A STUDY OF BEEF PRODUCTION ON A LOW RANGE OF COLORADO

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Constituting

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INTRODUCTION.

The State of Colorado with its 66,341,120 acres is seventh in size of the states composing the United States. The 1920 census (1) shows that 29,462,459 acres have been patented, 13,274,187 acres are in National Forest Reserves, and the remainder consists of State, Indian, and Government land. The division is further shown by 44.41% being patented land, 38.05% State, Federal and Indian, and 17.54% unclassified as to ownership. In 1920, 8,985,820 acres of unoccupied government land still remained in Colorado. (1)

The importance of the Grazing industry in Colorado is shown by the classification of 15,071,165 acres, or about 23% of total area of State outside of 13,274,187 acres of National Forest Reserves, as chiefly valuable for grazing purposes. If the National Forest area is included, we have about 43% of the State that is used more or less intensely for grazing purposes.

Statistics further show the importance of livestock raising in Colorado since the value of Colorado livestock practically equals the value of all farm crops raised annually. The rank of Colorado compared with other states

(1) Number in brackets refers to bibliography beginning on page 98.

as to number of domestic animals on farms, January 1, 1921 shows horses 19th, milch cows 28th, other cattle 12th, and sheep 11th.

By considering the foregoing facts, it is self evident that it is of vital need for an industry which is second only to mining in importance in the State, to be assisted in meeting its problems of decreased carrying capacity and productivity of the native ranges.

The decrease in the productivity of the range is perhaps best shown by the observations of an old and experienced cattleman*: "In 1886, fat, four year old steers, averaging 1333 pounds, were sold direct to packers from the range. In 1887, the fat four year old steers sold direct from the range to packers averaged 1278 pounds. In 1888, the fat four year old steers sold direct from the range to packers averaged 1228 pounds. But in 1893, the steers averaged only 1100 pounds and had to be sold as feeders." Mr. Painter has expressed his opinion, "that the falling off in weight of grass fat animals was due primarily to over stocking of the range and a subsequent decrease in vitality and productivity of the native grasses."

In the opinion of the writer, the solution of the decreasing productiveness of the native range and pastures

* Mr. John Painter, Roggen, Colorado.

lies in a study of the vegetative cover, with the many ecological factors effecting it, and the resulting gains secured, which is the final analysis, on stock grazed thereon by some definite system of grazing. From this wide field, the author has attempted to select a phase for study and investigation, that would be productive of indications in the brief period of one year.

Altho this manuscript bears the title of "A Study of Beef Production on a Low Range of Colorado", it really resolves itself into, Beef Production as Effected by the Densities of the Native Vegetation. If this supplementary title is kept in mind the succeeding pages will be much clearer.

ACKNOWLEDGEMENTS.

It is the desire of the author before proceeding further in the preparation of this paper to express his appreciation for the co-operation and guidance that has been extended to him by Professor George E. Morton, Head of the Animal Husbandry Department and to Professor E. J. Maynard of the Animal Investigations Section, who has given many valuable suggestions as well as co-operating in taking of periodic weights of the steers grazed on the pasture, during summer of 1921. Professor E. C. McCarty of the Botany Department has given many valuable suggestions and has made it possible for the author to complete his minor in Plant Ecology under his direction by a mutual working plan, the results of which have later been put at his disposal and from which a very important phase of this paper has been worked out.

Other members of the College Faculty, - Professor House of Civil and Irrigation Engineering Department and Professor W. J. Morrill of Forestry Department, the author wishes to thank for the use of certain surveying instruments.

History of Grazing in Colorado.

Before proceeding to a discussion of the methods and data presented in this paper, it seems well to briefly review the history of the grazing industry in Colorado in order that its present status may be better appreciated. Many references from Stone's History of Colorado (2) are included here.

The livestock industry in Colorado began with the migration along the Sante Fe Trail, in the early years of the Nineteenth Century, for few caravans came without one or more milch cows, and many had oxen for freighting. At Fort Bent (Arkansas Valley), when it was the celebrated way station, the first herd of cattle kept for beef and milk fed plentiful upon the native buffalo and bunch grasses of the country.

Between 1826 and 1836, the buffalo roamed from Independence, Kansas, to the fishing falls on the Columbia River, but after 1836 they began to diminish and by 1840 they had abandoned all the waters of the Pacific, north of Lewis' Fork. Five years after this the buffalo had all withdrawn to the so called Great American Desert. It was about 1845 that the destruction of the buffalo began. History records that in 1867 the number of robes annually traded for by American, Hudson Bay and other fur companies,

was 90,000 and this tells not half of their destruction. History again records, "that in a little more than three months, in the fall of 1874, over 50,000 buffalo hides were shipped from the station on the Sante Fe road, and the total shipment on this and the Kansas Pacific aggregated 125,000."

The cattle trading of the early days, that is 1860, about the district of Denver, took on the form of buying the train oxen, when they arrived in June, very thin and sold cheaply by their owners. Some of these oxen were fattened on native grass, while others were driven back to Iowa for finishing.

Samuel Hartsel, one of the earliest stockmen to adopt this practise, tells of buying in 1860 the broken down oxen that were brought in for $10 to $20, and selling them for $90 to $100 after he had fattened them. In 1861, Duke Green and Ed Shook brought in a bunch of good Shorthorns from Oskaloosa, Iowa. Hartsel bought these and was so successful with them that he determined to go back and bring in a larger herd to Colorado. He left Denver in 1864 and returned in 1866.

Upon reaching Clay County Missouri, he bought 148 cows and two bulls from Tom Gordon, a well known Shorthorn breeder of those days. At Fort Leavenworth, he pur-

chased a very fine team of oxen, paying $200. for them, a good price even in those days. The herd was wintered at Leroy, Kansas, in 1864. Many Indian attacks made travel slow, and, the winter of 1865 setting in, he left his herd at Springs Bottom, near Fort Bent on the Arkansas, where there was abundant feed and soldiers near enough to make the herd safe.

The herd was taken to his ranch in South Park early in the summer of 1866. "I considered that I had the best herd of cattle in the Rocky Mountains. They were all pure bred, and as I had the South Park to myself to graze, there was no chance for them to become mixed with any other cattle. Two thirds of them were pure white, and most of the balance were roans. One of the bulls was white and the other a roan."

The Herford made its appearance in the state about 1873, when Mr. T. L. Miller, of Beecher, Illinois, leader of the Breeders Livestock Association, sold three bulls to John Zweek, of Longmont. Wherever tried the Hereford blood made good, and became popular from the very first on Colorado ranges.

By 1866, it was estimated that there were 100,000 head of horses and cattle in this western territory, with large bands of sheep in southern portions that were run by Mexicans. At this time the first cost of cows was high,

from $60 to $100, but their keeping amounted to very little.

The discovery of the capabilities of this western area for grazing is said to be accidental. Theodore J. McMinn, of St. Louis, in the Government Investigation, thus relates it: "Early in December 1864, a Government Trader with a wagon train of supplies drawn by oxen, was on his way to Camp Douglas, Utah, but being over taken on the Laramie Plains by an unusually heavy snow storm, he was compelled to go at once into winter quarters. He turned his cattle loose, expecting of course that they would soon perish from exposure and starvation. But they remained about the camp, and as the snow was blown off the highlands, the dried grass afforded them an abundance of forage. When spring opened they were found to be in better condition than when they were turned out to die four months previous."

"This discovery," says the Government report, "led to the purchase of stock cattle in Texas, to be matured and fattened on the Northern ranges, and this steadily grew to enormous proportions, much accelerated by the building of the railroad." The first drive of Texas cattle to the state, was made in 1859, by John C. Dawson. The number of cattle driven north from Texas, between 1866 and 1884 was 5,201,132.

In these early days with the whole country from Texas

to Montana open as one large feeding ground, it was not strange that the blizzards should sometimes cause the cattle to drift several hundred miles off their own ranges. As a result of the open country there came the maverick, which was the object of legislation for many years, for they were made property of the State, but later the 'code of honor' was firmly established, and this matter was left to take care of itself.

From 1861 to 1863, the ranges, particularly the Arkansas Valley, were infested by thoroughly organized gangs of cattle thieves, who stole animals in what are now Fremont, Pueblo, Las Animas and Huerfano counties and took them via. Trinidad to Texas, where they sold them. The most notorious of these gangs were broken up, the criminals fleeing the country. In 1867 and 1868, a more formidable combination, under one William Coe, began to steal entire herds. This gang had a store, ranch and corral at Dry Cimarron, and a station just above Boggsville. Detectives sent after them were killed, and in 1868, a band of 3000 sheep was found in their possession at Adobe Creek. After they had been rounded up, the narrator of their fate writes: "shortly after, Coe was taken from the jail at Pueblo, and privately hung by a committee of soldiers."

"At Fort Collins in 1865, Lieut. E. P. Drake tried two cattle thieves, found them guilty and sentenced them

to leave the country never to return again. In 1861, after stealing several herds, they were brazen enough to ship them to Kansas City, where they were seized by Colorado Brand inspectors. They later served time in Canon City."

In the late seventies, the cattle business of Western America began to attract companies with large capital from England and Scotland, and many companies were known to have reported large dividends, some being as high as 30%. In 1883, English Companies alone, owned over 25,000,000 acres in the west. Lord Dunraven's purchase of 60,000 acres in Colorado, was of this period.

During these early days, when the range was free, all that was necessary was to drive in cattle from Texas, get control of the necessary water, and then set down to wait until the cattle had matured to the point when they were shipped to Kansas City for beef. The cattle population of Colorado increased to such a point that the range was beginning to be crowded. Following this condition came the long remembered blizzard of 1885 and 1886, when many outfits were cleaned out entirely.

Shortly after these discouraging conditions, many of the big outfits went out of business, giving way to the settlers and the man with smaller herds, who could give them better care. Probably the haste in getting out of

the cattle business by these big outfits caused the period of low prices in 1892-93, but the man who stayed was well paid a few years later.

The Prairie Cattle Company was the last of the big range cattle raisers to go out of business. In 1916, they sold their vast holdings, which was largely in the form of control, of some 2,000,000 acres, at the high market price of the year. This company was a foreign corporation, of Scottish origin and organized under the law of Great Britain in 1881, and all of its managers in America, except one, have either been Scotchmen or Englishmen. Their brand was JJ and it is claimed in 1886 this company owned 54,000 cattle and branded 26,000 calves.

After the crop failures of 1903-04 the settlements were cleaned out, and those who stayed were able once more to graze as many cattle as they wished. With the gathering together of many herds, it was not many years before the country was overstocked to the extent that it was with the large outfits.

It was in the early nineties that the sheep began to make themselves felt on the range and later to crowd the cattleman back to other ranges. This precipitated the many range wars.

In 1903, the Government under the Administration of President Roosevelt undertook an investigation of the

grazing industry in these western states. In August 1904, the commission conferred with the American Livestock Accosiation in Denver. This meeting was attended by leaders of agriculture and representative stockmen from all grazing land states and territories. As an outcome of the meeting the commission recommended that suitable authority be given to the President to set aside, by proclamation, certain grazing districts or reserves. To the Secretary of Agriculture was given the right to classify and appraise the grazing value of these lands, and to collect moderate fees for grazing permits. This was the starting of the system of grazing on the National Forest, and it is of interest to note that it was sponsored by the cattlemen.

At the present time the open range is almost a thing of the past, except in a few isolated sections of the state, some of which will always remain so due to their unfitness for agricultural purposes, and they cannot be homesteaded in large enough areas to be of much value for grazing homesteads.

The problem in this state now is to devise systems of management that will secure the greatest possible return from these unoccupied government lands, and native pastures to provide the future beef supply.

DISCUSSION OF METHODS AND DATA.

GENERAL

The experimental work for this manuscript was conducted on South College Pasture, Fort Collins, Colorado, located in the N. 1/2 Sec. 17, E. 1/2 of N.E. 1/4 and N.E. 1/4 of S.E. 1/4 of Sec. 18, E. 1/2 of S.E. 1/4 of Sec. 7 and S.W. 1/4 of Sec. 8 with a strip of some 23.84 acres from North College Pasture located in sections number 7 and 8, all of which is in T. 7 N., R. 69 W.

The South College Pasture was open range until 17 years ago (1905), when it was fenced and used as horse pasture for experimental breeding until the transfer of the horses to Buffalo, Wyoming on July 1st, 1920. Shortly after this date, the South College Pasture was acquired by the Animal Investigation Section of the Animal Husbandry Department to be used for Range Investigational Work. The pasture was allowed to seed and not grazed during year of 1920, but it was subdivided into individual pastures in spring of 1921 in sufficient time for the grazing season under discussion.

1. Preparation of Map.

Mapping boundaries.

The first consideration of any pasture or range that is to be used for grazing, is to determine it's carrying capacity, preferably by a reconnaissance (inventory) survey, if anything like accurate estimates are to be secured.

A map of practical accuracy of the area under inspection is the first requirement for a reconnaissance survey, but as none existed for the South College Pasture, it was necessary to supply one.

The plane table (3) with stadia alidade (4) method was selected as the most practical as it eliminated notes and kept the map forming as progress was made in the field. A starting elevation within the pasture was secured by establishing a B.M. (bench mark) near the main east pasture gate at the end of Mulberry street by running a set of levels from the nearest U.S. Geological Survey bench mark on the S.W. corner of S. 1/2 of E. 1/2 of Sec. 4, township 7 N., R. 69 W., one and one half miles distance.

All ditches and cross fences which divide the large pasture into pastures 1-2-3-4, and other improvements were noted and sketched as the work progressed. The boundary of the lake was sketched from points established by the method of inter-sections. Elevations were established by

means of stadia and Abney hand level.

Mapping of Vegetation.

From a series of observations during the grazing season of 1921, and to be given in some detail later (page 53) in the manuscript, it was noted that the steers grazed only the grasses to any appreciable extent. Buffalo (Bulbilus), Grama (Bouteloua), Wheat (Agropyron) and Bluestem (Andropogon) were the only grasses that assumed any importance as to area they occupied. Weeds were present, but their importance was only shown by occupying the ground and not permitting palatable grass to grow; hence it was thought desirable to list weeds and unpalatable grasses in order of importance to show their bearing upon the presence of grasses.

In making all observations and classification of types, and subtypes of vegetation found in an area, it was found necessary to base everything on occular observation. However, this occular observation was not employed until after the botanical studies of ground cover by means of the quadrat method (5) had been completed.

All linear measurements as to area occupied by the vegetation were taken by means of pacing. Altho this is not an accurate method according to engineers, it is the method employed by the Forest Service and observations show

that it is impossible to tell accurately within 10-15 feet where one type leaves off and another begins.

The method employed in the reconnaissance survey to map the vegetation on a large scale was a modification of a timber cruising method to meet the requirements.

To map the lower, more even surfaces of the pasture, the procedure is to go to some outside boundary and then step off any desired distance, say 30 paces, on another boundary at right angles to guide boundary to establish your starting point. From the newly established point, which should be marked, a course across the pasture parallel to the guide boundary is determined and the object toward which you are to pace is selected. Begin pacing in direction desired, carrying with you the boundary map of the area under inspection and whenever the type or subtype of vegetation changes stop, convert paces traversed into feet and map according to scale. In cases where types to either the right or left of the examiner may change, the hat is dropped as a mark and the area in question is paced out, mapped, after which return to hat is made and course across pasture resumed. In like manner, the types in each pasture were determined and listed on map with appropriate legend. As progress is made in running these strips across the pasture, the

lines showing changes in vegetation may be connected by aid of the eyes and definite types formed into as large areas as they comprise.

While the method given above is slow and laborious, it is productive of results and furnishes the working basis desired.

In the rougher area at the west of the pasture it was possible to pace out and map the vegetation from certain prominent points established in connection with the boundary survey. The boundaries were also employed as mentioned for the more level ground in the east pasture.

By pursuing these methods the entire pasture was mapped and certain areas remapped that did not appear consistent or accurate when other aspects were taken into consideration.

With the boundaries, cross fences which divide the pasture into individual pastures (1-2-3-4), general details, topography and the grass areas named and mapped, the field work of the reconnaissance survey was completed. The areas of the individual pastures and types and subtypes of each area now remained to be determined.

Measuring of Areas.

The method used to measure the acreage of the different areas was by the planimeter (6), reading to 1/10,000

of a square meter. The technique employed for measuring the areas of each pasture was the same. It is as follows: the boundary of each individual subpasture was measured ten times by lightly marking an initial starting point any where on the boundary and the pointer of the instrument set thereon with the disc wheel set at zero. With a clock-wise motion, the pointer of the instrument was made to traverse the boundary to initial point and the total area read directly from the disc wheel of the instrument. An average of the ten trials was taken to determine the true area of each individual pasture.

The measured area of each individual pasture is given as follows:

Taole 1.

	North 2	Center 1	S.E. 4	S.W. 3	Lake	Tame meadow
Inst.Rdg.for ground only	.4575	.4907	.3213	.3933		
Inst.Rdg.for lake only	.0420	.0857			.1277	
Inst.Rdg.for tame meadow only.		.0340				.0340
Total Inst. rdging.	.4995	.6104	.3213	.3933	.1277	.0340
Ground area in acres.	146.40	157.024	102.816	125.856		
Lake area in acres.	13.44	27.424			40.864	

Table 1. (Condt.)

	North 2	Center 1	S.E. 4	S.W. 3	Lake	Tame meadow
Tame meadow in acres.		10.880				10.880
Total acres in Pastures	159.84	195.328	102.816	125.856	(not counted in total)	

Total acreage within boundary of all individual pastures is 583.840 acres.

For the purposes of this paper only the ground area supporting native vegetation will be considered. The area of lake and tame meadow will be omitted.

The instrument readings secured from measurements on map and listed at first of Table 1 were converted in acres and listed in last part of Table 1 by the following method:

1 square centimeter = .15501 square inches.

1 square inch = 6.4514 square centimeters.

1 A. = 43,560 square feet.

If scale of 300 feet to one inch on the map is used, then 1 square inch on the map equals 90,000 square feet.

Therefore 1 square inch on the map = 90,000 sq. ft. ÷ 43,560 sq. ft. = 2.066+ acres.

But on the map the 1 square inch = 6.4514 sq. cm. = 2.066+ acres.

Therefore, 1 sq. cm. on map = 2.066 ÷ 6.4514 = .32+acres.

Since measurement of 1 sq. cm. with the instrument equals a reading of .0010, the reading of instrument must be multiplied by 1000 to get area into square centimeters. Then multiply area in sq. cm. by number of acres in sq. cm. (.32+) to equal number of surface acres in the desired area.

The measurement of each of the individual types or subtypes within the measured individual pasture areas was next obtained. The method used was the same for each of the individual pastures. All the types and subtypes in an individual pasture were listed on a separate sheet of paper and as each area was measured with the planimeter (method described before) the reading was entered under the corresponding name on separate sheets of paper. When all areas within an individual pasture were measured, a total of each type and subtype was made and the results tabulated as shown in table # 2 below:

Table 11.
Area of Types and Subtypes.

Names of grasses	2 N. Pasture Inst.	A.	1 Central Pasture Inst.	A.	4 S.E. Pasture Inst.	A.	3 S.W. Pasture Inst.	A.
1.A.*	.0409	13.088	.1334	42.688	.0745	23.840	.0583	18.656
1.A.Bo	.0502	16.064	.0004	.128	.0047	1.504	.0103	3.296
1.A.BoBa.	.0015	.480					.0010	.320
1.A.BoWd.	.0144	4.608						
1.A.BoRck.	.0360	11520						

Table 11. (Condt.)

Names of grasses	N.Pasture Inst.	N.Pasture A.	Central Pasture Inst.	Central Pasture A.	S.E. Pasture Inst.	S.E. Pasture A.	S.W.Pasture Inst.	S.W.Pasture A.
l.A.Bu.					.0022	.704	.0002	.064
l.A.Bu.Bo.							.0400	12.800
l.A.E.St.	.0012	.384						
l.A.Rck.	.0059	1.888					.0110	3.520
l.A.St.E.Wd.	.0010	.320						
l.A.Wd.	.0140	4.480	.0006	.192	.0618	19.776		
l.A.Wd.Rck.	.0175	5.600						
l.A.Y.			.0065	2.080	.0315	10.080		
l.Bo.(Pure)	.0475	15.200	.0242	7.744	.0571	18.272	.0006	.192
l.Bo.A.			.0065	2.080	.0724	23.168	.0108	3.456
l.Bo.Rck.							.0059	1.888
l.Bo.Bu.	.0379	12.128			.0054	1.728		
l.Bo.Wd.	.0200	6.400	.0025	.800				
l.Bo.Y.								
l.Bo.Sa.	.0020	.640						
l.Bo.Ar.			.1254	40.128	.0037	1.184		
l.Bu.			.0146	4.672	.0034	1.088	.0489	15.648
l.Bu.A.							.0044	1.408
l.Bu.Bo.							.0176	5.632
l.Bu.Wd.	.0014	.448	.0038	1.216				
l.An.							.0378	12.096

Table 11.(Contd.)

Name of grasses	North Pasture Inst.	A.	Central Pasture Inst.	A.	S.E.Pasture Inst.	A.	S.W.Pasture Inst.	A.
1.An.Bo.	.0013	.416	.0015	.480				
1.An.A.	.0067	2.144						
1.An.Rck.Bo.	.0140	4.480						
1.Ar.A.			.0174	5.568				
8. Rck.							.0062	1.984
7. Rck.Pine			.0133	4.256			.0109	3.488
1.Rck.Bo.							.0030	.960
1.Rck.Bo.Wd.	.0051	1.632					.0010	.320
1.Rck.An.	.0211	6.752					.0102	3.264
1.Rck.A.	.0131	4.192	.0104	3.328			.0223	7.136
1.Rck.A.Bo.	.0079	2.528						
3.Rck.Wd.	.0087	2.784						
4.Mg.A.	.0004	.128			.0002	.064		
4.Mg.An.							.0133	4.256
4.Mg.Rck.							.0052	1.664
4.Mg.Bo.	.0053	1.696						
4.Mg.Rck.Bo.An.	.0120	3.840	.0541	17.312			.0355	11.360
3 Wd.	.0362	11.584	.0374	11.968	.0032	1.024		
3 Wd.Bo.							.0006	.192
3.Wd.Bu.Bo.							.0053	1.696
3.Wd.St.E.Ar.	.0062	1.984						
3.Wd.Bo.A.	.0047	1.504						

Table 11. (Contd.)

Name of grasses	N.Pasture Inst.	A.	Central Pasture Inst.	A.	S.E.Pasture Inst.	A.	S.W.Pasture Inst.	A.
1.Shd.			.0150	4.800				
1.St.	.0023	.736						
1.St.E.Ar.Wd.	.0100	3.200						
1.Br.			.0027	.864				
4.B.Brush							.0012	.384
7.G.Wood	.0037	1.184						
Waste	.0036	1.152	.0003	.096			.0005	.160
Lane			.0004	.128			.0013	.416
Corral			.0009	.288				
Ditch	.0038	1.216	.0017	.544				
Transect			.0016	.512	.0012	.384		
1.Rck.Bo.An.			.0033	1.056				
4.Mg.Rck.Bo.Ar.			.0128	4.096				
4.Mg.Rck.A.							.0300	9.600
Total	.4575	146.40	.4907	157.024	.3213	102.816	.3933	125.856
Vegetation Unpalatable		23.840		27.744		1.408		6.112

Legend*

Types
1. Grassland
3. Weeds
5. Browse

Sub-types
A. Agropyron
Bo. Bouteloua
Bu. Buffalo
E. Elymus
St. Stipa

Ar. Aristida
An. Andropogan
Rck. Rock
Mg. Cercocarpos
Shd. Hordeum
G.W. Sarcobatus.

Table 11. (foregoing) gives the results from the mapped survey that shall serve as a working basis from which various studies and comparisons are made.

Summary.

The necessary map on which to base future studies was prepared by plane table and stadia-alidade method and the vegetation mapped into types and subtypes by a modified timber cruising method, that employed pacing as a means of determining the type and subtype boundaries.

The planimeter was used to determine all areas. An average of ten measurements was used to determine area of individual pastures. The types and subtypes within an individual pasture were measured separately and total taken, but if this total did not equal the average (10 - trials) measured area of the individual pasture the individual types and subtypes were remeasured until the total agreed.

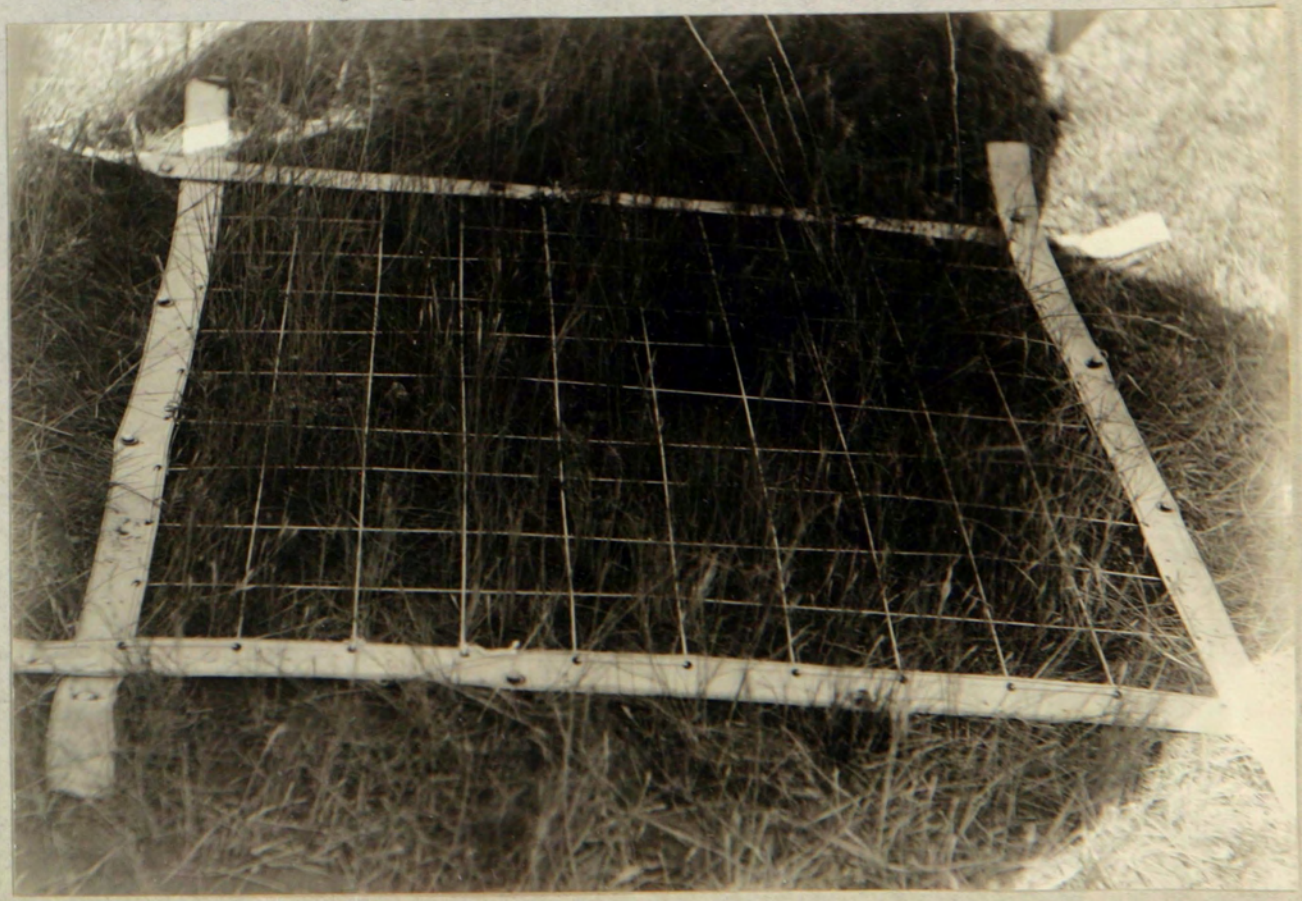
11. Vegetative Studies.
General.

Native vegetation forms the basis of feed for grazing animals. The amount and kind of vegetation may vary widely, but its extent is best shown by its density or actual ground area occupied.

The methods of study were (1) the quadrat, (2) measuring species on charted quadrats, (3) figuring of density of grass within quadrat, and (4) the preparation of density tables.

The Quadrat.

The method of reducing vegetation to a basis from which actual occupied area could be computed was found in the quadrat. Below is a photograph of a quadrat that will assist much in conveying an idea as to what a quadrat consists of.



The quadrats were charted by a convenient method of two people charting on separate sheets, after which the sheets were matched and pasted together before filing away for permanent records. The vegetation within the quadrat was charted on the basis of area actually occupied at the ground level.(7) At the end of this manuscript a printed sample of a charted quadrat is reproduced. The legend used in charting all quadrats and used at other places in this paper unless otherwise indicated is as follows:

A.- Agropyron.
B.- Bouteloua.
Br- Bromus.
Bs- Bulbilis.
E.- Elymus.
H.- Hordeum.
St- Stipa.
Y.- Yucca.
An- Andropogon.
Mg-Cerocarpus.
Rck- Rock.

While meter quadrats were found best for grass formations, 10 x 10 meter quadrats were found best suited for Cerocavpus formations.

Transects (17) of varying length were charted in each pasture to determine the composition of the rocky formations. These transects are reproduced at end of this paper.

Measuring of Species on Charted Quadrats.

The measuring of the area actually occupied by the vegetation as shown by the mapped area on charted quadrats

and transects to a definite scale that paper permitted presented some difficulties, but they are here discussed under the (1) planimeter and (2) actual measured area occupied by one stem.

In preparing the chart quadrats, it was often found necessary or desirable to chart the actual ground area occupied by the compact grasses as Bouteloua and Bulbilis, while the more open species as Agropyron were listed as a 10 etc., which means that 10 stems of Agropyron were found in one bunch of grass.

To measure all charted quadrats, the planimeter was used in same manner (page 18) as used to measure the areas on large map (plate 1), but due to smaller areas greater care was needed.

In as much as only the grasses actually grazed, which would occupy approximately 95-98% of ground cover, were being considered, they alone were measured. The general procedure was to prepare a sheet of small notebook paper for each quadrat by listing the represented plants found in quadrat and to record measured area (by planimeter) as follows:

Quadrat Number 20.			Middle meadow.	
B.	St. area.	A.	A. stems.	B.
.0279	.0004	.0004	375	18
.0068	.0004	.0003		
.0003	.0009	.0006		
.0004	.0005			
etc.				
.0795	.0117	.0050		

(Sample sheet from notes)

The numbers under stems give the total of all exponents as a^3, a^5, and a^2 of all Agropyron charted in quadrat number 20 and B the total of all Bouteloua stems found.

Each of the twenty four quadrats and the four transects were worked up in the manner explained above and filed for ready reference.

Figuring Density of Grass within Quadrat.

To convert the instrument readings taken from charted quadrats to percent of actual ground surface occupied, the planimeter was used to measure a large number of blocks (1 inch) on the graph paper (on which quadrats were charted) in order that an average instrument reading .0066 might be secured for the charted inch squares. Since one hundred of these squares are contained in a quadrat, the instrument reading or area would be .66 for the charted quadrats. The conversion of total measured areas in each charted quadrat into percent of whole occupied by kind of plant under question could now be done by dividing total measured area by .66 to give percent of the area occupied. It is shown by taking the total area of B. quadrat number 20 (page 27) .0795 and dividing by .66 to give 12% the actual amount of ground surface (basal area) occupied by Bouteloua.

The conversion of total number of stems present into

actual basal area occupied is more difficult as it is necessary to base all calculation on the area of one stem.

The area of one stem of each of the three main palatable grasses, Agropyron, Bouteloua and Andropogon was determined by actual measurements of stems (seed bearing) of these grasses on charted quadrats and other places over the pasture under varying conditions of grazing in order to reach a correct average. All measurements were taken of bunches of grass flush (basal area) with the ground and the number of stems counted. This method necessarily takes into consideration the area between the stems within the bunch of grass, but this was thot best as the growth in bunches of grass is generally so compact that the number of stems produced represents a maximum production for a given basal area. The measurements for Agropyron were recorded in millimeters as follows:

Stems		Area.
19		20 x 40 - 800 sq. mm.
7		20 x 10 - 200
8		20 x 7 - 140
6		8 x 11 - 88
11		25 x 8 - 200
	etc	
727		19602 sq. mm.

19602 ÷ 727 = 26.9 or 27 sq. mm. or 27 sq. cm. per stem of Agropyron.

The area of one Bouteloua stem was found to be 105 sq. mm. by measuring 480 stems that occupies a total surface

area of 50,220 sq.mm. The area of one stem in this case was much larger due to the habit of growing relatively few seed bearing stems, but many short fine leaves near to ground.

The area of one Andropogon stem was found to be 100 sq. mm., by measuring 64 stems that occupied a total surface area of 6,450 sq. mm. The large area of one stem in this case was due to much the same reason as the Bouteloua.

The conversion of stems tabulated from charted quadrat number 20 (page 27) into total area actually occupied by plants under consideration shows that:

375 a stems x .27 sq. cm. (area 1 stem) = 101.25 sq.cm. ÷ 645.14 sq. cm. (100 square inches area represented by charted quadrat) = 15.5% of ground occupied with Agropyron.

18 b stems x 1.05 sq. cm. (area 1 stem B) = 18.90 ÷ 645.14 = 2.93% + 12% (planimeter measured area %, page 27) = 14.93 % the total area occupied by B within quadrat number 20.

By employing the method given above all the data secured from the charted quadrats was converted into percent of area actually occupied by certain vegetation and listed in table 111, given below:

Table 111.
Summary of measured Quadrats
Figures in percent of total area occupied.

Quadrat Number	Transect	A	B or Bo.	Bs or Bu.	An.	Rck.	Mg.	Listed in order of importance
3	2	16.3						A = 16.3
4	1	14.46						A = 14.46

Table 111.

Quadrat Number	Transect	A	B.or Bo.	Bs.or Bu.	An.	Rck.	Mg.	Listed in order of importance.
5	2	12.88						A - 12.88
6	1	14.0						A. -14.0
7	1	18.9		.69				A - 18.9 Bs - .69
9	1	14.79						A - 14.79
10	3	21.00	6.4	11.44				A-21,Bs-11.44 B- 6.4
11	3	4.34	13.02	19.9				Bs-19.9,B-13.02 A-4.34
12	3	17.47	29.3					B-29.3, A-17.47
13	3	17.5	40.5	1.67				B-40.5,A-17.5, Bs-1.67
14(Pure)	c	32.4						A - 32.4
16(Pure)	c			29.02				Bs - 29.02
20	c	15.5	14.93					A-15.5, B-14.93
22	c	22.67	8.7					A-22.67, B-8.7
28	c	2.65	9.06					B-9.06,A-2.65
36	2	19.58	1.9					A-19.58,B-1.9
38	2	17.5						A - 17.5
40	1	21.1				.3		A - 21.1
42	1	21.5						A - 21.5
44(Pure)	3		49.2					B - 49.2
46	3	3.59	17.9	6.09				B-17.9,Bs-6.09, A-3.59
48	c	10.8	3.44	16.04				Bs-16.04,A-10.8, B-3.44
50	c				15.4	8.2		An-15.4,Rck-8.2
Brushy M.C.						19.67	6.86	Rck-19.67,M.G-6.86

Table 111. (Condt)

Transect	A.	B.or Bo.	Bs.or Bu.	An.	Rck.	Listed in order of importance.
1		1.56		8.41	24.25	Rck.24.25, An-8.41
2		9.20		2.17	41.6	
3		11.05		.75	24.3	
4		16.38		3.06	14.12	
Avg.						Rck.26.06,Bo-9.54 An-3.59

Note. Figures given above for each quadrat are secured from more or less mixed stands (only where marked pure) rated in importance of palatable grasses present.

The average of the four transects (table 111) was taken due to the varying conditions perhaps due to weathering and erosion of the ground cover that existed on the areas so designated in the reconnaissance survey in order to secure an average figure to represent this type of ground cover.

Preparation of Density Tables.

A study of table 111 shows a striking similarity in the percent of density of certain kinds of grass. These figures further show (when reference is made as to location of quadrates on the large map) as will actual observation, that the palatable grass cover on level land in the east

half of the pasture is less dense than that found in the north individual pasture, or on the hill sides and higher meadow.

By designating the more dense formations in north individual pasture as transect 3 (named in accordance with isolation transect in north pasture around and in which most of the quadrats were charted), the open formation in east part of pasture as transect 1 and 2 and the remaining area as average area, table 1V on density of grass was prepared. Transect 3 section was prepared by listing densities (table 111) of all quadrats (#10-11-12-13-44-46) charted in and around transect 3 in manner shown below:

Quadrat number	Primary	Secondary	Tertiary
	Bs.	B.	A.
44	49.2 (Pure)		
11	19.9%	13.02%	4.34
	A.	Bs.	B.
10	21.0%	11.44%	6.4%
	B.	A.	Bs.
12	29.3%	17.47%	
13	405%	17.5 %	1.67%
		2 34.97%	
		17.48	
		Bs.	A.
46	17.9%	6.09	3.59
	3 87.70		
	29.23		

The average of B in quadrats # 12,13 and 46 (primary importance) was found to be 29.23%. The average of A. in quadrats #12 and 13 (secondary importance) was found to be 17.48%. The average of A in quadrats # 11 and 46

(tertiary importance) was found to be 3.96%. The average of Bs. in quadrats # 10 and 46 (secondary importance) was found to be 8.76%. It will be noted that where more than one designation of primary importance was listed in above grouping, an average was taken on presence of this area to secure more accurate density for pasture two. In case of species of secondary importance, an average was also taken, as was the case in the tertiary importance column. The figures given above are rearranged and listed in transect 3 section of table IV given below:

Table IV.

Percent of total ground occupied by different kinds of grass.

Transect 3.	
A - ----------	Pure.
A - 21.0	Primary. (Quadrat # 10)
A - 17.48	Secondary. (Quadrat # 12 and 13)
A - 3.96	Tertiary. (Quadrat # 46 and 11).
B - 49.2	Pure. (44)
B - 29.2	Primary (12-13-46)
B - 13.02	Secondary (11).
B - 6.4	Tertiary (10).
Bs- --------	Pure
Bs- 19.9	Primary (11)
Bs- 8.76	Secondary (10-46)
Bs- 1.67	Tertiary (13)

Transect 1 and 2.

A - -------Pure

A - 17.10 Primary (3-4-5-6-7-9-36-38-40-42).

Average.

A - 32.4 Pure

A - 17.4 Primary.

A - 12.1 Secondary.

A - 4.1 Tertiary.

Bo - 49.2 Pure

Bo - 24.2 Primary.

Bo - 9.6 Secondary.

Bo - 4.9* Tertiary.

Bu or Bs - 29.02 Pure

- 18.00 Primary.

- 6.00 Secondary.

- 1.7 Tertiary.

An - 15.4 Pure

An - 15.4 Primary

An - 8.41 Secondary.

An - 3.59 Tertiary.

Table IV.(Contd.)

Mg. - 6.86

Rck. - 19.67

*Use in Mg.Rck.Bo.Ar.

In Mg	Rck	Bo	An	use
		9.54	3.59	

The same method for analyzing and rearranging quadrats #3-4-5-6-9-36-38-40-and 42 (10) into transect 1 and 2 section of table IV was employed.

Quadrats # 14-16-20-22-28-48-50 were not included in transect 3 or transect 1 and 2 section of table IV, as they represent density of ground cover in various parts of pasture, are now analyzed with all quadrats in transect 3 and transect 1 and 2 districts and rearranged by method explained before, into average section of table IV. These figures represent average density of grass for the entire pasture.

Summary.

The quadrat was adopted as the most convenient method of studying vegetation.

The basal area occupied by the native vegetation was measured by means of planimeter from the charted quadrats.

The density of grass within a quadrat was determined by considering only surface actually occupied as a percent of entire quadrat.

Density tables were prepared by using the density of grass in quadrats by considering the importance of different kinds of grass as to whether they were primary, secondary or tertiary.

111. Running of Steers on Pasture.

General Plan.

Good pasture or range shows itself best by the actual gain secured on livestock. Chemical analysis, density of forage, palatability of grass and weeds may be discussed, but are of secondary importance.

Mr. L. S. Douglas, Grazing Inspector for U.S. Forest Service made a general reconnaissance survey of the South College Pasture in the fall of 1920, from which a tentative allotment for the individual pastures was determined to be,

32 head of steers for South pasture # 3 and 4.

17 head of steers for Center pasture # 1.

13 head of steers for North pasture # 2.
62 total.

The general plan of the experiment determined upon by Mr. Maynard and Mr. Douglas was to divide the large pasture (583.84 A.) into four individual pastures (given below) in order to test out the three most commonly used sustems of grazing. (9)

The divisions were:

Number
1. Center pasture-check-turn stock on in spring at inception of plant growth. 195.328 A.

2. North pasture-deferred grazing-stock withheld

for 10 to 14 days from pasture after inception of plant growth. 159.840 A.

3. Defered rotation grazing with stock withheld
South pasture
4. for 10 to 14 days after inception of plant growth and to graze # 3 in spring until # 4 seeds after which graze # 4.

#3	125.856 A.
#4	102.816 A.
	583.840 A.

Animals Used.

In the spring of 1921, 62 range steers were secured from the Western Slope of this State and delivered in Ft. Collins, Colorado.

These steers were mixed Hereford and Shorthorn, two year old grades in thin condition, suggesting that they had wintered on poor range, but they possessed good bone and fair to good quality.

Weighing and Weights.

After several days of feeding to give steers a chance to fill to normal weight, they were branded with progressive numbers from 1 to 62 to make individual identification easy. Next, individual weights (May 3rd, table XII) were taken of steers noting the breed and condition in each case. From this initial data, an allotment sheet was prepared, balancing the initial weight, breed and condition as near as possible to distribute the necessary animals into each individual pasture.

The following morning 17 of the allotted steers were turned onto the center or check pasture (No. 1) as the grass was getting a fair start. The remaining 45 steers on the North College pasture to be held in reserve until the desired deferred period for pastures 2-3 and 4 had been accomplished.

The desired deferred periods, to permit a good start of grass in pastures number 2-3 and 4 were reached on May 26th. On this day the individual weights were taken on all (62) steers. Thirty-two head (previously allotted) were turned into S.W. pasture number 3 and the remaining 13 (previously allotted) were turned into north pasture # 2. Individual weights were again taken on the following days (May 27-28) in order to secure the best possible average weights to be listed under date of May 27th., (table V. VI, VII) in records. Periodic weights were taken ever thirty days with Fairbanks standard scales located at corrals in pasture. More frequent weights were taken near the end of grazing season to determine amount of loss in weight as season closed. (Table No. V)

Weights in all cases were taken between 10 A.M. and noon after steers were rounded up as quietly as possible, taken past lake to drink what water they desired and

coraled with as little excitement and handling as necessary. Individual weights were taken of steers in each pasture every 30 days after May 27th, with group weights on October 11th. The percent of total gain in each of the tables V, VI and VII given below was secured by dividing gain secured during each period by total gain between initial and final weights. The method of analysis for each table is given in each case in right hand column.

TABLE V.

Center Pasture (No.)	Weight of Steers on Center Pasture: May 3 to May 27	May 27 to June 26	June 26 to July 26	July 26 to Aug.25	Aug.25 to Sept.24	Sept.24 to Oct. 11	Oct.11 to Oct.24	Entire Season	No. Col.	Method Analysis
No.Days in Period	24	30	30	30	30	30	17	174	1	Record
No.Steers in Pasture	17	17	17	17	17	17	17	17	2	Record
Total Weight(Initial	11720	12813.3	14470	15555	16345	16825	17180		3	Record
All Steers (Final	12813.3	14470	15555	16345	16825	17180	17075		4	Record
Av.Weight (Initial	689.4	753.7	851.2	915	961.5	989.7	1010.6		5	3/2
Per Steer (Final	753.7	851.2	915	961.5	989.7	1010.6	1004.4		6	4/2
Total Gain all Steers	1093.3	1656.7	1085	790	480	355	-105		7	4-3
Av.Gain per Steer	64.3	97.5	63.8	46.5	28.2	20.9	-6.2	315	8	6-5
Av. Daily Gain Per Steer	2.68	3.25	2.13	1.55	.94	1.20	-.48	1.81	9	8/1
Percent of Total Gain	20.41	30.94	20.24	14.72	8.94	6.62	-1.87			

x -Weights not average of last three days

TABLE VI.

North Pasture (No.2) Early Protection	Weight of Steers on North Pasture: May 3 to May 27	May 27 to June 26	June 26 to July 26	July 26 to Aug. 25	Aug.25 to Sept.24	Sep.24 to Oct.11	Oct.11 to Oct.24	Entire Season	No. Col.	Method of Analysis
No.Days in Period	24	30	30	30	30	17	13	150	1	Record
No.Steers in Pasture	13	13	13	13	13	13	13	13	2	Record
Total Weight (Initial)		9848.3	11205	12110	12445	12400	13800		3	Record
All Steers (Final)		11205	12110	12445	12400	13800	13470		4	Record
Av.Weight (Initial)		757.6	861.9	931.5	957.3	953.8	1061.5		5	3/2
Per Steer (Final)		861.9	931.5	957.3	953.8	1061.5	1036.1		6	4/2
Total Gain all Steers		1356.7	905	335	-45 x	1400	-330		7	4-3
Av. Gain per Steer		104.3	69.6	25.8	-3.5	107.7	-25.4	278.6	8	6-5
Av. Daily Gain per Steer		3.48	2.32	.86	-.12	6.33	-1.95	1.86	9	8/1
Per cent of Gain		37.5	24.9	9.5	-1.2	38.6	-9.1			

X - Average of May 26-27-28

x - Not accurate as scales were out of order

TABLE VII.

Weights of Steers on South Pasture

South Pasture (No.3) Rotation with early Protection	May 3 to May 27	May 27 to x June 26	June 26 to July 26	July 26 to Aug.25	Aug.25 to Sep.24	Sep.24 to Oct.11	Oct.11 to Oct.24	Entire Season	No.Method Col. of Analysis
No.Days in Period	24	30	30	30	30	17	13	150	
No.Steers in Pasture	32	32	32	32	32	32	32	32	
Total Weight (Initial)		24746.7	27680	29745	31200	30890	32910		
All Steers (Final)		27680	29745	31200	30890	32910	32640		
Av. Weight (Initial)		773.3	865	929.5	975	965.4	1028.4		
per Steer (Final)		865	929.5	975	965.4	1028.4	1020		
Total Gain all Steers		2933.3	2065	1455	-310x	2020	-270		
Av.Gain per Steer		91.7	64.5	45.5	-9.6	63.4	-8.4	246.7	
Av.Daily Gain per Steer		3.1	2.15	1.52	-.32	3.73	-.64	1.64	
Per cent of Gain		37.1	26.1	18.4	-3.8	25.6	-3.4		

x - Average of May 26 - 27 - 28

x - Not accurate as scales were out of order

The above tables, besides the general information which they contain, bring out very clearly the seasonal aspect of the gains secured. The 30.9% of total gain made during June and 20.2% during July by Center Pasture (no early protection) is exceeded by North Pasture (early protection of 24 days) with 37.5% for June and 24.9% for July and further exceeded in the aggregate with 37.1% for June and 26.1% for July for the North Pasture. These figures show that the greatest gains were made during the main growing period of the grass. They further suggest by fluctuation in weights during August that greater consideration in future should be given gains secured and seasonal importance of most important grazed vegetative plants.

Management.

From tables V. Vl. and Vll. given above the following figures may be grouped:

Pasture	Days Grazed	Avg. seasonal rain.	Avg. daily gain	
Center Pasture	174	315 lbs.	1.81 lbs.	- check-turn on early.
North Pasture	150	278.6 "	1.86 "	- defered grazing.
South Pasture	150	246.7 "	1.64 "	- deferred & rotation grazing.

The above figures bring out very clearly the results of the different systems of pasture management for the past year.

It will be noted that the Center Pasture made the largest average gain for the grazing season, due to the 24 days longer grazing period. The North and South Pastures with 24 days less grazing period produced smaller average seasonal gains, showing that in no case was there any apparent shortage of grass for grazing.

With a progression of years the advantage of the different systems of management should become more apparent. It is believed that in a few years, the vegetation in Center Pasture will be weakened somewhat by the earlier grazing and as a result the average seasonal gain will be lowered. In the case of the other pastures, it is believed that as the vegetation grows stronger and seeds better, that the average seasonal gain will be increased. Time only can determine this point.

The average daily gains bring out the above conclusion with the exception of the North Pasture, which is to be discussed later, on page 79 of this manuscript.

Salt.

Block salt was available to all cattle at or near the suggested salting locations shown on large map. A summary of the salt utilized during season is given below:

Table VIII.

	# Animals.	Lbs. used.	Amt. per season per animal	Lbs. per month.	Cost salt per acre	Seasonal cost animal
C-Pasture	17	70.5	4.1	.69	.0066	.0615
N.Pasture	13	40.5	3.1	.60	.004	.0465
S-Pasture	32	60.0				

Salt charged at 1 1/2¢ per pound.

Why Steers Loose Weight in Fall of Year When Grazing on Grass.

A study of table V readily reveals the fact that, as the grazing season advances, the rate of gain made by grazing animals decreases, until there is finally an actual loss in weight during the last period.

By chance this loss in weight by grazing animals was forceably brought to light the last of September. The analyzing of the grass presented itself as the most feasable method of attack. A chemical analysis of the four important grasses, from a grazing standpoint, was made of material collected on September 29th and October 27th. The results of these analysis are incorporated in the following table:

Figures in %

TABLE IX
Chemical Analysis

	Agropyron Vaseyii				Bouteloua gracalis				Bulbilis dactyaloides				Andropogon frucatus			
	9-29-21	On Dry	10-27-21	On Dry	9-29-21	On Dry	10-27-21	On Dry	9-29-21	On Dry	10-27-21	On Dry	9-29-21	On Dry	10-27-21	On Dry
Moisture	6.08		6.37		7.48		6.13		6.51		5.80		6.32		5.04	
Ash	8.04	8.56	6.66	7.11	6.36	6.87	5.73	6.10	8.42	8.89	8.40	8.90	4.77	5.09	2.75	2.85
Crude Protein	4.25	4.52	2.71	2.88	4.69	5.07	5.00	5.32	7.03	7.52	6.17	6.55	2.04	2.18	1.80	1.89
Crude Fiber	32.86	34.99	33.90	36.21	35.97	38.88	36.80	39.23	26.12	27.93	27.10	28.69	41.35	44.14	43.21	45.61
Ether Extract	2.66	2.83	2.44	2.61	1.99	2.15	2.00	2.13	2.21	2.36	2.01	2.73	2.10	2.24	2.02	2.12
N.F.Extract	46.11	49.10	47.92	51.19	43.51	47.02	44.34	47.22	49.61	53.20	50.52	53.63	43.42	46.35	45.18	47.55

Above analysis were made by L.H.Wolf, Chemist, State Dairy Commission

x - Factor of 6.25 ti es nitrogen content to give amount of protein.

A critical examination of the above table shows that in all cases, with exception of Bouteloua gracalis, the crude protein content decreases and the carbohydrate content increases as the season approaches the end and the life cycle of grass nears completion. The same conclusion is shown to be true by Henry and Morrison (12), for Kentucky Bluegrass, and studies carried on by Wyoming Experiment Station. (11)

The loss in fall grazing is a physiological one. As the growing season for plants advances, the days of the late summer gradually become shorter, which means lowered temperature which reflects itself on the plants by decreasing the phytosynthetic activity, (12). It is supposed that cold weather causes the chlorophyl to deteriorate, (13) which in turn causes the plant to loose its green color, and it is supposed that the phytosynthetic activity of plant is impared to such an extent that the simple sugars are not condensed into starches and are not further built into proteins, but are stored in form of simple carbohydrates. If little or no sugars are formed into proteins, it seems reasonable to suppose the protein content of the plant will be decreased somewhat by the metabolic processes of the plant.

Another explanation given for the chemical change in

plants as the plant gradually looses its green color is included in the following quotation: "The simultateous presence of carotinoids in varying amounts undoubtedly serve to modify the amount and character of the radiant energy absorbed, as these pigments absorb different parts of the spectrum of light and hence undoubtedly produce a different chemical activity, or actinic effect of the absorbed energy. (14)

"Indeed there is much to support the view that the autumnal changes in foliage pigaments have the physiological functions of absorbing heat in order to hasten the metabolic processes of ripening and preparation for winter defoliation. The rapid and brilliant changes in foliage coloring after a sharp frost kills the tissues and makes rapid translocation of food material of the leaves to the storage organs immediately necessary, have been explained as the response of the pigmentation of the leaves to the need for increased heat absorption." (14)

It seems reasonable to suppose that a part of the protein content may be broken down into simpler compounds, in this translocation of plant food for storage in preparation for winter and with the dropping of the grass' seed, the analyzed plant will show a decreased percentage of

proteins and an increased percentage of carbohydrates.

Beginning with June 1st, observations were made every day or so, as weather and transportation permitted, to see that the steers were being held in their right pastures, to determine the seasonal importance of the different kinds of grass, the kinds of forage grazed where possible, the condition of grass as the grazing season progressed, and the percent of palatability of the different grasses.

Seasonal Importance.

The seasonal importance of the grasses found in the South College Pasture is best shown in table X, given below:

TABLE X.
Seasonal Importance of Grasses.

1. Name of Plant						
a. Common	Three awn	Wheat grass	Grama	Bluestem	Buffalo	Spear Grass
b. Scientific	Aristida longiseta	Agropyron Vaseyii	Boutelona gracilis	Andropogon frucatus (muhl)	Bulfilis daotyaloides	Stipa Sp.
2. Date of flower stalk production	June 6-20	June 9-20	June 9-20	Aug 1-15	June 1-10	June 1-15
3. Seed matured	July 15 to Aug. 1st	July 20-31	July 20-31	Sept 15-20	July 1-10	July 15-20
4. Roots*	Bunched fine 4 ft.	Deep	Deep	Deep - known 16 ft 10 in.	Shallow	Deep
5. Season grazed	Early	All	All	Late	All	Early
6. Remarks	Awns prevent eating early in season				The extent that steers graze this grass is questioned.	Early seeding awns prevents eating. Such small amount in pasture that it has no importance.

*From lecture given by Professor Gheen (sp?) of Teachers' College, Greeley, Colorado

A. Vaseyii (Scribn & Smith)
B. gracilis (H.B.K) Lag. (15-16-17)
B. oligostachya. Nutt. (agrostigny)

Andropogon
Provincialis (Lam).

The results of the observations contained in table VIII show the period of growth and the importance of the various grasses for grazing. It will be noted that the relatively unimportant grasses such as aristida and stipa are early maturing, during the period when much moisture usually prevails, but with the coming of the first indication of less moisture the stiff awns on the heads are produced and from then on stock will avoid grazing them. Without doubt the Agropyron and Bouteloua grasses are the important forage producing plants as is shown by large area occupied in pasture (plate 1) and the all seasonal importance in which they may be grazed. Bulbilus has all-seasonal importance from a grazing standpoint, but since it is a low, matted grass the actual extent of grazing by cattle, who prefer a taller grass that they can get their tongue around, is questionable. Andropogon is of late seasonal importance for it does not show much signs of growth before August 1st, and its importance as a grazing grass starts about the middle of this month and continues up until the stock are taken off the pasture in late fall. It is found on the higher hills among the rocks and during it's period of grazing importance it was grazed very closely.

It was intended to determine the kind of grass most grazed in order to work out the relative palatability (usability) of the different kinds of grass by observing the cattle, as they grazed, from a saddle horse; but as a horse was not available it was decided to guage preference for different kinds of grass by noting the type and sub-type areas most frequented.

The observations given below are incomplete, but they can be considered as indication of preference of grazing animals.

Table XI.

Movement Observations of Steers on Pasture.

Date	1 C.Pasture.		2 N.Pasture.		3 S.E.Pasture.	4 S.E.Pasture	Time
June 1	17	W. Hill	13	Lake	24 E.Wheat & up.grass		10 A.M. 1B
2	Rained - not out.						
3	17	SW.Hill	13	E.	11 S.E. Ag. 21 Up.		" " "
4	Rained						"
5	17	N.Cor.Ag.	13	N.Bo.	21 Up. 11 N. Ag.		" " "
6	17	E.	13	L.	21 Up. 11 N. Ag.		" " "
9	17	E.	13	W	21 Up. 11 N. Ag.		" " "
11	17	L.	13	C.	21 Up. 11 N. Ag.		" " "
16	17	E.	13	C.	14 E. 18 Up.		" " "
20	17	L.	13	L	27 E. 5 Up.		" " "
23	17	L	13	C	Up.		" " "

Table XI. (Contd.)

Date	C.Pasture.	N.Pasture.	S.E.Pasture.	S.E.Pasture	Time.
June 24	17 E.	13 N.			10 A.M. to 1 P.M.
25	17 L	13 N.	32 E.		" " " "
26	10 L. 7 L. Hill	13 N.	14 Up. 18 N. Bu.		" " " "
27	Hill	13. N.	Hill.		" " " "
28	17 E.	13 L.	32 Up.		" " " "
30	17 E.	13 L.	14 Bu. 18 Up.		" " " "
July 1	17 E.	13 L.	18 Up. 14 Shed		" " " "
5	17 E	13 N.	Up. Hill		" " " "
6	17 E	13 N.C.	19 Up. 13 Mg.		" " " "
13	10 E. 7 Hill	13 L.	32 Up.		" " " "
15	17 C. Ag.	13 N.	32 E.Ag.		6 A.M.
16	17 E.	13 N.	Up.		" "
23	17 E.	13 N.	Up.		10 A.M. to 2 P.M.
25	17 E.	13 Lake	10 Bu. 22 Up		" " " "
26	17 E.L.Ag.	13 E.Lake	10 Up. 22 L.Bu & Ag.		" " " "
27	Hill	13 N.W.		32 L.Ag.& Bu.	" " " "
29	Lake	13 N.W.		N.C. Ag.	" " " "
30	17 E.	13 L.		20 Lake 12 S.C. Bo.	" " " "
Aug. 1	17 E.	Hill to W.		20 S.W. Bo. 12 N.W. Ag.	" " " "
7	17 E.			32 S.C. Bo.	" " " "

Legend.

E - East.
N - North
L - Lake

S - South
W - West
For others refer to page

Of the above table XI, the observations on the center pasture should be considered more accurate due to accessibility afforded to person on foot.

The general tendency of steers in center pasture to graze in eastern part, that is east of instrument plots to east boundary fence, seems to show their preference for the Bouteloua (grama grass) found in this section. Observation during and at end of season showed this area of Bouteloua to be closely grazed, but the aristida found in this area remained standing apparently untouched, for the seeds and awns were perfectly formed and remained intact on plant. The steers of the North Pasture seemed to show preference for the north part of that pasture, which is very largely Bouteloua, but the Stipa, Elymus and Aristida found therein seemed to remain ungrazed for they produced flower stalks and seeded very early in season after which they remained untouched. The marked preference to graze the areas up the first hill in SouthWest Pasture may be attributed to the large percentage of Boutelous grass found there or to the shade that the few pine trees afforded.

The sum total of these observations seem to show a preference on the part of the grazing animals for Bouteloua and this statement is suostantiated by data presented in table XIX and discused on page 85 of this manuscript.

The effect of grazing on the grass cover with reference to it's future productivity, can only be determined after a period of years; hence it is outside the scope of this paper to more than discuss the methods that have been found in the past to maintain a forage cover under continuous grazing.

The grazing experiment on South College Pasture was evidently organized primarily with an idea of testing out the value of the different systems of pasture management over a period of years under Colorado conditions and the writer believes that it is productive of results. The known methods of pasture or range management that are commonly employed so that grass cover can hold it's own or increase in productivity while being grazed are "defered and "deferred and rotation" grazing. (9) - (18) -(19)

The deferred system consists of holding the stock off of an area to be grazed until the sheath about the grass culm begins to burst and the fruiting stem is sent up. This stage is generally reached within 10 to 14 days after the inception of plant growth in the spring. The general reason for this system of management is to give the plant a good start in growth in spring in order that it may successively maintain its food-life processes for continued

growth in face of continous judicious grazing. It is stated in plant physiologies that green (chlorophyl) plant tissues possess the power of food manufacture and as this green tissue increases, (20) it seems reasonable to suppose that more plant food is produced which incidentally results in more foliage or forage production. This also permits the storage of plant food in the fall if foliage still exists, which has the general tendency to protect the crown of the grass plant and to promote earlier growth next season.

The deferred and rotation system of grazing takes into consideration the above method, but goes one step further, in that grazing is deferred from the desired area until after a crop of seed has been produced by the plants, after which stock is turned onto the deferred area for complete and thorough grazing. The deferred pasture (No.4) in the college experiment was considered to have seeded by July 26th. The complete and thorough grazing is prosecuted with much vigor to insure the shattering of the seed from the flower stalk and it's thorough covering by the trampling from the feet of the grazing animals. The success of this method depends upon having two or more areas that are controllable, preferably under fence, so that the rotation from one area stocked to carrying capacity of both areas may be deferred until the desired time. A five year method to be employed for managing

ing the South Pasture is given as follows:

	Pastures	
Year	#3	#4
1922	First	Last
1923	Last	First
1924	Last	First
1925	First	Last
1926	First	Last

The two year rotation given above is for the purpose of giving the grass seedlings a chance to get started to a point where they can much better withstand grazing.

The original intention was to follow the grazing steers on a saddle horse, in order to observe clearly what vegetation was actually consumed. But since this plan was not possible, I have attempted to show the palatability as well as preference for certain plants by the total gains secured on animals compared to percentage of total area occupied by plant in question. These results are summarized on page 56 of this manuscript.

Special studies of steers and gains.

The individuality which exists among steers as well

as among people was suggested by the fact that some steers made extra heavy gains during the grazing season while others made very light gains. To determine the extent of these differences and the possible indications it might lead to, on the relative palatability of the different grasses grazed, a statistical study on the basis of actual gain in pounds made during the grazing season was undertaken.

The methods selected for statistical study were average deviation, (21) correlation, (21) and the surface of distribution (21) on basis of daily gains to bring out individuality of steer.

The average deviation (A.D.) was selected for study to bring out individual differences. Averages tell nothing concerning the preformance of individuals, but the average deviation gives the possible deviation of individuals from the average and serves as a means to check performance.

"The coefficient of correlation is a figure (not exceeding one) that represents the interrelationship that exists between two parts or traits coordinately, independently or antagonistally."

The results of these studies are given below in tables XII, XIII, and XIV.

TABLE XII

Center Pasture - 174 days

Number of Animal	Breed and Condition	Weights May 3d	Weights Oct. 3d	Seasonal Gain	Daily Gain
1	H.m.	695	1065	370	2.1
3	Br.Co.	695	1070	375	2.2
6	H.Co.	600	910	310	1.8
7	H.Br.m	700	1010	310	1.8
9	H.Br.f	640	985	345	2.0
10	H.m.	580	785	205	1.2
15	Br.f.	670	975	305	1.8
16	H.m.	665	970	305	1.8
17	H.Br.m.	670	1000	330	1.9
18	H.	8800	1085	285	1.6
20	H.f.	670	970	300	1.7
30	H/m.	7725	1030	305	1.8
31	H.Co.	755	1105	350	2.0
39	H.Br.m.	785	1055	270	1.6
50	H.m.	695	1020	325	1.9
57	Br.m.	650	960	310	1.8
60	H.m.	725	1080	355	2.0
Total		11720	17075	5355	31.0
Av. Seasonal Gain		689.4	1004.4	315	
Av. Daily Gain				1.81	1.8
A. D.				28.8	
Correlation		.88			

TABLE XIII.

North Pasture - 150 days

Number of Animal	Breed and Condition	Weights May 27th	Weights Oct. 24th	Seasonal Gain	Daily Gain
13	H.Br.m.	816.7	1155	338.3	2.3
14	H.m.	606.7	850	243.3	1.6
21	H.m.	701.7	980	278.3	1.9
22	H.f.	791.7	1040	248.3	1.7
34	H.m.	715.0	985	270.0	1.8
41	H.m.	840.0	1090	250.0	1.7
42	H.f.	776.7	1070	293.3	2.0
43	H.m.	786.7	1000	213.3	1.4
46	Br.m.	868.3	1180	311.7	2.1
49	H.m.	691.7	995	303.3	2.0
54	H.Br.m.	766.7	1045	278.3	1.9
56	Br.m.	788.3	1155	361.7	2.4
58	H.m.	698.3	930	231.7	1.6
Total		9848.5	13470	3621.9	24.4
Av. Seasonal Gain		757.5	1036.1	278.6	
Av. Daily Gain				1.86	
A.D.				33.1	
Correlation		.84			

TABLE XIV.

South Pasture - 150 days

Number of Animal	Breed and Condition	Weights May 27th	Weights Oct. 24th	Seasonal Gain	Daily Gain
2	H.f.	805	1060	255	1.7
4	H.m.	783.3	1040	256.7	1.7
5	H.f.	810.	1025	215.0	1.4
8	Br.m.	696.7	975	278.3	1.9
11	H.Co.	645.0	900	255.0	1.7
12	H.f.	771.7	1020	248.3	1.7
19	H.m.	830.0	1095	265.0	1.8
23	H.Br.m.	740.0	950	210.0	1.4
24	H.f.	785.0	1020	235.0	1.5
25	Br.f.	741.7	1030	288.3	1.9
26	H.Br.f.	776.7	1030	253.3	1.7
27	H.f.	743.3	975	231.7	1.5
28	H.f.	730.0	960	230.0	1.5
29	H.m.	748.3	1030	281.7	1.9
32	H.co.	725.0	1020	295.0	2.0
33	H.f.	748.3	980	231.7	1.5
35	H.f.	783.3	1000	216.7	1.4
36	Br.m.	940.0	1190	250.0	1.7
37	H.f.	750.0	975	225.0	1.5
38	H.Br.co.	858.3	1140	281.7	1.9

TABLE XIV. (Cont.)

Number of Animals	Breed and Condition	Weights May 27th	Weights Oct. 24th	Seasonal Gain	Daily Gain
40	H.Br.co.	776.7	1005	228.3	1.5
44	H.Br.co.	680.0	890	210.0	1.4
45	H.f.	786.7	1045	258.3	1.7
47	H.m.	895.0	1175	280.0	1.9
48	H.m.	761.7	940	178.3	1.1
50	H.f.	811.7	930	118.3	.8
52	H.f.	828.3	1100	271.7	1.8
53	H.Br.co.	775.0	1090	315.0	2.1
55	Br.m.	861.7	1050	288.3	1.9
59	H.f.	791.7	1080	288.3	1.9
61	H.m.	778.3	1035	256.7	1.7
62	H.m.	688.3	885	196.7	1.3
Total		24746.7	32640	7893.3	52.4
Av. Seasonal Gain		773.3	1020	246.7	
Av. Daily Gain				1.64	1.6
A. D.				30.3	
Correlation		.63			

Average Deviation and Correlation.

Table XII shows the A.D. (average deviation) for the Center Pasture to be 28.8 lbs. This figure confirms observations that these steers were very uneven as to individuality, which was further reflected by the ability of these steers to put on gains when pastured on grass. When the A.D. 33.1 , (Table XIII) for the North Pasture and the A.D. 30.3, (Table XIV) for the South Pasture is considered with the A.D. of the Center Pasture it is seen that the method used in allotting these steers, considering weight, breed and condition, to each of the pastures was very nearly perfect.

Table X further shows the correlation between the initial weight and final weight to be +.88. This figure shows the uniformity and response of individuals in Center Pasture to the feed (grass) available. It shows that the weight for age is a good indication of what the possibilities for further development may be and the writer is of the opinion that it has value as an indirect indication of the palatability (usability) of the vegetation found in this pasture, the exact nature of which is not known. The correlation of +.84 for North Pasture and +.63 for South Pasture between the initial and final weights shows a considerable uniformity of response as above.

Effect of Breeding on Pasture Gains.

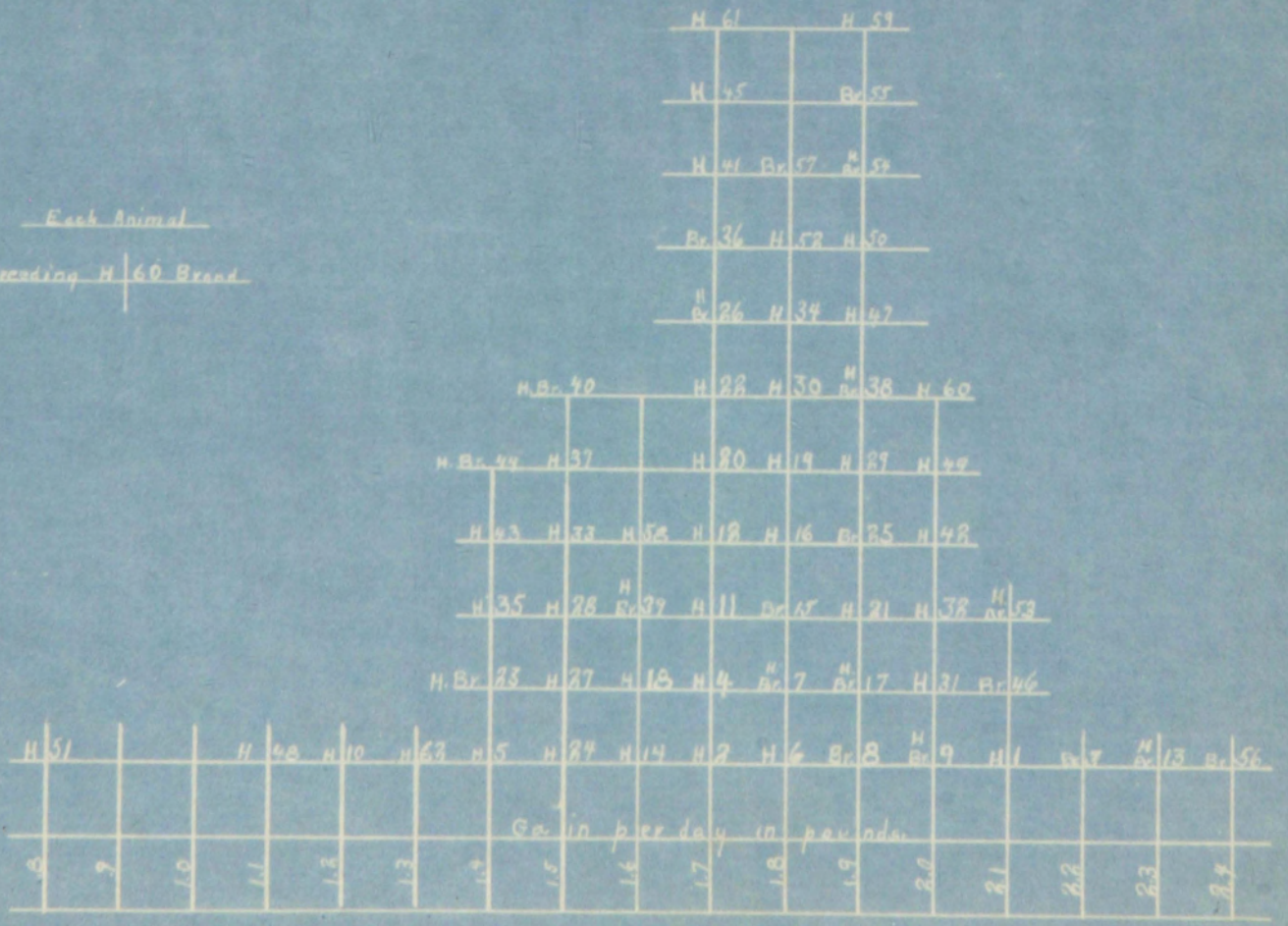
A graphical representation of the individuality, expressed by daily gains of steers is best shown by a surface of distribution.

The surface of distribution based on gain per day grazed with the breeding of the steers indicated by characteristic breed marking designated as H-hereford, HBR indicating some Shorthorn blood and Br-Brockle indicating more Shorthorn blood, of all steers was charted in figure 1 below. The number in the chart corresponds to the branded number on the steer.

Surface of Distribution.

Each Animal

Breeding H | 60 Brand



H.– Hereford. H.Br.– Hereford & Brockle. Br. – Brockle.

The above figure shows that half the animals are grouped between 1.6 and 2.0 pounds gain. A further study shows the following number of animals grouped according to breeding:

	1.7	1.6	1.9 Pounds gain per day.
H.	9	6	5
H.BR.	1	1	3
BR.	1	2	3

The above figures show that as the daily gains increase the number of Hereford animals decrease and the number of Brockle animals increased. A further examination of figure 1., will show that as the daily gain above 1.9 pounds increased, the percent of Brockle increases. These figures would seem to indicate that as the percent of Shorthorn blood increases in Hereford steers, a greater gain on grass can be expected.

The above conclusion is further brought out by a study of tables X, Xl, and Xll, by totaling the daily gains made by the separate breeds (indicated by markings) in each pasture and summarized as follows:

Table XV.

Average daily gain for steers in each pasture based on Breeding.

	H.		H.Br.		BR.	
Center Pasture	1.79	(10)	1.82	(4)	1.93	(3)
North Pasture	1.74	(9)	2.1	(2)	2.25	(2)
South Pasture	1.59	(22)	1.66	(6)	1.85	(4)

( ) shows the number of individuals averaged.

Altho only one breed is actually represented here, the amount of Shorthorn blood is represented by the Hereford Brockle face (cross bred) and Brockle face (more Shorthorn blood). It will be noted in every case, that, as the percent of Shorthorn Blood increases, the daily gain secured on grazing animals increases.

Summary.

Grade Hereford and Shorthorn steers were used for grazing on the experimental pasture.

Periodic weights were taken of grazing steers to determine gains as well as total seasonal gains.

The advantage of different systems of pasture management can only be determined after a period of years.

Grazing animals required .6 to .7 pounds of block salt per month.

The chemical analysis of grass was determined and a possible explanation offered as to why steers loose weight in fall when grazing on grass.

Observations of grazing animals show preference to feed upon grama grass (Bouteloua).

The statistical studies of weights secured on grazing steers show that individually they were very uniform in ability to put on gains. By considering the breeding of

Brockle faced steers to indicate degree of presence of Shorthorn blood, it was found that as the amount of Shorthorn blood increases in Hereford cross bred steers the ability of the animal to put on gains increases.

IV. CARRYING CAPACITY.

General.

The valuation of any land is ordinarily based upon what it will produce, but of necessity the value of grazing land is in direct comparison with it's carrying capacity of grazing animals.

The carrying capacity of grazing lands differs, but if the entire usable vegetation is reduced to some suitable unit, as vegetative or forage acre, the carrying capacity can readily be determined by applying thereto a unit in vegetative or forage acre necessary to support one animal under standard conditions to determine what the area will support.

Before proceeding further, it seems well to define what is understood by vegetative and forage acre. Since observations on page 56 leads one to conclude that 90% of vegetation grazed by grazing animals on South College Pasture consisted of the grama (Bouteloua), buffalo (Bulbilus), wheat grass (Agropyron) and bluestem (Andropogon), the definitions will be restricted to include only these four grasses. The vegetative acre is a hypotheical surface acre (basal area) growing a 100% density of the four above grasses. The forage acre is a hypothetical surface acre (basal area) growing a 100% density of the

four above grasses that is capable of 100% utilization by the grazing animal. The short period of one grazing season did not afford the writer an opportunity to determine the percent utilization of the four grasses in question; hence they are considered 100% usable with the equal chance in all pastures of this error taking care of itself when final alloting figure is determined.

Method of Figuring Carrying Capacity.

The inventory taken of the actual amount of vegetation in each pasture by means of the reconnaissance survey with acreage of each are determined on map by planimeter (table 11) and the density of each grass determined from quadrats (table 1V was now converted into vegetative acres. The conversion of surface areas into vegetative acres is shown in the following manner. By taking 1 BO.A. (table 11, Center Pasture) to equal 2.08 surface acres and multiplying this figure (2.08 acres) by 24.2% (average section of table 1V, which is actual density of this subtype determined from measured quadrats in all pastures, where Bo., is of primary importance in actual ground cover occupied) it equals .503 vegetative acres. The acreage of A., (Center Pasture) in 1 Bo.A., was determined by multiplying 2.08 acres (surface occupied

by this type and subtype) by 12.1% (Density of A., secondary importance average section table 1V) which equals .2516 vegetative acres. In like manner all sruface acres from table 11 were converted into vegetative acres by appropriate densities from average section of table 1V for the North Pasture, South West Pasture and transect 1 and 2 section of table 1V, for the Center and South East Pastures except where not complete in which case supplemented by using average section and all listed in corresponding headings in table XV1 given below:

TABLE XVI
Area of Types and Subtypes in Vegetative Acres.

Name of	N. Pasture (2)			C. Pasture (1)				S.E.Pasture (3)			S. W. Pasture (4)			
	A	Bo	Bu	An	A	Bo	Bu	An	A	Bo	Bu	A	Bo	Bu	An
F.A.(Pure)	4.240				13.830				7.724			6.045			
A.Bo	2.795	1.542			.022	.012			.257	.144		.574	.316		
A.Bo.Bu.	.084	.044	.008									.056	.031	.005	
A.Bo.Wd.	.801	.442													
A.Bo.Rok.	2.004	1.106													
A.Bu									.120	0.42		.011		.004	
A.Bu.Bo												2.227	.627	.768	
A.E.St.	.067														
A.Rok.	.328											.612			
A.St.E.Wd.	.056														
A.Wd.	.780				.033				3.382						
A.Wd.Rok.	.974														
A.Y.					.356				1.724						
Bo. (Pure)		7.478				3.810				8.990				.056	
Bo. A.					.252	.503			2.803	5.606		.418		.835	
Bo. Rok.														.456	
Bo.Bu.		.935	.728							.418	.104				

TABLE XVI Con't.

	1.				3				4			
	A.	Bo.	Bu.	An.	A.	Bo.	Bu.	An.	A.	Bo.	Bu.	An.
Bo. Wd.		1.549				.193						
Bo. V.												
Bo.Sa.		.155										
Bo. Ar.						9.710				.286		
Bu.(Pure)							1.356				.316	4.541
Bu. A.									.170			.253
Bu.Bo.										.541		1.014
Bu.Wd.			.081				.219					
An.												1.863
An.Bo.		.040		.064		.046		.074				
An. A.	.260			.330								
An. Rok.Bo.		.22		.690								
Ar.A.					.674							
Rok.Bo.										.092		
Rok.Bo.An.						.101		.038				
Rok.An.				.568								.275

TABLE XVI Con't.

	2					1					3				4				
	A.	Bo.	Bu.	An.	Mg.	A.	Bo.	Bu.	An.	Mg	A.	Bo.	Bu.	Mg	A.	Bo.	Bu.	An.	Mg.
Rck. A.	.507					.403									.863				
Rck.A.Bo.	.306	.124																	
Mg.A.	.015				.009						.007			.004					
Mg.An.																		.655	.292
Mg.Rck.																			.114
Mg.Rck.A																			
Mg.Rck.Bo.Ar.							.201		.273						&				
Mg.Rck.Bo.An.		.366	.138	.263		1.652		.622	1.188						1.084		.408	.779	
Mg.Bo.		.163		.116															
Wd.Bo.															.018				
Wd.Bu.Bo.															.083	.102			
Wd.Bo.A.	.062	.144																	
Total	13.279	16.308	.817	1.790	.388	15.570	16.229	1.575	.734	1.461	16.017	15.444	.462	.004	10,978	4.173	6.687	3.201	1.185
Grand Total		32.204					34.108					31.923				25.039			
Grand Total																	56.962		

There was much question on the part of the writer as to whether the density of the grasses in North Pasture should be considered on the basis of the six quadrats charted therein separately or only when they are considered in the average for the entire pasture. The quadrats are hardly representative enough and not of a large enough average for a precise conclusion. For this reason the figures given in table X for North Pasture are computed on basis of average section, in place of transect 3 section of table IV.

The total vegetative acres in each pasture call for a unit figure on which to base carrying capacity. The U.S. Forest Service uses one forage acre per steer or cow per month in rough country, but in the more controlled areas as pastures where salt and water are always available, closer utilization is possible and .75 of a forage acre per month (9) is considered sufficient. With vegetation reduced to terms of vegetative acres, and no palatability basis available, it seemed very clear that a unit in forage acres could not be used; hence a new unit on vegetative acres as a basis must be established.

The Center Pasture with its longer period of 174 days grazing seemed fairly equally utilized, and was

selected as the basis on which the other pastures should be compared.

The unit for carrying capacity based on vegetative acres contained in Center Pasture, which was grazed and reasonably well utilized by 17 steers for 174 days of grazing was determined by dividing 34.108 vegetative acres (total of all types and subtypes for center pasture table X) by 174 days which equals .196 vegetative acres required per day per bunch of 17 steers, which if further divided by 17 gives .0115 vegetative acres required by one animal for 1 days grazing or .34 vegetative acre per steer per month. This method is reasonably accurate, for the chances are high that with three pastures side by side that any error due to assuming an equal palatability for different grass plants for producing gains in one pasture will be equally taken care of on a utility basis when this unit is applied to the other pastures.

The South Pasture with a total of 56.962 vegetative acres divided by .0115 vegetative acres (amount consumed by one animal per day in Center Pasture) gives 4953 days grazing for one animal, which if divided by 150 days (total period grazed) gives a carrying capacity of 33 animals for this pasture. The addition of one animal to last years

stocked capacity of 32 steers seems to come within the limit of any error that might have crept into this method of procedure.

The North Pasture with a total of 37.104 vegetative acres, when considered on transect 3 high density section of table IV, divided by .0115 vegetative acres (1 animal's per day) equals 3226 days grazing for one steer, which if divided by 150 days (grazing period) equals a figured carrying capacity of 21.5 animals. The difference of 8 to 9 steers between the figured carrying capacity and the 13 grazed there on last season suggests an appreciable error. Considering the possibility of an error in basing density of grass in North Pasture on six measured charted quadrats, the totals, table XVI for North Pasture, secured by using average density tables on acreages of table II was also figured as follows:

32.204 v. a. - .0115 = 2800 days of grazing for 1 steer.

2800 days - 150 = 18.7 steers figured carrying capacity.

The above figures, on an equal basis with the other pastures, show a difference of 6 steers between the figured carrying capacity and the 13 grazed there on last year. The writer is inclined to select the conservative figure of 18.7 in place of 21.5 figure in absence of more charted quadrats.

Considering the same degree of error (one and a fraction steers) in figuring the carrying capacity of South and North Pastures based on even utilization of Center Pasture, the writer believes that the North Pasture should carry as many grazing animals (17) as the center Pasture (17) in place of the 13 grazed there the season of 1921. This conclusion is further brought out by a study of table I, in which it will be noted that total area exclusive of lake for North Pasture is 146.40 acres against 157.024 acres for Center Pasture of which the North Pasture has 23.840 acres unpalatable vegetation (mostly weeds) and 5.66 acres of low value grazing, browse type (cerocarpus) against 27.74 acres unpalatable vegetation (mostly weeds) and 21.41 low value grazing, browse type (cerocarpus) in Center Pasture. To those who may criticise this conclusion by using the high density figures for grass in 5 Mg. Rck. Bo. An. type (only data available after grazing season), the writer will say that if density figure for grass in above type is lowered the result in final carrying capacity figures in North Pasture will be raised instead of lowered.

The average daily gains secured on the steers graz-

ing the different pastures show that steers on the North Pasture produced a gain of 1.86 lbs., the Center Pasture 1.81 lbs. and the South Pasture 1.64 lbs. These figures suggest to the writer that the Center and South Pastures were about right, but that the high daily gain of North Pasture was due to understocking.

The foregoing conclusions are drawn from a very small amount of data, which only one grazing season affords; hence they are subject to correction, when the experiment has been carried on for a longer period of years and more data is available.

Authors method compared with method used by Forest Service.

At the special request of Professors Morton and Maynard, the results of the reconnaissance survey conducted by a representative of the Forest Service were included in table XVII given below, and the writer undertook to apply his basal area density table to each area to see if the two methods were subject to comparison.

Table XVII.

Summary of Forest Service Reconnaissance Survey.
Summary 1920.

Type	C.P. 1	N.P. 2	S.E.P. 2	S.W.P.	Total	Combined 3 & 4
1 Bf.Bs.	63	50	88	61	262	149
1 Bs.	40		29	2	71	31
3 Hd.	13	18	1.5		32.5	1.5
1 Rok.	5	40	5	26	76	31
1 Shd.	1.5			5	6.5	5
5 Mg.	33	19		22	74	22
1 Br.	3				3	
Lake	30	13			43	
Tame meadow	13				13	
Total	201.5	140	123.5	116	581	239.5

Legend.

RS.	Writer.
Bf. - - Buffalo-Bulbilis	- Bu. or Bs.
Bs. - - Bluestem-Agropyron	- A. or a.
Shd. -- Small Foxtail	- Shd.
Hd. - - Large Foxtail	- - -
Rok.- - Rocky land	- Rok.
Mg. - - Mountain Mahogany	- Mg.
Br. - - Brome grass	- Br.

(No grama [Bouteloua] listed. Probably included with buffalo.)

It will be noted that only 9 types and sub-types are included compared with 62 considered in preparation of this manuscript, but the basal area densities of average section table 1V are used after a study of what each represents; hence the comparison is as accurate as possible. The computed results are given below in table XV111.

Table XV111.

Area of Types and Subtypes in Vegetative Areas Based on Forest Service Reconnaissance Syrvey and Author's Density Tables (1V).

	CEnter Pasture				North Pasture				South Pasture			
Type	A.	Bo.	Bu.	An.	A.	Bo.	Bu.	An.	A.	Bo.	Bu.	An.
1 Bf.Bs	7.82		11.34		6.05				18.03		26.42	
1 Bs	12.96								10.04			
3 Hd												
1 Rck		.48		.18		.3.82		1.44		2.96		1.11
1 Shd												
5 Mg		3.15		1.18		1.81		.68		2.10		.79
1 Br												
Lake												
Tame meadow												
Total	20.58	3.63	11.34	1.36	6.05	5.63	9.00	2.12	28.07	5.06	26.42	1.90
Grand Total	36.9				22.80				61.45			
Carrying capacity as figured on P.71	17 head				12.5 head				34 head			
Grazed season 1921	17				13				32			

In the above table all figures were based on new established unit for one animal and computed on basis of Center Pasture.

The figures above show that the basal-area-density method applied by the author, which so far as he has been able to find, is original with him, is comparable to the method used in this instance by Forest Service.

Palatability.

The palatability of vegetation to any class of animals is here considered to mean the preference for and its usability, by that class of animals. Usability is considered to include the ability of animals to make efficient gains on kind of vegetation in question.

Table VIII shows the date of flower stalk production (considered by Forest Service as best time to begin grazing) for wheat grass (Agropyron), grama grass (Bouteloua) and buffalo (Bulbilus) to be during the early part of June. These three grasses are also shown to be grazed during the entire grazing season; but table IX, summarized on page 56, shows that the grazing animals showed preference for those areas in pasture that supported grama grass (Bouteloua) as the climax species.

The possible influence of grass upon the total gains made by steers during the grazing season is best shown by the following table.

TABLE XIX
Indications of Palatability

	Total gain all steers during grazing season Tables V-VI VIII.	Number of Steers in each pasture.	Total Vegetative acres. Table X.	% of total forage in Vegetative acres. A	Bo	Bu	An	Bunch Gain per Vegative Acre.	Gain in pounds per Steer per Vegative Acre.	Surface acres in pasture supporting Vegetative	Lbs gai surface acre in pasture
C-Pasture	5355	17	34.108	45.6	47.6	4.6	2.2	157	9.2	15.7	34.1
S-Pasture	7893.3	32	56.962	47.4	34.5	12.5	5.6	137.5	4.3	228.6	34.5
N-Pasture	3621.9	13	32.204	41.2	50.6	2.6	5.6	112.1	8.6	146.4	24.75

Legend:

A - Agropyrou - Wheat grass.
Bo- Boutelona - Groma
Bu- Bulbulis - Buffalo.
An- Andropogon - Bluestem.

From the above table the following significant figures may be grouped:

	% of total forage consisting of Bo (Bouteloua)	Gain for the season in pounds per steer per vegetative area.
Center Pasture	47.6	9.2
North Pasture	50.6	8.6
South Pasture	34.5	4.3

The above figures as well as table XVI show that the largest gains were made by steers that had the largest percent of grama (Bo-Bouteloua) on which to graze. The .6 of a pound greater gain made per steer per vegetative acre in Center Pasture was undoubtably due to the 24 days longer grazing period.

The south Pasture with only 34.5% grama grass (Bouteloua) compared with 50.6% of grama grass for North Pasture only produced 4.3 pounds gain per steer per vegetative acre in case of former compared with 8.6 pounds gain per steer per vegetative acre in case of latter when both pastures were grazed an equal period (150 days) of time. This condition might be further influenced by fact the North Pasture was under grazed.

The South Pasture with the lowest percent of grama grass (Bouteloua) has the largest percent of wheat grass

(Agropyron) but yet it produced the least gain per steer per vegetative acre of any of the pastures. From these figures, it seems reasonable to conclude that wheat grass does not have the nutritive value of grama grass.

The high gain (9.2 pounds table XIX) per vegetative acre for Center Pasture compared to other pastures shows that while the buffalo (Bulbulis) and bluestem (Andropogon) percent of area occupied is low and thereby allowing the percent of wheat grass to increase, the total gain on the steers increased. This shows that wheat grass is the second best forage grass.

The small amount of gain per vegetative acre for South Pasture is believed to be due to greater percent of total forage being made up of buffalo grass and bluestem grass. From observations made by writer, it is concluded that the buffalo grass has very little grazing value for steers due to its shortness, but that the late growing bluestem, which is grazed very persistently in the fall of the year has a grazing value that ranks it above the buffalo grass.

The coefficient of correlation (tables X, XI, XII) between the initial and final weights of steers for each pasture are given below.

Center Pasture	+.88
North Pasture	+.84
South Pasture	+.63

These above figures are in complete accord with the gains made per steer per vegetative acre (table XIX); hence the correlation between initial and final weight when all animals are allotted on as even a basis as possible is a good indication of the efficiency of grass for producing gains or it may be said that these correlations substantiate the conclusion deducted on the preceeding page.

Summary.

Observations during the past grazing season showed that the steers showed preference for those areas supporting grama grass as the climax species. Figures (table XVI) based on amount of grass present, compared to gains made by steers, showed that greater gains were made by steers that had the largest percent of grama grass to graze upon.

Correlations between the initial and final weights of steers grazed thereon show the highest correlation in the pastures that contain a large percent of grama grass.

On the basis of the figures presented in this manuscript, the writer submits the following grasses in their order of importance for palatability:

1. Grama (Bouteloua gracilis)
2. Wheat grass (Agropyron Vaseyi)
3. Bluestem (Andropogon frucatus)
4. Buffalo (Bulbilis dactyaloides)

Valuations and Costs.

Often the question is asked, "What is land worth for grazing purposes?" In the discussion to follow, it is hoped that some light may be thrown on this important question from a practical standpoint.

It seems reasonable to consider what grazing land will actually produce. The figures given below are based on the Center Pasture (exclusive of lake) as this unit more nearly represents actual range conditions.

Income.

157.024 acres ÷ 17 steers = 9.25 acres required for 1 grazing steer for season.

315 pounds gain secured on 9.25 acres = 34 lbs. gain per acre.

34 pounds x 6¢ (valuation placed on gains by Mr. E. J. Maynard) = $2.04 income per surface acre.

Charges.

The cost in connection with running these steers on the pasture was figured on a 640 acre basis at 7% (furnished by Mr. Maynard) and reduced to one acre, as a suitable unit in the table given below:

Table XX

$.227 Int., charges for 6 mo., on $60 steers.

Table XX (Contd.)

$ .105 Int., charges on fencing invest. for 1 year.

.075 Depreciation on fence per year (20 year life).

.037 Upkeep for 1 year (estimate furnished).

.0648 1% loss on $60 steers.

.022 Taxes ($8 assessed value at 28 mills).

.0066 Salt for season.

.5374 cost per A. exclusive of interest on valuation of land and labor.

The interest on the steers was figured at 7% and divided by acreage (9.25 A) necessary to carry one steer.

A good four barbed wire fence with split treated posts was considered as costing 75¢ per rod to build. One dollar and fifty cents was considered as cost per acre.

The life of the fence as 20 years, and upkeep for 1 year at $ 6 per mile, were estimated by Mr. Pearson, Superintendent of College Farm, to be representative of average conditions.

The 1 % loss on grazing steers was considered as reasonable.

The taxes (22) were figured on an $ 8 assessed valuation, estimated by County Assessor, the mill levy is the same as for the La Porte district.

The salt cost was taken from table given on page

The pasture is considered as having natural water on it.

What valuation can be placed on acre of grazing land.

This question may be answered by subtracting $.54 total charges from $2.04 total income per acre to give $1.50 net income per acre. By capitalizing $1.50 net income at 7% it is found that $21.43 may be payed for this land for grazing purposes when no labor charge is entered against the pastured steers. Theoretically there should be no charge for labor against grazing animals inside of a good fence where natural water is available; hence this item will be left for determination to fit the specific case, in which instance it should be considered as cost, to be deducted from income, and the net income capitalized at desired interest rate for valuation of land.

Believing that an average gain of 315 pounds per grazing season for steers to be exceptional, and not ordinary, and to be expected to vary from year to year, the idea of what this land would be worth if the average seasonal gain per steer varied was suggested and figured in table given below:

Table XXI

What you can pay for land based on the weight that can be put on grazing steers in one season.
(On the 1 acre basis)

1	2	3	4	5	6
Gain season	#gain per A.	Income per A.	Cost per A. Exc. of Int. on Land & Lab.	Net Income per A.	Price pay for Land exclusive of labor at 7%
315	34	$2.04	$.54	$1.50	$21.43
275	29	1.74	.54	1.20	17.14
250	27	1.62	.54	1.08	15.42
225	24	1.44	.54	.90	12.85
200	21	1.26	.54	.72	10.28
175	18	1.08	.54	.54	7.71
150	16	.96	.54	.42	6.00
125	13	.78	.54	.24	3.42
100	10	.60	.54	.06	.85

Method of Computing:

2 - divide 1 by 9.25

3 - multiply 2 x 6¢

5 - substract 4 from 3

6 - divide 5 by .07

The above table shows clearly as the average seasonal gain decreases that the value of land decreases when 9.25 surface acres are required to carry one animal for a graz-

ing season. This fluctuation may be indirectly due to the annual rainfall.

Elastic land valuation.

Considering the 157.024 surface acres of Center Pasture as containing 34.11 vegetative acres (table XVI), it is found that it takes 4.6 surface acres to equal 1 vegetative acre.

All figures given heretofore based on one surface acre may readily be converted into a vegetative acre basis by multiplying by 4.6.

Table XXII given below shows the valuation of 1 vegetative acre exclusive of labor that will produce different seasonal gains on grazing steers.

Table XXII.
Valuation based on Vegetative acres.

Gains.	Valuation of surface acre where 9.25 A. required to carry 1 animal	Valuation per Vegetative A.
315	$21.45	$98.58
275	17.14	78.84
250	15.42	70.93
225	12.85	59.11
200	10.28	47.29
175	7.71	35.47
150	6.00	27.60
125	3.42	15.73
100	.85	3.91

The valuations for 1 vegetative acre given above are fundamental, and can be used in valuing any similiar range, if you know the average seasonal gain that it is capable of producing, and the number of surface acres required to make 1 vegetative acre. This principle is made clear by supposing that an average seasonal gain of 315 pounds is produced on 6 surface acres of land supporting a medium growth of vegetation. In this case the valuation $98.58 for one vegetative acre is divided by 6 to obtain $16.43, the valuation to be given this grazing land on what it will produce. This unit figure based on 1 vegetative acre may be influenced by several factors.

Cost.

The charges made against each acre on page 89 represent with certain additions what it costs to run cattle under fence for a grazing season. By placing a valuation on grazing land, and computing interest thereon at desired rate this interest charge for land may be added to determine the total charge except labor against grazing animals, per acre. The difference between the total income per acre and total charge would leave the net profit or labor income to owner.

Summary.

The idea of figuring carrying capacity on the basal area occupied by the plant seems to be logical, but it will re-

quire more data to complete, than it is possible to collect in one year.

The method used by the writer compares favorably with method used by Forest Service, but a closer interpretation of both methods is needed to make them more fully comparable.

The palatability of the main grasses in the pasture when utilized by grazing steers indicates the following order of arrangement:- Grama (Bouteloua), Wheat Grass (Agropyron), Bluestem (Andropogon) and Buffalo (Bulbilis).

Grazing land (9.25 acres) that will produce 200 pounds gain on grazing steers per season is considered to be worth $10.28 per acre exclusive of labor involved. A vegetative acre that will produce 200 pounds of gain on a grazing steer per season is considered to be worth $47.29.

General Summary

The common method (ocular observation) used to determine carrying capacity is sure to vary in accordance with the intensity of grazing unless the examiner has unlimited experience at his disposal. The ocular observations of density takes into consideration quantity production, which will also vary with the many factors that influence plant growth.

Carrying capacity based on occular observations is the present practical method known, but to the authors knowledge no attempt has been made to base carrying capacity on a fundamental basis of actual ground area occupied. With a vegetative cover consisting very largely of perennial plants, and the opportunity of measuring this changing from year to year, it is believed that a stable ground cover could be determined and an exact inventory of vegetation on a basal area determined. This would permit the establishment of very accurate figures on a controlled experiment. Carrying capacity based on basal area of vegetation in itself means little, until it is translated into terms of quantity production, which will necessarily vary from year to year, but the author shall not attempt to enter into this vast field

of Ecology that is ably handled by his superiors.

The finding that grazing steers show a preference for grama grass (Bouteloua) with wheat grass (Agropyron) as second choice compares favorably with the palatability tables of U.S. Forest Service, District two, which rates these grasses as 85 to 95 percent palatable. The bluestem (Andropogon) was given third place due to its tender green growth in fall when other grasses are dry. The buffalo grass was placed last due to its shortness and the manner of grazing cattle to prefer reaching down around grass with tongue before taking it into mouth.

It is known that breeding makes much difference with the development of animals. The author has submitted an explanation of why he believes that crossbred Hereford steers, showing Shorthorn blood as indicated by Brockle face, make better gains than Herefords when grazing on native range.

The valuation placed on grazing land is a very important question at this time as the Forest Service has under way a range appraisal program that gives indications of being far reaching. A valuation based on gains secured on grazing animals is submitted that seems to be well in line with prevailing opinion among stockmen.

Conclusions.

1. The North Pasture will support 17 grazing steers in place of 13 as grazed there on last year (1921).

2. The following order of palatability for the grasses is given: Grama (Bouteloua), Wheat grass (Agropyron) Bluestem (Andropogon) and Buffalo (Bulbilus).

3. As the percent of Shorthorn (indicated by Brockle face) blood increases in Hereford crossbred steers, the ability of the animals to put on weight increases.

4. Grazing land that will produce the average gain (150-200 lbs.) per season on steers is valued at $6.00 to $10.00.

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