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# THE UTILIZATION OF BROWSE FORAGE AS SUMMER RANGE FOR CATTLE IN SOUTHWESTERN UTAH

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## CAN FULL USE BE MADE OF BROWSE PLANTS?

Many of the shrubby plants, or browse species, found on range lands in the West are recognized to be of high value for grazing and furnish a considerable portion of the range feed for livestock. These plants occur usually in mixture with grasses and weeds, varying in quantity from scattered specimens among the herbaceous plants to 50 per cent or more of the vegetation that livestock will graze. Such mixtures present a problem in range management that only the results of painstaking research can solve. Where browse and herbaceous plants appear on the same range, preference is nearly always given by the livestock to the herbaceous plants. If the range is grazed without limitation, the choice species will be overgrazed and eventually destroyed before the less choice vegetation is fully utilized. Determining the carrying capacity of such a range therefore involves a decision as to the relative values of browse and herbaceous plants and such methods of range management as will serve to perpetuate all species in the proportion that will go to make up the highest productivity of the forage crop.

Clearly, where the herbaceous plants make up approximately 50 per cent or more of the forage on the range, grazing should be so managed as to perpetuate this herbaceous vegetation even though much of the browse that is present goes unutilized. Where browse exceeds the other classes of forage on the range, the procedure is less easily defined. The principal object of the present study is to determine whether it is practicable on such areas to graze cattle so as to obtain reasonably full use of the browse.

One of the chief requirements of summer range for economical beef production is that it affords a sufficient quantity and quality of forage to produce satisfactory gains in weight and a thrifty condition in the

animals grazed. Raising or purchasing feed to replace or supplement summer range is, with very few exceptions, too expensive for profitable livestock production under range conditions. Moreover, if livestock production is to be on a sustained basis, the use of the range must be such as will maintain the desired quantity and quality of forage year after year and safeguard related resources. Investigation into the results of grazing to obtain reasonably full use of browse vegetation, besides showing the effect on the quality and quantity of all the forage produced, must take into consideration also the gains and growth of young animals and animals to be sold for slaughter and the effect on calf production.

The effect on the chief related resources, watershed values, and western yellow pine reproduction is an equally important field for study, but investigations have not yet reached a point where this can be determined. Although careful observations of western yellow pine reproduction of various sizes have thus far shown plainly that the cattle have not injured young trees above the seedling age, except by rubbing an occasional small tree, during the period of the study seed crops have not been adequate to determine what effect the cattle might have on young seedlings. Consequently the present study deals only with the effect of grazing on the forage plants and on the cattle grazed.

## METHOD OF STUDYING UTILIZATION OF FORAGE

### THE RANGE SELECTED

The browse range selected in 1920 for this study (pl. 1), on the east slope of the Pine Valley Mountains in the Dixie National Forest in Southwestern Utah, comprises approximately 179 acres. This was fenced and made ready for grazing in the spring of 1921, the subsequent study covering the years 1922 to 1925, inclusive.

The vegetation in the early summer of 1921 consisted approximately of—

	Per cent
Gambel oak ( <i>Quercus gambelii</i> )	30
Red serviceberry ( <i>Amelanchier rubescens</i> )	18
Birchleaf mahogany ( <i>Cercocarpus montanus</i> )	12
Sagebrush ( <i>Artemisia tridentata</i> )	11
Bitterbrush ( <i>Purshia tridentata</i> )	2
Quinine bush ( <i>Garrya flavescens</i> )	4
Other shrubs <sup>1</sup>	9
Grasses <sup>2</sup>	2
Lupine ( <i>Lupinus barbiger</i> and <i>L. alpestris</i> )	8
Miscellaneous weeds <sup>3</sup>	4

Shrubs alone amounted to approximately 86 per cent of the total and comprised about 70 per cent of the palatable part of the vegeta-

<sup>1</sup> The more common miscellaneous shrubs include the following: *Pentstemon abietinus*, *Ceanothus greggii*, *Arctostaphylos platyphylla*, *Rosa fendleri*, *Acer grandidentatum*, *Alnus* sp., *Salix* sp., *Cercocarpus ledifolius*, *Odostemon fremontii*, *Populus aurea*, *Cornus stolonifera*, *Prunus melanocarpa*, *Rhus trilobata*, *Chrysothamnus nauseosus*, *Symphoricarpos oreophilus*, and *Clematis ligusticifolia*.

<sup>2</sup> Grasses include: *Agropyron smithii*, *Sitanion hystrix*, *Poa sandbergii*, *Festuca octoflora*, *Bromus porteri*, *Stipa lettermani*, and *Trisetum* sp. There is a trace of sedge, *Carex* sp.

<sup>3</sup> The term "weeds," as used in this circular, refers to herbaceous plants exclusive of grasses or grasslike plants. The more common miscellaneous weeds include the following: *Lotus trispermus*, *Gutierrezia sarothrae*, *Phlox austromontana*, *Allium* sp., *Comandra pallida*, *Frasera* sp., *Agoseris* sp., *Lathyrus* sp., *Zygadenus paniculatus*, *Balsamorhiza* sp., *Aster* spp., *Calochortus flexuosus*, *Epilobium* spp., *Phacelia fremontii*, *Erigeron divergens*, *Polygonum sawatchense*, *Collinsia tenella*, and *Collomia grandiflora*.



tion. Scattered reproduction of western yellow pine (*Pinus ponderosa*) varying from small seedlings to pole size occurred over parts of the land inclosed.

The entire area is fully accessible to livestock. The topography is generally rolling, and no forage is unavailable by reason of steep slopes. A small stream traverses the entire length of the pasture, so that cattle are not required to travel more than one-fourth of a mile to water from any portion.

The soil is a sandy loam with a high gravel content, and is of sufficient porosity to absorb precipitation quite readily.

Temperature is adequate for a long growing season. Killing frosts usually do not occur later than April 15 in the spring and not earlier than October 15 in the fall.

Precipitation is not so favorable. The 10-year average annual precipitation at Anderson's Ranch, 8 miles south and approximately 2,500 feet lower, the nearest station where records have been kept for a period of years, is 13.6 inches. Of this amount, 26 per cent (3.54 inches) falls during the period May 1 to September 30. June, with an average of 0.19 inch of rainfall, is the driest month. Three years' records on the study area for the period May 1 to September 30 indicate that the summer precipitation there is approximately 85 per cent greater than the average at Anderson's Ranch. As a result of the distribution of precipitation throughout the year, most of the herbaceous plants make their maximum growth during the period between the beginning of the occurrence of favorable temperatures, about April 10, and approximately June 15. The growth of most of the herbaceous vegetation is arrested by the dry period during the month of June, and many of the weeds, especially the annual species, dry up before July 1. The shrubs and the deeper-rooted grasses and weeds continue their growth for some time after this date and, indeed, throughout the summer if the customary rainfall after July 1 is received.

The annual rainfall at Anderson's Ranch for the years of study ended September 30, 1922, 1923, 1924, and 1925, was 19.04 inches, 9.37 inches, 6.43 inches, and 16.08 inches, respectively, indicating that the year ended September 30, 1924, in particular was much drier than the average year. Most of this deficiency, however, occurred during the period October 1, 1923, to May 1, 1924. Observations indicate that the winter was dry on the experimental area also, although no records are available for that place other than those for the grazing season, May 1 to September 30, for the years given in Table 1.

TABLE 1.—*Monthly precipitation, May to September, inclusive, on the experimental area, 1923-1925*

Month	1923	1924	1925
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
May.....	0.72	0.90	0.40
June.....	.44	( <sup>1</sup> )	3.40
July.....	1.44	3.02	2.73
August.....	1.53	.12	2.25
September.....	.94	.60	1.02
Total.....	5.07	4.64	9.80

<sup>1</sup> Trace, less than 0.01 inch.

As the result of the deficient precipitation for the period from October 1, 1923, to May 1, 1924, followed by the lack of rain during June, there was much less growth of both annual and perennial herbaceous vegetation on the experimental area in 1924 than in the other years. Although a total of 3.02 inches fell in July, 1924, 2.6 inches of this precipitation fell during heavy showers on July 3, 4, and 14, and much of it ran off and did not become available for vegetation. Foliage production of shrubbery plants apparently was not affected materially by the deficient precipitation; the principal evidences of its influence were less new growth late in the season of such plants as birch-leaf mahogany, and drier and apparently less-palatable foliage during August and September.

#### THE CATTLE GRAZED

The pasture was grazed by cows and calves, dry cows, and yearlings, 2-year-old and 3-year-old cattle during the first four of the five consecutive years beginning in 1921. Cows with calves and dry cows only were grazed in the fifth year. The animals, which were obtained from near-by ranchers and had been grazed on adjacent range each summer since they were calves, were grade Herefords and Shorthorns, comparing favorably with the grade of average range cattle in southwestern Utah. During the winters prior to and during the period of the experiment most of the cattle were grazed on adjacent open public domain or privately owned pasture lands. This range is so poor in quality and usually so short of feed that the animals lost in weight during the winter. A few of those in poorest condition, particularly cows with late calves and cows to calve early in the spring, were cared for apart from the others and were fed a small amount of hay during the winter to supplement the range forage. This feeding, however, was only sufficient to prevent losses from starvation, and with few exceptions the cattle were very thin by the time the higher mountain range was ready for grazing in the spring.

The cattle were so selected as to obtain an average lot. Some of the older cows that had attained culling age, and a portion of the calves, yearlings, and 2-year-old steers, and all 3-year-old steers were sold each fall. This interfered materially with the attempt to return the same animals to the pasture each year. However, this procedure conformed to the general practice followed by producers in the locality.

#### MANAGEMENT OF THE CATTLE DURING THE EXPERIMENT

In 1921 the pasture was grazed by 22 head, exclusive of calves, from May 27 to November 12, to determine the approximate proper season of use and the number of animals to graze in order to obtain reasonably full use of the oak and other browse species of approximately the same feed value. The next year the beginning of the grazing period was advanced to near the 1st of May and the number was increased to 30 head, exclusive of calves, and to 31 head in 1923 and 1924. Because of the poor condition of cattle and the reductions in the forage occasioned by such heavy use, the stock were reduced to 23 head in 1925.

Beginning in 1922, each individual animal was weighed when turned into the pasture and again at various intervals during the season. The first weighing in 1922 was made on a scale near the ranches where the cattle were obtained, the day before they were taken to the pasture. A scale was then installed at the experimental area and subsequent weighings made there. In 1923 the first weighing was made the afternoon of the day the cattle had been driven to the pasture. This was before the animals had an opportunity to recover from the shrink incident to standing in a corral without feed overnight and being driven approximately 11 miles to the pasture. It was necessary to allow for this shrink in the initial weights that year. In 1924 the cattle were placed in the pasture about noon on May 5, allowed to graze during the remainder of that day and the following night, and were weighed about the middle of the forenoon the following day. In 1925 the cattle were driven to the pasture on the afternoon of May 1, allowed to graze on adjoining range until the morning of May 2, and were then rounded up and weighed.

Round-up for subsequent weighings each season was made in the morning, and the cattle were weighed about noon, after having been on water some time in the morning. When occasional animals were missed in the round-ups their weights were arrived at by interpolation. The weighing dates were not entirely uniform in all cases each year, and this made it necessary to calculate weights for the dates that were missed in some years, in order to obtain average gains. For example, it was customary to weigh about September 1 each year. This date was missed in 1923, and weights for this date were arrived at on the basis of average daily gain or loss between August 1 and September 15, the nearest weighing dates to September 1. The number of instances when it was necessary to calculate or interpolate weights are few, and the error which may have entered in is too small to affect the general results in any way.

Except in 1921 the animals were watched closely during September each year, and a few were removed a few days to several weeks before the last of the month to make sure that there would be no serious overgrazing of the predominant browse vegetation. The remaining animals were kept in the pasture in the fall until sharp declines in weight indicated that feed had been exhausted to a point where it no longer afforded a maintenance ration for the majority of the animals retained.

Sufficient rock salt was placed at three stations in the pasture throughout each season, so that plenty was available at all times. The quantity consumed by each animal for the season was 9 pounds in 1922, 1923, and 1924 and 10 pounds in 1925. The animals were not disturbed between round-ups for weighing and were handled as gently as possible during these round-ups. As a result they appeared to be contented to remain in the pasture until the last week or 10 days in the fall.

The data on grazing, including number and class of cattle grazed (exclusive of calves), the duration and length of the grazing season, and number of animal-days grazed in the pasture each year are summarized in Table 2. For the purpose of comparison, the animal-



days grazed have been reduced in this table to the number of animals for a 160-day grazing period, and the number of acres available for each animal each season for that period.

TABLE 2.—*Summary of grazing data, 1921-1925*

Datum	1921	1922	1923	1924	1925
Class of animals grazed: <sup>1</sup>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Dry cows.....	3	6	4	1	3
Cows with calves at side all season.....	4	3	4	2	14
Cows that calved during season.....	1	3	6	9	4
3-year-olds.....	2	4	4	4	-----
2-year-olds.....	3	4	5	5	-----
Yearlings.....	10	11	6	9	-----
Bull.....	1	1	1	1	1
Total.....	22	30	30	31	22
Opening of grazing season.....	May 27	May 13	May 5	May 5	May 2
Closing of grazing season.....	Nov. 12	Oct. 20	Oct. 17	Oct. 15	Sept. 27
Length of grazing season.....days.....	169	160	165	163	148
Total animal-days grazed <sup>1</sup> .....	3,552	4,910	5,175	4,702	3,183
Average number head grazed on basis of 160-day season.....number.....	22.2	30.7	32.3	29.4	19.9
Area grazed per head on basis of 160-day season.....acres.....	8.06	5.83	5.54	6.09	8.99

<sup>1</sup> The late entry of 8 head of cattle in 1921, the breaking out or turning in of outside cattle for a few days at a time in 1922, the early removal of 12 head of cattle in 1923, and the grazing of a few head of work and saddle horses at odd times in all three years, the removal of 8 head early and the late entry and the breaking out of the bull in 1924, and the late entry of 1 cow and the bull in 1925 caused the total animal-days shown in this table to vary from the product of the number of experimental animals grazed, multiplied by the length of the grazing season each year.

#### RECORDS OF VEGETATION

Records of development and utilization of the forage were obtained each time the cattle were weighed during the last three seasons of the experiment. These records included information on the stage of development or growth of the plants, what plant species the cattle were eating, an estimate of the percentage that each species made up of the total forage being eaten on the various dates, and the extent to which each species had been utilized.

Sample plots were established to obtain data on the effect of grazing upon the various plant species. These included both a major plot (32 by 32 feet) and a meter quadrat on grazed range and on range fenced against grazing in each of the two major forage types. Measurements were made of the growth each year of selected representative plants of the more important browse species on areas protected against grazing. Careful estimates, checked by measurements of ungrazed twigs, were made of the growth on the grazed areas.

#### DEGREE OF UTILIZATION OF DIFFERENT FORAGE GROUPS

The utilization of the vegetation which resulted from grazing the experimental pasture to obtain reasonably full use of the oak is summarized in Table 3. This table shows for successive dates throughout the grazing seasons of 1923 to 1925 the percentage that each important plant or group of plants made up of the feed being eaten on each date and the portion of the total herbage of each species that had been utilized up to that time. The percentage that each of the species or groups of species made up of the total vegetation being eaten at the various dates is shown graphically in Figure 1.



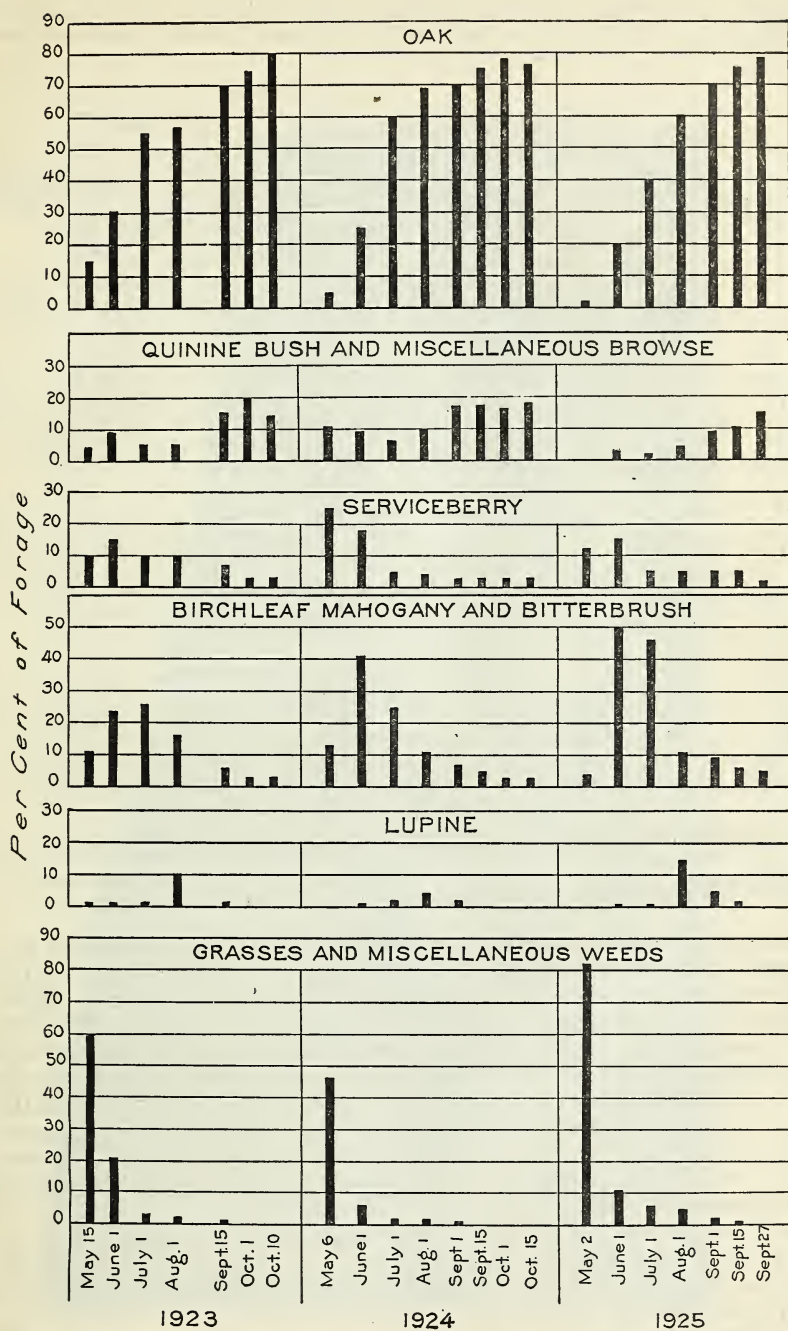


FIGURE 1.—Percentage that each group of forage made up of total vegetation being eaten at different dates (1923-1925)

TABLE 3.—Percentage that each important plant or group of plants made of feed being eaten on various days, and the percentage of each species utilized by the dates of observation, seasons 1923–1925

Date of obser- vation	Shrubs (86.4 per cent of all the vegetation)														Weeds (12 per cent)				Grasses (1.6 per cent)			
	Birch- leaf mahog- any (12.1 per cent)		Bitter- brush (2.4 per cent)		Oak brush (30.1 per cent)		Service- berry (18.2 per cent)		Quinine bush (3.5 per cent)		Miscel- lane- ous (9.2 per cent)		Sage- brush (10.9 per cent)		Lupine (7.9 per cent)		Miscel- lane- ous (4.1 per cent)					
	PF	PU	PF	PU	PF	PU	PF	PU	PF	PU	PF	PU	PF	PU	PF	PU	PF	PU	PF	PU		
1923																						
May 15-----	10	3	1	5	15	1	10	1	1	1	3	2	0	0	1	1	54	25	5	45		
June 1-----	20	5	3	30	31	2	15	3	2	2	6	4	1	1	1	2	20	48	1	90		
July 1-----	24	50	2	55	55	10	10	8	1	5	3	8	1	2	1	3	3	65	0	100		
Aug. 1-----	15	80	1	90	57	25	10	20	2	10	2	19	1	3	10	15	2	75	-----	-----		
Sept. 15-----	6	95	0	100	70	65	7	22	8	15	6	24	1	4	1	65	1	85	-----	-----		
Oct. 1-----	3	98	-----	-----	74	68	3	23	12	18	7	27	1	5	0	65	0	85	-----	-----		
Oct. 10-----	3	100	-----	-----	80	69	3	25	9	20	4	29	1	5	0	65	0	85	-----	-----		
1924																						
May 6-----	10	-----	3	-----	5	-----	25	-----	0	-----	11	-----	0	-----	0	-----	44	-----	2	-----		
June 1-----	40	10	1	60	25	1	18	8	0	0	9	5	0	0	1	1	6	75	0	100		
July 1-----	24	40	1	75	60	15	5	15	2	5	4	10	0	0	2	8	2	80	-----	-----		
Aug. 1-----	10	80	1	95	69	25	4	18	2	10	7	20	1	2	4	30	2	85	-----	-----		
Sept. 1-----	7	85	0	95	70	45	3	20	9	18	7	25	1	3	2	80	1	85	-----	-----		
Sept. 15-----	5	90	0	100	75	60	3	22	10	22	6	30	1	5	0	100	0	85	-----	-----		
Oct. 1-----	3	95	-----	-----	78	70	3	25	10	25	5	32	1	6	-----	-----	0	85	-----	-----		
Oct. 15-----	3	100	-----	-----	76	73	3	26	15	28	2	34	1	7	-----	-----	0	85	-----	-----		
1925																						
May 2-----	3	-----	1	-----	2	-----	12	-----	0	-----	0	-----	0	-----	0	-----	77	-----	5	-----		
May 15-----	25	5	4	15	10	1	18	2	0	0	0	0	0	0	0	0	42	25	1	100		
June 1-----	49	10	1	35	20	2	15	10	0	0	3	1	0	0	1	2	11	50	-----	-----		
July 1-----	45	60	1	55	40	15	5	12	0	0	2	5	0	0	1	3	6	65	-----	-----		
Aug. 1-----	10	85	1	85	60	20	5	15	2	5	2	10	0	0	15	35	5	75	-----	-----		
Sept. 1-----	8	95	1	95	70	35	5	18	5	15	3	15	1	3	5	55	2	80	-----	-----		
Sept. 15-----	6	96	0	100	75	50	5	19	8	20	2	20	1	5	2	60	1	85	-----	-----		
Sept. 27-----	5	98	-----	-----	78	65	2	20	8	23	6	25	1	6	0	60	0	85	-----	-----		

PF=Percentage that this plant or group of plants made of all feed being eaten on that date.

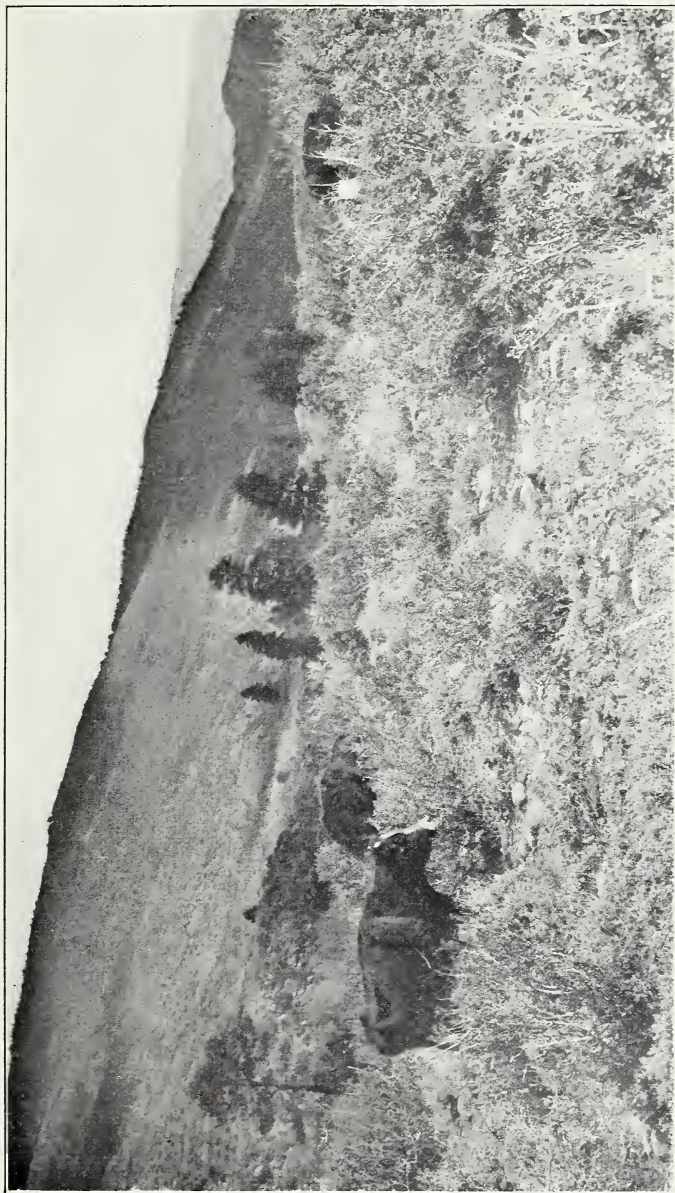
PU=Percentage of the total available and edible portion of the vegetation of that species eaten by that date.

Percentage figures in parenthesis indicate the portion that each species or group of species made up of the total vegetation available to cattle in the pasture.

The grasses and more choice weeds, although they constituted but a small part of the vegetation, furnished the greater part of the feed supply during the first few weeks of the grazing season. Their herbage was soon exhausted, however, and as the supply dwindled the consumption of the shrubs, especially birchleaf mahogany and bitterbrush, increased. Practically all plants were used from the first, but the consumption of oak, quinine bush, and most of the other browse species increased only as the utilization of the more select plants became more nearly complete. Such growth as was made by the more select species in the latter part of the season furnished some feed.

Red serviceberry appeared to be more palatable during spring, when the leaves and new green shoots were tender and succulent. At that time it reached its highest point in percentage of the total feed being eaten.

The use of oak increased during each season from a very small part of the ration at the beginning until it comprised 70 to 80 per cent



F177176

### THE EXPERIMENTAL PASTURE

Grazing of such range should aim to perpetuate the more palatable forage species, such as birdchief mahogany and bitterbrush, as well as the weeds and grasses, even though considerable growth of oak and other browse is left unused





F207601

F207600

### OVERGRAZED BIRCHLEAF MAHOGANY

- A.—Stunted by overgrazing which, if continued, will kill the plants  
B.—Showing the result of one season of protection. Birchleaf mahogany is normally an upright, spreading shrub

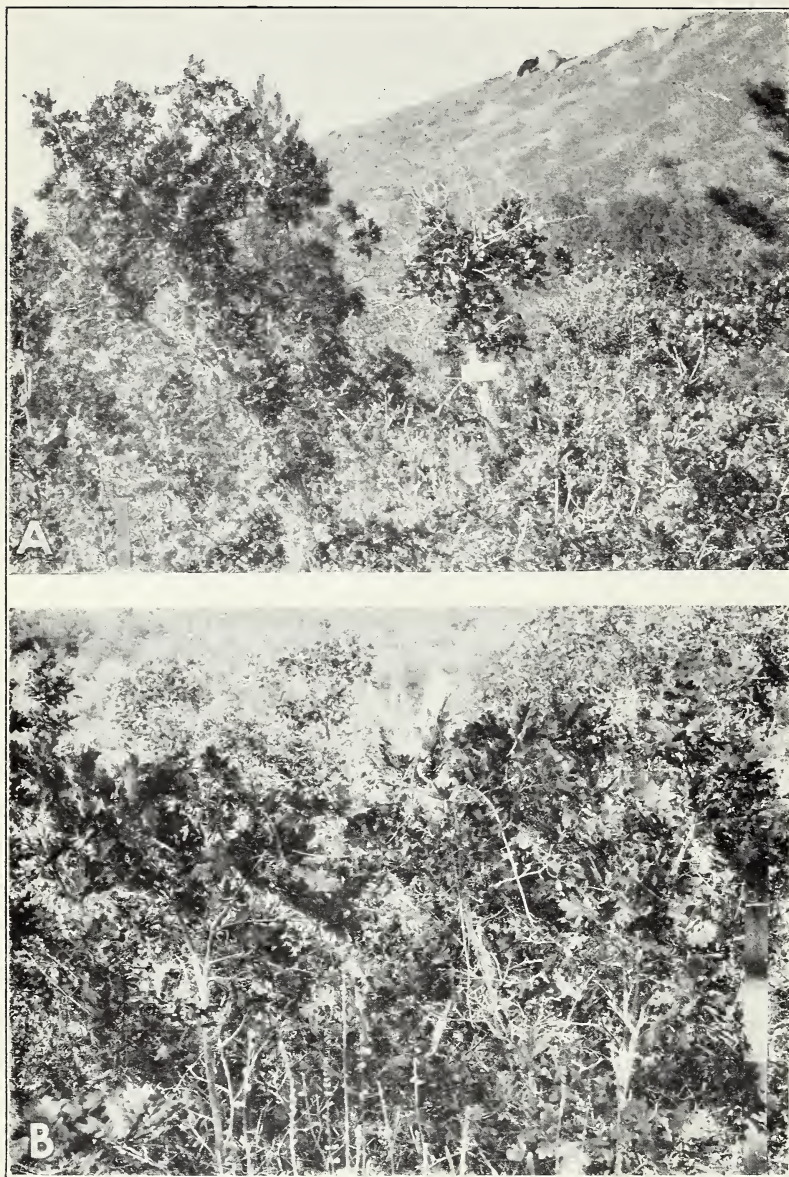


**A LOW SPREADING FORM OF BITTERBRUSH**

A.—The result of very close grazing

B.—The same plant ungrazed for one year. Bitterbrush is normally a spreading bush 2 to 5 feet high





F198428

F198429

#### FOUR YEARS OF CLOSE GRAZING VS. EXCLUSION

- A.—Close grazing, although it did not kill out the oak, reduced the vigor of the plants and rendered them less productive of foliage
- B.—After four years of total exclusion of grazing the oak is vigorous and produces luxuriant foliage



of the forage being eaten late in the season.<sup>4</sup> Although oak appeared to be more palatable on the whole than were quinine bush, red serviceberry (after the first month or six weeks of the grazing season), and sagebrush, the cattle did not confine themselves to oak alone, but preferred a variety of feed. This resulted in an increase in the use of quinine bush and miscellaneous shrubs toward the end of the grazing season. However, none of the less choice plants, including oak, were considered to have been overutilized by the close of the season in any year.

Lupine<sup>5</sup> was grazed little if at all until it had reached the stage of seed maturity and the seed pods were beginning to open, in July and August, but at that time the major portion of it was eaten.

The time of use and degree of utilization of the plant species in the experimental pasture show that under the conditions prevailing on the area the important plants rank in palatability to cattle as follows: (1) Grasses and certain choice spring weeds, (2) birchleaf mahogany and bitterbrush, (3) certain less choice weeds including lupine, (4) oak, (5) miscellaneous shrubs, (6) serviceberry, (7) quinine bush, and (8) sagebrush. The comparatively small quantity and high palatability of the first three groups of plants resulted in their becoming practically exhausted about the middle of the grazing season each year. These plants comprised approximately 28 per cent of the total vegetation. By August 1 an average of 82 per cent of the total current year's growth of birchleaf mahogany, 90 per cent of the bitterbrush, 27 per cent of the lupine, 78 per cent of miscellaneous weeds, and 100 per cent of the grasses had been utilized. By the end of the season these plants had been utilized to the extent of 99 per cent, 100 per cent, 75 per cent, 85 per cent, and 100 per cent, respectively. Oak, which made up 30 per cent of the vegetation had been 23 per cent utilized by August 1, and 69 per cent utilized by the end of the grazing season. On these two dates, an average of 12 per cent and 20 per cent, respectively, had been utilized of the serviceberry, quinine bush, sagebrush, and other miscellaneous shrubs, which comprised 42 per cent of the total vegetation. The fact that oak and the remaining less-extensively utilized shrubs were grazed to some extent prior to the time the more select plants were practically exhausted indicates that the cattle, out of choice, will graze a portion of such vegetation along with the better plants. However, after August 1, when such plants made up the bulk of the forage, they were grazed more out of necessity than choice.

#### THE EFFECTS OF GRAZING ON THE VARIOUS KINDS OF FORAGE

The effect of the method of grazing on the vegetation and especially on the more important forage plants is of prime importance in any system of range use. Various investigators (3, 4, 9, 11, 12, 13)<sup>6</sup> have shown that continued overgrazing results in (1) a reduction in the

<sup>4</sup> Oak is known to have caused losses of cattle under some conditions (6), but no trouble was experienced from this cause during the 5-year period that the pasture was closely grazed. (See footnote 6.)

<sup>5</sup> Some species of lupine are known to be poisonous to livestock under certain conditions, but no trouble was experienced from lupine under the conditions prevailing in this study. (2) (7). (See footnote 6.)

<sup>6</sup> Italic numbers in parenthesis refer to "Literature cited," p. 28.

vigor and quantity of forage produced by the important forage plants; (2) a decrease in the number of better forage plants with no corresponding reduction in the less palatable and the unpalatable species left to reseed, and consequently wider occupation of the range by plants of inferior forage value; (3) a reversion of the plant cover to annual and perennial vegetation of inferior value for grazing; (4) a reduction in the carrying capacity<sup>7</sup> of the range; and (5), if severe enough and continued over a sufficient period, the denudation of the range and material injury to watersheds. Sustained use of the range requires that the forage be so grazed and utilized as to maintain the productivity of the forage and watershed values of the land.

In the present experiments grazing to obtain reasonably full use of the oak resulted in the grasses and more choice weeds other than lupine being severely overgrazed and depleted, the better browse species such as birchleaf mahogany and bitterbrush being badly overgrazed and injured until they slowly died out, and the oak, although apparently not killed out, declining in vigor and producing less edible growth. But such species as red serviceberry, quinine bush, and sagebrush were not affected adversely. Lupine was the only palatable herbaceous plant of any importance that was able to hold up under the intensity of grazing practiced. If such grazing were continued for a sufficient period, it would result in the elimination of the grasses, the palatable weeds (except lupine), and the more palatable shrubs, and eventuate in a range having only such species as oak, serviceberry, quinine bush, sagebrush, lupine, and less-choice weeds, all of which are of relatively low palatability.

#### GRASSES AND WEEDS

The effect on grasses and weeds of the degree of grazing practiced is indicated by representative quadrats. (Table 4.) The perennial herbaceous vegetation on quadrat No. 9, ungrazed since 1920, and on No. 14, ungrazed since 1922, increased or held its own between the two dates of record, while that on quadrats 10 and 15, grazed each year from 1921 to 1925 inclusive, showed a marked decline between the 1923 and 1925 mappings. There was, however, no similar consistency in the annual plants on the grazed check plots. Many of these plants had dried up before the quadrats were mapped late in June, in both years, and a reliable record of the annual plants could not be obtained. Moreover, these plants, coming from seed each season, vary more or less in quantity and distribution from year to year. The perennial vegetation shows the progressive effects of grazing much more accurately than do the annuals.

<sup>7</sup> Carrying capacity as here used may be defined as the maximum number of livestock of a given class or classes a range unit will support in satisfactory condition during the proper season of use without impairing the sustained productivity of the range forage crop or associated resources.

TABLE 4.—Comparison of number of plants by species on ungrazed quadrats with number of plants on grazed quadrats

Number and condition of quadrat	Plant species	Specimens		Increase or decrease
		1923	1925	
Quadrat 9, oak type, grazing excluded, 1921-1925, inclusive.	Perennial weeds:	No.	No.	No.
	Calochortus.....	0	1	+1
	Epilobium.....	2	0	-2
	Lupinus.....	6	10	+4
	Phacelia.....	18	33	+15
	Total.....	26	44	+18
	Annual plants:			
	Collinsia.....	45	0	-45
	Collomia.....	3	2	-1
	Polygonum.....	8	11	+3
	Festuca octoflora.....	3	0	-3
	Total.....	59	13	-46
	Shrubs:			
Quadrat 14, mixed oak-serviceberry-birchleaf mahogany type, grazing excluded, 1923-1925, inclusive.	Odostemon.....	1	0	-1
	Quercus seedlings.....	6	0	-6
	Total.....	7	0	-7
	Perennial weeds and grass:			
	Allium.....	5	2	-3
	Balsamorhiza.....	1	1	0
	Crepis.....	2	4	+2
	Calochortus.....	0	1	+1
	Poa fendleriana.....	2	2	0
	Zygadenus.....	1	1	0
	Total.....	11	11	0
	Annual plants:			
	Polygonum.....	0	14	+14
	Unknown.....	0	1	+1
	Total.....	0	15	+15
	Shrubs:			
	Artemisia seedlings.....	2	0	-2
	Pentstemon.....	7	7	0
	Total.....	9	7	-2
GRAZED				
Quadrat 10, oak type adjoining protected quadrat No. 9, grazed season long, 1921-1925.	Perennial weeds and grass:			
	Epilobium.....	1	0	-1
	Lupinus.....	10	4	-6
	Phacelia.....	8	7	-1
	Sitanion.....	1	0	-1
	Total.....	20	11	-9
	Annual plants:			
	Collinsia.....	43	0	-43
	Collomia.....	5	1	-4
	Polygonum.....	20	32	+12
	Unknown.....	0	8	+8
	Total.....	68	41	-27
	Shrubs:			
	Quercus seedlings.....	16	0	-16
Quadrat 15, mixed oak-serviceberry-birchleaf mahogany type, grazed season long, 1921-1925.	Perennial weeds:			
	Aster.....	5	2	-3
	Calochortus.....	0	1	+1
	Comandra.....	3	0	-3
	Erigeron.....	0	3	+3
	Lotus.....	14	14	0
	Phlox.....	8	5	-3
	Zygadenus.....	1	0	-1
	Total.....	31	25	-6
	Annual plants:			
	Polygonum.....	0	6	+6



Lupine was the only perennial herbaceous plant of importance which increased in density throughout the pasture from 1923 to 1925. On one grazed area it increased in density from 0.058 to 0.146, or 151.7 per cent, while on a near-by ungrazed area it increased from 0.047 to 0.121, or 157.4 per cent. There was, it is true, a decline in number of plants on one of the quadrats in Table 4, but further observations indicate that the lupine on the pasture as a whole had not been injured. The cattle did not start to graze this species considerably until the latter part of July, when it was in the seed-bearing stage, and it was not more than two-thirds utilized at the close of the season in any year except in 1924. The time of grazing and degree of utilization were such as not to interfere materially with the vigor of the plants or with seed production, conditions favorable for reproduction, and spread of vegetation.

The increase in perennial herbaceous forage species on the ungrazed plots and the decrease in most of such vegetation on the grazed areas seem to indicate that the range was already below its potential productivity of the more palatable herbaceous forage when the plant studies were started and that the degree of grazing practiced was heavier than such vegetation could withstand.

#### THE MORE PALATABLE SHRUBS

Birchleaf mahogany and bitterbrush, the most palatable of all the shrubs on the area, were very closely utilized each season, and such use if continued would eventually eliminate them from the range. The natural form of birchleaf mahogany is a tall, spreading bush, 4 to 6 feet in height. The annual increment in length of the shoots for a number of years when not grazed is shown in Table 5. The new growth on the grazed plants was eaten off each year. Practically none of the leaves or new shoots within reach of the animals were left at the close of the grazing season. The overgrazing has reduced the bushes to a gnarled, stunted form (pl. 2) or to a small number of shoots near the ground. Examination of a large number of specimens distributed over the entire pasture showed that the close use was materially reducing the vigor of a large percentage of the birchleaf mahogany plants. Although but few plants had been completely killed out by the fall of 1925 many of them were partially dead or very weak.

TABLE 5.—*Annual increment of shoots of birchleaf mahogany on ungrazed plots*

Number of shoots measured	Year of growth	Period of protection	Growth	
			Maximum	Average
		Years	Inches	Inches
15.....	1923	1	10.50	6.74
15.....	1924	2	14.50	12.50
15.....	1925	3	13.25	8.59
20.....	1925	3	13.37	9.08

<sup>1</sup> The small increment in 1924 was due to unfavorable moisture conditions.

Bitterbrush also was adversely affected by close grazing. The annual increment on shoots of plants which were not disturbed by grazing averaged 8.8 inches, with a maximum of 11.5 inches in 1925. Bitterbrush naturally is a semierect shrub, 2 to 5 feet in height. Under close grazing the upright stems may be killed back to the surface of the ground, and the plant then assumes a more or less prostrate spreading form. (Pl. 3.) It appears to be more resistant to grazing in this shape, since the stubs of the branches left by grazing animals become harsh and serve as a protection against closer grazing. Most of the bitterbrush plants on the experimental area were of the decumbent type when the experiment was started. The continued close grazing of this species for five years has proven injurious, even in the decumbent form, and parts of closely grazed plants were found to be in a much weakened condition or dead in the fall of 1925.

#### OAK, RED SERVICEBERRY, AND QUININE BUSH

An average of approximately 70 per cent of the available edible portion of oak was taken each season. The effect of this degree of utilization is apparent from the records of grazed plot No. 10, which showed a reduction in density during the period 1923 to 1925 from 0.235 to 0.146, equivalent to about 40 per cent. (Pl. 4, A.) On a companion plot protected from grazing since 1921 the density was practically stationary, making a 4 per cent increase from 0.189 to 0.197 during the same period. (Pl. 4, B.) In 1925 the average increment in length of twigs on plants ungrazed for several seasons was 1.5 inches with a maximum growth of 2.9 inches. Twigs on plants which had been closely grazed for a number of seasons previous to 1925 but protected in that year put on an average increment of only 0.98 inch, with a maximum of 1.07 inches. The decline in oak forage produced on the grazed plot represented no loss in the number of plants, but rather a decline in growth and productiveness of existing plants as the result of loss of vigor.

Serviceberry and quinine bush, each of which was taken to the extent of approximately 25 per cent of the edible portion by the close of each grazing season, appeared to suffer no injurious effects from grazing.

#### THE EFFECTS ON THE CATTLE GRAZED

The gains in weight and condition of the cattle when the experimental pasture was grazed to obtain reasonably full use of the oak were in general unsatisfactory. They were very good during the early part of the grazing season when considerable grass, weed, and more palatable browse forage was available, but when this class of forage was used up gains declined, eventually ceased, and were succeeded by losses. Dry cows attained fair flesh but did not fatten. Yearling, 2-year-old, and 3-year-old steers and heifers made very slow growth and did not reach a condition suitable for marketing except as inferior stockers or feeders. Cows that calved one year usually remained so unthrifty while in the pasture that they did

not breed while on the range to calve again the next year, a situation that required extra care to produce more than a 50 per cent calf crop and resulted in many late calves. These unsatisfactory results are attributable in part to inadequate feed and care of the animals during the winter and the consequent unthrifty condition when they were placed in the pasture in the spring. In the main, however, the low gains and unthrifty condition of the breeding animals were the result of the inferior quality of the browse forage that the animals were forced to subsist on for a large part of the summer grazing season.

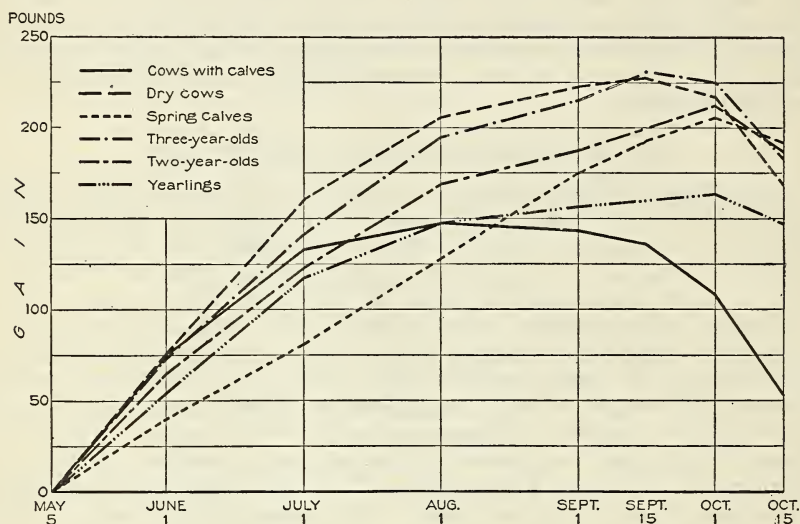


FIGURE 2.—Average annual cumulative gains of cows with calves, spring calves, and dry cows (1922-1925), and of 3-year-olds, 2-year-olds, and yearlings (1922-1924).

#### GAINS IN WEIGHT

The average weight of each of the several classes of cattle grazed (except cows which calved during the summer) at the time they were placed in the pasture, at various dates throughout the season, and at the time they were removed in the fall, and the average daily gains or losses during each interval between weighings for the whole 4-year period are given in Table 6. The average cumulative gains of the four seasons for each class of cattle have been summarized and are shown in Figure 2.



All classes of animals made excellent gains from the time they were placed in the pasture until approximately July 1. The average gain by all classes except calves was between 2 and 3 pounds a day during this period. From July 1 until September 15 spring calves, 3-year-olds, 2-year-olds, dry cows, and yearlings continued to make moderate gains in the order named. Cows with calves little more than held their own from July 1 to August 1, and were losing weight before September 1. Dry cows lost some weight during the last half of September and 3-year-olds remained about stationary, while calves, yearlings, and 2-year-olds continued to gain. From October 1 until they were removed from the pasture all classes except calves and yearlings suffered sharp declines in weight. All of the cattle except cows with calves, showed marked improvement when they left the pasture in the fall, as compared to their thin condition on entering. (Pl. 5.) Cows that suckled calves failed to hold the gains made earlier in the season, and were rather thin on leaving the pasture in October each year. (Pl. 6.) Calves which had followed their mothers all season reached the best condition<sup>s</sup> during the season, followed in order by dry cows, 3-year-olds, 2-year-olds, and yearlings. At that, however, none of the animals were fat. Almost every fall a number of the cattle grazed in the pasture during the summer were marketed, and, with the exception of some of the dry cows which would qualify as canners or cutters, the animals sold graded only as stockers or feeders, and were usually shipped to California for fattening.

#### GAINS IN RELATION TO CLASS OF FORAGE

The average daily gains of the various classes of cattle, except calves, appear to bear a direct relation to the class of forage being eaten. Figure 3 shows the average daily gains or losses in weight of dry cows and yearlings as compared with the percentage of each of the two main classes of forage eaten during each month or portion of a month for four years, 1922 to 1925, inclusive. Dry cows and yearlings are fairly representative. The greatest gains occurred during May. This coincides with the period when good forage, including grasses and choice weeds, together with considerable birchleaf mahogany and bitterbrush and some serviceberry, made up 67 per cent or more of the ration, and only a comparatively small amount of the inferior forage species, as oak and quinine bush, was being eaten. The animals continued to make fairly good gains during June, and, although most of the available grasses and choice weeds had been consumed by that time, a considerable amount of birchleaf mahogany was still available and being eaten. Lupine, which was grazed heavily the latter part of July and the first of August, apparently helped in making possible some gains at that time; but after this feed was gone and the animals were forced to subsist almost entirely on oak and other inferior forage species, gains declined further or ceased.

<sup>s</sup> Condition as here used refers to the degree that each class approached being fat and not to gains in weight. The two are not necessarily synonymous.

TABLE NO. 6.—Average summer gains in pounds for various classes of cattle, as shown at various weighing dates, 1922-1925

1922

Class	Num- ber of ani- mals	May 12		June 1		June 22		Aug. 2		Sept. 2		Sept. 16		Oct. 1		Oct. 10		Oct. 20		Net gain 1
		Weight		Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	
Cows with calves...	3	651.7				765.0	+2.76	817.3	+1.28	775.7	-1.34	833.0	+4.09	810.7	-1.49	805.0	-0.63	766.7	-3.83	159.0
Dry cows...	6	768.3				912.5	+3.52	979.8	+1.64	1,012.8	+1.06	1,018.0	+1.37	1,034.2	+1.08	1,030.3	-1.43	998.3	-3.20	265.9
3-year-olds...	2	650.0				697.5	+1.16	830.0	+3.23	860.0	+1.97	895.5	+2.54	881.0	-1.97	872.5	-1.94	852.5	-2.00	231.0
2-year-olds...	4	528.8				578.8	+1.22	681.2	+2.50	712.5	+1.01	739.5	+1.93	743.8	+1.29	749.8	+1.67	736.2	-1.36	215.0
Yearlings...	11	295.0				365.4	+1.72	433.4	+1.66	434.7	+1.04	457.2	+1.61	462.3	+1.34	468.9	+1.73	454.1	-1.48	167.3
Calves...	3	145.0				195.0	+1.22	263.3	+1.67	317.0	+1.73	335.0	+1.29	360.0	+1.67	361.7		350.0	-1.17	215.0

1923

Class	Num- ber of ani- mals	May 5		June 1		July 1		Aug. 1		Sept. 1		Sept. 15		Oct. 1		Oct. 10		Oct. 17		Net gain 1
		Weight		Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	
Cows with calves...	4	766.2		813.0	+1.73	833.0	+0.67	829.2	-0.12			865.2	-0.51	781.0	-1.58	702.5	-8.72			14.8
Dry cows...	4	774.5		844.2	+2.58	896.5	+1.74	939.2	+1.38			937.5	-0.04	911.8	-1.61	865.0	-5.20			137.3
3-year-olds...	4	598.8		690.8	+3.41	751.5	+2.02	795.5	+1.42			821.2	+1.57	812.5	-1.54	779.3	-3.69			213.7
2-year-olds...	3	421.7		495.3	+2.73	554.0	+1.96	601.3	+1.53			607.7	+1.14	636.7	+1.81	588.7	-5.33			215.0
Yearlings...	6	403.0		487.2	+3.12	557.3	+2.34	582.0	+1.80			584.2	+1.05	585.3	+1.07	548.0	-4.14			182.3
Calves...	2	96.0		154.0	+2.15	181.0	+1.90	242.5	+1.98			305.0	+1.39	315.0	+1.69	298.0	-2.00			220.0

1924

Class	Num- ber of ani- mals	May 6		June 1		July 1		Aug. 1		Sept. 1		Sept. 16		Oct. 1		Oct. 10		Oct. 15		Net gain <sup>1</sup>
		Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	
Cows with calves...	2	535.0	+4.71	657.5	+1.85	713.0	+1.85	729.5	+0.53	710.0	-0.63	702.5	-0.50	686.0	-1.10	633.0	---	633.0	-3.79	151.0
Dry cows...	1	870.0	-1.19	865.0	+4.40	997.0	+4.40	1,038.0	+1.32	1,025.0	-1.42	1,035.0	-1.67	1,020.0	-1.00	935.0	---	935.0	-6.07	150.0
3-year-olds...	4	552.5	+4.09	658.8	+2.97	747.8	+2.97	756.5	+1.26	773.8	+1.56	749.8	-1.60	782.8	+2.20	713.8	---	713.8	-4.93	230.3
2-year-olds...	3	485.0	+3.76	582.7	+2.25	650.3	+2.25	658.3	+1.26	680.0	+1.70	665.3	-1.89	695.0	+1.98	661.7	---	661.7	-2.38	210.0
Yearlings...	9	377.2	+2.00	429.1	+2.06	490.8	+2.06	503.1	+1.40	527.8	+1.80	514.4	-1.89	518.3	+1.26	488.8	---	488.8	-2.11	141.1
Calves...	2	140.0	---	---	+1.21	207.5	+1.21	236.0	+1.92	237.5	+1.66	231.0	-1.43	316.0	+2.33	292.0	---	292.0	-1.71	176.0

1925

Class	Num- ber of ani- mals	May 2		June 1		July 1		Aug. 1		Sept. 1		Sept. 15		Sept. 27		Oct. 10		Oct. 15		Net gain <sup>1</sup>
		Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	Weight	Daily loss or gain	
Cows with calves...	14	612.6	---	---	+2.68	773.1	+2.68	---	---	787.9	+0.24	769.2	-1.34	722.9	-3.86	---	---	---	---	110.3
Dry cows...	3	612.0	---	---	+3.92	847.0	+3.92	---	---	936.7	+1.45	944.3	+1.54	930.0	-1.19	---	---	---	---	318.0
Calves...	14	129.1	---	---	+1.82	238.4	+1.82	---	---	321.2	+1.34	339.2	+1.29	344.4	+1.43	---	---	---	---	215.3

<sup>1</sup> Oct. 1 or weighing date nearest thereto taken as end of season for this figure. This represents date when sharp declines began to occur in most classes, on account of autumnal coloring and falling off of leaves of principal species being eaten.

<sup>2</sup> One animal not weighed this date; average figure obtained by interpolation.

<sup>3</sup> Based on two animals only; other two turned out Sept. 16.

<sup>4</sup> Two animals not weighed this date; average figure obtained by interpolation.

<sup>5</sup> Based on four animals only; other five turned out Sept. 16.



The sharp decline after October 1 among all classes appears to bear relationship to the condition of the foliage of the shrubs being eaten at that time. In general the sharp declines in weight corresponded to the attainment of full autumn color by the leaves of serviceberry and oak.

#### IMPORTANCE OF CONDITION OF CATTLE IN THE SPRING

The condition of the cattle in the spring at the time they were placed in the pasture influenced the amount of gain during the grazing season. Potter and Withycombe (8), working with steers in Oregon, found that steers which had been so fed as to make light gains during winter made greater gains on pasture the follow-

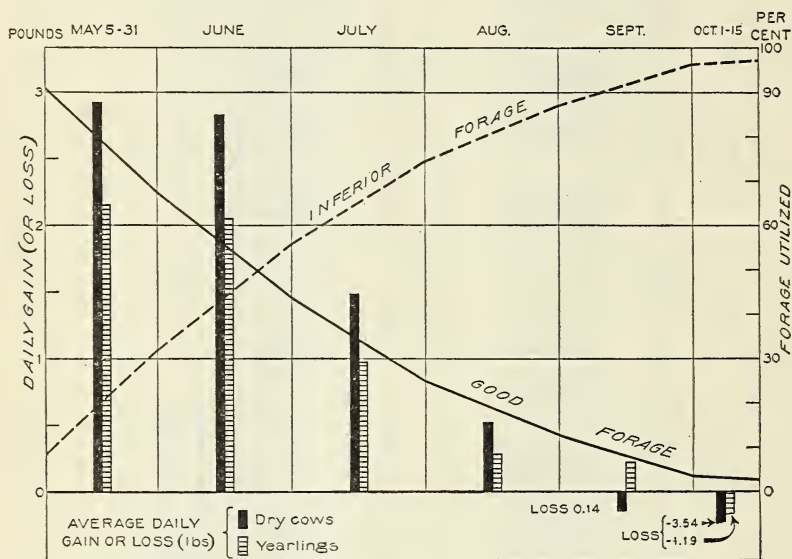


FIGURE 3.—Average daily gains of dry cows and yearlings in relation to the percentage of class of forage being eaten

ing summer than steers that were fed to make larger gains during the winter period. However, this advantage was offset in the final weights, for the lightly wintered animals did not recover the difference in weight and weighed less than at the close of the grazing season. Similar results were obtained by Sheets (14). The cattle used in the present experiment were poorly wintered and were usually very thin on entering the pasture in the spring, although they were thinner in some years than in others. This left much room for large gains during the summer periods, and the degree of summer gain may be attributed in part to this condition.

The effect of the method of wintering on cows grazed in the experimental browse pasture is shown in Figure 4. The cows which were dry one season and calved the next lost the most during the intervening winter. Since these animals were in the best condition in the fall they received the least attention during winter, and also had the greatest amount of reserve flesh to lose. Cows which had

calves were so thin in the fall that some supplemental feeding was necessary during the intervening winter to carry them through. These animals gained slightly during this period. All these groups were rather thin in the spring, however, although the cows which were in the best condition in the fall were in the best condition the next spring.

The greatest subsequent summer gains of dry cows and cows with calves were made in those years when the animals were in the thin-

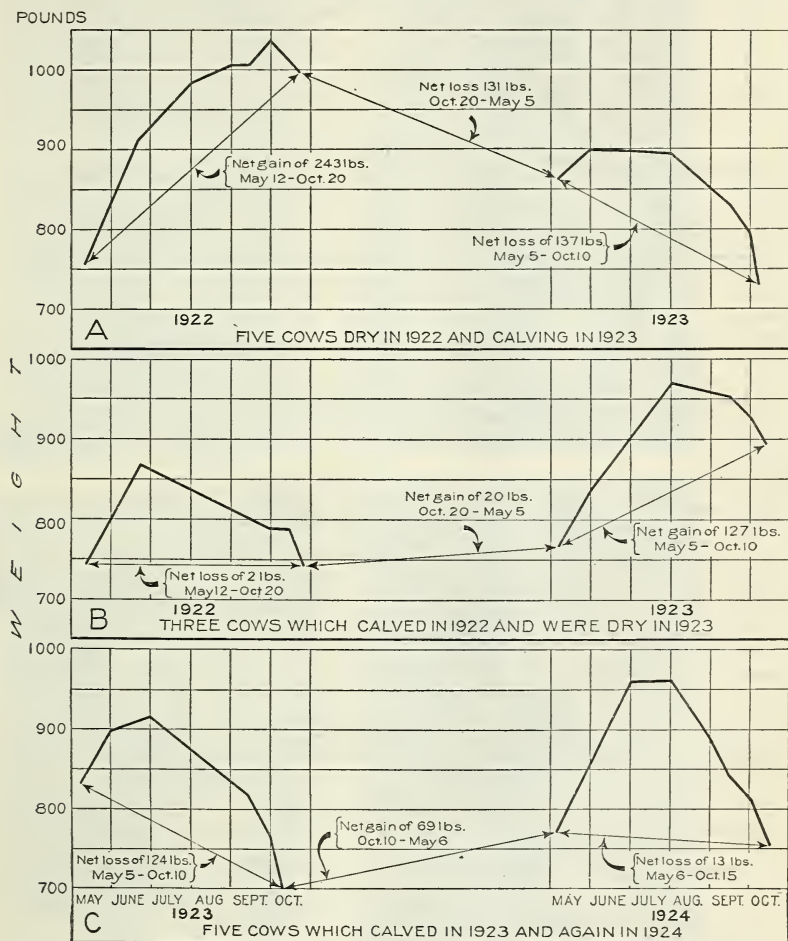


FIGURE 4.—Periods of the year when gains and losses in weight occurred in different classes of cattle

nest condition on entering the pasture and the smallest gains occurred in the years when the cows were in the best condition in the spring. The average annual cumulative summer gains of cows with calves and dry cows are shown in Figure 5. The cows with calves entered the pasture in best condition in 1923. Their average gains during the early part of that season were less than in the other years, and their final weights actually showed a loss. On the other hand

the cows with calves were thinnest on entering in 1924, and their average gains early in the season were greatest, though the final seasonal gains were little different in that year from what they were

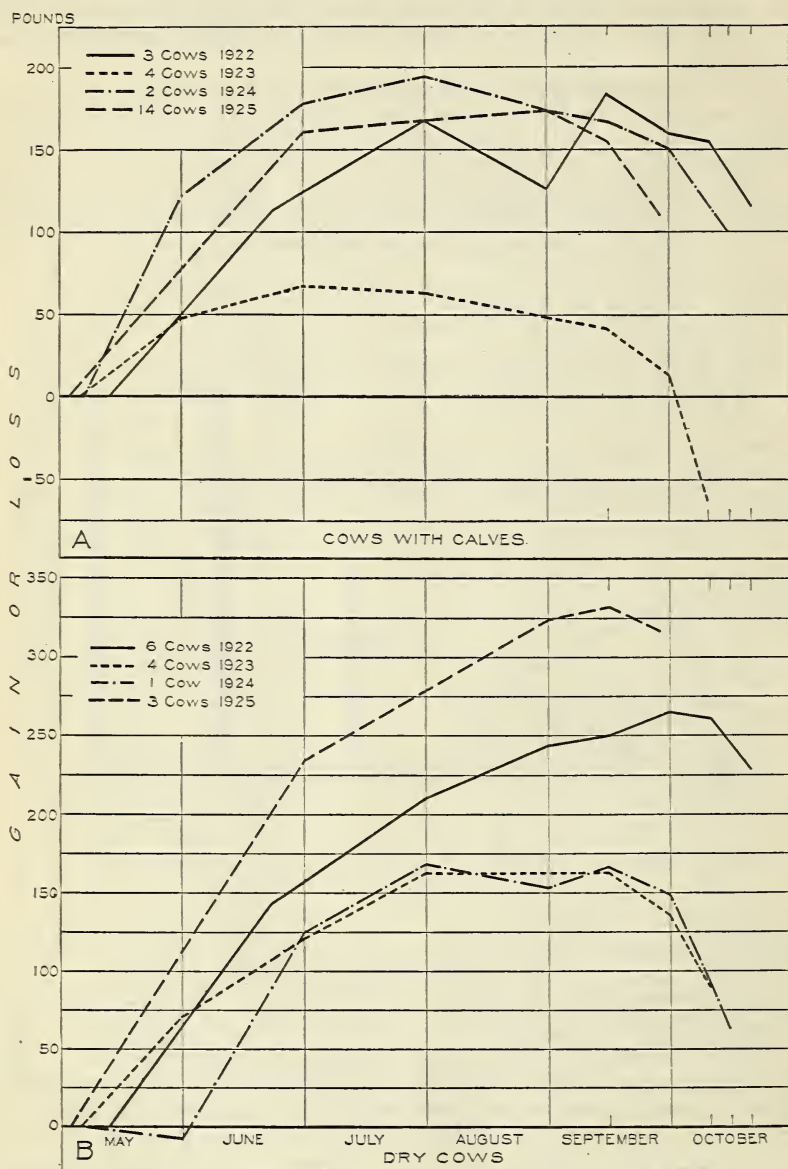
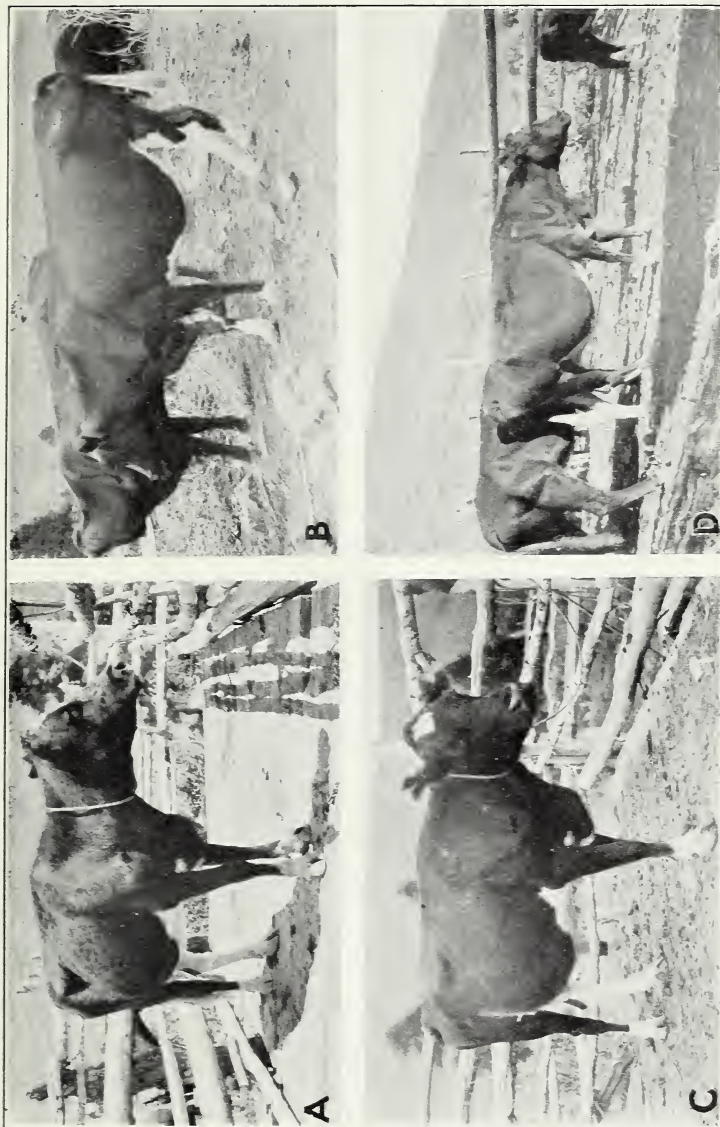


FIGURE 5.—Average annual cumulative gains of cows with calves and dry cows (1922-1925)

in 1922 or 1925. The gain in 1922 continued later than in any other year. The more palatable forage was most abundant that year before the serious overgrazing of such vegetation provided by the



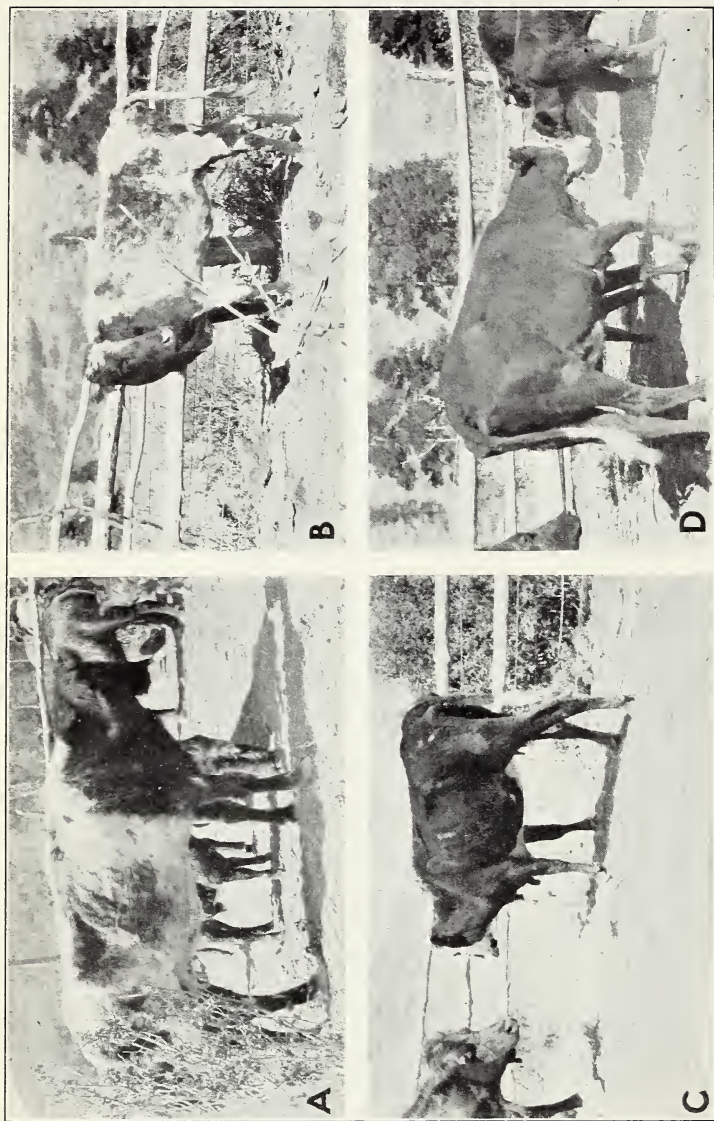


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#### CHANGE IN CONDITION OF A DRY COW ON BROWSE RANGE

Cows which entered the experimental pasture thin made good gains during May and June when better browse and herbageous forage was available but did not do well later in the season when they were required to subsist on the less palatable browse forage. A.—Very thin and unthrifty on May 1. B.—In fair condition on July 1. C.—Beginning to lose weight on September 1. D.—Losing weight rapidly on September 27.

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## CHANGE IN CONDITION OF COWS WITH CALF ON BROWSE RANGE

Cows with suckling calves, although they made fair gains in weight, remained unthrifty throughout the season and did not breed to calve again the following year when required to subsist mainly on inferior browse forage. (This results in not to exceed a 50 per cent crop of good salable calves each year. A.—Cow No. 67, very thin on May 1, 1925. B.—Cow No. 67, had gained 125 pounds by September 27, 1925, but still was only in fair condition. C.—Cow No. 77, very thin on May 1, 1925. D.—Cow No. 77, had gained 85 pounds by September 27, 1925, but was still rather thin

experiment had depleted the stand. Similar results were obtained with dry cows. The 4 dry cows grazed in 1923 and 1 dry cow grazed in 1924 were in the best condition in the spring as compared to dry cows in the spring of other years and showed the least gains for the grazing season. The 3 dry cows grazed in 1925 were in the poorest condition in the spring, and they made the best gain in the subsequent summer. The 6 dry cows grazed in 1922 were intermediate between the other two groups of dry cows both in condition in the spring and in subsequent summer gains.

Young cattle also exhibited an effect of wintering on subsequent summer gains, in which, however, age appeared to be an additional factor. Although there was little difference between one year and

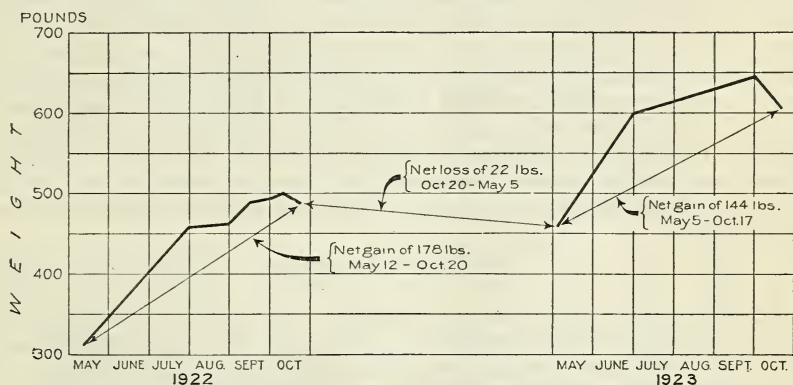


FIGURE 6.—Periods of gain and loss in animals that were yearlings in 1922

another in the condition of yearlings, 2-year-olds, and 3-year-olds at time of entering the pasture, losses or gains during the winter varied between these classes. The average winter losses by six head which were yearlings in 1922 and were included in the experiment again as 2-year-olds in 1923, is shown in Figure 6. These animals showed a net loss of 23 pounds during the winter. The differences between the average weight of calves, yearlings, and 2-year-olds in the fall and the weight of the corresponding yearlings, 2-year-olds, and 3-year-olds in the spring for three years are given in Table 7. Calves are the only class showing a gain during the winter, and this gain was only 11 pounds. Yearlings and 2-year-olds lost 8.3 and 79.5 pounds, respectively. The gains and losses rank in accordance with the age of the animals, save for the calves' gain, which was influenced by the additional care they received during the winter.

TABLE 7.—Average fall weights of young stock compared with spring weights, 1922-1924

Fall weights		Spring weights		Gain or loss during winter
Age class	Weight	Age class	Weight	
	<i>Pounds</i>		<i>Pounds</i>	<i>Pounds</i>
Calves.....	337.4	Yearlings.....	348.4	+11.0
Yearlings.....	491.8	2-year-olds.....	483.5	-8.3
2-year-olds.....	670.0	3-year-olds.....	590.5	-79.5



The summer gains of the several classes varied inversely with the gains or losses during the winter. As shown in Figure 2, on the average, up to October 1, the date after which sharp declines began to occur on account of the autumnal coloring of the leaves of the principal species being eaten, yearlings had made the least gain (163.6 pounds), 2-year-olds the next (213.3 pounds), and 3-year-olds the greatest gain (225 pounds). On the basis of percentage of initial weight, however, the results were not so unfavorable to the younger animals. By October 1, on the average, yearlings had made a gain of approximately 46 per cent of their initial spring weight, 2-year-olds had gained about 45 per cent, and 3-year-olds had gained only approximately 37 per cent of their initial weights. It will be noted from Figure 2 also that, on the average, there were rather sharp declines in the weight of all classes after October 1. During this period, yearlings lost an average of 16.6 pounds, or 3.2 per cent of their weight on October 1; 2-year-olds lost 26.9 pounds, or 3.9 per cent; and 3-year-olds lost 42.2 pounds, or 5.1 per cent. As already pointed out, 3-year-olds were in the best condition on leaving the pasture in the fall, followed in order by 2-year-olds and yearlings. Thus the animals in the best condition lost the most in both actual weight and percentage of weight, although age also may have had an influence.

#### INFLUENCE OF RAINFALL

Forage growth, especially of grasses and weeds, is more or less closely associated with rainfall (4, 10). On the experimental area in years of deficient rainfall less herbaceous forage was produced. As a result the gains of the cattle grazed in such years were smaller for a portion of the season as compared to years of greater rainfall.

As a result of the unfavorable weather conditions in the fall of 1923 and during 1924 and the consequent poorer growth of herbaceous vegetation in 1924, the gains, especially those made by yearlings, 2-year-olds, and 3-year-olds, as is shown in Table 6, were less during July, 1924, than in the other years. But because the herbaceous and more palatable shrub forage was practically exhausted shortly after August 1 in the two preceding years, little difference in the gains after the early part of August, when the cattle subsisted largely on browse forage, are apparent in 1922, 1923, and 1924.

#### GROWTH AND DEVELOPMENT

One of the outstanding characteristics of the cattle used was the tardy development of the younger stock. This slow growth appears to be characteristic under conditions similar to those in this study and to be one result of the inferior quality of the range forage to which the cattle were limited. The average weight on October 1 of the various age classes of cattle grazed in the experimental pasture and the weight at marketing time, early in October, of the same age classes of cattle grazed on the high mountain summer range of Utah, some of them being fed hay during the winter, are shown in Table 8.

Calves, yearlings, 2-year-olds, and 3-year-olds from the pasture are 71, 147, 195, and 186 pounds lighter, respectively, than the same age classes grazed under other conditions. The calves from the Manti National Forest used in this comparison were slightly above average; the difference in weight between the pasture calves and the average calves grown under better conditions is greater in Table 8 than it would be normally. Each age class of the younger cattle, with the exception of calves, is approximately one year behind in size and growth as compared to cattle summered on the high mountain ranges. The dry cows 4 to 13 years old used in the browse study, however, were almost as heavy in the fall as dry cows summered on the higher range, which indicates that animals produced on the browse range will eventually attain a size approximately equal to that of cattle raised on better range.

TABLE 8.—*Comparison of average fall weight of various age classes of cattle grazed on high mountain summer range in 1922, with the same classes grazed in the browse pasture, 1922-1924*

Locality	Calves	Yearlings	2-year-olds	3-year-olds	Dry cows
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Ashley National Forest, Utah.....		660	835	975	950
Fishlake National Forest, Utah.....		641	900	1,000	1,092
Manti National Forest, Utah.....	412	650	984	1,000	1,080
Powell National Forest, Utah <sup>1</sup> .....		650	850	1,000	950
Average.....	412	650	892	994	1,018
Browse-study cattle <sup>2</sup> .....	<sup>3</sup> 341	503	697	808	962
Deficiency in weight of study cattle.....	71	147	195	186	56

<sup>1</sup> These animals were wintered under conditions comparable to those experienced by the study cattle, but entered high mountain range on approximately May 15 each year, and had an ample supply of good forage, consisting of a mixture of highly palatable grasses, weeds, and browse, until they were removed from the range early in October, a period of approximately 137 days.

<sup>2</sup> The cattle grazed in the experimental pasture were on good feed only about 56 days, or from the time of entering the pasture until about June 30, when practically all the grasses, weeds, and more palatable browse had been eaten and only the inferior forage plants remained.

<sup>3</sup> Calves are figured for 1922-1925, inclusive, October 1.

Clawson (1) in connection with the investigations of stock-poisoning plants at the Bureau of Animal Industry experiment station near Salina, Utah, obtained considerable data on gains in weight of cattle such as might be expected on the higher mountain summer range of central Utah. The area where these cattle were grazed is located about 140 miles northeast of the experimental browse pasture and at an altitude of approximately 8,000 feet. Table 9 shows the weight and gains of yearlings, 2-year-olds, and 3-year-olds during 1922, 1923, and 1924 as calculated from Clawson's data, as compared with the weights and gains during the same grazing seasons of the same age classes of cattle grazed in the browse experimental pasture. Both the spring weights and the summer gains were much lower for the animals grazed on the browse range. The cattle at the Salina station made fairly uniform gains until September (fig. 7), whereas the gains of the cattle in the browse pasture fell off each month as the season advanced.

TABLE 9.—Comparison of average weights and gains<sup>1</sup> of cattle grazed in experimental browse pasture, and cattle grazed at Salina experiment station

Age class	Years of record	Initial weight			Final weight			Average gain in weight		
		Salina station	Browse pasture	Difference	Salina station	Browse pasture	Difference	Salina station	Browse pasture	Margin at Salina
		<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Yearlings....	1922 and 1923..	566.5	406.8	159.7	809.9	524.0	285.9	243.4	117.2	126.2
2-year olds....	1922, 1923, and 1924.	624.7	543.1	81.6	863.8	691.8	172.0	239.1	148.7	90.4
3-year olds....	1923 and 1924..	751.0	674.8	76.2	989.0	797.6	191.4	238.0	122.8	115.2

<sup>1</sup> The initial weights of the Salina experiment station cattle were obtained on June 10, June 9, and June 14 in 1922, 1923, and 1924, respectively, and final weights were obtained on September 23, September 22, and September 21, for the same years respectively. The initial weights of the experimental browse pasture cattle are as of June 1 and the final weights as of October 1 for each year. (Weights of Salina experiment cattle calculated from data by Clawson (I).)

The difference in the character of forage at the experimental browse pasture and at the higher mountain summer range is chiefly responsible for most of the gains and growth of the animals. The forage on the high mountain ranges, including the range at the Salina experiment station, consists of choice grasses, weeds, and browse, in a quan-

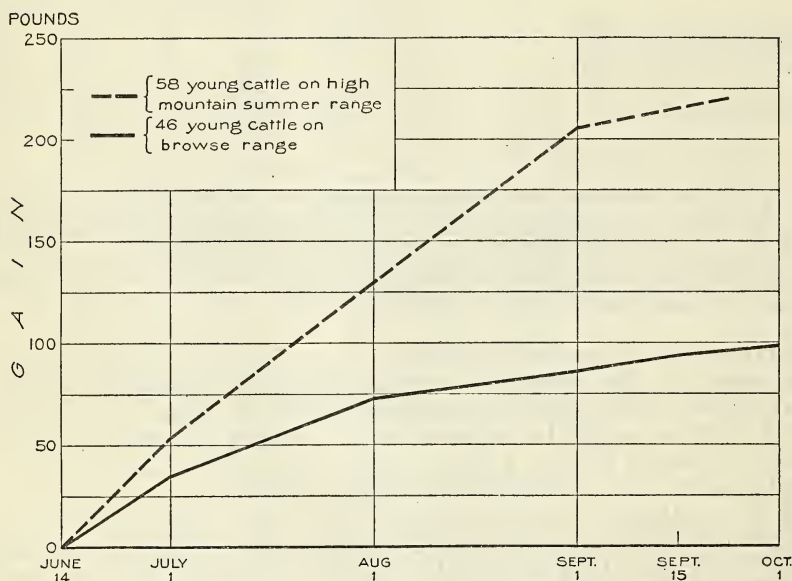


FIGURE 7.—Average cumulative gains of cattle grazed on high mountain summer range compared with gains of cattle grazed on experimental browse range (1922-1924)

tity sufficient to afford the cattle all three classes of forage throughout the full season. Only under rare circumstances, such as where there is overgrazing, are cattle forced to eat excessively of the less-palatable plants. The animals grazed in the browse pasture, on the other hand, were forced to subsist on inferior feed for fully half the season and failed to make average gains on it.



## THE CALF CROP

An average annual calf crop of less than 70 to 75 per cent is not considered efficient in cattle production. Matt J. Culley, director of the Santa Rita Range Reserve, states that under the adverse climatic conditions on the range of the Southwest, not less than a 60 per cent calf crop of fairly uniform-aged, salable calves is required to yield a profit. Of the cows 3 years of age and over which were grazed in the experimental pasture during the 4-year period 1922 to 1925, inclusive, 1 cow grazed all 4 years, 1 grazed in the pasture 3 years and her calving record outside was obtained for the fourth year, 5 head were grazed for 3 years, 9 head for 2 years, another was grazed in the pasture 1 year and her calving record outside was obtained the next year, and 20 head were grazed for 1 season only, making an aggregate of 63 cow-years. A total of 42 calves were raised by these cows during the 4 years, which amounts to a 66 $\frac{2}{3}$  per cent calf crop. Eleven of the 42 calves were late calves, dropped after August 1, the mothers requiring extra winter care and the calves themselves not matching up in size with the bulk of the calves produced. This leaves but 31 head or, roughly, a 50 per cent crop of good, readily salable spring calves.

TABLE 10.—*Breeding of cows for which one or more years complete records are available*<sup>1</sup>

Cow No.	1922	1923	1924	1925	Cow No.	1922	1923	1924	1925
1-----	D, B	S, N	D	-----	12-----	L, N	D	-----	-----
2-----	D, B	S	-----	-----	31-----	-----	S, A	L, N	D
3-----	D, B	S, A	L	-----	34-----	-----	L, A	L	-----
4-----	L, N	D, B	S, B	S	35-----	-----	D, B	S	-----
5-----	S, A	L, A	L	-----	36-----	-----	D, B	-----	-----
6-----	D, B	S, N	D, B	S	45-----	-----	-----	S, B	S
7-----	D, B	S, A	L	-----	46-----	-----	-----	L, N	D
8-----	D, N	D	-----	-----	47-----	-----	-----	L, N	D
11-----	L, N	D	-----	-----					

<sup>1</sup> D=cow dry; S=cow with spring calf; L=cow with late calf; B=bred while in pasture; A=bred after leaving pasture; N=not bred.

It was found in investigations on ranges in the Southwest that thrifty condition of the breeding cows, especially during the breeding season, and at calving, and adequate bull distribution were necessary to obtain a good percentage of calves (4, 5). Bull distribution was satisfactory in the browse experimental pasture, since one bull was in the comparatively small pasture each season with not to exceed 20 cows in any one of the three years for which breeding records were obtained. The breeding record of the cows for which one or more years' complete information is available (Table 10) shows that the comparatively low calf crop may be attributable largely to unthrifty condition during the summer grazing season of cows with calves as the result of the inferior quality of the forage and probably, indirectly, to poor wintering. In the 63 cow-years involved there were 26 complete breeding records. Of this total there were only 2 cows (Nos. 4 and 45) with calves at side that were bred while in the pasture to calve again the following year. There were 6 additional instances of cows that had calves two or more years in succession, but in each of these cases they were not

bred until in the fall after they had been removed from the pasture and placed on better feed. In 10 cases cows were dry, and in 9 of these the cows were bred while in the pasture to calve the next season. In the tenth case the cow was dry 2 years in succession. In 2 instances where cows had early calves and in 6 others where the cows had late calves the cows were not bred either while in the pasture or in the fall after being removed and were dry the following year.

All of the breeding cows used in the experiment were very thin at the beginning of the summer grazing season each year. Dry cows made the best gains and attained a more thrifty condition than cows which had calves at side during the summer months. Moreover, this thrifty condition was attained during the first two to two and one-half months of the grazing season in 6 cases out of 9. These 9 cases were the only ones among the 26 recorded, with the exception of Nos. 4 and 45 in 1924, which were settled with calf while they were in the experimental pasture. In 1923, the cows with calves were placed on alfalfa pasture for several weeks in the fall after being removed from the browse range, and there they improved in condition quite rapidly. The 5 cows which calved in 1923 and again late in 1924 were included in this lot. They did not reach breeding condition until they were placed on alfalfa pasture in the fall after leaving the browse range.

In order to produce a 70 to 75 per cent or better calf crop of even-aged spring calves practically all of the cows, including those with calves, should be in condition to breed during the summer they are suckling a calf, but the browse forage available was not adequate to produce such condition. It is quite evident that from the standpoint of calf production grazing browse range of the character used in this study to obtain reasonably full use of the oak will not give satisfactory results.

#### APPLICATION OF THE RESULTS

##### THE BASIS FOR DETERMINING THE GRAZING CAPACITY OF BROWSE RANGE

The results of this study lead to the conclusion that browse range should be handled far more conservatively than is the customary practice. Where approximately 30 per cent of the total vegetation is of the most palatable plant species, another 30 per cent is oak and intermediate in palatability, and the remainder of the vegetation (approximately 40 per cent of the total) consists of various shrubs of relatively low palatability, browse range may not be grazed on a stable and profitable basis to the point of reasonably full use of the oak. The consequences of such use are overgrazing and injury to the main palatable species of such a nature as will eventually lead to their disappearance from the range. Further consequences are poor gains and slow growth of the cattle grazed and calf crops far below what may be considered satisfactory. That the more palatable plants are essential for maintaining the quality of the forage was indicated by the good gains made by the cattle during the period when the more choice forage was available and the poor gains in the latter part of the season when practically the only subsistence was oak and less choice shrubs. If the better forage were to be eliminated, very

poor gains would be made throughout the season, the range would be of questionable value for future grazing, and there would doubtless be considerable injury to timber reproduction and possibly also to the watershed.

In view of such possibilities, the best summer use that may be made of browse range is to graze it only to the degree that will not injure the more palatable browse and the grasses and weeds of approximately equal palatability, even though this will entail but light use of the less palatable species. Even with such use, the species that are of exceptionally high palatability but make up only an insignificant portion of the total forage may be overgrazed and destroyed. However, this loss may be disregarded as long as it does not reduce the quality of the balance of the forage below requirements for the most economical livestock production, or result in material injury to the watersheds or timber growth.

It was found that the less palatable shrubs were always utilized to some extent along with the more palatable species. On the average, over a period of three years, 23 per cent of the available oak forage and 15 per cent of the inferior shrubs had been utilized by the time the better forage was fully utilized. Consequently, use which maintains the better species will not involve a total loss of the less palatable plants. The carrying capacity of the range, then, should be based on the amount of the better forage that is available, with additional allowance for the less palatable shrubs that will be utilized incident to the use of the better forage species.

#### EXTENT TO WHICH BROWSE SHOULD BE GRAZED

The use of the better browse species, birchleaf mahogany and bitterbrush, to the extent that all of the current year's growth was taken by the close of the growing season resulted in a decline in vigor and slow dying out of the plants. If continued, this use would eliminate such forage. The plants that had a sufficient portion of each year's twig growth left in the fall to insure the leaving of one or more lateral buds on them, were the most vigorous and continued to hold up. How much of the current year's growth should be left to insure perpetuation of the plants is a point for further study, but it is apparent that no more of each year's growth should be grazed than will leave at least one lateral bud on a majority of the twigs. It is considered that leaving 10 to 20 per cent of each year's growth will meet this requirement.

#### BEST SEASONS FOR USE

The conclusion may reasonably be drawn that the browse range is much better adapted to late spring and fall grazing than to full-season use, if more succulent feed is available for the midsummer period. Satisfactory gains were obtained during May and June in the present experiment. Experiments at the Great Basin Experiment Station, near Ephraim, Utah, indicate that browse range somewhat similar in character may be utilized satisfactorily from about September 10 to October 10, if not fully utilized previously. At that time such species as birchleaf mahogany and bitterbrush were found to be at least as fully palatable to cattle as the dried grass and weed forage.



Grazing of browse range of this character should not begin before the leaves of birchleaf mahogany are three-eighths to one-half of an inch wide and one-half of an inch long, the leaves of bitterbrush one-eighth to one-fourth of an inch wide and one-fourth to one-half of an inch long, the flower buds conspicuously swollen, and the bunch grasses 6 to 8 inches high (12). This is about May 1 to 5 on the experimental area. Removal of the cattle the latter part of June would provide for recuperation of the palatable browse plants after the spring grazing. Satisfactory results from fall use could not be expected after the leaves of the shrubs have turned color in the fall, usually between October 1 and 10 on the experimental area, and this period should mark the close of the grazing season.

#### BETTER WINTER CARE OF CATTLE NEEDED

The general practice with the animals used in this study did not provide sufficient care during the winter. The results suggest the need for better winter care, especially where cattle must subsist on browse range for the full season. The development of young range cattle depends to a considerable degree upon proper care during winter as well as upon good gains during the spring and summer. It should be possible also to increase the calf crop by supplemental feeding. The best practice would be to provide sufficient supplemental feeding during winter, and especially in early spring, when range feed is shortest, to keep cows with calves or about to calve in a thrifty condition at that time. Being in fair condition, they would be better able to take advantage of the early range feed, and a larger percentage of the cows could be expected to be bred to calve again the next season.

If larger calf crops could be obtained by means of better winter care it might be more profitable on browse range to raise calves only and not attempt to carry animals over until they were 1 year or older before selling them. The annual increments in weight from calves to yearlings, yearlings to 2-year-olds, and 2-year-olds to 3-year-olds, in the present study were 162, 194, and 111 pounds, respectively. These are much below the average gains on better range. The small increases in weight from one year to the next provide but a very small margin to cover expenses and losses and permit any profit from the operation. Calves and full-grown dry cows are the only classes which compare at all favorably in weight with the average animals of the same age produced on western ranges. Better care of breeding cows during the winter and spring may result in establishing the browse range as more valuable for breeding cattle than for producing beef.

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April 29, 1929

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