any degree of their capacity which is 100 per cent of heavy class only.

Size of pasture and slope - The relation of extent of of browse pasture to its full utilization has been a subject of conjecture. In California, chaparral areas that have a plant cover of from 90 to 100 per cent have been opened up by brushing out of fire lines and power line right-of-ways. It was observed there that penetration of cattle into the chaparral was increased. In the pasture here studied with a more open cover the immediate benefit was not seen. Trails thru the area merely increased grazing immediate to the trail. Where only a few plants are present in a zone intersected by the trail, the effect will be noticed in the resulting data. However, analysis of data and location of trails indicate the noted effect.

The results from Tables 10, 11, and 12 are re-established in Table 14 and comparison made with reference to zones. The 0-25 meter zone represents the lower edge of the pasture while the last zone the upper margin. These values are more clearly expressed in a graphic

Table 14.---Distribution of grazing by zones and different intensities of grazing - Season of 1930-31.

Degree of grazing	0-25		25-50		50-75		75-100		100-125		125-150		150-175		175 +	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Period - November, 1930 Distance in Meters																
None	1	3.8	5	20.8	7	31.8	11	55.0	5	100.0	7	70.0	5	45.4	0	0
Light	3	11.5	4	16.7	5	22.7	3	15.0	0	0	1	10.0	2	18.2	2	50.0
Moderate	11	42.4	6	25.0	6	27.3	4	20.0	0	0	1	10.0	4	36.4	1	25.0
Heavy	10	38.5	9	37.5	4	18.2	2	10.0	0	0	1	10.0	0	0	1	25.0
Very heavy	1	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	26	100.0	24	100.0	22	100.0	20	100.0	5	100.0	10	100.0	11	100.0	4	100.0
Period - December, 1930																
None	2	6.2	8	22.8	9	27.3	14	43.7	7	50.0	13	48.2	12	44.5	0	0
Light	2	6.2	5	14.4	8	24.2	8	25.0	6	25.9	7	42.9	8	29.6	7	70.0
Moderate	14	43.8	8	22.8	11	33.3	7	21.9		0	2	7.4	7	25.9	2	20.0
Heavy	11	34.4	12	34.3	3	9.1	3	9.4	1	7.1	5	18.5	0	0	1	10.0
Very heavy	3	9.5	2	5.7	2	6.1	0	0	0	0	0	0	0	0	0	0
Total	32	100.0	35	100.0	33	100.0	32	100.0	14.	100.0	27	100.0	27	100.0	10	100.0
Period - January, 1931																
None	1	3.1	8	22.8	8	24.2	14	43.7	7	50.0	13	48.2	11	40.8	0	0
Light	1	3.1	6	17.2	9	27.3	8	25.0	6	42.9	7	25.9	8	29.6	5	50.0
Moderate	11	34.4	9	25.8	10	30.3	7	21.9	0	0	2	7.4	6	22.2	4	40.0
Heavy	14	43.8	8	22.8	4	12.1	2	6.2	1	7.1	3	11.1	2	7.4	1	10.0
Very heavy	5	15.6	4	11.4	2	6.1	1	3.1	0		2	7.4	0	0	0	0
Total	32	100.0	35	100.0	33	100.0	32	100.0	14	100.0	27	100.0	27	100.0	10	100.0
Period - August, 1931																
None	2	15.3	4	36.4	5	55.6	8	80.0	5	100.0	6	60.0	8	72.7	1	25.0
Light	4	30.8	7	63.6	3	33.3	2	20.0	0	0	3	30.0	2	18.2	2	50.0
Moderate	6	46.2	0	0	1	11.1	0	0	0	0	1	10.0	1	9.1	1	25.0
Heavy	1	7.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Very heavy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 14 (continued)

Degree of grazing	0-25		25-50		50-75		75-100		100-125		125-150		150-175		175 +	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Period - September, 1931 Distance in Meters																
None	3	9.7	16	48.6	21	63.7	26	81.2	14	100.0	20	83.4	24	80.9	8	72.7
Light	10	32.3	11	31.4	9	27.3	6	18.8	0	0	3	12.4	2	7.4	2	18.2
Moderate	10	32.3	4	11.4	2	6.0	0	0	0	0	1	4.2	1	3.7	1	9.1
Heavy	6	16.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Very heavy	3	9.7	3	8.6	1	3.0	0	0	0	0	0	0	0	0	0	0
Total	31	100.0	35	100.0	33	100.0	32	100.0	14	100.0	24	100.0	27	100.0	11	100.0
Period - October, 1931																
None	2	6.5	12	34.3	14	42.2	21	65.7	11	78.4	11	45.8	10	74.1	4	36.4
Light	4	13.0	10	28.6	10	30.4	8	25.0	2	14.4	9	37.5	4	14.8	4	36.4
Moderate	11	35.5	8	22.8	6	18.2	2	6.2	1	7.2	4	16.7	2	7.4	2	18.2
Heavy	9	29.0	1	2.9	1	3.0	1	3.1	0	0	0	0	1	3.7	1	9.1
Very heavy	5	16.0	4	11.4	2	6.0	0	0	0	0	0	0	0	0	0	0
Total	31	100.0	35	100.0	33	100.0	32	100.0	14	100.0	24	100.0	27	100.0	11	100.0
Period - December, 1932																
None	2	6.5	10	28.6	11	33.3	17	53.1	9	64.2	9	37.5	20	74.1	4	36.4
Light	3	9.7	10	28.6	11	33.3	6	18.8	3	21.4	7	29.1	3	11.1	2	18.2
Moderate	11	35.5	6	17.1	5	15.2	8	25.0	2	14.4	6	25.0	4	14.8	4	36.4
Heavy	10	32.3	4	11.4	2	6.1	1	3.1	0	0	1	4.2	0	0	1	9.1
Very heavy	5	16	5	14.3	4	12.1	0	0	0	0	1	4.2	0	0	0	0
Total	31	100.0	35	100.0	33	100.0	32	100.0	14	100.0	24	100.0	27	100.0	11	100.0

manner in Figures 33 to 44. The relationship existing between intensity of grazing and extent and slope of pasture is brought out in trend of the various grazing classes.

In Figures 33, 34, and 35 the different intensities of grazing, i. e., ungrazed, light, medium, heavy, and very heavy, are compared for each zone in the pasture. These figures represent the 1930-1931 season.

Figure 33 shows the trend and distribution of grazing as affected by slope and extent of pasture for November 1930, our first record of utilization. The most significant difference is in the distribution of grazing. The trend is uniformly upward, as indicated by the increase in per cent of shrubs ungrazed. However, at 100-125 meter zone there is a break and the per cent of ungrazed shrubs decreases to the last zone. A comparison with following months of December and January, illustrates how this distribution is maintained. It is further substantiated by the results of the 1931 season indicated by Figures 36 to 44. These results are contrary to supposed grazing of this type of vegetation.

In returning to Figure 33, we find no uniformity in the trend of amount and the distribution of the grazing classes. The bulk of the shrubs that have been touched are only moderately grazed. The heavy class is greatest

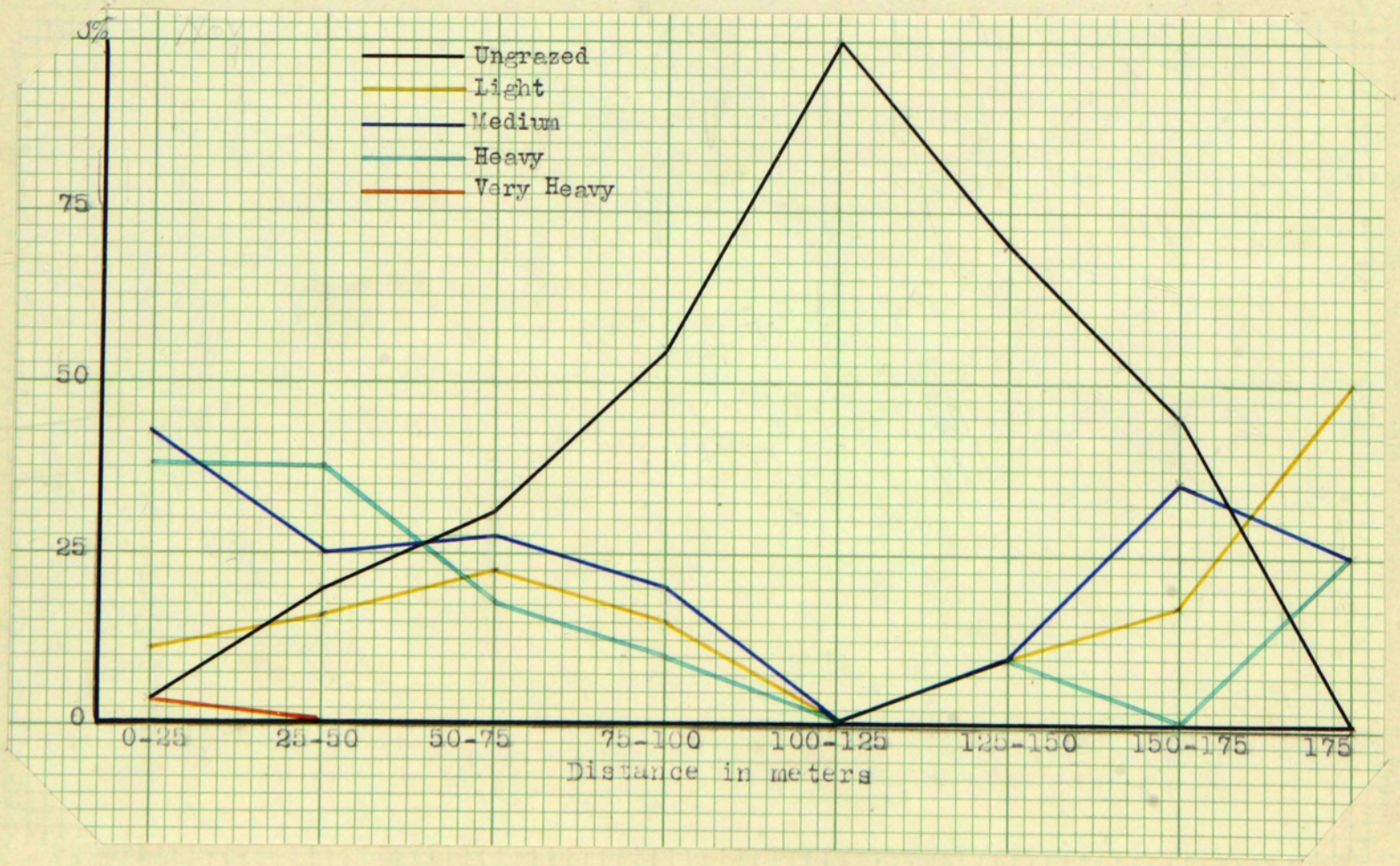


Fig. 33.--Trend and distribution of grazing for November 1930, as affected by slope and extent of pasture.

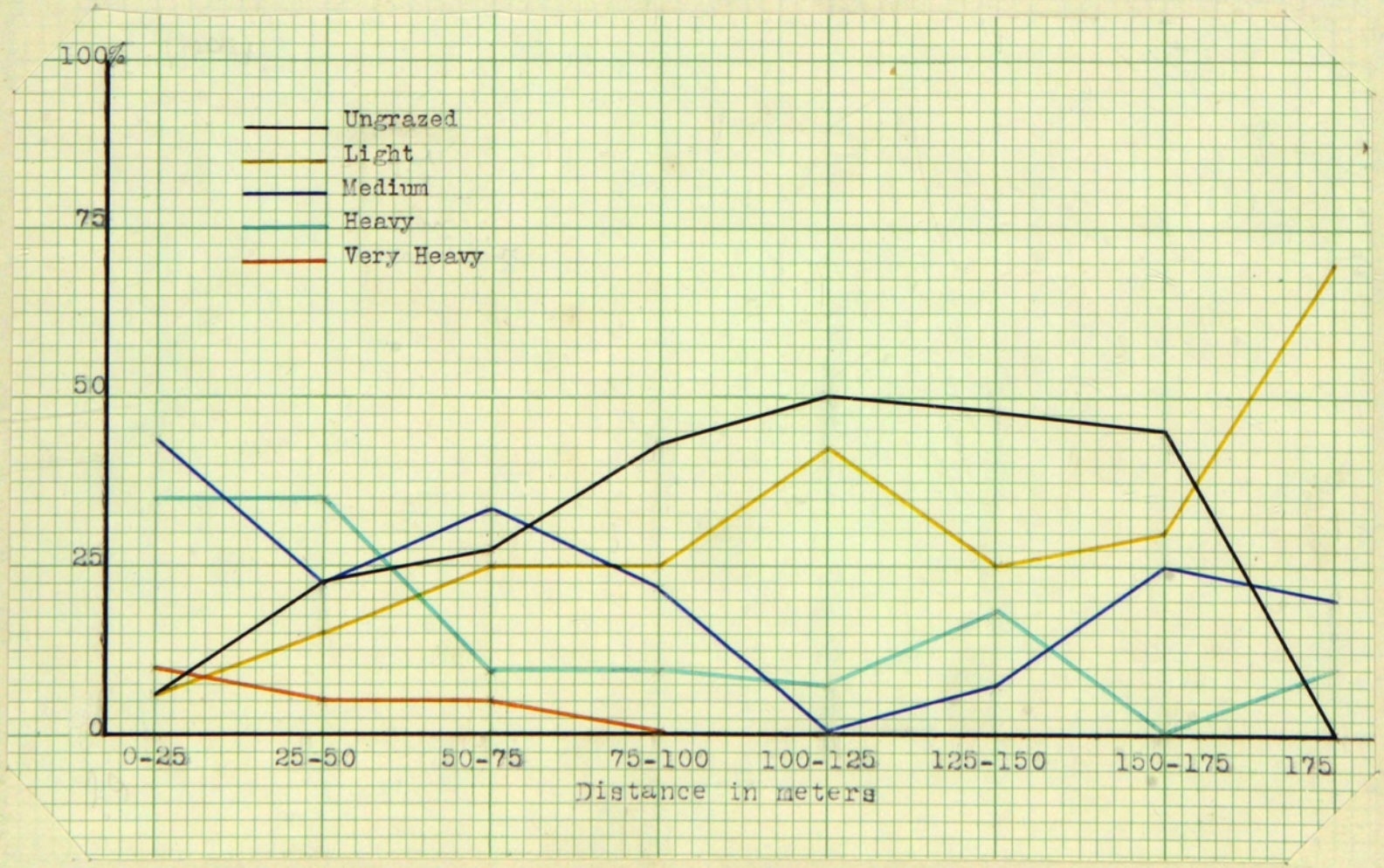


Fig. 34.--Trend and distribution of grazing for month of December 1930, as affected by slope and extent of pasture.

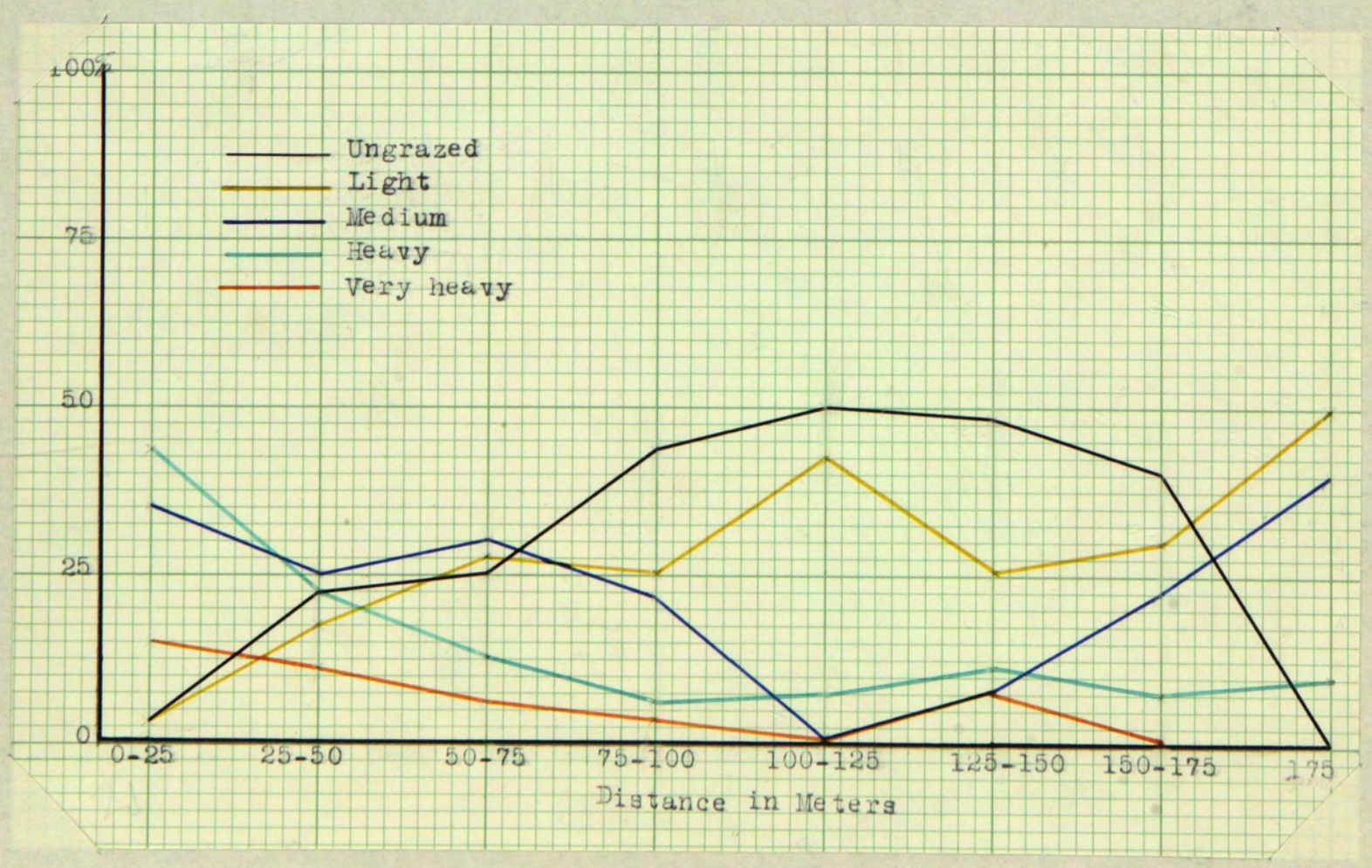


Fig. 35.--Trend and distribution of grazing for month of January, 1931 as affected by slope and extent of pasture.

at the lower end of the slope and is replaced by the light and medium grazed class in the upper zones. The pasture has been very heavily grazed in the first lower zone.

As indicated by Figures 34 and 35, the distribution has become more uniform. At least the center of the pasture is being grazed. The increase in the light and heavy classes is noticeable. The trend of the very heavy class is indicative of repeated grazing and greater penetration by stock.

The results obtained during the 1931 season, August to December, inclusive, are in general similar to the previous years grazing. The upward trend of the ungrazed class to maximum in the 100-125 meter zone is again illustrated. The grazing being heaviest in the lower zones and next heaviest in the upper zone and least in the 100-125 zone and other zones adjacent to it.

In Figures 31 and 32 the difference in amount grazed for the two seasons was noted. A comparison of the graphs for slope relation in Figures 33 to 39 again bring out this point.

Further analysis of utilization with respect to slope can be seen in Figures 40 to 44.

In Figure 40 the per cent of non-grazed plants is

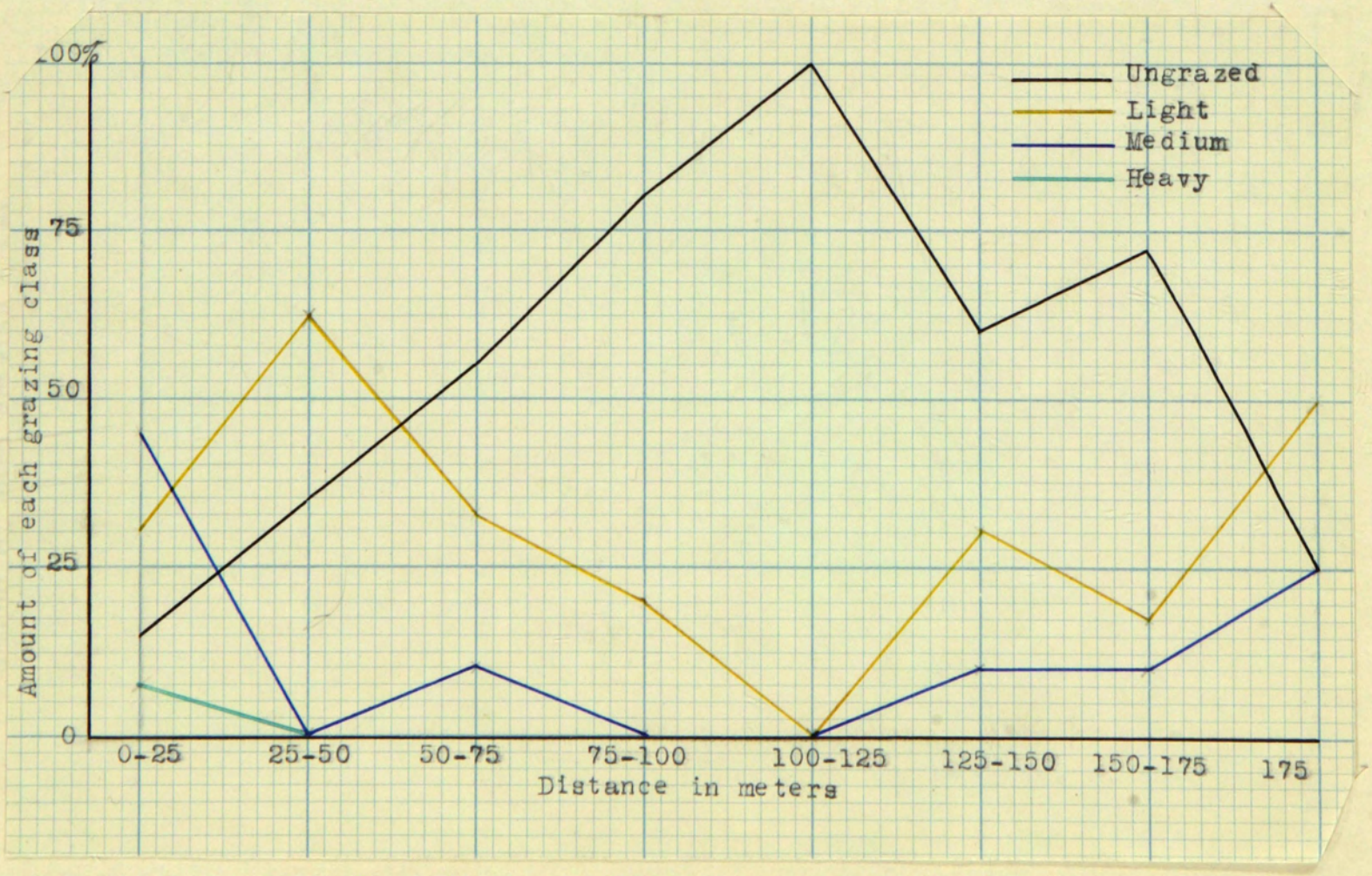


Fig. 36.--Trend and distribution of grazing for August 1931, as affected by slope and extent of pasture.

Fig. 37.--Trend and distribution of grazing for September 1931, as affected by slope and extent of pasture.

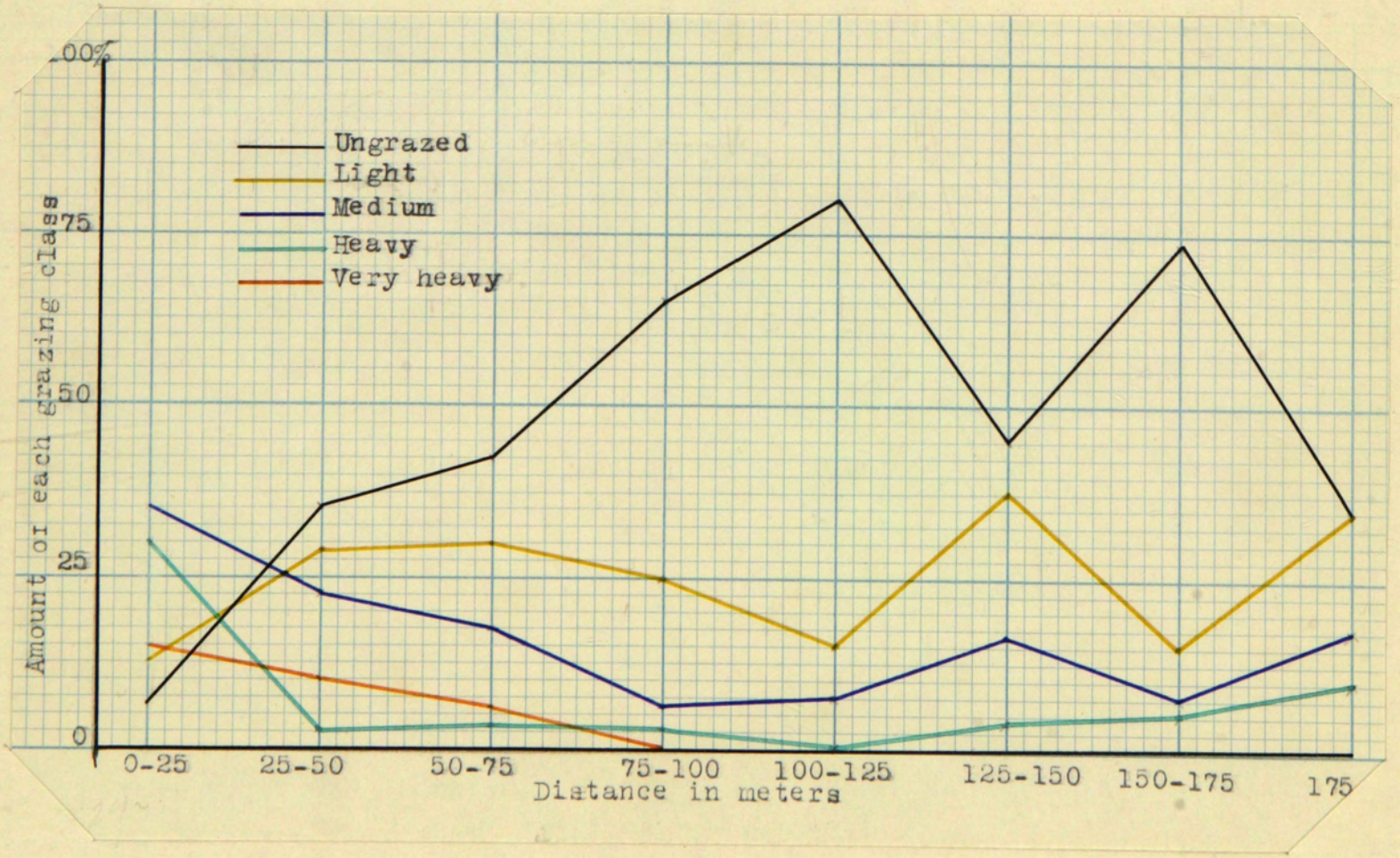


Fig. 38.--Trend and distribution of grazing for October 1931, as affected by slope and extent of pasture.

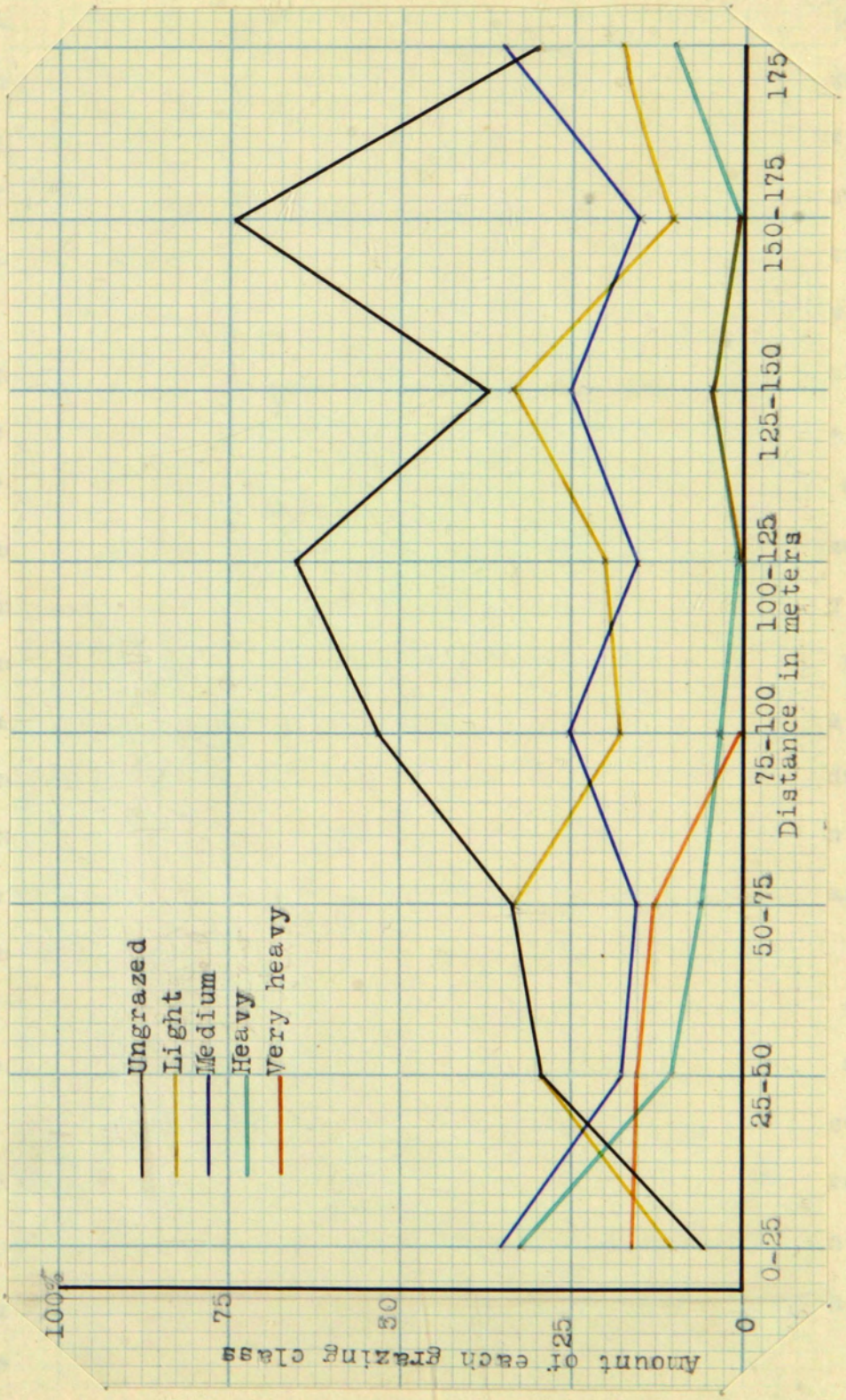


Fig. 39.--Trend and distribution of grazing for December 1931, as affected by slope and extent of pasture.

shown. The monthly increase in grazing in center of pasture is much greater than at either end of the pasture. The uniform progression of increased grazing from month to month is readily seen. (The August curve is the result of data from one transect and would be based on fewer plants with the natural disagreement with general trend.)

In Figure 41 where the monthly trend of lightly grazed shrubs is shown the change from month to month indicates the penetration of stock rather markedly. The effect of slope is a bit more uniform as one might expect. There is a decrease in the per cent of lightly grazed shrubs, i. e., shrubs are being grazed more heavily at the lower end of the pasture and at the upper end, while in the center the per cent of lightly grazed shrubs is increasing. In Figure 42 where the per cent of moderately grazed shrubs is plotted, there is a decrease again at the bottom and top of slope with a corresponding increase in the center.

In Figures 43 and 44 the increase in heavy and very heavy classes shows a uniform increase with season and slope. These classes are replacing the other classes as grazing becomes heavier. Shrubs which were only grazed lightly or moderately on the lower end and upper end of the pasture are grazed again during the season with an increase in the heavy and very heavy classes.

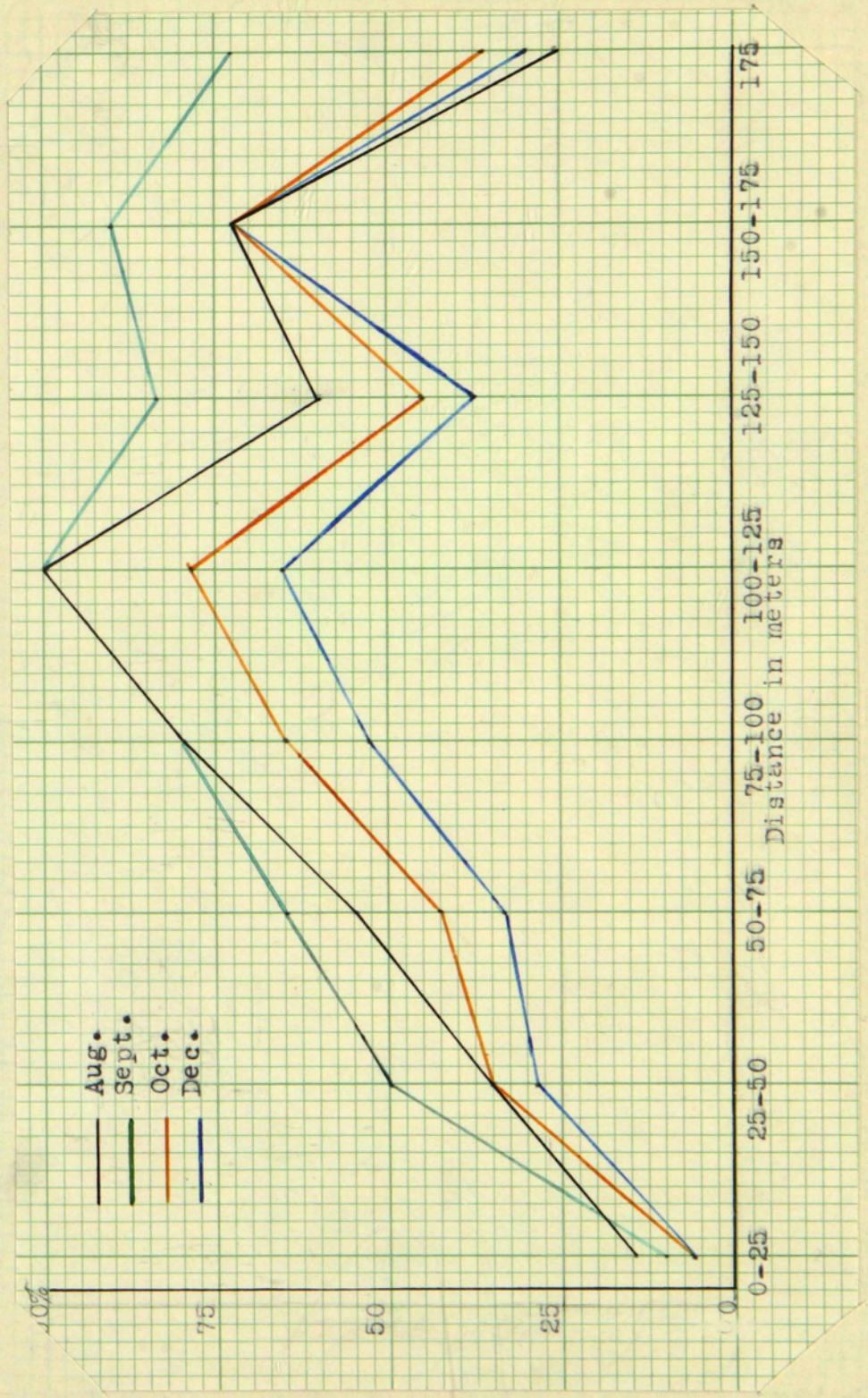


Fig. 40.--Monthly trend of per cent of ungrazed shrubs as affected by slope and extent of pasture.

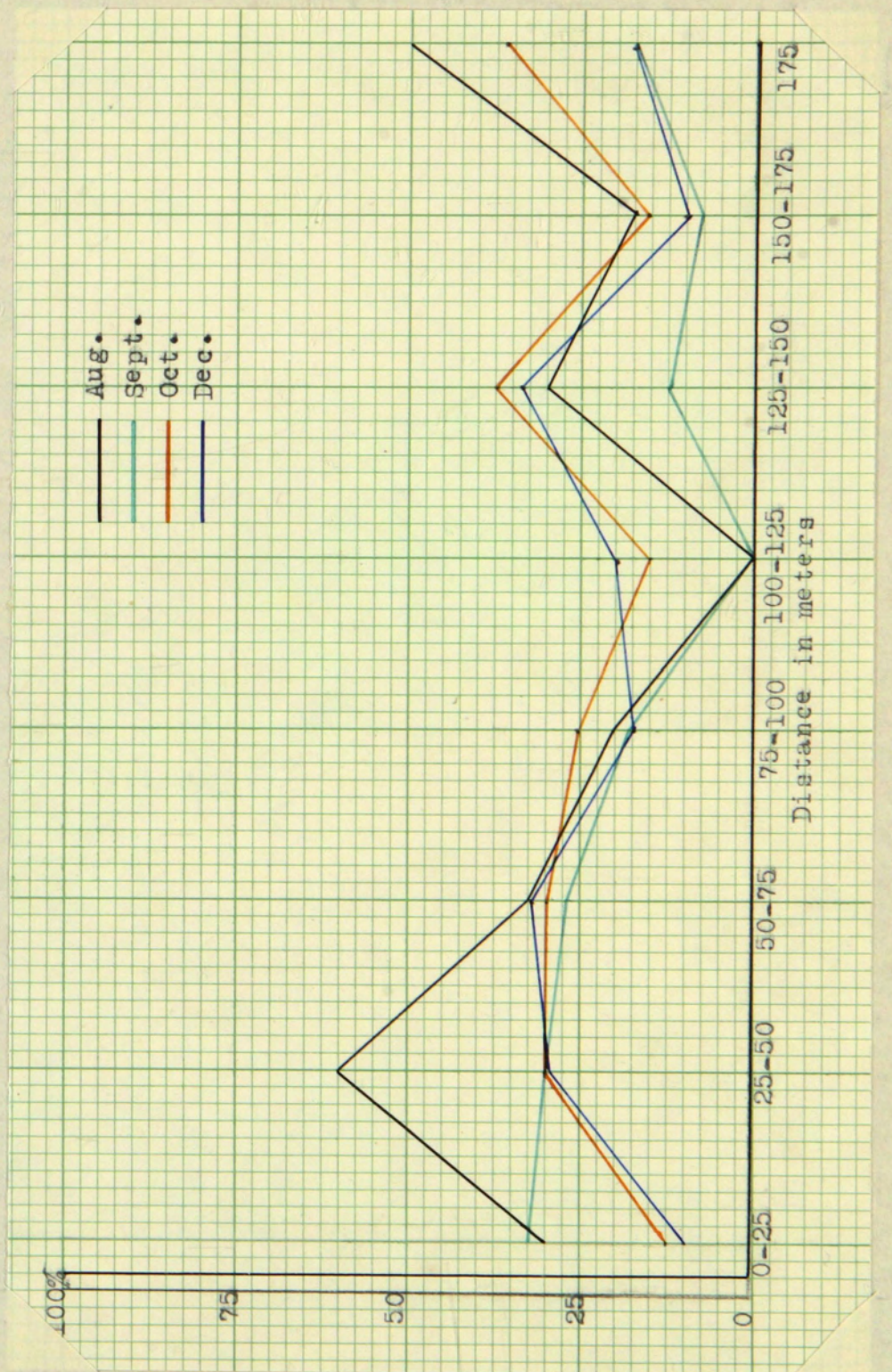


Fig. 41.--Monthly trend of per cent of shrubs lightly grazed as affected by slope and extent of pasture.

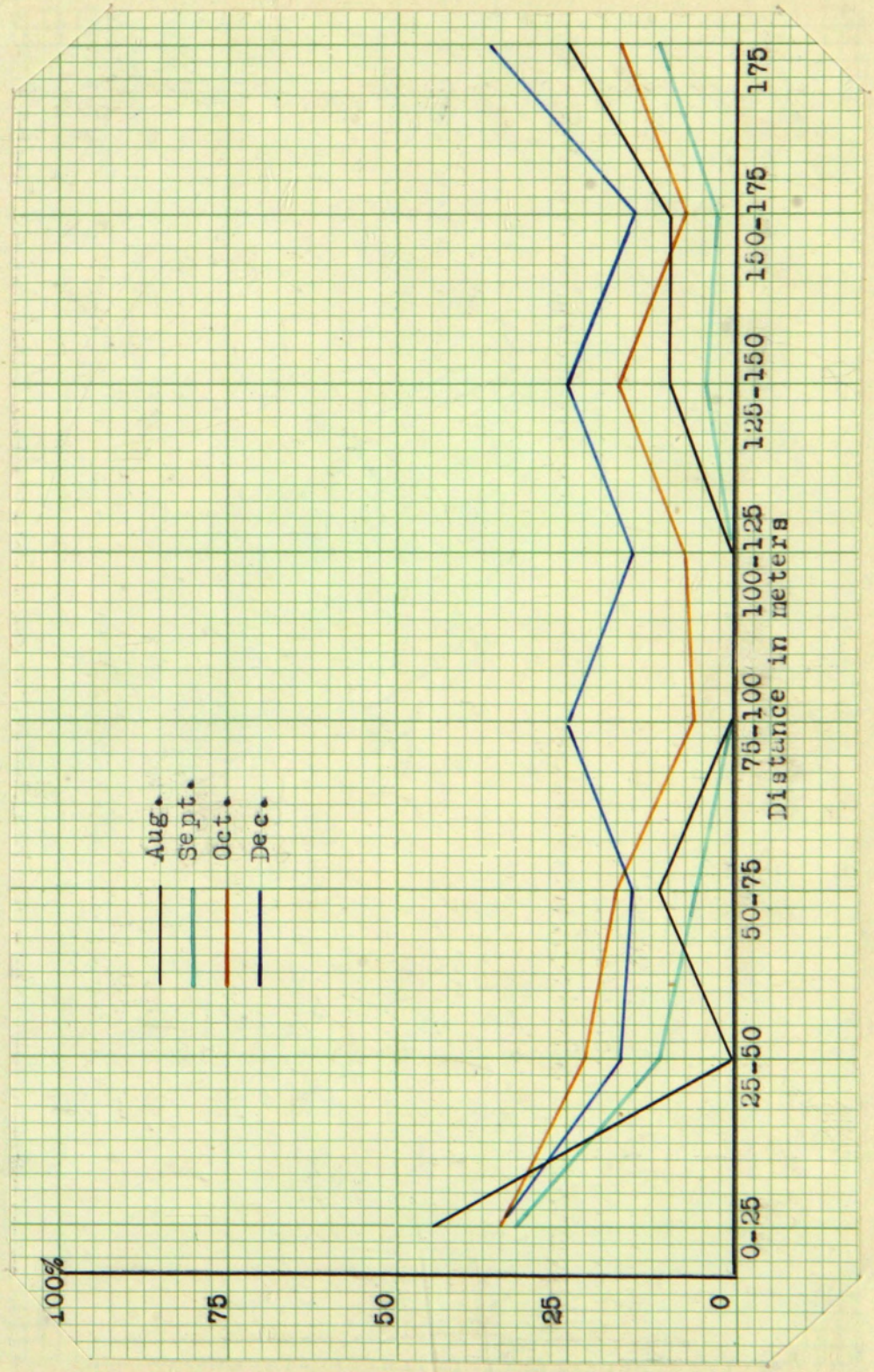


Fig. 42.--Monthly trend of per cent moderately grazed as affected by slope and extent of pasture.

Fig. 43.--Monthly trend of per cent heavily grazed as affected by slope and extent of pasture.

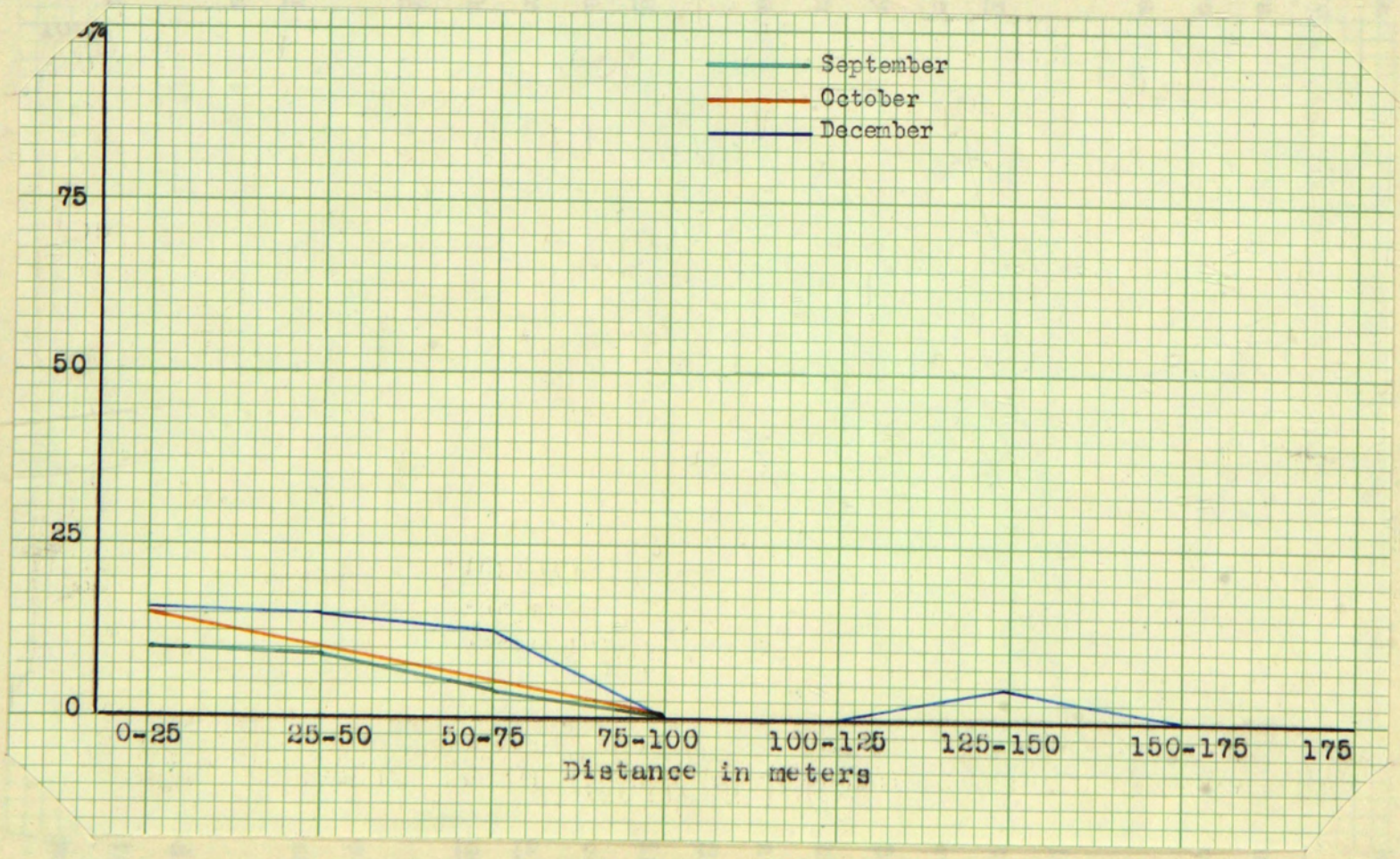


Fig. 44.--Monthly trend of per cent very heavily grazed as affected by slope and extent of pasture.

From the foregoing analysis it is evident, then, that slope and extent of pasture as well as season has a pronounced effect on the distribution and intensity of grazing in the pasture. Trails evidently permit access from one margin of the type to another. Penetration of grazing is from both margins toward the center.

Utilization of different species - The utilization of Cercocarpus is identical with the use which the pasture received. To restate some of the observed values, we can say that the shrub is grazed principally to about 50 per cent of its current annual growth. This is comparable again to the palatability value of 40 per cent given to it.

In comparing the values in Tables 10, 11, and 12, for Rhus, with adjacent individuals of Cercocarpus we find that it was either lightly grazed or not grazed as compared to moderately grazed or lightly grazed Cercocarpus. Ribes was not grazed adjacent to lightly grazed Cercocarpus.

Rosa, on the other hand, was heavily grazed before Cercocarpus was touched. After the spines matured and leaves turned color no further grazing was noted.

Prunus showed considerable variation in observed utilization. It occurred so infrequently in the established transects that the observations are meager. As the

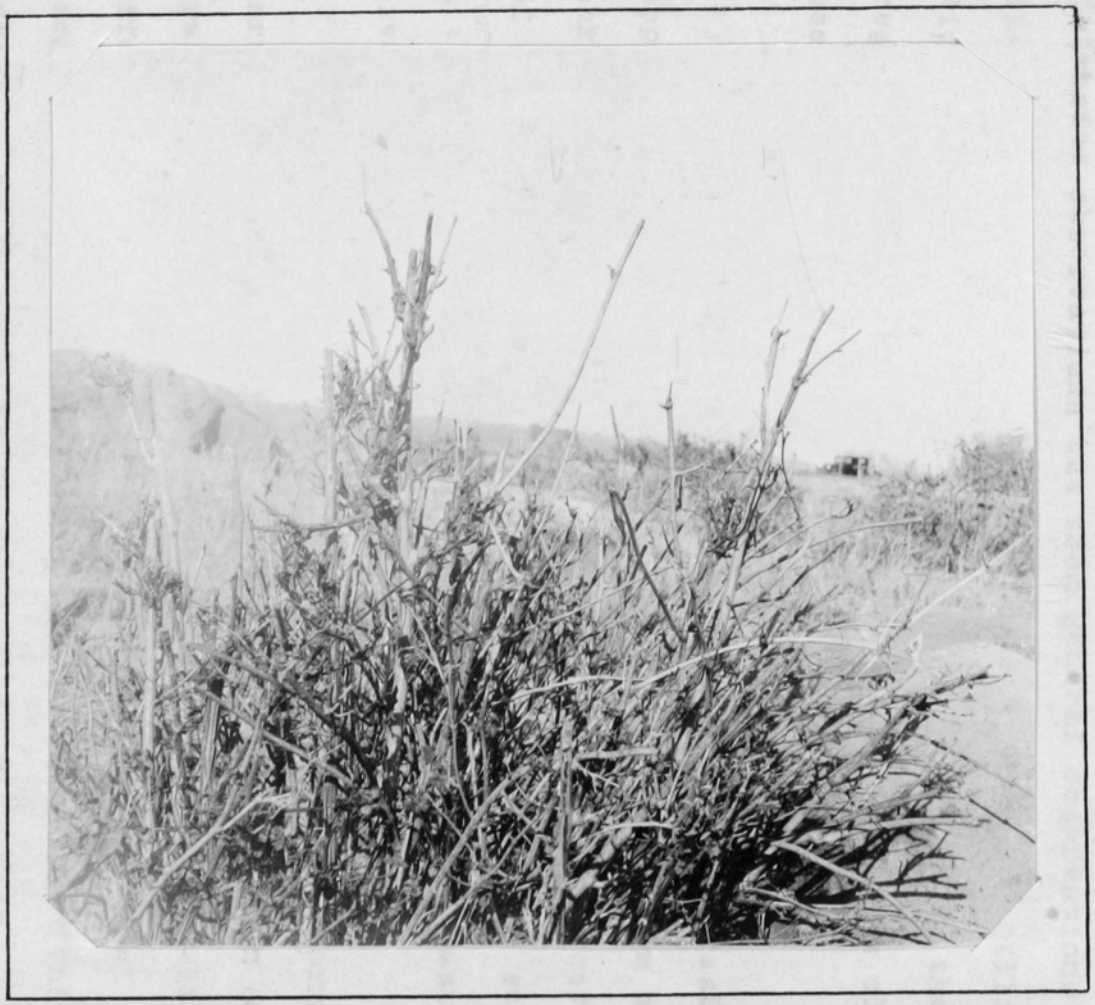


Fig. 45.--An isolated plant of Bossekia in mixed-prairie grassland. The heavy grazing of thick stems is indicative of its palatability when not associated with Cercocarpus.

plant approaches a small tree in size and form, with but slight development of branches as compared to the other shrubs, it frequently shows considerable use.

Bossekia also being rather infrequent did not permit intensive observations but from general observations in the pasture occasional shrubs showed very light utilization while isolated plants occurring elsewhere in the region would show very heavy utilization. This is clearly seen in Figure 45.

Effect of grazing on shrubs - Any degree of grazing appears to have a characteristic effect on the form of the shrubs. This is so general an observation that records of other workers need not be cited. Every one has seen a trimmed hedge and this effect is identical to grazing by livestock.

In Figures 45 to 50 the result of grazing on form of shrub is shown. Figure 46 illustrates a comparison of grazed and ungrazed Cercocarpus plants. The broom-like effect is readily seen. The removal of the terminal buds seems to accelerate the development of laterals. This effect is again shown by Cercocarpus in Figure 47.

The grazing of Bossekia results in an effect similar to that occurring on grazed Cercocarpus. Figures 45 and 48. Bossekia and Cercocarpus also showed considerable

Fig. 46.--A comparison of ungrazed and grazed plants of Cercocarpus. The modification of form and growth is evident.

Fig. 47.--Another view of a heavily grazed Cercocarpus plant. Note the varied tendency in shoot development. Long basal shoots are clearly seen at the base of the shrub.

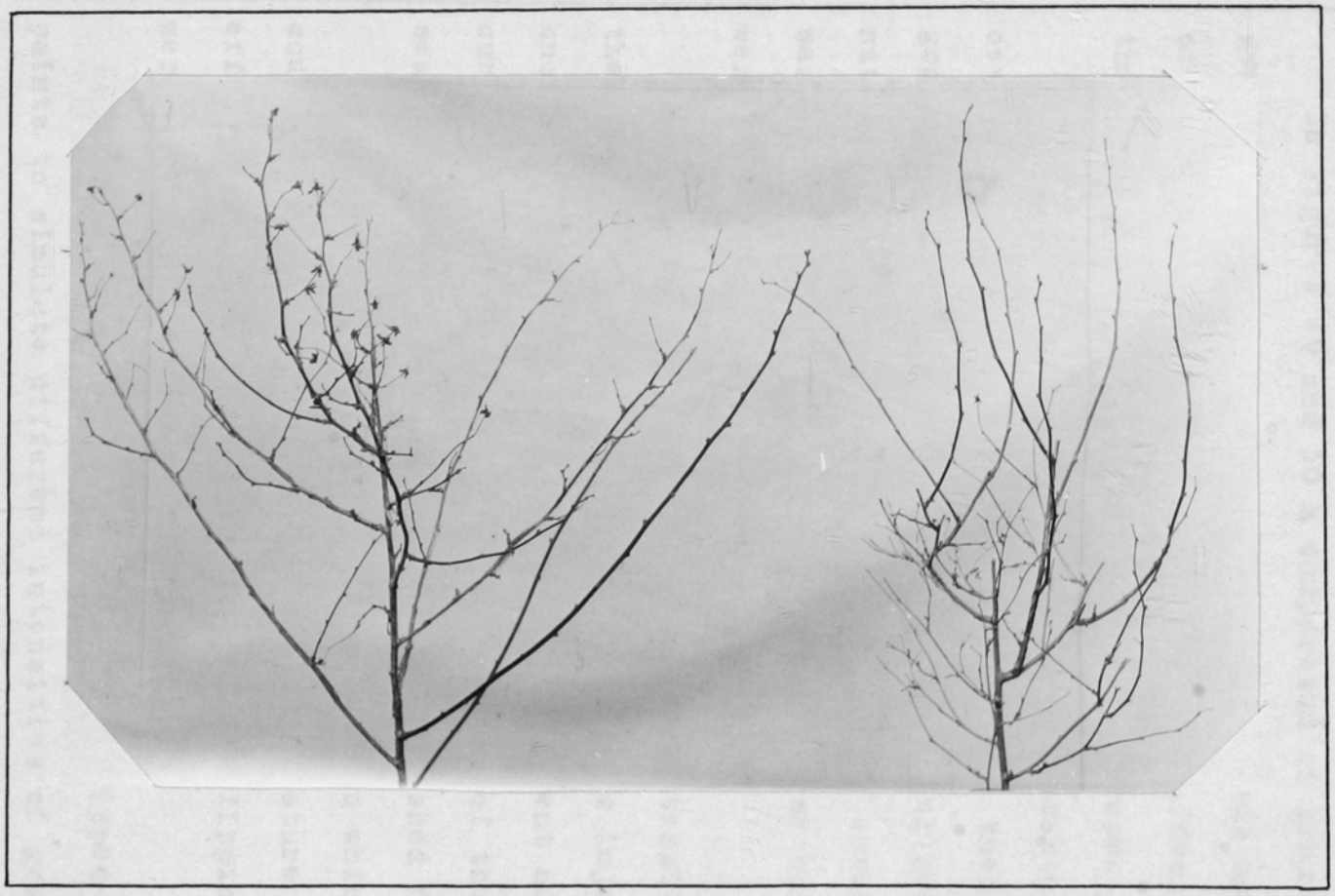


Fig. 48.--*Bossekia* showing a comparison of grazed and ungrazed plants. The grazed ends of stems and resulting branching is readily seen in the plant on the right.

development of suckers which were longer than the normal development of other growth.

In Figures 49 and 50 a comparison of grazed and ungrazed Rhus is shown. The grazed shrub was on the margins of the type and shows a more pronounced effect of grazing than one normally sees within the type proper.

Rosa and Prunus did not show this characteristic development under grazing, due perhaps to their form of growth. Retarded development and resulting growth must naturally be similar to that of the other shrubs. Ribes was so slightly grazed that observations of this type were not noted.

Effect of clipping on shrubs - The intensity to which these plants can be grazed without serious injury is unknown. Sampson (48) states that 15 per cent of the current growth should be left at the end of the grazing season. This has been definitely established for grasses.

In order to determine the intensity to which they could be grazed without injury, and the nature of the effect of such grazing, some elementary clipping studies were made on Cercocarpus and Rhus.

Stems of Cercocarpus and Rhus were clipped at various points to simulate different intensities of grazing. The results obtained in the clipping study are shown in Tables 14A and 14B.

Table 14A.--Clipping studies. CERCOCARPUS

Clipped to one inch			Clipped to four inches			Clipped at tip		
Plant	Stems clipped	New stems	Plant	Stems clipped	New stems	Plant	Stems clipped	New
1S1	4	Died	1R1	4	0	1U1	3	3
1S2	3	Died	1R3	4	0	1U3	2	2
1S1	3	7	1R4	2	7	2U1	3	-
1S4	4	Died	2R3	5	10	2U2	1	3
2S1	3	3	2R4	6	11	2U3	3	3
2S2	4	1	2R5	7	8			
2S3	8	3	3R1	5	9			
2S4	7	7	3R2	7	2			
			3R3	4	8			
			3R4	6	9			
			3R5	3	2			
	41	21		60	68		12	11

Table 14B.-- Clipping studies. RHUS

1S1	3	8	1R1	4	9	2U2	4	12
1S2	8	27	1R2	2	8	2U3	3	8
1S3	5	17	1R3	5	18	2U4	4	8
1S4	3	4	1R4	3	11	3U1	5	16
1S5	5	9	2R1	3	12	3U2	4	12
2S1	3	7	2E2	4	11	3U3	5	8
2S2	4	8	2R3	4	11	3U4	3	15
2S3	4	5	2R4	8	21	3U5	3	15
2S4	4	7	2R5	3	12			
3S1	6	5	3R1	5	13			
3S2	4	6	3R4	3	10			
3S3	8	12	3R5	5	14			
3S4	5	10						
3S5	7	12						
	60	137		49	150		31	94

Fig. 49.---Rhus growing within the pasture. Typical low, spreading habit is clearly shown. Plants like this are seldom modified in form by grazing.

Fig. 50.--*Rhus* growing on the edge of the shrub pasture. Isolated plants located in this way are heavily grazed and frequently killed.

The data thus obtained are not conclusive but serve to indicate the nature of different intensities of grazing on growth of these shrubs.

When the stems were clipped to within one inch of the previous year's growth, the effect on the plant was more severe in that there were fewer stems developed. And in the case of Cercocarpus this was too severe with the death of the stem being the result. Stems clipped to four inches or approximately half their annual growth, showed the greatest acceleration of branching than the other two intensities of grazing.

Terminal clipping did not materially increase branching in Cercocarpus but it did for Rhus. While it appears that Rhus shows much more branching as the result of grazing, a definite comparison can not safely be made. It is sufficient to say that, if clipping approaches grazing in its effect on the growth of the shrubs, complete utilization is detrimental. Clipping of about 50 per cent of growth tends to accelerate maximum branching and light clipping, no appreciable effect.

The effect of grazing must certainly result in an open stand of low shrubs which may not be desirable on western ranges where watershed protection is of primary concern. Should modification of this type encourage other forms of vegetation more desirable for this purpose,

then grazing is beneficial. These factors are of great concern in the management of our extensive brush areas in the West.

Isolated plants receive the heaviest grazing as shown by the illustrations and the effect on them is readily seen in Figures 45, 47, and 50. These plants were subjected to repeated grazing because of the location, which is contrary to normally grazed areas. It might be added that this heavy grazing is often noticeable on the margin of shrub areas in the region. This seems to prevent the extension of the type and to accelerate invasion by the short grasses of the adjacent mixed-prairie vegetation.

The effect of grazing on growth is difficult of interpretation. If we refer to Tables 10, 11, and 12 to compare the height and diameter of the plants with reference to previous grazing, no sharp conclusions can be drawn. Terminal branches may or may not have been grazed. The effect of removal of stem competition for light and nutrient supply further obscured values obtained.

CONCLUSIONS

The chaparral area which varies from one to five miles in diameter along the front range, provides sufficiently large pastures for handling as separate areas. This extensive distribution of the type involves every rancher in the area who, by adjusting his fences, can more suitably utilize the forage provided.

As the type is intermediate between two major grazing types far more extensive than itself, it must take a secondary position as to use. Use of these various range areas are for the most part based on ownership. The alpine meadows are used for sheep range. The yellow pine forest for cattle and the plains area for both sheep and cattle. The procedure of use is generally as follows: Cattle are moved from the mixed prairie range to the yellow pine forest for the summer period and then back to the plains for the remainder of the grazing season. Sheep are moved to the alpine meadows for summer period and are brought down for the remainder of the grazing season on the plains. The chaparral areas are not considered except as they chance to occur in a particular pasture.

The relation of composition to grazing used by the various classes of stock is a very fine one. The abundance of the various species of browse would lead one to suggest that grazing by sheep would be its most

suitable use. The Forest Service values attached to the dominants and those from our present studies indicate that the management of the type should be based on the most desirable forage plants such as Bouteloua gracilis, Agropyron spicatum, Carex stenophylla, Cercocarpus and others. This would then suggest grazing by sheep to the degree these plants could withstand such grazing. However, the composition of the type itself is not the determining factor. The adjacent grassland with its greater extent would determine the class of stock. Where the adjacent grassland consists largely of short grasses as grama and buffalo grass sheep would obtain the maximum utilization of the range including the chaparral. Where the grassland characterized by Agropyron smithii, Stipa spp., and other tall grasses, then cattle would be the most suitable class of stock. The presence of poisonous plants would be the final factor in the use of the type.

The seasonal development of Cercocarpus is not early enough to provide new spring growth in advance of the mixed prairie vegetation but does still retain considerable food materials in late current growth to provide spring grazing. If the grassland is to be grazed continuously in the summer season, this is especially important.

Carex and the tall grasses are often in advance of the grassland members and should provide earlier grazing.

Such spring use as may be possible is handicapped by the presence of two important poisonous plants, Zygadenus species and Delphinium species. They both start growth before Cercocarpus but about the same time as the early grasses. This, then, would exclude either class of stock from the areas that are occupied by these plants during the spring period. However the area occupied by larkspur can be grazed by sheep with comparative safety but areas containing death camas would be unsafe for either class of stock. The presence of Prunus melanocarpa in the spring would be an added danger, however, this source would not be hazardous under pasture conditions.

Summer use of chaparral as far as plant development is concerned would offer no grazing problem except that poisonous plants would be a lesser factor.

At the advent of late summer and fall, plant development is very important in the use of the type and associated types. The mixed prairie grasses and forbs are matured or nearly matured. These plants become less succulent and less palatable . The plants of the chaparral are later in maturing and would extent the period of green forage available for grazing. The contin-

ued growth and leaf maintainance of Cercocarpus would be decidedly advantageous for fall grazing of sheep but not necessarily for cattle as they do not show any great degree of preference for leaf over the stem. Sheep, on the hand, show a more decided preference for leaf. The winter period merely presents a continuation of forage available.

In concluding the role of phenology, we can say that the nature of development of Cercocarpus and associates, both herbaceous and woody, is of extreme importance in the best use of the type. The shrub type will provide spring grazing while the grassland can be protected, providing poisonous plants are not present. During the summer this type can be closed to grazing without materially reducing the value of the forage produced at that time. The grassland or forest and alpine range is now available for use and offers more suitable pasture. During the fall period sheep come off of forest land earlier than cattle. They can be grazed on the chaparral and graze the weedy growth and leafage of Cercocarpus before this substance is gone. The grazing of cattle on this type fits very nicely the date of removal of stock from forest land and the development of forage on the chaparral and mixed prairie. Loss of leaf material is of no great concern as cattle will readily graze the stems of Cercocarpus from their first appearance

in the type until the end of winter.

The application of results obtained from the palatability studies must have as its basis the composition of the type. This, then, resolves itself upon the palatability of Cercocarpus. The diameter and length grazed is indicative of its high palatability as compared with associated shrubs. The high lignin content is no barrier to the readiness it is grazed by cattle, and to a lesser degree, by sheep. The location and amount of stored food in the form of starch is of considerable importance. This condition of stored food fits well the use of the type. The type can be reserved for fall, winter, and spring grazing without seriously reducing the forage produce during the growing season. It appears that it is highly advantageous to restrict summer grazing so that the volume of stored material can be allowed to accumulate for the periods indicated above.

The results from observations on phenology and palatability are substantiated by the results of values obtained from the utilization studies.

In a pasture containing both grassland and chaparral vegetation stocked to its maximum capacity, the preference for various plants proceeded from utilization of most desirable species of grassland plants to chaparral (Cercocarpus) and the less desirable herbaceous plants.

As this closely followed development and increased palatability of the shrubs the relative amounts of each kind of pasturage was satisfactory for the grazing study. However, if the chaparral type is to reach its best use grassland should be sufficient to provide grazing until fall.

The nature of the use of extensive chaparral does not have direct application here, but for extensive types it appears that distribution measures usually associated with the control of stock on the range would need modification for chaparral. Large types could be mapped for utilization studies and the results obtained would more nearly indicate the location of fences, watering places, and salt grounds.

Grazing must have considerable influence on the successional trend of the chaparral community. Heavy grazing would modify the cover to the extent that annuals would make up the bulk of the cover in the understory and that the crown cover of shrubs would be considerably reduced. Such resulting cover would be unsatisfactory for vital watersheds. The normal trend of the community itself is evidently to yellow pine forest or savannah with an understore of one or more of the mixed prairie grasses.

SUMMARY

In Colorado there is a large acreage of shrub plants known as chaparral which has considerable value for forage and plant cover.

Ecological studies show that topography regulates the distribution of communities thru the control of soil development and soil moisture. Grassland occupied the more highly developed soils. Chaparral intermediate soils, and forest the poorest developed soils. The lower limits of forest and chaparral are dependent upon a deeper moisture supply than the grassland.

Individual species of the type likewise showed preference for certain sites. Root studies made indicated that this distribution of species was quite evident. Cercocarpus, Bossekia, Ribes, and Purshia occupied the poor sites. Prunus spp. and Rosa spp. intermediate sites while Rhus and Symphoricarpos the best sites in the type.

The specific study on palatability and utilization of chaparral was located five miles west of Fort Collins, Colorado, on a pasture containing both mixed-prairie grassland and chaparral. The pasture was completely accessible to the Hereford cattle used in the study.

The chaparral slope was dominated by several shrubs which made up over 60 per cent of the cover and had

a density of 33.6 per cent of the ground. Cercocarpus had a frequency of 100 and an abundance of 26.351 in plots studied. Rosa and Rhus were next most abundant. Prunus melanocarpa, Prunus americana, Bossekia deliciosa, and Ribes cereum were associated with them. The understory consisted chiefly of downy brome (Bromus tectorum), and common members of the mixed prairie and yellow pine forest. Cercocarpus dominated and characterized the community throughout its distribution.

The seasonal development records indicated early spring growth of Ribes cereum and Prunus melanocarpa. Growth starting early in April or late March. Cercocarpus soon followed. Rhus was late in starting growth but maintained the bulk of its leafage later than the others with the possible exception of Cercocarpus. The early plants were likewise late growers as new leafage continued to develop until late October and often into the winter period.

Climatic records indicated much severer growing conditions for the two years the study was conducted. 1931 was more severe than 1930. This condition would modify the grazing results. Rainfall records when correlated with evaporation, provided a much better measure of the climate than either weighed separately.

Cercocarpus was grazed to a higher average diameter than the others excepting Rosa. Prunus, Bossekia and Rhus were next, with lower values. Ribes was grazed to the smallest diameter of all shrubs. On the basis of length of twigs grazed, Cercocarpus continued to be uniform in preference. The average rating of this dominant shrub was 42.5 per cent. However, the palatability value of the others was materially raised on this basis. Prunus would be rated 64 per cent, Rhus 47.2 per cent, and the others proportionately higher. This indicates that length grazed is not always a true index of palatability.

Camera lucida drawings and photomicrogrpahs illustrated the important relationship between diameter grazed and starch material present. The proportion of starch to all other tissue was greatest for Cercocarpus. Starch storage areas were highly developed in the stem of this species.

Forest Service palatability values for this region were lower for all species in the chaparral when compared on the basis of observed grazing and histological studies.

Grazing use followed definitely the development and utilization of adjacent pasture as well as the difference in palatability of the various shrubs. Use did not begin until August, and increased in intensity with the

advance of season. At the end of the 1930-1931 season 70 per cent of the shrubs had been grazed. 35 per cent more of the heavy grazed class could be grazed without maximum damage. For the 1931 period the grazing last recorded was 10 per cent less than for the previous year, and had been only utilized 9 per cent of the heavy grazed class as compared to 17 per cent for the last year.

The nature of distribution of grazing was clearly indicated by the methods used. From the first season's results the utilization curve showed heaviest use at the lower end of the slope and least at the center. The second year's results emphasizes the previous year's results except for minor variations. Variation from year to year and from month to month was recorded by the method used.

Cercocarpus, or mountain mahogany, did not only show higher palatability but also heavier use and was the most important plant of our foothills chaparral. The utilization of the pasture can be considered to be the utilization of Cercocarpus.

BIBLIOGRAPHY

(1) Adams, John
1927 A survey of Canadian plants in relation to their environment. Dom. of Can. Dept. of Agr. Bull. 58:1-16. N. S.

(2) Aldous, A.E. and H.L. Shantz
1924 Types of vegetation in the semi-arid portion of the United States and their economic significance. Jour. Agr. Res. 28:99-128.

(3) Baker, F.S. and Clarence F. Korstian
1931 Suitability of brushland in the intermountain region for the growth of natural or planted western yellow pine forest. U. S. Dept. Agr.,Tech. Bull. 256:1-82.

(4) Bates, C.L.
1923 Physiological requirements of Rocky Mountain trees. Jour. Agr. Res. 24:97-164.

(5) _____
1924 Forest types in the central Rocky Mountains as affected by climate and soil. U. S. Dept. of Agr. Bull. 1233:1-152.

(6) Beatie, R.K.
1913 Plants used for food by sheep on the Mica Mountain summer range. Wash. Agr. Exp. Sta. Bull. 113:1-29.

(7) Cain, S. A., R. E. Friesner and J. E.Potzger
1930 A comparison of strip and quadrat analysis of the woody plants on a central Indian bluff. Butler Univ. Bot. Studies, 1, Paper 10:1-14.

(8) Cannon, W. A.
1913 A note on the chaparral-forest relation at Carmel, California. Plant World,16: 64-67.

(9) Chamberlain, C.J.
1905 Methods in Plant Histology. Univ. of Chicago Press, Chicago. 262 pp.

(10) Chapline, W. R.
1919 Production of goats on far-western ranges. U. S. Dept. of Agr. Bull. 749:1-36.

(11) Clements, F. E.
1916 Plant Succession. Carnegie Inst.Wash., Pub. 242. 512pp.

(12) _____
1920 Plant Indicators. Carnegie Inst. Wash., Pub. 290. 388pp.

(13) Cory, V.L.
1927 Activities of livestock on the range. Texas Agr. Exp. Sta. Bull. 367:1-47.

(14) Cooper, W. S.
1922 The broad-sclerophyll vegetation of California. Carnegie Inst. Wash., Pub. 319:1-132.

(15) Coulter, J. M. and Aven Nelson
1909 Manual of Botany of the Central Rocky Mountains. Amer. Book Co. New York. 646pp.

(16) Dayton, W.A.
1931 Important western browse plants. U. S. Dept. Agr. Miscl. Pub. 101:1-214.

(17) Durrell, L. W. and G.H. Glover
1927 Poisonous plants of Colorado. Colo. Agr. Exp. Sta., Bul. 316:1-28.

(18) Eckerson, S.H.
Microchemistry. U. S. D. A. Mimeograph.

(19) Fleming, C. E., et al.
1926 The common chokecherry. Nev. Agr. Exp. Sta., Bull. 109:1-30.

(20) _____ and R.Dill.
1928 The poisoning of sheep on mountain grazing ranges in Nevada by western chokecherry. Nev. Agr. Exp. Sta. Bull. 110:1-14.

(21) Forsling, C.L. and E. V. Storm
1929 The utilization of browse forage as summer range for cattle in southwestern Utah. U.S. Dept. Agr. Circ. 62:1-29.

(22) Fuller G. D.
1914 Evaporation and soil moisture in relation to the succession of plant associations. Bot. Gaz. 58:193-243.

(23) _____ and A.L. Bakke
1918 Raunkier's "life forms", "leaf size classes" and statistical methods. Plant World 21:25-37, 57-63.

(24) Greenlet, E. R., et al.
Land classification of the Central Great Plains, Parts 1, 2, and 3. U.S.Dept. of Interior, Geological Survey.

(25) Hanson, H. C.
1917 Leaf-structure as related to environment. Am. Jour. Bot., 4:533-560.

(26) _____
1929 Range resources of the San Luis Valley. Colo. Agr. Exp. Sta. Bull. 335:1-62.

(27) _____ and L. D. Love
1930 Size of list quadrat for use in determining effects of different systems of grazing upon Agropyron smithii mixed prairie. Jour. Agr. Res. 41:549-560.

(28) _____ and M. S.Morris
1931 Effects of different systems of grazing by cattle upon a western wheat-grass type of range. Colo. Agr. Exp.Sta. Bull. 377: 1-82.

(29) Hatton, J.H.
1913 Eradication of chaparral by goat grazing. Lassen Nat. For. U. S. Dept. of Agr. Forest Service Invest. 2:25-28.

(30) Ingram, D. C.
1931 Vegetative changes and grazing use on Douglas fir cut-over land. Jour. Agr. Res. 43:387-417.

(31) Jepson, W.L.
1925 A manual of the flowering plants of California. Univ. Press. Berkeley, Calif. 1238 pp.

(32) Korstian, C. F.
1917 Indicator significance of native vegetation in the determination of forest sites. Plant World, 20:267-287.

(33) _____
1919 Native vegetation as a criterion of site. Plant World, 22:253-261.

(34) Larsen, J. A.
1923 Association of trees, shrubs and other vegetation in the northern Idaho forests. Ecology, 4:63-67.

(35) Livingston, B. E. and Forrest Shreve
1921 The distribution of vegetation in the United States, as related to climatic conditions. Carnegie Inst. Wash., Pub. 284:326-342.

(36) Mackie, W. W.
1903 The value of oak leaves for forage. Calif. Agr. Exp.Sta. Bull. 150:1-21.

(37) Marsh, C. D.
1929 Stock poisoning plants of the range. U.S. Dept. Agr., Dept. Bull. 1245:1-36.

(38) Ramaley, Francis
1908 Ecological notes from north-central Colorado. Univ. of Colo. Studies 5,No. 2.

(39) _____
1919 Some mountain plant communities of sandy soil. Plant World, 22:313-328.

(40) _____
1931 Vegetation of chaparral -covered foothills southwest of Denver, Colorado. Univ. of Colo. Studies 18, No. 14.

(41) _____
1931 Autumn vegetation of the foothills near Boulder, Colorado. Univ. of Colo. Studies 81, No. 4.

(42) Region 2, U. S. Forest Service,
Palatability tables of range plants.

(43) Robbins, W. W.
1917 Native vegetation and climate of Colorado in their relation to agriculture. Colo. Agr. Exp. Sta. Bull. 224:1-56.

(44) Rydberg, P.A.
1905 Flora of Colorado. Colo. Agr. Exp. Sta. Bull. 100:1-447.

(45) Salisbury, E.J.
1931 The standardization of descriptions of plant communities. Jour. of Ecology 19:177-189.

(46) Sampson, A.W.
1919 Climate and crop growth in certain vegetative associations. U. S. Dept. Agr. Bull. 700:1-72.

(47) _____
1919 Plant Succession in relation to range management. U. S. Dept. Agr. Bull. 791: 1-59.

(48) _____
1924 Native American forage plants. John Wiley and Sons, N.Y. 435 pp.

(49) _____ and Harry E. Malmsten
1926 Grazing periods and forage production on the national forests. U. S. Dept. of Agr. Bull. 1405:1-54.

(50) Shrimper, A. F. W.
1903 Plant geography upon a physiological basis. Clarendon Press, Oxford. 839 pp.

(51) Swingle, D. B.
1928 A text-book of systematic botany. McGraw-Hill, New York 254 pp.

(52) Trimble, R.E.
1928 The climate of Colorado. Colo. Agr. Exp. Sta. Bull. 340:1-68.

(53) United States Department of Agriculture. Weather
1930-1931 Bur. Climatological Data. Vols. 35 and 36.

(54) United States Dept. of Agriculture, Forest Service
1923 Instructions for grazing reconnaissance on National Forests.

(55) Vestal, A. T.
1917 Foothill vegetation on the Colorado front range. Bot. Gaz. 64:353-385.

(56) Warming, Eugene
1925 Oecology of plants. Oxford Univ. Press, London. 422 pp.

(57) Weaver, J. E.
1914 Evaporation and plant succession in southeastern Washington and adjacent Idaho. Plant World, 17:273-294.

(58) _____
1919 The ecological relation of roots. Carnegie Inst. Wash., Pub. 286. 128 pp.

(59) _____
1920 Root development in the grassland formation. Carnegie Inst. Wash., Pub. 292. 151 pp.

(60) _____ and F. E. Clements
1929 Plant Ecology. McGraw-Hill, New York. 520 pp.