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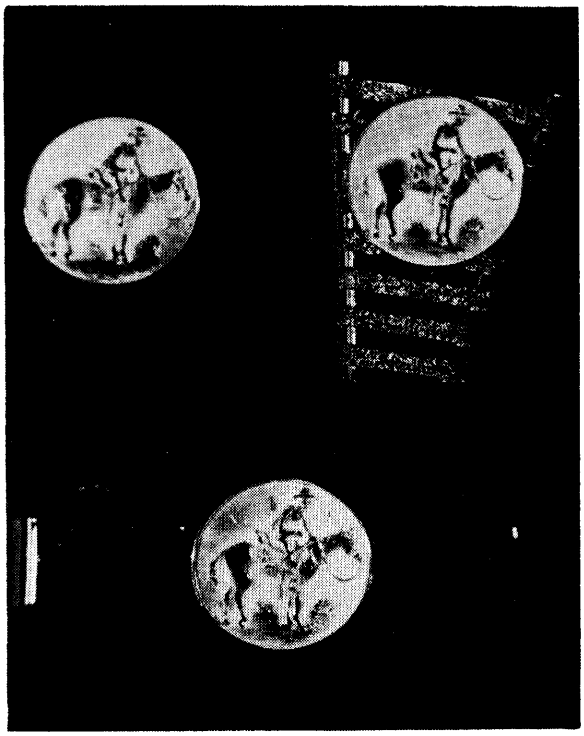
Circle S ranch—Lassen National Forest, California. By Waldo E. Wood Range Conservationist, U.S.F.S., San Francisco, California.



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RANGE MANAGEMENT

The Effect Of Range Condition And Intensity Of Grazing Upon Daily Intake And Nutritive Value Of The Diet On Desert Ranges

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The desert ranges of the Intermountain area furnish forage for about nine million head of cattle and sheep for five to six months each winter. Many of these ranges are in good condition, but many are in poor condition.

When ranges are overgrazed, grazed during unsuitable seasons, grazed by the wrong kind of livestock, or otherwise used improperly, they deteriorate. Obvious results from grazing abuse are changes in plant density and species composition (Klemmedson, 1956; Short and Woolfolk, 1956; Stewart *et al.*, 1940; Parker, 1954; Reid and Pickford, 1946). Ranges in supposedly good condition produce at maximum potential, whereas ranges in poor condition produce less than their potential (Humphrey, 1949; Goebel and Cook, 1960).

A few investigators have stated that poor ranges support a greater number of plants low in nutritive value compared to good ranges (Renner and Johnson, 1942; Hutchings, 1954). However, Goebel and Cook (1960) found that many species that become abundant on poor ranges were as nutritious as dominants on good ranges, and in some cases were higher in nutrient content.

Studies by Cook *et al.* (1953) and Pieper *et al.* (1959) showed that increased intensity of grazing reduced daily forage intake and digestibility of the nutrients. On ranges producing a single species, increased intensity of grazing decreased the nutrient content of the diet; but on ranges supporting mixtures, change in use from one species to another accompanying increased intensity of grazing actually increased the nutrient intake in some cases.

Cook *et al.* (1950) found that forage remaining on good ranges following grazing was lower in nutrient content than originally and that continued use caused still greater reductions in nutrient value.

The present study was carried out on typical salt-desert ranges in southwestern Utah during two winter grazing seasons, 1957 and 1959, from November to March, to determine the effect of range condition and intensity of grazing on the daily intake and nutritive value of the diet.

Description of the Area

Vegetation in the study area included the shrubs big sagebrush *(Artemisia tridentata)*, bud sage *(Artemisia spinescens)*, winterfat *(Eurotia lanata)*, fourwing saltbush *(Atriplex canescens)*, and yellowbrush *(Chrysothamnus stenophyllus)*. Grasses included needle-and-thread grass *(Stipa comata)*, squirreltail *(Sitanion hystrix)*, galleta grass *(Hilaria jamesii)*, sand dropseed *(Sporobolus cryptandrus)*, blue grama *(Bouteloua gracilis)*, Indian ricegrass *(Oryzopsis hymenoides)*, three-awn grass *(Artistida longiseta)*, and downy bromegrass *(Bromus tectorum)*. Forbs included globemallow *(Spaeralcea grassulariaefolia)* and Russian-thistle *(Salsola kali* var. *tenuifolia)*.

The region is used primarily as winter range for livestock. Overgrazing in many areas has resulted in marked changes in vegetation cover compared to protected areas.

The average annual precipitation for the area is about 9 inches with maximum temperatures reaching 102°F in summer and as low as —26°F during the winter.

Methods and Procedures

A total of six areas which showed ranges in obviously different condition on the two sides of existing fences were studied for two winter grazing seasons. At one location three fence-line contrasts were selected where grass was more abundant than shrubs on the good range and where shrubs were more abundant than grass on the adjacent poor range. At a second location three other study areas were

FIGURE 1. Experimental sheep grazing desert range judged to be in good condition.

selected where browse was more abundant than grass on good ranges and grass was more abundant than browse on adjacent poor ranges. Ranges on the protected side were termed "good" range and those on the deteriorated side, "poor." Classification of range condition followed the procedure outlined by the two-phase method currently being used by the Bureau of Land Management (1957).

The size of the paddocks was such as to allow equal volume of herbage on each side of the fence. Six wether sheep equipped with fecal collecting bags and three with esophageal-fistula cannulae were grazed in each paddock for collecting fecal and forage samples (Figure 1). Herbage production and diets were determined by the method outlined by Edlefsen *et al.* (1960). The fistulated sheep were penned each evening and turned out to graze with the other animals at daybreak the following morning. It required from 2 to 3 hours to obtain forage samples. The remainder of the day the fistulated animals were allowed to graze for themselves with the other experimental animals.

Sheep were grazed for a preliminary period of six days on similar range adjacent to the trial paddocks. Each trial area was grazed for two five-day collection periods. In the first five-day period the animals used the forage only lightly, whereas the second five-day period was considered heavy use.

Forage samples were collected daily from each fistulated sheep in each area. The first forage samples were collected the day before fecal samples were collected and forage collection was terminated the day before fecal collection ended. A composite forage sample for each sheep was taken for each period on each area.

Fecal bags were emptied twice daily, in the early morning and at nightfall. The feces of each sheep were stored in separate containers and weighed at the end of each five-day trial period. A composite sample for each period from each sheep was taken for chemical analyses. All data are presented on an oven-dry basis.

Daily forage intake and digestion coefficients were determined by the lignin-ratio technique (Cook *et al.*, 1951).

Results and Discussion

Production

Data from the study areas showed that the paddocks rated "good" produced from 59 to as

Table 1. Average species composition, production, utilization, and diet from three trials at each of two locations where fenceline contrasts presented good and poor range conditions

Condition and species	Pounds per acre	Period 1 Utilization at end of period	Period 1 Diet	Period 2 Utilization at end of period	Period 2 Diet
Location 1		— — — — (percent)	— — — —		
Good					
Indian ricegrass	73.32	73.6	23.60	97.5	10.12
Galleta grass	93.27	27.1	11.05	61.1	18.31
Needle-and-thread grass	263.64	31.8	36.66	70.5	58.93
Three-awn grass	.00	0.0	.00	0.0	.00
Grasses	430.28	37.9	71.31	72.8	87.36
Yellowbrush	41.76	4.9	.90	26.6	5.23
Winterfat	92.31	63.5	25.63	75.9	6.61
Big sagebrush	8.14	45.8	1.63	56.6	.51
Browse	142.21	45.3	38.16	60.3	12.35
Globe mallow	1.78	68.0	.53	96.5	.29
Total and Average	574.27	39.8	100.00	69.9	100.00
Poor					
Indian ricegrass	43.87	87.2	38.30	96.8	8.04
Galleta grass	49.59	28.5	14.15	60.6	30.32
Needle-and-thread grass	.88	65.0	.57	85.0	.33
Three-awn grass	.75	0.0	.00	65.0	.00
Grasses	95.09	55.7	53.02	77.0	38.69
Yellowbrush	157.41	2.3	3.63	18.6	48.88
Winterfat	40.54	65.0	26.39	73.5	6.57
Big sagebrush	41.76	36.4	15.26	43.7	5.73
Browse	239.71	18.8	45.28	32.2	61.18
Globe mallow	.44	90.2	.40	98.5	.07
Russian thistle	2.79	46.6	1.30	47.7	.06
Total and Average	338.03	29.5	100.00	45.1	100.00

Location 2					
Good					
Indian ricegrass	31.27	35.0	7.08	78.9	16.47
Squirreltail	.91	21.9	.13	38.7	.17
Three-awn grass	1.90	0.0	.00	1.7	.04
Galleta grass	65.37	20.8	4.23	53.3	25.49
Needle-and-thread grass	34.50	50.4	11.25	83.4	13.66
Sand dropseed	1.90	1.5	.02	12.0	.24
Grasses	135.85	25.8	22.71	60.2	56.07
Yellowbrush	76.60	2.9	1.44	26.6	21.77
Winterfat	125.33	88.7	71.95	97.7	13.53
Big sagebrush	28.50	4.7	.87	24.5	6.77
Browse	230.43	49.9	74.25	65.1	42.07
Globe mallow	4.35	68.0	1.91	90.1	1.15
Russian thistle	5.73	30.3	1.12	40.6	.71
Forbs	10.08	46.6	3.04	62.0	1.86
Total and Average	376.36	41.1	100.00	63.2	100.00
Poor					
Indian ricegrass	16.57	82.0	11.16	91.3	3.05
Squirreltail grass	.00	0.0	.00	0.0	.00
Three-awn grass	3.46	13.3	.38	19.8	.44
Galleta grass	125.10	37.9	38.95	59.6	53.77
Needle-and-thread grass	7.73	80.8	5.13	90.9	1.54
Sand dropseed	1.83	15.0	.22	56.0	1.49
Grasses	154.69	43.9	55.85	63.6	60.29
Yellowbrush	97.53	15.3	12.26	27.3	23.17
Winterfat	24.83	88.3	18.01	98.3	4.91
Big sagebrush	30.30	39.2	9.76	53.2	8.40
Browse	152.66	31.9	40.03	44.0	36.48
Globe mallow	2.00	94.3	1.55	97.0	.10
Russian thistle	8.10	38.7	2.57	58.2	3.13
Forbs	10.10	49.7	4.12	65.8	3.23
Total and Average	317.45	38.3	100.00	54.2	100.00

much as 136 pounds more herbage per acre than those in poor condition (Table 1). Good ranges produced considerably more Indian ricegrass, needle-and-thread grass, and winterfat, whereas poor ranges produced more three-awn grass, yellowbrush, and in some cases galleta grass.

Utilization and Diet

Even though the same quantity of herbage was available for the experimental animals on both good and poor ranges, the overall use of forage was never as high on poor ranges as on good ranges. This difference was generally greater during the second grazing period than the first (Table 1).

In some areas in good condition where species of secondary palatability were sparse, the use was higher on these secondary plants than on poor ranges where they were abundant. This was true of both yellowbrush and big sagebrush where they produced less than 0.3 percent of the herbage on good ranges. It appears that under these conditions animals ate them for variety. This suggests that some plants invade an area in rather large quantities in order to become established on ranges in downward trend. On all ranges in poor condition, the species which were more palatable on good ranges were consumed extremely heavily before the less palatable species were eaten even moderately.

With increased utilization—period 2 compared to period 1—intensity of use generally increased more on grasses than on browse. This was more pronounced on good than on poor ranges (Table 1).

The average diet from the three study areas at Location 1 during the first grazing period contained more grass than browse under both good and poor range conditions. However, during the second grazing period the diet on poor ranges contained twice as much browse as grass, and the diet on good ranges contained seven times more grass than browse (Table 1).

The average diet from the three study areas at Location 2 during the first grazing period contained more than three times as much browse as grass on good ranges, but on poor ranges the diet during the first period contained only slightly more grass than browse. During the second grazing period, the diet on good ranges contained slightly more grass than browse, and the diet on poor ranges contained almost twice as much grass as browse (Table 1).

Thus, the quantity of the various forage classes on the range is not an index to the quantities of each in the diet.

Chemical Content of Diet

The changes in nutrient content of the diet with increased intensity of use is a result of changes in species and portions of plants consumed.

The ingested forage on poor ranges from the three areas at Location 1 was higher in protein, lignin, and ash, whereas ingested forage on good ranges was higher in cellulose and gross energy (Table 2). This might be expected since grass made up materially more of the diet on good ranges and browse made up more of the diet on poor ranges. Grasses on desert winter ranges are generally higher in cellulose and other carbohydrates than browse; however, browse species are higher than grasses in protein, ash, and lignin (Cook *et al.*, 1954).

On good range at Location 1 the average diet decreased in protein and cellulose and increased in ash, lignin, and other carbohydrates with increased utilization. These changes are partly a result of increased quantity of grass in the diet with in-

Table 2. Average nutrient content of ingested material from fence-line contrasts displaying good and poor conditions, grazed at two intensities at two separate locations shown in Table 1.[1]

Location and condition	Utilization	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Gross energy
	(percent)							kcal/lb
Location 1								
Good	39.8	2.7	8.0	9.3	12.0	25.8	42.2	1722
	69.9	2.9	7.3	9.7	12.7	23.6	43.8	1717
Average		2.8	7.6	9.5	12.4	24.7	43.0	1720
Poor	29.5	2.9	9.2	11.5	12.1	22.2	42.1	1678
	45.1	3.1	9.6	11.6	14.3	20.0	41.4	1634
Average		3.0	9.4	11.5	13.2	21.1	42.7	1656
Location 2								
Good	41.1	3.2	8.6	9.9	12.4	23.5	42.4	1791
	63.2	2.1	7.6	10.3	11.9	24.2	43.9	1804
Average		3.6	8.1	10.1	12.2	23.8	43.2	1797
Poor	38.3	2.7	7.4	11.2	11.3	23.7	43.7	1787
	54.2	2.4	7.0	11.9	12.9	23.2	42.6	1737
Average		2.5	7.2	11.5	12.1	23.5	43.2	1762

[1]Forage material was collected from esophageal fistulae and chemical content was corrected for ash content of the saliva.

creased intensity of use. The effect of increased intensity of utilization resulting from the consumption of coarser material counteracted the influence of increased grass in the diet somewhat, since both ash and lignin increased (Table 2).

On poor ranges at Location 1 the diet increased in protein, ash, and lignin and decreased in cellulose, other carbohydrates, and gross energy with increased utilization. The increase in protein was a result of the increase of browse in the diet. Other changes in nutrient intake were a result of both increased consumption of coarse material and increased browse in the diet.

At Location 2, under light use, the average diet on good ranges was higher in protein and lignin compared to diets on poor ranges which were higher in cellulose and other carbohydrates. However, with heavy use—period 2—the average diet on good ranges was higher in protein, cellulose, and other carbohydrates, whereas diets on poor ranges were higher in lignin and ash.

The increase of cellulose and other carbohydrates and the decrease of lignin with increased utilization on good ranges at the second location was largely a result of the marked change from a high percentage of browse in the diet during period 1 to a high percentage of grass during period 2 (Table 1). There was a slight increase of grass in the diet on poor ranges during the second period. However, increased consumption of coarser material with increased intensity of utilization apparently offset the effect of increased grass in the diet, since all nutrients except ash and lignin decreased with increased use (Table 2).

Digestibility

The average digestibility coefficients from the three areas at Location 1 showed that the digestibility of protein and ether extract was higher on poor range than on adjacent good range, but the digestibility of cellulose, other carbohydrates, and gross energy was higher on good range (Table 3).

The digestibility of protein decreased and the digestibility of cellulose, other carbohydrates, and gross energy increased with increased intensity of use on good ranges as a result of increased grass in the diet. However, on poor ranges where browse increased in the diet with increased grazing intensity the digestibility of protein increased slightly, but the digestibility of cellulose, other carbohydrates, and gross energy decreased.

On the three areas at Location 2 digestibility of protein was materially higher on good ranges compared to poor ranges for both periods. The digestibility of other chemical constituents in the diet was not consistently high or low on good or poor ranges because it was affected differently by intensity of grazing (Table 3).

Digestibility of protein decreased and digestibility of cellulose, other carbohydrates, and gross energy increased with increased intensity of grazing on good ranges where grasses replaced browse in the diet as degree of use increased. However, on poor ranges where forage classes remained about the same percentage in the diet during both grazing periods, the digestibility of all constituents decreased with increased intensity of utilization (Table 3).

Daily Intake

In all cases daily intake of forage was less on poor ranges than on adjacent good ranges (Table 3). Intensity of utilization decreased daily consumption of forage in all study areas. This was more pronounced on poor ranges than on good.

Conclusions

The nutrient content of herbage on good compared to poor ranges depends upon the species composition. This is especially true of the quantity of herbage produced by browse species compared to grass species. If palatable browse herbage predominates, the diet will be higher in protein, ash, lignin, and ether extract; but if palatable grass herbage predominates, the diet will be higher in cellulose, other carbohydrates, and metabolizable energy.

The nutrients in herbage on poor ranges are as highly di-

Table 3. Average daily intake of dry matter and digestibility of forage material from adjacent good and poor range at two separate locations when grazed at two intensities.

Location and condition	utilization	Daily intake	Digestibility					Digestible protein	Digestible protein intake	Metabolizable energy	Metabolizable energy intake
			Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy				
	(percent)	(lbs/day)	(percent)						(lb)	(kcal/lb)	(kcal)
Location 1											
Good	39.8	3.21	5.9	37.9	50.2	60.0	38.1	3.03	.097	501	1608
	69.9	3.03	20.1	37.1	50.3	65.6	41.4	2.71	.082	576	1745
Average		3.12	13.0	37.5	50.2	62.8	39.7	2.85	.089	538	1679
Poor	29.5	3.01	20.7	41.8	44.1	59.1	37.5	3.85	.116	497	1496
	45.1	2.53	30.1	42.9	43.4	54.8	36.0	4.12	.104	423	1070
Average		2.77	24.4	42.4	43.8	36.9	36.8	3.99	.111	460	1274
Location 2											
Good	41.1	3.09	29.8	51.0	42.1	47.6	36.0	4.39	.136	567	1752
	63.2	2.93	30.1	43.6	49.9	63.4	41.0	3.31	.097	604	1770
Average		3.01	29.9	47.3	46.0	55.5	38.5	3.83	.115	586	1764
Poor	38.3	2.63	33.5	35.5	45.0	56.1	37.2	2.63	.070	512	1347
	54.2	2.23	26.8	32.0	34.3	54.7	33.3	2.24	.050	431	894
Average		2.43	30.2	33.8	39.6	55.4	35.2	2.44	.060	472	1147

gested as nutrients in herbage on good ranges when degree of utilization is similar. However, light grazing on relatively unpalatable species may be associated with extremely heavy use of the more palatable ones.

Increased use on both good and poor ranges results in decreases in the daily intake of forage. Generally, more intensive grazing decreases the content of the more desirable nutrients in the forage, and furthermore, decreases the digestibility of these nutrients because of forced utilization of the coarser plant material. However, decreased nutrient content and digestibility with increased utilization may be compensated for when the diet changes from one forage class to another or from heavily used species to species only lightly or not previously used.

Summary

During two winter grazing seasons—1957 and 1959—a study was conducted on typical desert ranges in southwestern Utah to determine the effect of range condition and intensity of grazing upon the daily intake and nutritive content of the grazing animals' diet.

At each of two locations three areas displaying fence-line contrasts of good and poor range were selected and fenced so that areas on each side included equal herbage for the same number of experimental animals. Three sheep with esophageal fistula and six wethers equipped with fecal collecting bags were grazed on each side of the fence. Daily intake and digestibility were determined by the lignin-ratio technique. Each paddock was grazed for two five-day periods, the first representing light use and the second, heavy use.

Ranges in good condition produced more herbage than those in poor condition.

Even though the same quantity of herbage was available on both good and poor ranges, the use was lighter on poor ranges.

Diets showed that animals ate more grass in some areas and more browse in others. Likewise, diets changed from a large percentage of one forage class to a large percentage of another with increased intensity of use.

The nutrient content of the diets on good and poor ranges depended upon the species composition and the intensity of utilization. When browse was high in the diet, the nutrient intake was generally high in protein, ash, lignin, and ether extract; but when grass was high in the diet, the nutrient intake was generally high in cellulose, other carbohydrates, and metabolizable energy.

The digestibility of nutrients in diets on both poor and good ranges was about the same if use of similar species was not too different. Increased utilization decreased digestibility of forage unless the diets changed substantially in percentages of grass or browse.

Daily intake was less on poor ranges than on good ranges, and increased intensity of grazing reduced daily intake on both good and poor ranges.

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Forage Intake By Cattle Grazing Wiregrass Range[1]

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In the South, range herds that are not given feed supplements usually lose weight during a part of the year, even though ample amounts of wiregrass forage are available. Whether or not nutritive value, intake of forage, or both, are limiting factors has not been demonstrated. This paper reports a test designed to answer the question.

The degree to which nutritive value, intake of forage, or both, contribute to cattle performance cannot be measured directly. Established procedures are available for determining chemical composition and digestibility of wiregrass forage (Halls et al., 1957). Indirect methods employing an index substance provide an opportunity for estimating intake (Kane et al., 1950). Animal nutritionists have shown that if a completely indigestible index material such as chromic oxide is incorporated in the diet, the amount of feed from which the feces was derived can be calculated (Schürch et al., 1950). This method avoids the necessity of total measures on either food intake or feces output.

Accordingly, the study reported here was undertaken to estimate daily intake of native forage by cattle grazing wiregrass-pine range using chromic oxide as the index material. In addition to intake, chemical analyses and digestibility coefficients of the cattle diet and weight changes by the test cows were obtained.

Materials and Methods

Tests were conducted in April, June, September, and December 1956, in the wiregrass-pine grazing type of range (Williams et al., 1955) at the Georgia Coastal Plain Experiment Station's Alapaha Experimental Range in south Georgia. Principal forage species were pineland threeawn *(Aristida stricta)*, Curtiss dropseed *(Sporobolus curtessii)*, bluestems *(Andropogon* spp.), carpetgrass *(Axonopus affinis)*, panicums *(Panicum* ssp.), and paspalums *(Paspalum* spp.). In previous digestibility trials at Alapaha (Halls et al., 1957), these grasses comprised the bulk of the cattle diet.

Five mature grade Hereford and Brahman-Hereford cows with calves grazed a single range unit from March 15 through December 1956. Ample forage was available throughout the year on range burned over in January 1956. Cows had continuous access to a complete mineral mixture. From October 15 to December 31, cows were fed 2 pounds cottonseed meal per head daily, expect for the period December 8 to December 22. Calves were weaned October 16.

For each test, chromic oxide was placed in a large gelatin capsule and given orally during a 14-day period. One capsule containing 7.5 grams of the index substance was given each cow daily about 6:00 a.m. and another about 6:00 p.m.

Herbage samples approximat-

[1] *Cooperative investigations of the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture; the Forest Service, U. S. Department of Agriculture; and the University of Georgia, College of Agriculture Experiment Stations, Coastal Plain Experiment Station, Tifton, Georgia. Published with the approval of the Director as Journal Series Paper No. 89.*

FIGURE 1. Gentle cows enabled close observation of exact kind and portion of plant eaten.

ing the cattle diet were obtained on the 11th and 12th days of each trial in accordance with procedures devised by Halls (1954). Two collectors, working separately, followed the cows and sampled the forage on separate days. Gentle cattle enabled close observation and selection of plant portions actually grazed (Figure 1). Collections were composited and dried for 24 hours at 70° C.

Fecal samples were taken on 2 successive days beginning on the second day of the forage collection period. A small portion of feces from each cow was taken when grazing began in the morning and again in the afternoon. All samples were composited, oven dried at 70° C., ground, and stored in airtight jars at room temperature.

Plant and fecal samples were analyzed for ash, crude protein, and ether extract as outlined by the Association of Official Agricultural Chemists (1950). Lignin was determined by the method suggested by Davis and Miller (1939), and percent of carbohydrates other than lignin was obtained by difference. Chromic oxide content of feces was determined by the method of Dansky and Hill (1952). The lignin ratio technique described by Kane et al., (1949) was used to calculate digestion coefficients.

With values for the indigestibility of the forage determined by the lignin ratio technique and the total fecal output calculated from the chromic oxide content of a representative fecal sample, the amount of forage consumed was computed by use of the formula:

Total forage intake = Total weight of feces/Percent indigestibility of forage.

Results and Discussion

Grasses furnished a major portion of the cattle diet on winter-burned wiregrass-type forest range. Cattle exhibited a strong preference for pineland threeawn and bluestems in the spring, various bluestems in summer and fall, and Curtiss dropseed in winter (Table 1). Shrubs including saw palmetto (*Serenoa repens*) and a wide variety of other browse plants contributed about one-third of the total diet in winter. Grasses averaged 77 percent of the total forage collections, broad-leaved herbs 6 percent, and shrubs 17 percent.

Chemical analysis of diet samples was unusually high in ash content in April and September collections, and the lowest in December (Table 2). Raindrop spatter of mineral soil apparently contributed a considerable amount of ash in addition to the amount contained in the vegetation itself.

As the grazing season advanced, crude protein declined gradually to critically low levels in September and December. Ether extract, which comprised only a small fraction of total dry matter, followed the same trend until winter, when it increased due probably to greater consumption of highly resinous browse. Lignin was high, even in April, but did not increase sharply until December after grasses had matured and large amounts of browse plants were consumed.

Table 1. Seasonal components of herbage samples from wiregrass range representing the cattle diet.

Plant species	April	June	September	December
	— — — (Percent by weight) — — —			
Grasses: Total	83	80	87	59
Pineland threeawn	24	3	6	12
Curtiss dropseed	7	1	4	23
Florida dropseed	7	10	6	4
Bluestems	22	35	35	8
Toothachegrass	4	6	3	1
Carpetgrass	1	3	11	3
Panicum spp.	7	7	8	1
Misc. grasses	11	15	14	7
Broad-leaved herbs	7	3	8	6
Shrubs	10	17	5	35

Table 2. Chemical composition of native forage, by seasons[1]

Components	April	June	September	December
	(Percent)			
Ash	8.27	6.84	8.60	4.88
Crude protein	8.65	8.23	5.28	5.13
Ether extract	2.35	1.94	1.78	2.09
Lignin	10.26	12.92	11.75	15.38
Carbohydrates	60.47	60.07	62.59	62.52

[1] Based on 90 percent dry matter content.

Carbohydrates, other than lignin, were only slightly greater in fall and winter than in spring and summer.

Seasonal decline in nutritive value of forage (Table 3) was accompanied by a consistent declining forage intake (Table 4) and body weight of test cows (Figure 2). Both daily intake of forage and of total digestible nutrients declined during the summer and fall from their maximums in the spring, and then dropped abruptly in winter.

According to standards established by the National Research Council (1958), the diet was deficient throughout the trials (Table 3). Percent total digestible nutrients in the diet decreased from 44.48 in April to 42.64 in September, then dropped sharply to 32.16 in December. Other digestible nutrients in the animal diet followed a similar seasonal pattern. Digestion coefficients for crude protein, ether extract, and carbohydrates showed a gradual decline from April through September, and a rather noticeable decline in December. Digestible protein was deficient yearlong and the deficiency became more serious as the grazing season advanced (Figure 3).

The study demonstrates conclusively that feed supplements are necessary for maximum beef production in wiregrass-pine ranges. Cattle apparently were reluctant to eat enough low quality herbage to offset its declining nutritive content. On a 90-percent dry matter basis, forage intake dropped from a high of 20.46 pounds in April to a low of 11.66 pounds in December (Table 4). According to the National Research Council (1958), 28 pounds dry matter containing 5-percent digestible protein and 60-percent total digestible nutrients is needed to meet daily requirements of beef cows during the first 3 or 4 months of lactation. That cows were forced to draw on body reserves to satisfy their needs is evidenced by failure of test animals to maintain body weight. During the period of March 15 to October 16, cows lost an average of 59 pounds.

The animal diet apparently descended to a critical level during the winter, and death by starvation could have occurred had the test cows been left on the range without supplements. Biswell et al., (1942) reported heavy death losses in herds of cattle that grazed native range year-round without supplements. However, recent trials at Alapaha suggest that supplements for cows on burned native range may be

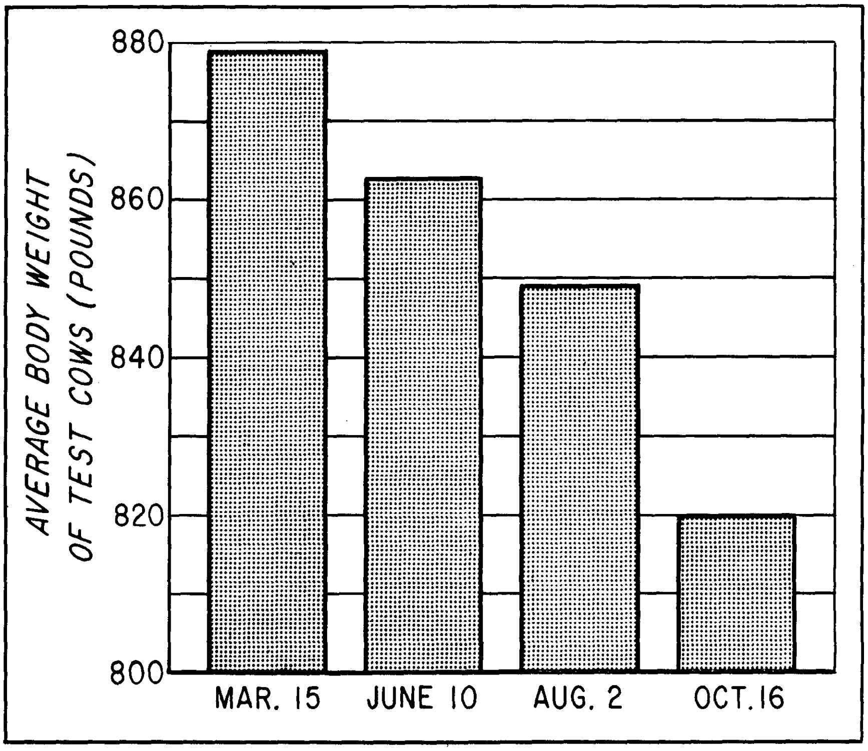

FIGURE 2. The five test cows lost an average of 59 pounds between March 15 and October 16.

Table 3. Digestion coefficients, total digestible nutrients, and nutritive ratio of native forage as determined by lignin ratio method.[1]

Date of collection	Digestion coefficient: Crude protein	Ether extract	Carbohydrates	T.D.N.	Nutritive ratio
	(Percent)				
April	36.00	39.87	62.01	44.48	1:13
June	29.16	19.62	60.84	44.12	1:16
September	23.67	6.12	58.95	42.64	1:30
December	9.99	Negative	45.45	32.16	1:55

[1] Based on 90 percent dry matter content.

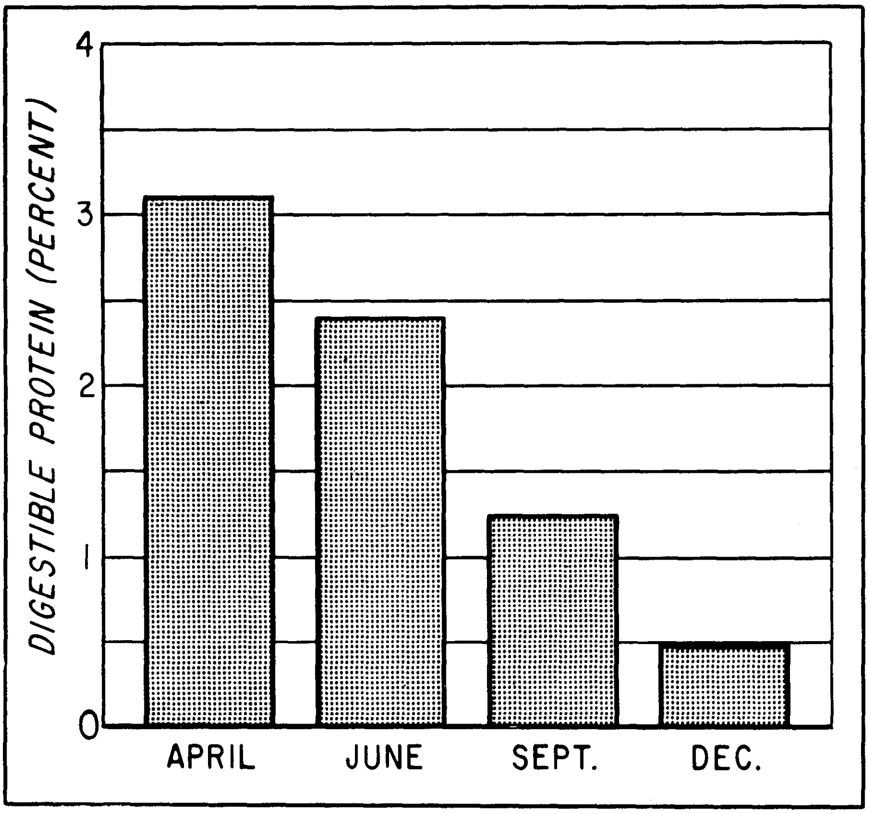

FIGURE 3. Native forage was deficient in digestible protein (crude protein based on 90 percent dry matter x percent of digestibility).

limited to the fall-winter period with good results (Halls and Southwell, 1956).

Summary

Chromic oxide was used as an index substance to estimate forage intake in April, June, September, and December, 1956, by five test cows grazing wiregrass-pine range in Georgia. Forage samples approximating the cattle diet were used to determine chemical composition and, with fecal samples, to determine digestibility of the native forage.

The data revealed a rather clearcut relationship between seasonal trend in nutritive value of the animal diet, amount of forage consumed, and weight changes of cows. Chemical composition of diet was influenced by season as well as kind of plants consumed. Digestion coefficients decreased gradually from April through September and dropped sharply in December. Average daily intake of forage was greatest in April, but even then was less than the suggested amount for optimum performance of lactating cows. By December, forage intake had dropped to less than one-half the suggested amount. Feed supplements high in digestible protein and energy were needed to offset nutrient deficiencies and low intake of native forage.

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Table 4. Daily intake of forage and of digestible nutrients by cows grazing native range.

Date of collection	Green forage (as fed basis)	Dry forage	Digestible nutrients[1] Protein	Ether extract X 2.25	Carbohydrates	T.D.N.
	— — —	— — —	— — — (Pounds)	— — —	— — —	— — —
April	56.40	20.46	.65	.43	7.76	8.84
June	50.91	19.58	.48	.17	7.21	7.86
September	41.04	18.48	.23	.05	6.88	7.16
December	22.32	11.66	.06	Negative	3.35	3.41

[1] Based on 90 percent dry matter content.

The Relationship Between Depth Of Planting And Maximum Foliage Height Of Seedlings Of Indian Ricegrass[1]

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Indian ricegrass (*Oryzopsis hymenoides* Roem. and Schult.) is a component of the deserts and plains flora. It is found throughout Nevada principally on well-drained soils at elevations from 4,000 to 7,000 feet but is most common on arid winter ranges in the southern part of the state. In some areas, it is an important constituent of the plant population and provides abundant nutritious forage when growing conditions are favorable (Figure 1).

Conservationists have recently shown an increasing interest in the use of Indian ricegrass in attempts at seeding arid ranges where crested wheatgrass is not well adapted. However, the literature reveals that little experimental seeding has been done with Indian ricegrass, perhaps because the hard, impermeable seed coat makes large-scale seedings with this species an uncertainty. Until a commercial seed source is available and the impermeable seed coat can be eliminated by the plant breeders or scarified in sufficient quantity, large scale seedings with this species will probably not be attempted.

Information concerning depth of planting as related to foliage height of Indian ricegrass seedlings seems particularly important before attempts are made to seed any sizeable acreage. During the spring of 1956, 1957, 1958, and 1960 excellent reproduction of Indian ricegrass occurred on deep sandy soil and provided an opportunity to study natural germination and growth of seedlings.

Procedure

The principal study location was 2 miles north of Fernley, Nevada, on a beach remnant of prehistoric Lake Lahonton. The soil is gravelly sand of very low fertility. Measurements of the depth of seed germination and maximum foliage height of the seedlings were recorded for approximately 250 seedlings each spring at the Fernley site. Another 250 seedlings growing on active sand dunes 25 miles east of Fallon, Nevada, were measured in 1958. The germinated seeds were exposed by careful excavation (Figure 2) and the depth of the seed below the soil surface and the maximum height of foliage was recorded for 1125 seedlings during 4 years of study.

One-hundred seedlings were located with small iron stakes and measured periodically to determine any changes occurring in the relationship of foliage height and depth of seed, and also, to determine longevity of seedlings.

In order to determine if increased soil moisture at deeper soil depths influenced quicker germination and more rapid elongation of the seedling, the following experiment was conducted. Seeds of Indian ricegrass were planted in the greenhouse at depths ranging to 80 mm. in a container 2 ft. by 10 ft. by 1 foot deep filled with sand from the Fernley site. The sand was kept moist throughout to determine if the same relationship between foliage height and depth of seed existed when moisture was not limiting.

Correlation and regression coeffecients and statistical significance for linearity of regression were determined for the meas-

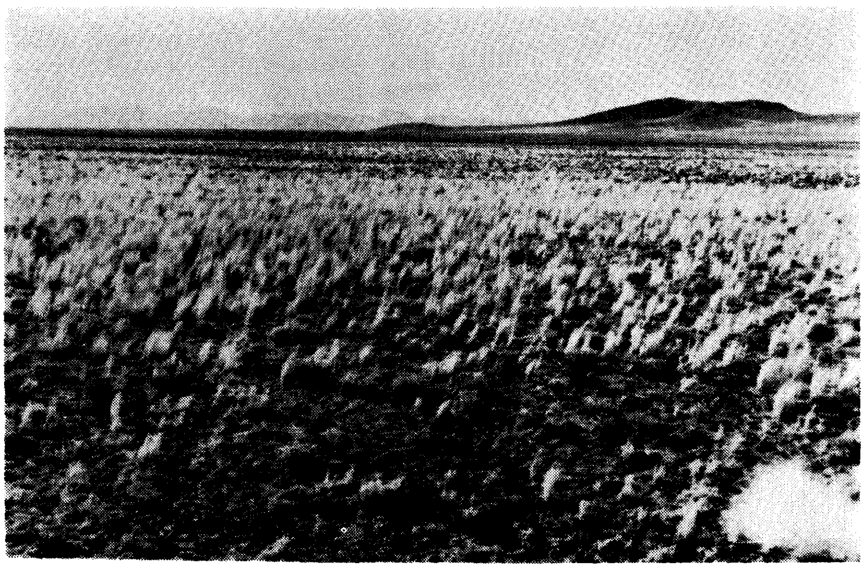

FIGURE 1. Large areas of arid western grazing lands support an abundance of Indian ricegrass when conditions are favorable.

[1] *Data contained herein were collected as a part of Nevada Agricultural Experiment Station Project 4 with land and facilities made available through the cooperation of the Truckee-Carson Irrigation District, Agricultural Research Service, and the Bureau of Land Management.*

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FIGURE 2. Seedlings were excavated to the depth of seed germination by carefully removing the sand or soil.

urements made each spring and for the total of all measurements.

Results and Discussion

Average depth at which seed germinated and height of foliage for all seedlings was 59.0 and 181.2 mm., respectively (Table 1). Height of foliage varied according to the particular growing conditions during early spring and the time of measurement and had no particular importance in the study reported here except as it related to the depth at which the seed germinated.

The correlation coefficient between depth of seed and height of foliage for the total of 1125 observations was r = 0.508 and was highly significant (Table 1, Figure 3). The positive correlation indicates that the most deeply planted seed produced foliage of greater maximum height and suggests that moisture in the deeper soil provides an advantage for deeper germinating seeds. However, a greenhouse experiment in which moisture was not a limiting factor at any depth showed also a significant and positive correlation between depth of seed and height of foliage. Moisture, therefore, apparently has little influence on the relationship between depth of seed and foliage height of seedlings but undoubtedly plays an important role in growth of Indian ricegrass after the seedling becomes established.

Seedlings from seed which germinated at lower depths in the sand had longer, more slender and delicate stems and leaves, such as etiolated seedlings might have, than the thick sturdy stems and more tillers of the seedlings from shallow planted seeds (Figure 4). The possibility that light or heat may inhibit the germination of seeds nearer the soil surface was not investigated. However, germination of seeds of some species is retarded or even prevented by light (Curtis and Clarke, 1950; Meyer and Anderson, 1952). Germination of lettuce seed is inhibited by light of certain wave lengths and is favored by light of other wave lengths (Flint and McAlister, 1935 and 1937). Germination of seeds of many members of the lily family is inhibited or retarded by exposure to light (Crocker, 1936). The possibility that germination of even the most shallow seeds (19 mm.) of Indian ricegrass was influenced by light appears doubtful. Perhaps some of the growth responses of Indian ricegrass were due to the phytochrome pigment which is known to influence photoperiodism and many other aspects of plant growth resulting in a general control of growth by light (Borthwick and Hendricks, 1960). These authors state that "in nature, the shoot from a deeply planted seed elongates until the food reserves are exhausted or until it reaches the surface and is exposed to light, which inhibits further lengthening."

In 1957, the depth of germinating seed and maximum foliage height of 100 seedlings were measured and marked with nearby iron stakes so that measurements might be taken periodically. Measurements made on April 26, 1957, of seed depth and foliage height were highly significantly correlated, r = 0.397 (Figure 5). Measurements were again made on May 27, 1957, but only 88 seedlings survived since the last measurement. Seed depth was assumed to be the same and foliage height increased from 171.8 mm. to 191.3 mm. The correlation coefficient for the May 27 measurements was r = 0.562 (Figure 5). Measurements of foliage height made a year later, April 30, 1958, of 71 surviving seedlings showed an even greater correlation, r = 0.736, with depth of germinating seed as measured earlier. In 1960, only 8 of the original plants remained alive. Increasing r valves with successive measurements suggest that those seedlings in which seed depth and foliage height are best correlated are the surviors. Sixteen, 32, and 54 percent of the variation in foliage height was due to variation in depth of seed of

TABLE 1. Average depth of seed and maximum height of foliage of Indian ricegrass when measured on dates indicated and correlation coefficients (r) between depth of seed and maximum height of foliage.

Date measured	Depth of seed, mm.	Height of foliage, mm.	Correlation coefficient
May 26, 1956	51.9 (22-79)[1]	144.1 (70-206)	0.431**
April 26 to May 10, 1957	53.1 (19-97)	187.1 (78-305)	0.588**
April 30, 1958	57.7 (25-92)	170.3 (74-252)	0.591**
May 10, 1958[2]	77.0 (28-141)	207.6 (95-361)	0.565**
May 12, 1960	62.3 (28-115)	150.8 (80-231)	0.478**
Average of all observations	59.0	181.2	.508**

**Indicates significance at the 1 per cent level of probability.

[1]Range of measurements in parenthesis.

[2]Measurements taken 25 miles east of Fallon, Nevada; all others at Fernley, Nevada.

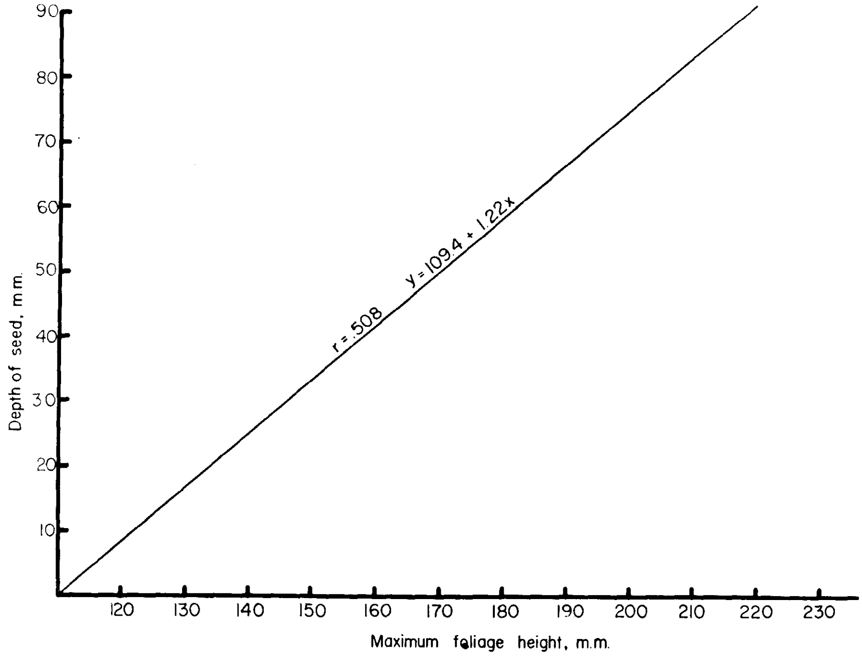

FIGURE 3. Regression line of maximum foliage height of Indian ricegrass seedlings as related to depth of germinating seed.

measurements made on April 26 and May 27, 1957, and April 30, 1958, respectively. The data suggest that depth of germinating seed has an increasing influence on foliage height as the seedlings become older.

Of the 1125 seedlings measured since 1956, 62.4 percent of the seed germinated at depths ranging from 41 to 70 mm. or from 1.6 to 2.8 inches (Table 2). Approximately 20 percent of the seed germinated in each of the ranges from 41 to 50, 51 to 60, and 61 to 70 mm. Below 41 mm. and above 70 mm. seed depth, germination and emergence were greatly reduced.

TABLE 2. Various depths and percent of total of germinating seed of Indian ricegrass under natural conditions on sandy soil.

Depth of germination, mm.	Percent of total germinating seeds
10 or less	0
11-20	0.4
21-30	3.2
31-40	11.2
41-50	20.0
51-60	22.0
61-70	20.5
71-80	11.0
81-90	6.3
91-100	2.4
100 or more	3.0

Summary and Conclusions

The depth of germinating seed and maximum foliage height of 1125 seedlings of Indian ricegrass has been measured since 1956. The seedlings were growing on sandy soils of low fertility under natural climatic conditions at Fernley and Fallon, Nevada. Correlation and regression coefficients and statistical significance for linearity of regression were determined to learn the influence of depth of germinating seed on maximum foliage growth.

A positive and highly significant correlation was found to exist between depth of seed and maximum foliage height. Results indicate that deeper seeds have an advantage, perhaps better moisture, for germination and growth over seeds planted shallow. However, greenhouse studies indicate the same relationship exists when moisture is ample at all soil depths. The presence or absence of soil moisture undoubtedly plays a prominent role in growth after the seedling becomes established.

The long, slender, delicate seedlings from seed at deeper depths suggested that light or

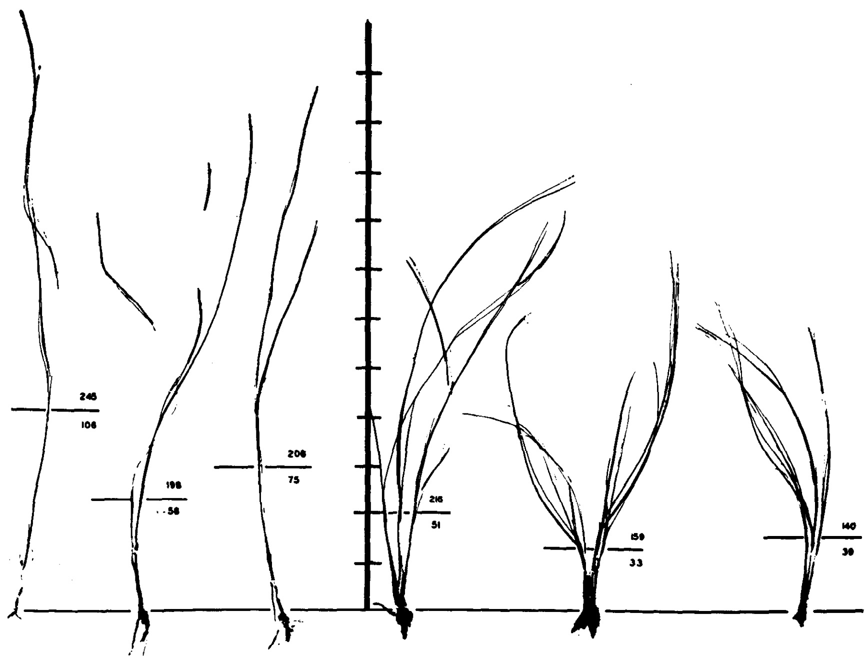

FIGURE 4. Three seedlings on the left illustrate the growth response to deeply planted seeds; seedlings on the right developed from seed planted shallow. Short horizontal lines indicate the soil surface. Average depth of seedlings on the right was 41 mm. and average maximum height of foliage was 172 mm.; on the left, average depth was 80 mm. and average height 217 mm. Scale in the center in inches.

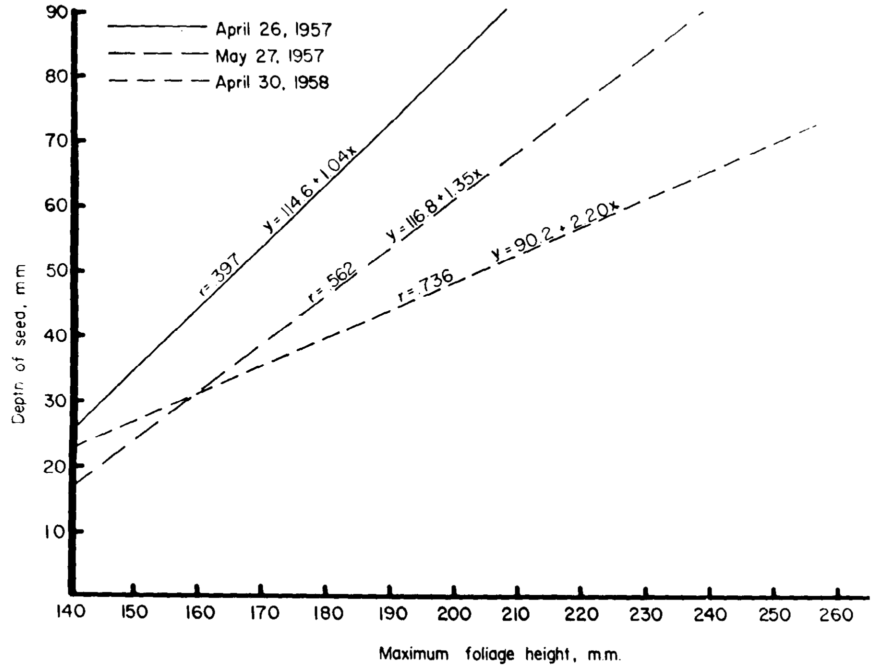

FIGURE 5. Regression lines of maximum foliage height of 100 marked Indian ricegrass seedlings as related to depth of germinating seed when measured on April 26 and May 27, 1957, and April 30, 1958.

heat may inhibit germination at shallow depths. However, this assumption was not investigated.

Correlation coefficients of depth of seed and height of foliage of 100 marked seedlings measured on April 26 and May 27, 1957, and again on April 30, 1958, were r=0.397, 0.562, and 0.736, respectively. Of the 100 original seedlings, 88 percent survived on May 27 and 71 percent on April 30.

As the seedlings became older, depth of seed had more influence on maximum foliage height. For instance, when the seedlings were first measured on April 26, 16 percent of the variation in foliage height was due to variation in depth of seed. On May 27, 1957, and April 30, 1958, the values were 32 and 54 percent, respectively. Seedlings in which depth of seed and foliage height were best correlated were the survivors of the original 100 seedlings.

Average depth of seed of all seedlings measured was 59.0 mm. or 2.3 inches. Sixty two percent of the seed germinated between depths ranging from 1.6 to 2.8 inches. When seeding Nevada's arid southern rangelands to Indian rice grass, planting the seed at this range of depths has distinct advantages: (1) the seed is placed nearer the limited soil moisture and (2) away from high soil surface temperatures common on southern desert ranges. However, seedlings from seed planted deep are slender and delicate compared to more tillers and thick, sturdy stems of seedlings of shallow planted seed.

Recommendations for most grass species state the seed should be planted at depths of one-fourth to one-half inch. Few grass species can be planted deeper than 1 inch and produce a crop. Indian ricegrass seed is unique in that the majority of seed will germinate and emerge from depths up to 3 inches in a sandy soil providing distinct advantages in seeding arid ranges which have loose, sandy, well-aerated soils.

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Burning and Grazing Increase Herbage on Slender Bluestem Range

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This paper describes how prescribed burning, in combination with cattle grazing of various intensities, affected grass production, utilization, and litter accumulation in the bluestem-longleaf pine type. The study was conducted on open grassland of the Palustris Experimental Forest in central Louisiana. Most of the longleaf pines had been cut over 20 years previously.

Prior to 1951, the area had been burned every 2 or 3 years during winter or early spring according to local custom of removing litter and hastening new grass growth.

Grasses constitute over 90 percent of the herbaceous cover. Slender bluestem *(Andropogon tener)* and pinehill bluestem *(A. divergens)* rank first and second as the principal forage plants and are the key management species. Slender bluestem is most abundant on treeless flatlands that have been grazed intensively and burned frequently. It matures early—usually by mid-June. Repeated close grazing is necessary to prevent the formation of wiry, persistent flower stalks and to prolong the period of palatability (Figure 1). Pinehill bluestem is more prevalent under longleaf pine timber stands and on cutover, sandy hills. It produces less herbage than slender bluestem but matures later and is more palatable.

Other grasses contributing significant quantities of forage are the panics *(Panicum* spp.), paspalums *(Paspalum spp.)* and miscellaneous bluestems, including fineleaf bluestem *(Andropogon subtenuis)*, paintbrush bluestem *(A. ternarius)*, Elliott bluestem *(A. elliottii)*, and big bluestem *(A. gerardii)*. Carpetgrass *(Axonopus affinis)* is the principal invading perennial grass.

Grassleaf goldaster *(Chrysopsis graminifolia)* and swamp sunflower *(Helianthus angustifolius)* are the most common perennial, broad-leaved herbs. Grasslike plants include pinehill beakrush *(Rhynchospora globularis)*, and several species of *Carex* and *Cyperus.*

Shrubs and deciduous trees are sparse. Important species include blackjack oak *(Quercus marilandica)*, southern wax myrtle *(Myrica cerifera)*, shining sumac *(Rhus copallina)*, and blackberry *(Rubus* spp.).

Soils are deep, medium textured, and slowly permeable to very slowly permeable. Surface drainage is generally good.

Annual precipitation averages about 58 inches, with about 36 inches occurring during the growing season—March through October. Summer droughts of 4 to 8 weeks duration are fairly common.

In February 1952, eighteen 1/3-acre paddocks were installed on a range burned by wildfire the previous year. From 1952 through 1959, 6 paddocks were grazed heavily and 6 moderately, while 6 were ungrazed (Figure 2). Moderate grazing was aimed at utilizing about 40 percent of the herbage. Cows were in paddocks intermittently for a total of about 15 animal days during the 130-day grazing season. For heavy grazing the number of animal days was doubled.

In January 1955, 6 paddocks were burned by slow-moving backfire, and in March, 6 were burned by free-running headfire. The remaining 6 were left unburned. The 9 grazing-burning treatments were replicated twice.

Grass production was measured at the end of each growing

FIGURE 1. Ungrazed, cutover bluestem-longleaf pine type on which slender bluestem is the principal species.

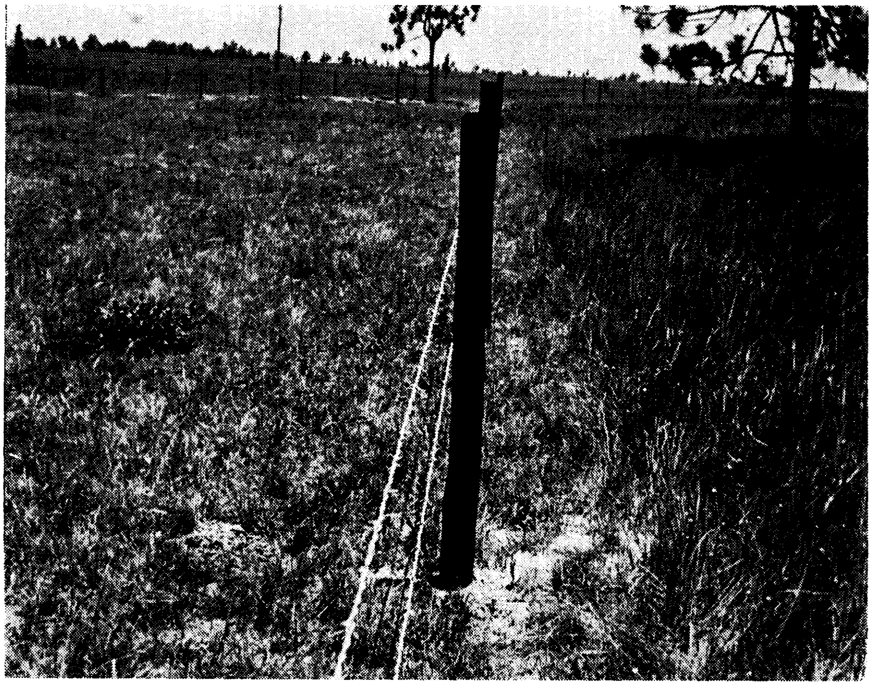

FIGURE 2. Fenceline contrast showing degree of utilization immediately following a grazing period, heavily grazed range (left), ungrazed range (right).

season on four 3.1- by 3.1-foot clipped quadrats per paddock. Quadrats in the grazed paddocks were protected by wire cages. Residual grass herbage was determined by clipping 16 quadrats in each grazed paddock. Quadrats were relocated each year. Grass utilization was the difference between residual and total production. Litter was hand-separated from current production on all quadrats.

Forage Utilization

Over the 8 years, cattle removed an average of 47 percent of the total grass growth from the moderately grazed paddocks and 67 percent from the heavily grazed (Figure 3). Year-to-year variations in rainfall and the difficulty of estimating utilization interfered with the goal of 40-percent removal under moderate grazing. Annual fluctuations in utilization were less under heavy than under moderate grazing.

Indicated average forage intake was 34 pounds (air-dry) per animal-unit day under moderate grazing. Cows in the heavily grazed paddock were forced to eat less palatable plants and plant parts, and consumption was only 27 pounds per day. Greater deposits of excreta on the heavily grazed range may also have lowered forage palatability. The difference in consumption is in general agreement with the findings of Pieper *et al.* (1959), who reported that intense grazing reduced daily dry-matter consumption as much as 25 percent.

Grass Production

In the fall of 1952, there was little difference in grass production among grazing treatments. Yields averaged about 2,800 pounds (air-dry) per acre and varied from 2,645 pounds on ungrazed paddocks to 2,925 pounds on those grazed heavily. However, wide differences between grazed and ungrazed paddocks were apparent 2 years later. Over the entire study, grazed paddocks produced significantly more than ungrazed, and the heavily grazed yielded significantly more than the moderately grazed (Figure 4).

The late winter and early spring burning of 1955 markedly increased grass production on ungrazed range but not on grazed. There were no important differences in yields between paddocks burned by backfire in January and those burned by headfire in March. The beneficial effect of burning the un-

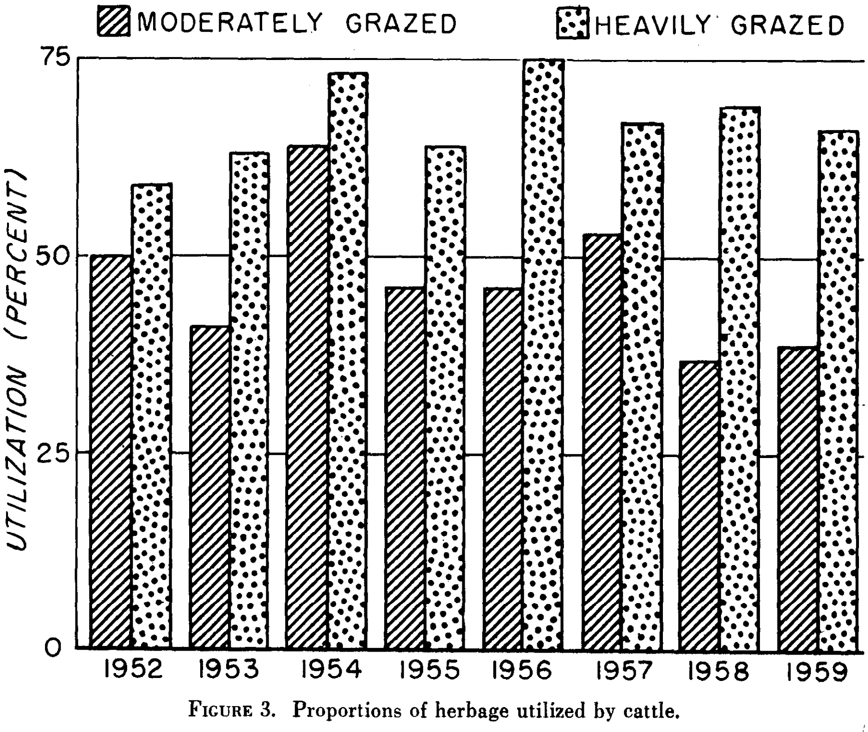

FIGURE 3. Proportions of herbage utilized by cattle.

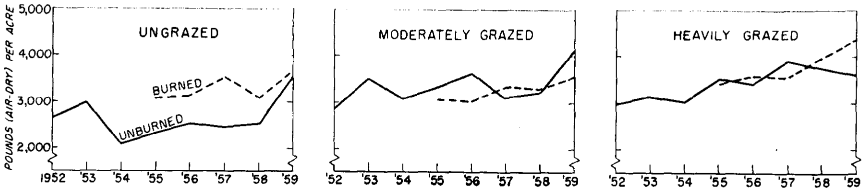

FIGURE 4. Grass production under three grazing intensities.

grazed paddocks lasted through 1958 (Figure 4).

The results illustrate the ability of slender bluestem to make regrowth despite repeated herbage removal. In this respect it reacts quite differently from grasses reported by Albertson *et al.* (1953), Newell and Keim (1947), and Tomanek and Albertson (1953). In the South, Halls (1957) reported that grazing decreased yields on annually burned wiregrass-pine ranges. Cassady (1953) found that close clipping of bluestem-longleaf pine range at 2-week and 4-week intervals for 3 years depressed production, but the effects of long-term clipping were not studied.

Litter Accumulation

On unburned range, the amount of litter was directly related to grazing intensity. Ungrazed paddocks averaged 5,300 pounds per acre, while moderately grazed and heavily grazed paddocks averaged 2,340 and 1,240 pounds, respectively. These differences were highly significant.

Burning ungrazed range reduced litter from about 5,000 pounds per acre in early 1955 to 3,190 pounds one growing season later. On moderately grazed range, the reduction was from 2,400 to 1,690 pounds. Three growing seasons after burning, litter in ungrazed or moderately grazed paddocks had regained the preburning levels.

Under heavy grazing, burning had little influence on litter weight but changed litter composition. Prior to burning, about 35 percent of the litter consisted of residue from prior years. One growing season later, litter was composed entirely of new herbage.

Similar results have been reported by Wahlenberg *et al.* (1939), who found that slender bluestem was highly susceptible to smothering by litter, and by Ehrenreich (1959), who noted that litter on protected native prairie retarded plant growth.

Practical Application

Moderate grazing is preferable on bluestem-longleaf pine ranges. Though heavy grazing may increase herbage yields, it is likely to damage forest regeneration and lessen the vigor and survival of some forage species. It may also impair soil and hydrologic conditions. Moderately stocked ranges are more likely to have a reserve of forage during droughts and for winter grazing.

Preventing large accumulations of herbaceous litter is apparently the key to high herbage yields. Ranges that have been ungrazed for several years should be burned before they are stocked with cattle. On lightly grazed ranges, burning on a 3- to 4-year cycle will help maintain high yields. Where grazing is moderate to heavy, burning does not appear to benefit herbage production.

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SEXTON LIVESTOCK MAN OF THE YEAR

J. Kenneth Sexton, member and past chairman of the California Section, ASRM, has been named Livestock Man of the Year by the San Francisco Chamber of Commerce.

Ken is a 1923 graduate of the University of California and has been nationally prominent in livestock affairs for many years. In association with his two sons and Glen Eidman, he operates three ranches in Glenn County.

Occurrence and Toxicology of Selenium in Halogeton and Associated Species[1]

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Seleniferous soils occur throughout extensive areas in the western United States, Canada, and Mexico. In the semiarid regions of the Great Plains and Rocky Mountains where annual precipitation is 20 inches or less, many soils contain sufficient quantities of selenium to produce plants high in selenium.

Halogeton glomeratus (M. Bieb.) C. A. Mey., first identified in the United States during the mid-thirties, did not invade the seleniferous areas of Wyoming and eastern Utah until after most of the mapping of seleniferous soils and analyses of flora indigenous to these regions had been completed. Therefore, this species had not been studied for its ability to accumulate selenium or the effect such accumulation might have on its toxicity to sheep. In addition, no studies had been conducted to determine whether sheep would be more adversely affected by consuming both halogeton and selenium-bearing species. Ingesting both seleniferous species and halogeton would involve intake of two separate and very toxic compounds.

Halogeton is poisonous to livestock, especially sheep, because of its high soluble oxalate content. The leaves of this annual may contain over 20 per cent soluble oxalates (dry weight) after June 15, and more than 30 to 35 percent soluble oxalates by mid-October. The soluble oxalate content of the whole plant varies during the season but may reach 16 to 18 percent when the plant is fully mature.

Highly seleniferous soils in Utah occur principally in the east central area of the state. Soils derived from the Morrison formation of the Jurassic system and the Mancos formation of the Cretaceous system are high in selenium and usually support a variety of seleniferous plants wherever outcrops occur. Many of these plants are utilized as forage by livestock. The Morrison is widely exposed in an area southeast of Thompson, Utah, and immediately east and northeast of the Arches National Monument. Here the Salt Wash Sandstone member of the formation forms the so-called "poison strips" which contain such high levels of selenium that nearly all vegetation rooted there is seleniferous. Trelease and Beath (1949) reported numerous losses of cattle and sheep from selenium poisoning in this area. The Mancos Formation is exposed in the vicinity of Cisco, Utah, and highly seleniferous indicator species are prevalent on derived soil. Indicator plants are species of certain genera which absorb large quantities of selenium and thrive only on seleniferous soils (Trelease and Beath, 1949).

The invasion of halogeton east of the Wasatch Mountains in Utah has to date been limited principally to the Uinta Basin and an area adjacent to U. S. Highway 50 from Price, Utah, to Grand Junction, Colorado. The spread of halogeton over the seleniferous areas from Green River to Cisco, Utah, and south of Thompson was accelerated in part by the extensive uranium boom during the 1940's and early 1950's. Construction of new roads and disturbance of the soil by prospectors and miners created an ecological situation favorable for invasion by halogeton. Today, halogeton is widespread throughout the mining area and may be found in dense stands on deposits of ore waste, at mine entrances, along the borders of roads, and in washes. It is still generally confined to disturbed sites in the Yellow Cat Mining District and has not yet invaded the surrounding desert.

The research reported was initiated to study the ability of halogeton to absorb selenium and to determine the effect of the combination of selenium and soluble oxalates on sheep.

Methods

Greenhouse

Halogeton seeds were germinated in sand on a greenhouse bench. After germination, the sand was kept moist with a 1:4 dilution of Hoagland's nutrient solution. A 0.001 M solution of NaCl was added to the sand to stimulate vigorous growth (Williams, 1960). When the first leaves appeared, two plants were transferred to one-gallon polyethylene containers with full-strength Hoagland's solution, 0.01 M NaCl, and 0, 2, 4, and 8 ppm of selenium as Na_2SeO_4. There were six replications per treatment. Each container was aerated continuously via a capillary tube from a 1/6-HP pump.

The solutions were replaced every two weeks. The plants were harvested at the end of six weeks and divided into leaf and stem fractions. These fractions were weighed fresh, and then divided into two samples of equal weight. One sample was digested immediately in HNO_3 and H_2SO_4 with HgO fixative; the other was dried at 60 degrees

[1] *Cooperative investigation of the Crops Research Division and Animal Disease and Parasite Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Utah Agricultural Experiment Station.*

C for 24 hours. Both samples were analyzed for selenium (Lepper *et al*, 1950). A fraction of the leaf sample was analyzed for soluble oxalates (Dye, 1956).

Plant Collections

Five sites were chosen for study: 6.5 miles west of Green River, ½ mile north of Crescent Junction, 1 mile east of Thompson, 1 mile west of Cisco, and 11 miles southeast of Thompson near the Yellow Cat mine. The first four sites were adjacent to Highway U.S. 50.

Halogeton was collected at these sites between the 14th and 16th of the month beginning in June and ending in November. In addition, samples of fourwing saltbush, *Atriplex canescens* (Pursh) Nutt., milk vetch, *Astragalus preussii* A. Gray, and dropseed, *Sporobolus flexuosus* (Thurb.) Rydb. were collected occasionally.

Two 50-gram fresh samples of halogeton leaves (and later flowers, sepals, and seeds) and two 25-gram samples of stems were collected. One sample was placed in a cardboard container and oven-dried at 60 degrees C upon return to the laboratory. The other sample was immediately placed in a pint polyethylene bottle containing 100 ml HNO_3, 50 ml H_2SO_4, and 10 ml of a fixative solution containing 1 gram of HgO. These methods were used to determine the volatility of selenium in halogeton. In many plants, particularly those which absorb large quantities of selenium, a considerable portion of the element is lost through volatilization by air and oven drying. This error is minimized when fresh material is digested upon harvest. The Hg in the digestion solution prevents loss of selenium by combining with this element to form a nonvolatile compound. The digestion mixture was prepared in the laboratory. The fixative was prepared separately and added to the acid in the field just before the addition of the plant material.

Table 1. Dry weight and selenium and soluble oxalate contents of halogeton grown in nutrient solution containing 0, 2, 4, and 8 ppm selenium.

Sample	Selenium added	Dry weight per plant	Selenium in		Soluble oxalates
			Digested sample	Oven-dried sample	
	ppm	mg	ppm	ppm	Percent
Leaves	0	210	0.0	0.0	14.9
Leaves	2	190	70.7	55.4	13.5
Stems	2	90	27.8	14.5	......
Leaves	4	190	128.2	126.7	12.4
Stems	4	70	129.8	79.2	......
Leaves	8	140	500.2	229.7	9.0
Stems	8	60	264.8	207.8	......

The same procedures were used for collection and analysis of the other species except that the terminal 4 inches of branches and leaves of milk vetch and fourwing saltbush was analyzed and whole plant samples were taken of the dropseed.

The leaf or the leaf-seed-sepal fraction of halogeton was analyzed for soluble oxalates to determine whether uptake of selenium affected the amount of soluble oxalates which would be formed. Soil samples 1 to 12 and 12 to 24 inches in depth were taken for selenium analysis at Yellow Cat and Cisco at the site of maximum halogeton infestation.

Precipitation from January 1 to October 15, 1959, measured only 2.83 inches at the weather station at Green River. Of this, only 0.3 inch fell between April 19 and August 18.

Sheep Feeding Experiments

Halogeton containing 15.3 percent soluble oxalates and 11 ppm selenium was harvested 1 mile west of Cisco, Utah, in September, 1959. *Astragalus preussii* and *Atriplex canescens* containing 2044 ppm and 295 ppm selenium, respectively, were collected in August near the Yellow Cat mine. Nonseleniferous halogeton was collected west of Snowville, Utah. The plant material was dried at 60 degrees C, ground to a 20-mesh powder, and stored in airtight polyethylene containers and bags.

Nine rumen-fistulated ewes 3 to 5 years old were divided into 3 groups of 3 each. Halogeton was fed to all animals at a level to provide a daily dose of 847 mg of soluble oxalate per kg of body weight.

Group one was fed seleniferous halogeton which provided 0.061 mg selenium per kg of body weight daily. Group two received nonseleniferous halogeton and sufficient seleniferous milk vetch to provide a daily dose of 0.167 mg of selenium per kg of body weight. Group three was fed nonseleniferous halogeton and enough seleniferous fourwing saltbush to provide a daily dose of 0.344 mg of selenium per kg of body weight.

Selenium occurs in the organic form in species of *Astragalus* but in species of *Atriplex* it is primarily of an inorganic type (Beath and Eppson, 1947).

The ingestion of organic selenium by laboratory animals caused a higher accumulation of selenium in the tissue with less excreted in the urine than did ingestion of the inorganic form (Smith, Westfall, and Stohlman, 1938).

All animals were fed ½ pound of rolled barley each morning and given free access to good quality alfalfa hay until they had a normal fill. They were then fed the respective plants through a plastic rumen fistula apparatus daily for 30 days. Blood calcium and blood urea nitrogen levels were determined on each animal just before the

Table 2. Selenium content of dry tissue of *Halogeton glomeratus, Atriplex canescens, Sporobolus flexuosus,* and *Astragalus preussii* collected in eastern Utah, June to November, 1959.

Sample	Site	June	July	Aug.	Sept.	Oct.	Nov.
		— — — — — — (ppm) — — — — — —					
Halogeton							
Leaves	Cisco	0.5	35.0	3.3	11.1	6.6	0.5
Stems	Cisco	0.3	6.1	0.6	0.9	6.1	0.9
Leaves	Yellow Cat	8.9	2.4	0.3	1.9	5.4	0.0
Stems	Yellow Cat	3.0	1.8	0.3	2.2	9.0	0.9
Leaves	Thompson	6.4	1.2	2.2	1.8	2.1	0.5
Stems	Thompson	1.2	1.8	1.0	0.5	1.8	0.0
Leaves	Green River	0.9	0.8	0.9	2.9	3.4	0.5
Stems	Green River	3.1	1.3	0.0	0.3	0.0	0.0
Leaves	Crescent Junction	0.3	0.0	2.0	0.0	0.0	0.0
Stems	Crescent Junction	0.2	0.2	0.5	0.0	0.0	0.0
Sporobolus	Yellow Cat	2.4	....	4.0	....	....	....
Atriplex	Yellow Cat	102.4	....	1014.2	382.5	....	....
Astragalus	Yellow Cat	1332.0	....	564.7	1853.9	....	....

beginning of the feeding trial and once each week throughout the feeding period, with the final test before death. Data by Binns and James (1960) indicated that neither clinical symptoms nor fatalities occurred during a 90-day feeding period at sublethal levels of either selenium or halogeton fed separately to different animals maintained on a medium protein diet.

Results

Symptoms of selenium toxicity have never been reported in plants growing under natural conditions regardless of the availability or content of the selenium in the soil. Symptoms of toxicity are common, however, when sodium selenate or sodium selenite is added to greenhouse soils or nutrient cultures. The most obvious symptoms are reduced vigor and size and varying degrees of chlorosis. The addition of sodium selenate to nutrient solution in which halogeton was growing resulted in these symptoms. As shown in Table 1, the dry weight of the stems decreased with each increase in selenium. Leaf dry weight was not seriously affected until the concentration of selenium reached 8 ppm. Soluble oxalate content became lower with each additional level of selenium. Slight chlorosis was noted in halogeton grown in the solution containing 8 ppm selenium.

The plant tissue was carefully examined after harvest for any selenium odor but none was detected in the fresh material. After drying, the characteristic garlicky odor of selenium was faintly detectable. The odor was intensified and easily detected when the leaf tissue was ground to a powder preliminary to analyzing for oxalates. It would therefore appear to be very difficult to detect seleniferous halogeton in the field through odor. Halogeton is not likely to have 500 ppm in the field and the characteristic sour odor in the leaves tends to mask what odor of selenium might be present.

The analyses for selenium (Table 1) show that a considerable portion of the selenium present may be lost through drying and indicates the merit of immediate digestion of fresh samples.

The selenium content of halogeton collected in eastern Utah was low (Table 2). The highest selenium content was found at Cisco. All analyses except 2 yielded less than 10 ppm selenium in the leaves and stems. Samples of leaves taken in August, 1958, however, yielded 90 ppm at Cisco, 95 ppm at Yellow Cat, 20 ppm at Crescent Junction and Green River, and 10 ppm at Thompson. That year was favorable for good growth because of near normal precipitation in the area. Selenium concentration decreased rapidly in November after the death of the plants.

The low selenium accumulating power of halogeton is further shown in that milk vetch and fourwing saltbush growing near halogeton accumulated much higher concentrations of this element. The digestions of samples in the field was decidedly advantageous for these species but little or no difference was apparent in halogeton because of the very low selenium concentration. Data in Table 2 are from samples digested in the field.

The selenium content of the soil from the Salt Wash near Yellow Cat ranged from 0.6 to 0.8 ppm at the 10 to 12-inch level, and from 1.1 ppm to 1.5 ppm at the 12 to 24-inch level. At Cisco, selenium content averaged 4.2 ppm in the surface 12 inches and 2.9 in the 12- to 24-inch sample. The findings at Cisco compare favorably with soil analyses reported by Beath (1943) for this general area. In the Morrison alluvium, however, he reported a selenium content of 35 ppm in the 1- to 12-inch layer and 82 ppm in the 12- to 24-inch layer. The difference apparently results from the soil types and sites studied. Our samples were taken from very sandy deposits at the bottom of the wash. This area is subject to periodic flooding, and one would therefore expect much of the selenium to be leached. Since halogeton infestations were confined to these sandy deposits, soil samples were taken only from these particular sites.

The soluble oxalate content of the leaf-seed-sepal fraction of halogeton collected at sites in eastern Utah was similar to that found in halogeton collected on nonseleniferous soils by Williams (1960). The almost pure leaf sample from Cisco collected in

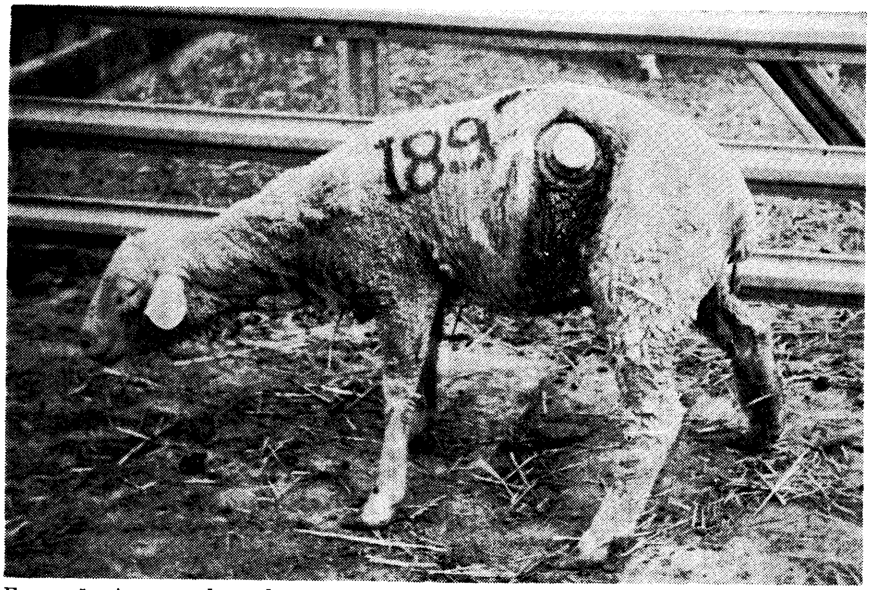

FIGURE 1. Acute oxalate-selenium poisoning in a ewe fed nonseleniferous halogeton and seleniferous fourwing saltbush. The head dropped, the hindquarters were stiff, and respiration was 130 to 140 vs a normal of 70 to 80.

November contained 38.3 percent soluble oxalates. This was among the highest concentrations of this compound ever found in Utah by the authors.

Sheep Feeding Trials

The blood calcium and urea nitrogen concentrations shown in Table 3 are those taken May 23, one day preceding the beginning of the feeding experiment, and June 22, the day the feeding was terminated. The final samples from the 4 animals which died during the 30-day feeding trial were obtained at the time of death.

One ewe fed seleniferous halogeton died 7 hours after feeding on the 5th day. Total selenium administered up to time of death had been only 20.15 mg. The pathology was unusual in that necropsy revealed symptoms typical of oxalate poisoning; but blood calcium concentration was 9.4 mg per 100 ml of serum which, while below normal, was much higher than the level associated with acute hypocalcemia. It would be difficult to assess the role of the small quantity of selenium present. Blood urea nitrogen was normal.

Two of the 3 ewes fed seleniferous fourwing saltbush and nonseleniferous halogeton died (Figure 1). The first ewe died on the 15th day of the feeding trial after receiving 237 mg of selenium and the second died on the 27th day after ingesting 470 mg of selenium. Pathological examination revealed discoloration, swelling, and congestion of the kidneys and liver. The lungs were marked by large areas of hepatization, passive congestion, and atelectasis. Heart muscles were flaccid, but no hemorrhages were present. The abdominal cavity contained about a quart of clear fluid. Blood calcium was 8.0 and 8.6 mg per 100 ml of serum at the time of death. Again, the blood calcium was not at a level which should result in hypocalcemia. It seemed that an interraction occurred which produced acute toxicity without typical hypocalcemia. Moderate to severe injury to the liver and kidneys was indicated. Blood urea nitrogen concentration was 22.8 and 35.5 mg per 100 ml of blood plasma. Normal range for sheep is 8 to 20 mg per 100 ml of blood plasma.

One ewe died after receiving 187 mg of selenium in milk vetch plus nonseleniferous halogeton over a 22-day period. Petechial hemorrhages occurred in the lungs, the heart was flaccid, with a slight swelling and mottling of the liver. No excess fluid was found in the peritoneal cavity, but hypocalcemia was marked with 4.9 mg calcium per 100 ml of serum. Blood urea nitrogen increased to 43.3 mg per 100 ml of plasma which indicated an increase in blood urea nitrogen from disfunction of the kidneys.

The remaining animals were sacrificed at 33 days. Swelling and mottling of the liver were present in each case. Kidney abnormalities were found in one ewe fed seleniferous milk vetch and halogeton and one which had been fed seleniferous fourwing saltbush and halogeton. Blood

Table 3. Blood calcium and urea nitrogen levels in 100 ml of blood plasma of sheep fed sublethal concentrations of soluble oxalates and selenium for 30 days.

Group and sheep no.	First sample		Final sample		Remarks
	Ca	Urea N	Ca	Urea N	
	— — — (mg) — — —				
Seleniferous Halogeton					
176	13.0	6.1	9.4	11.2	Died May 28
146	13.8	14.0	12.3	17.3	Killed June 25
180	14.2	10.3	12.3	14.9	Killed June 25
Atriplex and *Halogeton*					
175	13.6	10.3	11.7	10.3	Killed June 25
185	13.7	14.9	8.6	22.8	Died June 19
189	13.5	11.2	8.0	35.5	Died June 7
Astragalus and *Halogeton*					
160	14.3	12.1	11.7	9.3	Killed June 25
142	13.5	11.7	11.5	8.4	Killed June 25
153	13.1	6.5	4.9	43.3	Died June 15

calcium and urea nitrogen levels were normal.

Death of the experimental animals during the first 30 days was considered to be primarily due to respiratory and heart failure induced partly by extensive impairment of the liver and disfunction of the kidneys. Necropsy revealed pathological changes in the liver, lungs, heart, and kidneys characteristic of oxalate and selenium poisoning (Cook and Stoddart, 1953; Dudley, 1936; Rosenfeld and Beath, 1945). The kidneys, liver and lungs are primarily the target organs in selenium poisoning, whereas the kidneys are most severely affected in halogeton poisoning. When the normal pathways for detoxification and elimination are reduced, a sustained sublethal dosage will result in steadily increasing concentration of oxalates and selenium within the tissues.

Discussion

Halogeton is one of the many plant species which have a very low accumulating power for selenium. The inability of halogeton to absorb sizable quantities of this element is further stressed by the analyses of milk vetch and halogeton which grew adjacent to each other in the poison strips near the Yellow Cat mine. In one instance, a robust halogeton plant rooted in alluvium near the bottom of the wash contained 1.8 ppm selenium while milk vetch growing 20 inches away contained 385 ppm. Milk vetch rooted on ore waste near the entrance of an abandoned mine yielded 2378 ppm selenium, while an exceptionally large plant of halogeton 3 feet away on the same ore deposit contained only 2 ppm.

Sheep feeding experiments by Cook and Stoddart (1953) have indicated that symptoms of oxalate poisoning did not become apparent until blood calcium level dropped to about 7.4 mg per 100 ml of blood. Fatalities are seldom encountered until the calcium drops below 7, but no recoveries can be expected when the calcium concentration reaches 6.2 mg per 100 ml or below.

Rosenfeld and Beath (1945) reported that sheep excreted more selenium in the urine when they were fed a medium and high protein diet as compared with a low protein diet. The elimination of selenium decreased as kidney damage increased. They also found that selenosis did not become apparent in the medium and high protein group until 860 mg of selenium had been administered, whereas symptoms appeared after the ingestion of only 360 mg in sheep on the low protein diet. Since our experiments utilized a medium protein diet, the quantity of selenium ingested by the 4 sheep which died was far below that reported as necessary to produce symptoms of selenosis.

The work reported herein indicated, with the exception of one death from acute hypocalcemia, that the majority of the animals died from the combined effects of oxalate-selenium poisoning. The liver and kidneys appeared to be more severely affected when selenium and oxalates were fed in combination rather than when they were fed separately. As the ability of these organs to eliminate the poisonous substance decreases, the lethal dose of either selenium or soluble oxalates required also decreases. Thus, when soluble oxalates and selenium were fed in combination, the acute stage of intoxification was achieved in at least some of the experimental animals at levels which, if administered separately, would have resulted in no external symptoms.

The occurrence of small quantities of selenium in halogeton is not considered of great importance on the range. The very rapid decrease in the selenium following the death of the plant would remove any danger of this element from practical consideration. Oxalate content, however, usually remains high well into the winter. If conditions prevailed under which the selenium content in halogeton exceeded 60 to 70 ppm, the selenium-oxalate concentration would then equal that of the fourwing saltbush and nonseleniferous halogeton used in the experiment.

The ingestion of moderate amounts of halogeton and selenium-bearing plants could result in increased losses of sheep on ranges where both types of plants occurred. The extent to which this problem would exist would depend upon range condition and the protein content of the diet. Since both halogeton and selenium-bearing plants are unpalatable, little or no poisoning would likely be anticipated under good range conditions. As range condition deteriorates and these plants constitute a greater part of the available forage and general diet, one might expect greater losses where both plants occurred than if only one type were present. There is no evidence to indicate that any losses of sheep poisoned by both halogeton and seleniferous plants have occurred. Because of the similarity of symptoms characteristic of each type of poisoning, it is doubtful that field evaluation would be possible without a complete necropsy and laboratory examination of tissues.

Summary

The selenium content of halogeton collected from seleniferous soils in eastern Utah ranged from 0 to 95 ppm. Maximum selenium concentration was usually less than 10 ppm.

Halogeton grown in nutrient cultures containing 8 ppm selenium as sodium selenate accumulated 500 ppm selenium in the leaves. Both dry weight and soluble oxalate content were reduced at this concentration.

Growth and oxalate content were not affected by selenium accumulation in the field.

Sublethal doses of selenium and soluble oxalates administered daily to sheep were more toxic than when each was fed separately. The increased toxicity resulted from a more rapid and severe injury of the liver, lungs, and kidneys. Necropsy of sheep which died during the feeding trials indicated pathology characteristic of both selenium and oxalate poisoning. Death was attributed directly to acute hypocalcemia in only one case. No symptoms of poisoning occurred in sheep fed only soluble oxalates or only selenium for 90 days at comparable dosages.

Except under unusual circumstances, halogeton is unlikely to contain enough selenium to increase its toxicity. Where range condition is so poor that halogeton and seleniferous species constitute an unusually high proportion of the diet, losses among sheep may be more severe when both types of plants are eaten together.

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Conservation and Common Sense

RUSSEL WEEKS
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I've often wondered what I would be doing today if I hadn't swung into conservation-ranching 20 years ago. One thing sure, I wouldn't be raising cattle.

Looking back over the years, I figure I've had as many tough range problems to whip as most ranchers. One of the things I've learned along the way is that it takes more than home-spun, hand-me-down methods to make it in the highly competitive cattle business. I've found it helps to work out my problems with range technicians like Tom Turner of the Wells, Nevada office of the Soil Conservation Service. So instead of plodding along by dead reckoning, I use the conservation range plan that Tom and I worked out together. My long range goal is to step up calf production and my conservation plan is helping me do this.

Driving through Clover valley in the Clover Soil Conservation District, things look pretty much as they did when I came here in 1916. Cattle look a little beefier and you see fewer dry cows. Two and three year old steers aren't around either. More calves come in the spring now. Years back they came the year around and were all sizes.

My ranch produces nearly twice the weight of feeder cattle at sale time each year than 20 years ago. If it didn't, I would be out of business. I couldn't operate profitably with increased costs, labor and taxes building up my overhead.

Except for a few irrigated areas, Nevada is largely feeder cattle country. Our grandfathers

raised two- and three-year old steers, but our fathers had trouble selling that kind, so sold mostly yearlings. Now with cheap grain for feeders, calves bring five cents a pound more than yearlings. That's the reason I put my effort into raising cows and calves. Calves are sold around January 1 after they are weaned, de-horned, and started on a little concentrate. This operation works fine for me. With weaning and de-horning behind them, calves are not likely to be troubled with diseases and other difficulties usually encountered. Calves weigh around 450 pounds and they only cost me 15 cents a day for over a pound of gain. It would cost me more if I kept them longer. To increase my calf production I must hike the percentage of calves weaned, then increase their weaning or selling weight. This means more early calves, largely a management problem.

I have 90- to 95-percent weaning success and at maximum weights I can sell at premium prices. So my program is aimed at increasing numbers in my cow herd and this means increasing our total carrying capacity. Increasing my calf crop and carrying capacity through a well proven program of range management, fencing, re-seeding and water development has gone a long way to bring up my weaning percentage.

The extra feed and earlier growing season of crested wheatgrass gets cows in shape to breed sooner after calving. Fences make it much easier to keep cows with the bulls. Calves start coming around March 10 and three-fourths of my calves are branded before I turn out on pasture, usually right after the middle of April. I brand up calves dropped after I leave the home ranch, and pick cows for sale around the last of May when bulls are turned in with the cows. I usually take out around a carload of old cows, those that don't raise good calves or have spots on their eyes. These are taken home to irrigated pasture with their calves. After about a month or six weeks calves are weaned, put on calf feed and the cows sold off grass. They pick up very fast and most go as top dry cows.

Much has been said about advantages of range seeding and fencing. I have planted over four sections to crested wheat and other grasses, made miles of fence, dug six wells and installed windmills and tanks. This work was expensive but paid off well. Increasing an outfit's carrying capacity calls for increasing forage production and making the most of what we have. Here are some of the reasons why most of the old places in Nevada valleys still look much as they did when our parents and grandparents ran them. Precipitation in most valleys averages below 9 inches per year, and nearly all of it comes in winter. Everything raised on ranches must be irrigated. Most ranches have their own creeks fed by melting snows. There are no sites suitable for reservoirs, so water must be used as snow melts. Some years high water comes early in May. Sometimes it is late after winds have burned the grass. In an ordinary year, by mid-May I can usually flood 1600 acres. By late June I am lucky to irrigate 160 arces if needed. Through August there is barely enough water to irrigate my garden and keep grass and trees wet around my yards and buildings so windbreaks may be kept alive and fire risk held to a minimum. Alfalfa and tame grasses do well. Still hay improvement practices must be confined to areas that are fairly well drained but can be kept moist through most of July. Most tame grasses cannot survive our hot dry summers without July moisture. We had wetter than average years from 1940 until 1955. Everyone was over-optimistic. I had around 200 acres of tame hay that were yielding well. Since 1955, we have had only one wet year, the rest drier than average, and about half of my 200 acres that were on high well drained sites were lost and there is little chance in sight of re-establishing them.

I have observed through the years that the safest, surest, and most practical way to increase production is to use our natural resources to the best advantage. Our greatest natural resouce is the tough native sod found wherever irrigation waters have reached. Sedges, wiregrass, native bluegrass and wild ryes and wheat grasses that nature has selected through thousands of years for their ability to survive and thrive under our natural conditions occupy these areas. These grasses thrive best when flooded during high water, and as our soils are our only storage reservoirs, the better we fill them in May the longer they will retain enough moisture for grass growth. The tough sod and grass cover also retard evaporation and prevent hardening and cracking under saline conditions so common in lower valleys in this Great Basin area where there is no drainage to the ocean. Besides standing flooding and saline conditions, nature has also selected these sods on their ability to withstand drought. I have been through droughts of two and three years when not a drop of water reached our lower fields and everything looked completely bare and dead. Still after a good flooding fields have greened up in a week and feed was even better than after a series of wet years.

We have gone a long way in selecting and improving forage plants that yield more and have more feed value and palatability. But we haven't even come close to selecting any species that can survive and thrive under our prevailing conditions. How, then can carrying capacity be doubled under said conditions? I did it by taking full advantage of the resources that nature favored us with. Probably the first and most important is our native sod. It can survive flooding and drought but not plowing or severe chiseling or renovation. Once this sod is broken it takes at least 20 years of flooding and protection from trampling to restore it. Soils are heavy and saline and lose their structure easily if the native cover is broken. Weeds come in and there are so many setbacks that it makes these meadows economically impractical to restore. These native grasses show very little response to fertilizer. I've found that the best way to improve these meadows is to give them better distribution of irrigation water by using wide, shallow, lateral ditches. I always start these from a point that is hard to irrigate and run them back to the source of supply. I make substantial dikes through the hollows and plane off the high places with my dozer so I can turn the water out on them. There are always plenty of holes and low places to dump the extra sods and dirt so the field will be left smoother. Greasewood and rabbitbrush die with the first irrigating and one will be surprised how fast these high places cover with sod when they are kept wet and the excess salts washed away. In many places one can grade a wide ditch on a ridge and use the sods to fill a nearby hollow, using high water as a level. Anything a rancher does to keep water on high places and distribute it evenly so all places will stay wet longer helps. Hay yields from these native meadows run from one-half to three-quarters of a ton if they are smoothed up enough to profitably hay them. This hay is low in protein and high in fibre but it works out well when fed with a protein supplement or with high protein hay from improved fields. Stacked loose it keeps its value in storage and is very welcome during dry years when hay goes up to $35 or $40 per ton. An occasional haying holds wild flags and briars to a minimum. Another thing, I always avoid mowing patches of willows as stock do much better with some windbreak and browse and these afford both.

The value of the sods doesn't end with forage and hay value. To get a good weaning weight I must calve in March. While winter snows seldom lay on these lower fields, March is noted for its raw winds and blustery storms. Many a young calf that would freeze down and die if he were dropped on a muddy stubble or alfalfa field or in a greasewood patch is saved by the warmth that this cover of old grass and roots provides. They look so much brighter and they are a lot healthier. It seems all of our scours and pneumonia come around muddy lots and corrals. I believe that year after year, a good sod cover and few willows can be credited with a 10-percent saving in my calf crop. Besides saving calves, good sod bed grounds save a lot of flesh on cows that otherwise would be burnt up for thermal energy if they had to bed on mud or ice.

Land reseeded to alfalfa and tame grasses and clovers must be treated so everything possible can be raised on it. Two 80-pound bags of ammonium nitrate (33 percent) will raise the yield a ton. Two bags of 20-20-0 will do about the same for alfalfa and clover mixtures. Most of our soils have plenty of potash and trace minerals. Besides raising the yields, fertilizers increase the quality, palatability and protein content, and you can make a crop with less water as it grows faster and starts earlier in the season. To get the most from this high quality hay I feed it as a supplement when cows are on dry meadow pasture or on poorer quality hay from native meadows. Cows crave it and pick up all the stems and leaves as the old meadows always make a clean feed ground.

I feed my calves in mangers and they waste quite a bit of alfalfa by sorting out the fine stuff and leaving the stems. In wet weather they waste even more; occasionally, one will bloat. I feed my calves a concentrate consisting of 100 pounds bran, 100 pounds rolled barley, and 65 pounds cottonseed flake (41 percent) at the rate of 2 pounds per day, and find they do just as well on early cut grass, and it takes much less.

If I don't have high quality hay to feed at least every other day I give my cows around 1¼ pounds of 41-percent cottonseed pellets daily. This protein keeps cows thrifty and they will hold their own on grass. Hay thus saved can be used during a hard winter. I also use vitamins A and D concentrate with my salt and phosphate mixture. The cost of the vitamin concentrate and the soybean meal to mix it runs around $1.25 per head for the last 100 days from January 1 to April 15 when cattle need it most.

It is true that costs are rising on all these things—seed, fence, fertilizer, plowing, ditching, and supplements. When one compares these costs with the amount he receives with doubled production, they are small. There are risks involved. Dry years, late cold springs, disease, and things that some would call bad luck. In ranching I feel we should write this type of bad luck off as something that happens to a fellow when he has no preparation to meet an emergency or an opportunity.

The Clover Soil Conservation District, Soil Conservation Service, Experiment Stations, and many fertilizer and biological companies have given us a start. By using common sense and our natural resources, plus bending all our efforts to get increased and more efficient production, we will be able to keep our agricultural industry abreast of others in our nation.

Chemical Control of Foothill Deathcamas[1]

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Foothill deathcamas (*Zigadenus paniculatus* (Nutt.) S. Wats.), a poisonous plant for cattle and especially sheep (U.S. Forest Service, 1937, p. W209), has required the exclusion of spring grazing on certain ranges to prevent livestock losses. Such restrictions in range utilization and management might be alleviated if herbicides could be used to eliminate the undesirable plants. Parker (Range Seeding Equipment Committee, 1959) summarized the available information on the chemical control of deathcamas species and advised that fair kills could be obtained with 2,4-D (2,4-dichlorophenoxyacetic acid) ester at 3.0 lb/A. Bohmont (1952) reported that 2,4-D ester at 3.0 lb/A applied at the bud to bloom stages of development killed virtually all old deathcamas plants and that 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) appeared to be less effective than 2,4-D. Blaisdell and Mueggler (1956) reported that foothill deathcamas was severely damaged by 2,4-D at 1.5 to 2.0 lb/A applied on large areas for controlling big sagebrush. Species differences and seasonal changes in the susceptibility of deathcamas to foliage sprays may be important in control recommendations.

The present paper includes data on mortality resulting from foliage sprays containing 2,4-D or 2,4,5-T applied to foothill deathcamas at various stages of vegetative and reproductive development. Strong seasonal changes in herbicidal effectiveness constitute new information that will be important to successful chemical control of this species.

Procedure

Two split-plot experiments were established with 4 replications in each and 6 spraying dates randomized by whole plots. In the first experiment the treatments were applied on April 30, May 14, June 2, June 13, June 23, and July 9, 1958, and in the second experiment the plots were treated on April 28, May 6, May 23, May 28, June 3, and June 10, 1959. The intervals between spraying were shorter in 1959 than in 1958 because the 1959 season was much drier than normal. Individual 1/50-acre subplots were sprayed with 2,4-D or 2,4,5-T propylene glycol butyl ether esters[2] at 1.5 or 3.0 lb/A emulsified in water containing 0.2 percent spreader[3] at a total spray volume of 10 gal/A. The spray emulsions were applied with a 4-nozzle (800067 tips), 4-foot, hand-held boom operated from a back-pack, compressed-air sprayer at 35 psi.

Both experiments were established on a deep pumice-pebble deposit having a weakly developed loamy-soil profile located about 2 miles west of Burns, Oregon, at an elevation of 4,300 feet in the foothills adjacent to the Ochoco National Forest. Precipitation at Burns in crop-year periods of September-June, inclusive, was 13.19 inches in 1957-1958 and 7.12 inches in 1958-1959 as compared with a median amount of 11.6 inches.

The vegetation on the experimental site included a shrub overstory of big sagebrush (*Artemisia tridentata* Nutt), bitterbrush (*Purshia tridentata* (Pursh) DC.), and occasional plants of *Tetradymia canescens* DC. and *Ribes cereum* Dougl. *Juniperus occidentalis* Hook is common to the area, but is intermitten in distribution. The herbaceous vegetation included Sandberg bluegrass (*Poa secunda* Presl), *Agropyron spicatum* (Pursh) Scribn. & Smith, *Stipa thurberiana* Piper, *Festuca idahoensis* Elmer, *Sitanion hystrix* (Nutt.) J. G. Smith, and foothill deathcamas.

The area was grazed by cattle during April, May, and June each year. All herbaceous plants including deathcamas were grazed closely by the end of June when the cattle were moved to higher elevation ranges within the Ochoco National Forest. Cattle poisoning was not evident, and deathcamas bulbs, which were located about 10 inches below the surface of the pumice-pebble material, apparently were not pulled by grazing animals.

The vegetative and reproductive development of deathcamas and associated species were observed at each date of spraying. The deathcamas on 8- by 80-foot strips centered within each subplot were counted a year after spraying. The largest treatment-mean density per subplot each year (120 in 1958 and 61 in 1959) was arbitrarily assigned a stand value of 100, and mean densities for other treatments were expressed in percentage comple-

[1] *A contribution from Squaw Butte Experiment Station, Burns, Oregon. This station is financed cooperatively by the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Oregon Agricultural Experiment Station, Corvallis, Oregon. Technical Paper No. 1453, Oregon Agricultural Experiment Station.*

[2] *Esteron Ten-Ten and Esteron 245 O. S. were provided for this experiment by the Dow Chemical Company. The trade names given do not constitute preference or recommendation over comparable products.*

[3] *The spreader used was X-77, Colloidal Products Corporation, San Francisco, California.*

Table 1. Mortality of foothill deathcamas after spraying with 2,4-D or 2,4,5-T.

	Mortality for indicated herbicides and acid rates (lb/A)								
Dates of	2,4-D		2,4,5-T		Means by acid rates		Means by herbicides		Grand
spraying	1.5	3.0	1.5	3.0	1.5	3.0	2,4-D	2,4,5-T	mean
1958					(Percent)				
April 30	96	98	80	89	88	93	97	85	91 [1]
May 14	90	94	68	75	79	85	92	72	82
June 2	38	45	30	11	35	28	42	21	31
June 13	22	38	6	20	13	29	30	12	22
June 23	20	22	4	10	12	16	21	8	14
July 9	4	4	13	0	8	2	4	7	5
1958 mean	45	50	33	34	39	42	48 [2]	34	41
1959									
April 28	98	100	84	95	92	97	99 [1]	90 [1]	94 [1]
May 6	100	100	80	90	90	95	100	85	94
May 23	85	94	48	34	67	64	89	41	66
May 28	76	89	20	16	48	52	82	18	51
June 3	62	84	38	15	51	49	72	26	49
June 10	41	52	0	7	20	30	48	3	25
1959 mean	77	87	44	43	61	64	82 [2]	44	62

[1] Data groups that include significant variation (95 percent) have non-significant means connected by vertical lines.

[2] The difference between means by herbicides was highly significant (99 percent) each year.

ments and reported as mortality percentages.

Results and Discussion

Spraying dates and herbicides introduced highly significant differences in mortality each year, and the date by herbicide interaction introduced highly significant differences in 1959.

The mortality of foothill deathcamas was higher after spraying with 2,4-D at 1.5 lb/A than after spraying with 2,4,5-T at 3.0 lb/A on each date of application (Table 1). Nevertheless, time of spraying introduced the most important differences in mortality. The date by herbicide interaction in 1959 data resulted from a more rapid seasonal decline in the effectiveness of 2,4,5-T as compared with that of 2,4-D. The effectiveness of both herbicides decreased to virtually zero in 1958, when the spraying season was extended until the time of seed dissemination—one month later than in 1959.

Foothill deathcamas was highly sensitive to 2,4-D in vegetative-growth stages and became yellow and wilted within a week after spraying. The lack of significant difference between herbicide rates of 1.5 and 3.0 lb/A emphasizes the dominant importance of proper timing. Mortality with 2,4-D remained above 90 percent until the flower buds appeared and decreased rapidly during reproductive development (Table 2). Applications of 2,4-D at either 1.5 or 3.0 lb/A in late April and early May, when foothill deathcamas had 3 to 6 leaves, killed all plants except a few protected from the spray by an overstory of shrubs.

The high sensitivity of deathcamas to 2,4-D during early vegetative development as compared with relatively high tolerance during reproductive stages of development is similar to the results obtained on low larkspur in previous trials (Hyder, Sneva, and Calvin, 1956). A rate of 1.5 lb/A of 2,4-D ester applied before the appearance of flower buds is sufficient for the control of foothill deathcamas. Since big sagebrush can be controlled effectively with 2,4-D ester at 2.0 lb/A applied as early as the head-emergence stage of development on Sandberg bluegrass (Hyder and Sneva, 1955), big sagebrush and foothill deathcamas may be controlled simultaneously by spraying at that time. Many desirable forbs also appear to be highly susceptible to 2,4-D during vegetative stages of growth; consequently, range areas need to be considered carefully before deciding whether and when to spray (Blaisdell and Mueggler, 1956).

The occurrence of complete grazing of foothill deathcamas without apparent pull-up of bulbs or poisoning symptoms indicates that deathcamas control might be unnecessary on the spring range selected for these experimental trials.

Summary

Spray applications of 2,4-D and

Table 2. Developmental stages of growth of foothill deathcamas and Sandberg bluegrass in 1958 and 1959.

Spraying dates	Foothill deathcamas	Sandberg bluegrass
1958		
April 30	3 or 4 leaves	heads low in boot
May 14	5 or 6 leaves	heads completely emerged
June 2	full bloom, partially grazed	late anthesis
June 13	full pods, heavily grazed	herbage curing
June 23	pods dry	herbage completely cured
July 9	seed shattering	herbage completely cured
1959		
April 28	4 to 6 leaves	heads in the boot
May 6	6 or 7 leaves	heads completely emerged
May 23	flower buds 2-3 inches high	early anthesis
May 28	early bloom, some grazed	full anthesis
June 3	late bloom	herbage curing
June 10	full pods, heavily grazed	herbage completely cured

2,4,5-T at rates of 1.5 and 3.0 lb/A were made on 6 dates each during 1958 and 1959 to evaluate their effects on foothill deathcamas at various stages of vegetative and reproductive development. Applications of 2,4-D at 1.5 lb/A were more effective than applications of 2,4,5-T at 3.0 lb/A throughout the season. Foothill deathcamas was highly sensitive to 2,4-D during vegetative development, in late April and early May. Effectiveness remained high during the 3- to 6-leaf stage of development but decreased rapidly after the flower buds appeared.

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Soil Fertility Investigations and Effects of Commercial Fertilizers on Reseeded Vegetation in West-Central Kansas[1]

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Much of the native grass reseeding in western Kansas is done on eroded cropland of low fertility. When moisture conditions are favorable, most sites may be revegetated successfully with native grasses, but subsequent forage production often is low, especially where most of the topsoil has eroded away. Evaluation of soil fertility needs and the responses of vegetation to fertilization are problems associated with management of many reseeded areas.

This experiment was conducted to investigate the relationships between a rapid soil-test method and a greenhouse pot-test method to determine major element deficiencies in soils, and to study yield responses of reseeded grasses fertilized with nitrogen and phosphorus on two soils exhibiting nutrient deficiencies typical of many reseeded areas in west-central Kansas.

Review of Literature

Rapid soil-tests designed to measure available plant-nutrient supplies are used in many areas in an attempt to determine the fertilizer requirements of soils for various crops. Generally such tests are not considered entirely reliable in estimating fertilizer needs (Millar and Turk, 1943). To overcome the shortcomings of rapid soil-tests biological methods have been developed using indicator plants in potted top soil under greenhouse conditions. Nutrients are added in various combinations, and yields relative to a standard full treatment of nitrogen, phosphorus, and potassium are interpreted as a measure of the soil's ability to supply a given element under the experimental conditions that exist (Jenny, Vlamis, and Martin, 1950). They showed that the lower the relative pot-test yield, the greater was the chance of securing a field crop response to added plant nutrients.

Numerous field applications of fertilizers in various forms and combinations have been tested. In the drier areas much of the emphasis has been placed on increasing cultivated grain yields. During years when moisture conditions were favorable, grain crop yields generally were increased by adding nitrates and phosphates in Kansas (Throckmorton and Duley, 1935); in Oklahoma (Eck and Stewart, 1954); in eastern Colorado (Greb and Whitney, 1953); in Nebraska (Lowry, Ehlers, and Pumphrey, 1954); and in the Texas Pan Handle region (Box and Jones, 1954).

A number of fertilizer trials have been conducted on native range vegetation throughout the Great Plains region. Immediate and residual responses have resulted from the application of 10 to 12 tons of cattle manure per acre in southern Saskatchewan (Clark, Tisdale, and Skoglund, 1943) and in northeastern Colorado (Klipple and Retzer, 1959). Other trials on native range involving commercial forms of nitrogen and phosphorus applied at rates up to 90 pounds of nitrogen and 100 pounds of phosphorus pentoxide per acre have shown that when nitrogen was included, yields generally were increased significantly, but not enough to make the fertilizer applications economical (Clark and Tisdale, 1945; Westin, Buntley, and Brage, 1955; Klipple and Retzer, 1959; and Rogler and Lorenz, 1957).

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[1] *Contribution No. 160, Fort Hays, Branch, Kansas Agricultural Experiment Station, Hays, Kansas.*

Table 1. Survey mapping symbols and descriptions of soils selected for fertility studies.

Soil No.	Survey Mapping Symbol[1]	Soil Characteristics: Effective Depth, inches	Topsoil Texture[2]	Permeability of First significant zone	Permeability of Second significant zone	Parent Material	Percent Slope	Degree of Erosion	Range Site
1	1M34T / 2-1	60 or more	Silt loam	Moderately slow	Moderate	Loess and outwash	1 to 3	None apparent	Clay Upland
2	1M4T / 6-3	60 or more	Loam	Moderate	Moderate	Loess and outwash	5 to 7	Severe	Limy Upland
3	1M23D / 2-2	60 or more	Silt loam	Slow	Moderately slow	Loess	1 to 3	Moderate	Clay Upland
4	1F34T / 2-2	60 or more	Silt loam	Moderately slow	Moderate	Loess and outwash	1 to 3	Moderate	Clay Upland
5	1S5X / 2X-2	60 or more	Loamy sand	Moderately rapid	Moderately rapid	Recent alluvium	1 to 3 undulating	Moderate	Sandy
6	1M34T / 2-2	60 or more	Silt loan	Moderately slow	Moderate	Loess and outwash	1 to 3	Moderate	Clay Upland
7	XR / 8-3	10 or less	Loam	Moderate	Slow to very slow	Tertiary mortar beds	7 to 9	Severe	Breaks
8	XR / 8-3	10 or less	Clay loam	Moderate	Slow to very slow	Tertiary mortar beds	7 to 9	Severe	Breaks

[1]Standard mapping symbols for coding soil characteristics. U.S. Department of Agriculture Soil Conservation Service, 1951.
[2]From mechanical analyses by Lyle Linnell, former graduate student, Fort Hays Kansas State College, Hays.

Fertilizing reseeded cool-season grasses in pure stands with nitrogen at various rates up to 133 pounds per acre in the northern Great Plains generally produced significantly higher forage yields than those obtained from the untreated checks (Carter, 1955). In many cases, yields were such that nitrogen applications on cool-season species were economically feasible (Rogler and Lorenz, 1957). McIlvain and Savage (1950) reporting on the effects of fertilizing reseeded weeping lovegrass *(Eragrostis curvula* (Schrad.) Nees) in the southern Great Plains with 30 pounds of nitrogen per ace one year and 53 pounds the next showed that the grazing capacity was increased 33 percent and steers gained nine pounds per head more than those on unfertilized weeping lovegrass pasture. Gains were increased to the extent of 37 pounds per acre.

Procedure

During the fall of 1956, seven areas reseeded to native grasses near Hays, Kansas were selected to represent a wide range of soils and degrees of erosion[2]. The soil designations and descriptive characteristics appear in Table 1. The range seedings were made prior to 1950 and, except for one site (soil number 5) which supported a pure seeding of sand lovegrass *(Eragrostis trichodes* (Nutt.) Wood); native warm-season mixtures were planted on all sites. In addition, an upland site (soil number 1) of unbroken sod, representing large acreages of the type of land presently under cultivation, was included to indicate inherent soil fertility prior to cultivation and subsequent revegetation. Plots of at least one acre were located in each area and 50 randomly-collected soil cores four inches in diameter and six inches in depth were composited from each site to be used for rapid soil-test and pot-culture test analyses.

Rapid Soil-Tests

The soil samples from the various sites were given the following general soil fertility tests:[3] (1) limemeter test to determine pH as an indicator of lime requirements; (2) spectrophotometer test to determine percentage organic matter content (indicator of nitrogen requirement), available phosphorus in pounds per acre, and exchangeable potassium in pounds per acre.

Pot-Culture Tests

The pot-culture tests described by Jenny, Vlamis and Martin, 1950 were modified for use in this study. Six barley *(Hordeum vulgare* L.) plants of the early variety, Beecher, were grown to maturity in six-inch asphalt-coated clay pots and saucers filled with 1,500 grams of soil. The major elements were added in solution to the pots in the

[2]*Bert Soderblom, Edward E. Bookless, and Robert K. Glover, USDA, Soil Conservation Service, Hays, Kansas, assisted with the site selections and furnished the soils descriptions.*

[3]*Analyses were made by the Soil Testing Laboratory, Department of Agronomy, Kansas State University, Manhattan.*

[4]*Field plots were situated 11 miles east of Hays, Kansas.*

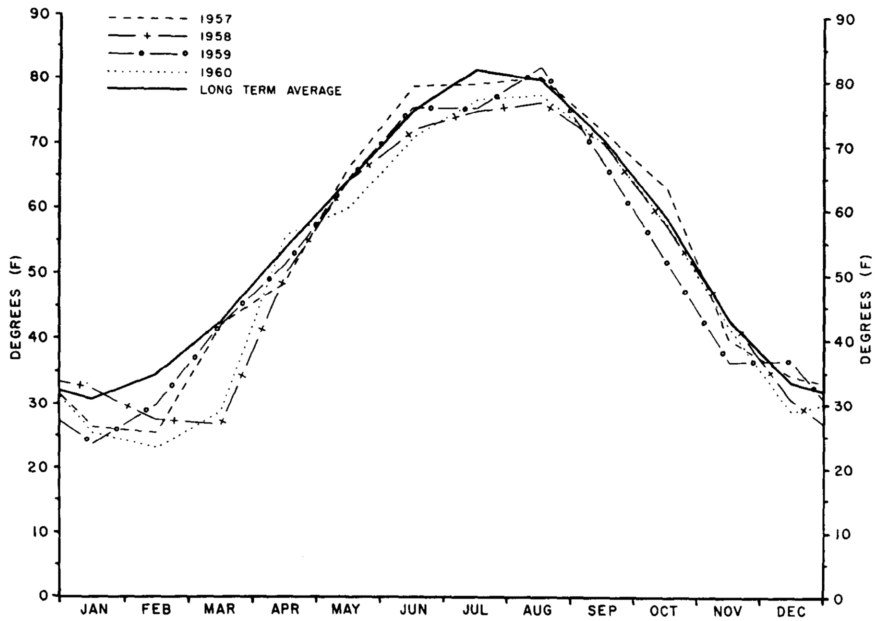

FIGURE 1. Monthly average temperatures for the four-year period in relation to the long-term average at the site of fertilizer applications.

combinations and rates shown in Table 2. The treatments were replicated four times and the pots were rerandomized on the greenhouse benches at two-day intervals to reduce location effects. The pots were watered as necessary to maintain optimum soil moisture conditions. Recorded information included total dry matter yields at maturity and crude protein analyses of the harvested material.

Field Application of Nitrogen and Phosphorus

Broadcast applications of nitrogen and phosphorus were made during April, 1957, at two adjacent field locations, soils 2 and 3[4], selected on the basis of barley performance in the pot-culture tests. The treatments consisted of 80 pounds of nitrogen per acre in the form of ammonium nitrate, 60 pounds of phosphorus pentoxide per acre in the form of treble superphosphate, a combination of the two fertilizers at the above rates, and an untreated check. Plot size was 15 by 45 feet in a randomized block design with four replications at each soil location. Carry-over effects of the various treatments were measured during 1958. The plots were given the original fertilizer treatments again in April, 1959. Carry-over effects were measured during 1960.

Dry weight yields were obtained from a 39-inch sample strip mowed two inches high along the longitudinal center of each plot. Additional plot sampling consisted of dominant species height measurements, species composition estimates, and crude protein content analyses of the dominant grasses during June and September. Plots were harvested annually during September, near the close of the growing season.

Weather Conditions During the Field Trials

The climate of west-central Kansas has been described by Flora, 1948. The experimental area weather is characterized by extremes in temperatures and wide variations in the annual precipitation pattern. Figure 1 shows the long term average monthly temperatures and monthly averages during the four years of study. Figure 2 illustrates the long term average precipitation and amounts received during the study period.

Temperatures were much lower than average during the late winter months each year and only occasionally above average the remaining months. Annual precipitation was one inch to over eight inches above average during the four-year period. Growing conditions were favorable during 1957 and 1958 when adequate moisture was received throughout the growing season. Although below-average April and June precipitation caused the 1959 season to be somewhat drier than the two previous years, the vegetation had sufficient moisture for growth during the summer months. Severe drought conditions from late June to early August reduced growth during the summer of 1960. The effects of this drought were moderated considerably by below-average temperatures during the dry period; thus there was significant recovery in late August and early September.

Results

Rapid Soil-Tests

These tests revealed large differences among the soils in terms of soil reaction, organic matter content, and usable amounts of phosphorus and potassium (Table 3). Soils with a high per-

Table 2. Combinations and equivalent amounts on a surface acre basis of major elements added to the 1,500 grams of soil in the pot-culture tests.

Treatment	Nitrogen	Phosphorus	Potassium
	— — (Equivalent Rates in Pounds Per Acre) — —		
$N_0P_0K_0$	0	0	0
$N_0P_3K_2$	0	300	200
$N_3P_0K_2$	300	0	200
$N_3P_3K_0$	300	300	0
$N_3P_3K_2$	300	300	200

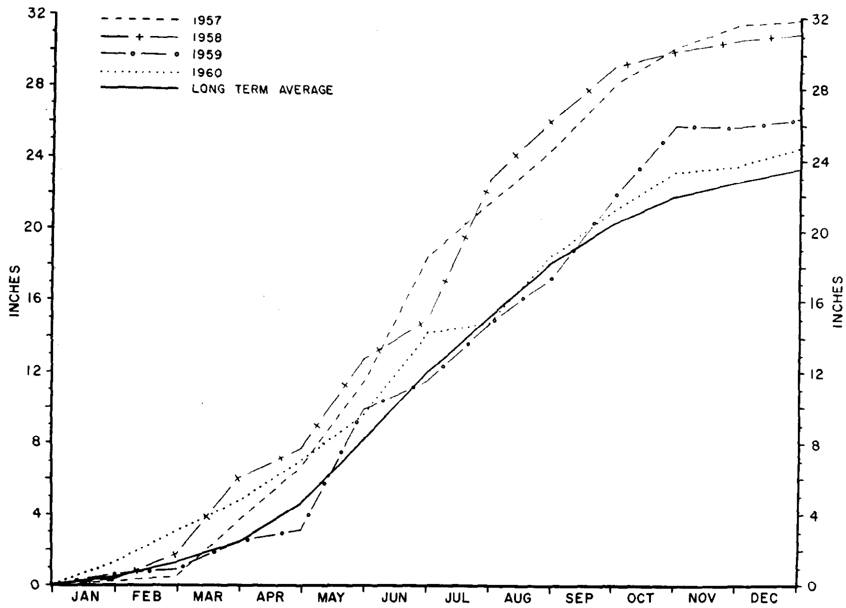

FIGURE 2. Accumulative monthly precipitation amounts compared with the long-term average during the four-year period at the sites of fertilizer applications. The slope of an annual curve in relation to the long-term average curve indicates plus or minus departures from average at monthly intervals.

centage of topsoil intact were slightly acid, while the severely eroded areas were definitely alkaline. Because of leaching, calcium carbonate accumulates in the B horizon and may occur as free lime on the surface of severely eroded areas. Organic matter content was highest in the unbroken sod and lowest in the lowland loamy sand site. The soil samples from reseeded upland sites contained percentages of organic matter nearly proportional to the amounts of remaining topsoil. Using the rapid soil-test as a guide, nitrogen fertilizer requirements for most dryland crops were about half as great on the native sod area as on the other sites. Available phosphorus ranged from a medium amount of 34 pounds per acre on the slightly eroded upland site 3 to nine pounds per acre on the eroded shallow slope on site 8; however, there was no direct relationship between degree of erosion and phosphorus content. Several of the most severely eroded sites contained more available phosphorus than the unbroken native grass area. The required phosphorus amendments recommended from these rapid soil-tests varied from none for grain crops and cool-season grasses on soils 3 and 4 to 30 or 40 pounds per acre on soil 8. The amount of exchangeable potassium was high to very high in all samples and as with percentage of organic matter, there was a positive relationship with the proportion of remaining topsoil.

Pot-Culture Tests

Plants on all eight soils responded to additions of nitrogen and phosphorus but not to potassium in the pot-culture tests (Table 4). Nitrogen was highly deficient in all the soils except number 1 which was benefited least. The soils were differentiated into two groups on the basis of the nitrogen-phosphorus interaction. On highly eroded soils 2, 7, and 8 and the loamy sand site 5 the responses to phosphorus or nitrogen were not significant unless the two elements were added in combination. The remaining soils were not benefited by the addition of phosphorus without nitrogen, but showed responses to nitrogen when phosphorus was absent. These reactions to fertilizer combinations are illustrated by barley dry matter yields in Figure 3. Soil 2 is representative of the group needing a combination of nitrogen and phosphorus, and soil 3 is typical of the group in which nitrogen without phosphorus gave a response intermediate between the check and full treatments. Soil number 1 is included to indicate the relative inherent fertility associated with unbroken native sod.

Crude protein content of the mature barley plant was not influenced significantly by pot-culture treatment except in the four soils requiring the addition of both nitrogen and phosphorus to obtain significant yield increases

Table 3. Data from rapid soil-tests and recommendations for plant nutrients to be added to the soil for small grains, sorghums, and cool-season grass pastures.[1]

		Organic Matter		Phosphorus		Potassium	
Soil	Reaction	Content	N Needed	Available	P_2O_5 Needed	Exchangeable	K_2O Needed
No.	pH	%	lb/A	lb/A	lb/A	lb/A	lb/A
1	6.6	2.5	30-40	18	20-30	550	0
2	7.9	0.5	40-80	20	20-30	275	0
3	6.4	1.3	40-80	34	0-20	550	0
4	6.8	1.5	40-80	28	0-20	550	0
5	8.5	0.3	40-80	13	20-30	314	0
6	7.4	1.5	40-80	15	20-30	550	0
7	8.0	1.0	40-80	22	20-30	440	0
8	7.8	0.7	40-80	9	30-40	480	0

[1]Fertilizer recommendations obtained from: Interpretation and Explanation of General Soil Fertility Tests. Form ST 4E 9-55. Departments of Agronomy and Extension Service, Kansas State University, Manhattan, cooperating.

(Table 5). Here the addition of nitrogen without phosphorus increased the percentage crude protein of the barley two to three times above the other treatments. The plants incorporated the nitrogen without making any measureable increase in growth over those on the unfertilized soil.

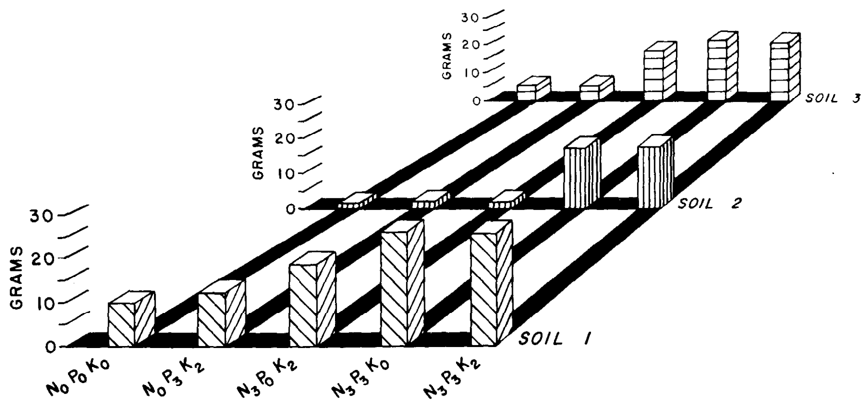

FIGURE 3. Barley dry matter yields in reponse to various fertilizer combinations in potted top soils. Soils 1 and 3 exhibited a significant response to nitgoren without the addition of phosphorus. Soil 2 required nitrogen and phosphorus in combination to obtain a response.

Field Application of Nitrogen and Phosphorus

Table 6 shows the average total dry matter yields of fall-harvested vegetation on soil site 3 during the four-year study. In 1957, treatments containing nitrogen produced yields significantly higher than the phosphorus alone or check treatments. The 1958 residual effects showed the same trend but differences were not significant. The treatments containing nitrogen produced significantly higher yields again in 1959, and 1960 yields from carry-over nitrogen were large enough to be significantly greater than the residual phosphorus or check yields. The addition of phosphorus in the presence of nitrogen gave no significant increases in yields over the nitrogen alone on this site. The progressive decrease in forage production from year to year, as reflected in the check and phosphorus treatments, was brought about by a combination of mowing effects and reduced precipitation during the last two years of the study.

Table 4. Dry weight yields per pot of six barley plants grown to maturity in the various soils and fertilizer combinations under greenhouse conditions.

Fertilizer Treatment		Soil Number 1	2	3	4	5	6	7	8
		(Grams)							
$N_0P_0K_0$		10.1	1.8	5.6	3.0	1.6	2.6	3.0	2.8
$N_0P_3K_2$		12.0	2.2	5.4	3.3	1.7	2.6	4.0	3.4
$N_3P_0K_2$		18.4	2.1	18.0	13.2	3.0	9.5	3.8	3.3
$N_3P_3K_0$		25.7	17.5	22.0	17.5	14.5	16.2	16.9	16.1
$N_3P_3K_2$		25.3	18.5	20.8	18.5	15.3	17.2	17.2	16.9
L.S.D.	.05	2.0	1.0	1.3	1.4	1.4	3.0	1.1	1.1
	.01	2.7	1.4	1.9	2.0	2.0	4.1	1.6	1.6

Annual bromes (*Bromus japonicus* Thunb., and *B. tectorum* L.) played an important role in the plots on soil site 3. Figure 4 illustrates production of the three major vegetation components, switchgrass (*Panicum virgatum* L.), annual bromes, and other species (blue grama (*Bouteloua gracilis* (H. B. K.) Lag. ex Steud.), buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.), sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), little bluestem (*Andropogon scoparius* Michx.), red threeawn (*Aristida longiseta* Steud.), and a trace of native forbs) separately by years and fertilizer treatments. During 1957 and 1959, the years when fertilizers were applied, annual bromes responded more to nitrogen fertilization than did switchgrass and other species. Considering total vegetation minus annual bromes, the yield increases due to nitrogen fertilization were not significant in 1957; however, the yield of each component was increased significantly by nitrogen fertilization in 1959. Switchgrass and the annual bromes each responded significantly to carry-over nitrogen during 1960.

Yield increases due to nitrogen fertilization on low fertility site 2 were highly significant each year (Table 7). In addition there were significant nitrogen-phosphorus interactions in 1957 and 1959. During the years the fertilizers were applied, plots receiving both elements yielded more than those receiving only nitro-

Table 5. Crude protein content of barley plants in percentages grown to maturity in the pot-culture tests.

Fertilizer Treatment	Soil Number 1	2	3	4	5	6	7	8
	(Percent)							
$N_0P_0K_0$	6.7	8.2	6.4	6.2	7.5	6.9	7.2	6.7
$N_0P_3K_2$	5.9	7.8	6.6	5.8	7.0	8.0	6.2	6.5
$N_3P_0K_2$	7.7	19.0	7.0	7.2	13.3	7.2	13.6	12.3
$N_3P_3K_0$	7.3	5.9	6.2	5.9	5.9	5.4	5.4	5.8
$N_3P_3K_2$	7.3	6.1	6.4	6.1	5.9	5.3	5.6	5.8

Table 6. Yield responses of total forage to field applications of 80 pounds of nitrogen and 60 pounds of phosphorus pentoxide per acre alone and in combination on soil site 3. Plots were fertilized in April, 1957, and again in April, 1959.

Fertilizer Treatment		Yield Following: 1957 Application	1958 Carry-over	1959 Application	1960 Carry-over
		— — — — — (Pounds per acre)			— — — — —
NP		5,029	3,058	3,805	1,664
N		4,923	3,042	3,554	1,547
P		3,385	2,586	1,618	1,189
O		3,522	2,672	1,600	1,250
L.S.D.	.05	742	n.s.	374	218
	.01	1,067		538	313

gen. As on soil site 3, there was no response to the addition of phosphorus alone. No annual grasses were present on the low fertility site 2, and although over 90 percent of the production was sideoats grama, there was no differential response of species to fertilizer treatment. Other species on site 2 included blue grama, little bluestem, buffalograss, and a trace of native forbs.

Crude Protein Content of the Forage

The crude protein content of switchgrass on site 3 at two annual sampling dates during the four-year period is shown in Table 8. As expected, crude protein content decreased between June and September each year. Only the June, 1959, measurements were significantly different between treatments. At that time samples from the nitrogen and nitrogen-phosphorus plots contained higher percentages of crude protein than samples from the phosphorus and check plots. By September, 1959, the differences no longer existed. Similar analyses for crude protein in sideoats grama on site 2 resulted in findings nearly identical with those from switchgrass on site 3.

Discussion

The general soil-test and the pot-culture techniques agreed reasonably well in determining the relative nitrogen requirements for the various soils. The two methods did not agree in estimating the relative needs for phosphorus. In most instances when pot-tests indicated a low inherent phosphorus content, the rapid soil-test showed relatively high amounts of available phosphorus and vice versa. Because of the abundance of potassium in all soils tested, there were no apparent discrepancies in the two methods. Organic matter content found by the rapid soil-test was the most reliable indicator of soil potential in supplying both nitrogen and phosphorus for plant growth in the pot-culture tests.

Considering the limited number of locations where fertilizers were applied in the field, direct comparisons of the three methods for all of the soils are not possible; however, yield results from the two field sites differed from predictions based on pot-culture results. Soil number 3, a relatively high fertility site with a low but significant nitrogen-phosphorus interaction in the pot-culture tests, responded as well to field applications of nitrogen alone as to a combination of nitrogen and phosphorus. Soil number 2 which required nitrogen and phosphorus in combination to produce any increase in pot yields, responded significantly to field applications of nitrogen alone, although nitrogen in the presence of phosphorus produced the highest yields under field conditions.

Several factors may account for these inconsistencies in greenhouse and field results. First, only the upper six inches of soil was used in the pot-culture tests, while the perennial grasses in the field were extracting nutrients throughout the depth of their root systems. Second, barley as an indicator plant may have had different requirements for the various nutrients under greenhouse conditions than established vegetation in the field plots. The growing period, temperature, soil moisture, and nutrient availability relationships in the field were totally unlike those under greenhouse conditions, suggesting that growth time and nutrient avail-

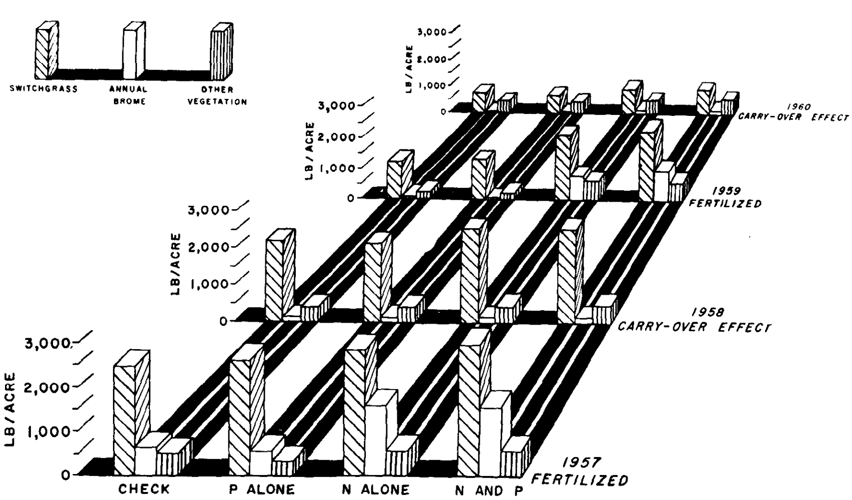

FIGURE 4. Dry matter yields of the major vegetation components on soil 3. Note the differential stimulation of annual brome to treatments containing nitrogen during years of fertilizer application.

Table 7. Yield responses of total forage to field applications of 80 pounds of nitrogen and 60 pounds of phosphorus pentoxide per acre alone and in combination on soil site 2. Plots were fertilized in April, 1957, and again in April, 1959.

Fertilizer Treatment		Yield Following: 1957 Application	1958 Carry-over	1959 Application	1960 Carry-over
		(Pounds per acre)			
NP		1,204	484	1,426	393
N		721	410	718	417
P		233	209	111	76
O		266	252	161	127
L.S.D.	.05	244	95	153	71
	.01	350	144	220	102

ability at various depths in the field may have played a large part in making more phosphorus available than the pot-culture tests indicated. The pot-culture technique, to be practical, must utilize quick-maturing indicator plants, but these greenhouse and field comparisons show that it might have been advantageous to composite a soil sample representative of the soil profile containing the established plant root systems. Identical yield responses to carry-over nitrogen and nitrogen plus phosphorus on soil 2 suggest that high levels of nitrogen were needed to produce a nitrogen-phosphorus interaction on this site.

The differential response of winter annual bromes to nitrogen fertilizer supports the conclusion that cool-season species are benefited more by nitrogen fertilization than are associated warm-season species (Rogler and Lorenz, 1957). Increases in forage production on both sites were not of sufficient magnitude to justify the expense of fertilization, considering forage yields alone. The economic value of such a practice should be measured by animal response which would integrate the factors of forage quantity and quality. Crude protein content was increased during the early growing period of 1959 by nitrogen fertilization in these trials, but similar increases were not detected during the other years. In related studies, forage protein content usually was increased by applications of nitrogen (Carter, 1955; McIlvain and Savage, 1950; Williams, 1953; and Westin, Buntley, and Brage, 1955); however, this was not always true (Clark and Tisdale, 1945).

Summary

1. The nitrogen, phosphorus, and potassium levels in the upper six inches of eight soils were compared by a rapid soil-test and a pot-culture technique.

2. Organic matter content used as an index to available nitrogen in the rapid soil-test was a good indicator of the ability of each soil to supply nitrogen in the pot-culture tests.

3. Organic matter content was better than soil-test phosphorus determinations in predicting the ability of a soil to supply phosphorus in the pot-culture tests.

4. The rapid soil-test showed a wide range, but high amounts of potassium in all soils. The pot-culture tests indicated no potassium deficiencies in any of the soils used in this experiment.

5. Pot-culture yields of barley were greatest for all soils when both nitrogen and phosphorus were added. Adding potassium was not necessary. Yields were not increased over those from untreated check pots by phosphorus without nitrogen. Nitrogen without the addition of phosphorus increased pot yields to an intermediate level between the check and full treatment in the four soils having the highest amounts of organic matter. Plants grown in the four soils containing the lowest amounts of organic matter did not respond to the addition of nitrogen without phosphorus in the pot-culture tests.

6. Field applications of 80 pounds of nitrogen per acre, 60 pounds of phosphorus pentoxide per acre, the two in combination, and no treatment were made on a high organic matter content site and a low organic matter content site in the spring of 1957,

Table 8. Average crude protein content of switchgrass on June 15, and September 15, annually from fertilizer plots on soil site 3. Fertilizers were applied at rates of 80 pounds of nitrogen and 60 pounds of phosphorus pentoxide per acre alone and in combination in April, 1957, and again in April, 1959.

Fertilizer Treatment		1957 June	1957 Sept.	1958 June	1958 Sept.	1959 June	1959 Sept.	1960 June	1960 Sept.
		Crude Protein Content in: (Percent)							
NP		6.1	3.1	5.9	3.4	7.0	2.9	6.6	3.1
N		6.9	2.7	5.8	3.2	7.0	3.0	6.6	3.1
P		6.1	2.9	5.9	3.7	5.9	3.4	6.9	3.0
O		6.8	3.1	5.7	3.5	5.9	3.4	6.9	3.1
L.S.D.	.05	n.s.	n.s.	n.s.	n.s.	0.3	n.s.	n.s.	n.s.
	.01					0.4			

and the plots were retreated in the spring of 1959.

7. Forage yields on the high organic matter site were increased significantly by nitrogen. Nitrogen and phosphorus together did not increase yields over nitrogen alone. Phosphorus alone did not increase yields above those of the untreated check plots. Cool-season annual bromes growing with the reseeded grasses responded more to nitrogen fertilization than did the warm-season perennial grasses. Carry-over effects of nitrogen were small each year following fertilizer application.

8. Yields were greatly increased by nitrogen and phosphorus in combination on the low organic matter site over relatively low producing untreated check plots. Nitrogen alone gave an intermediate response. Phosphorus alone produced no increase in yields. Carry-over responses to nitrogen and phosphorus and nitrogen alone were the same and were relatively high.

9. Forage crude protein content was increased in plots receiving nitrogen on both soil sites during the early growing season of 1959. This was the only time when differences were found.

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Water Yield as Influenced by Degree of Grazing in the California Winter Grasslands[1]

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The increase of water produced by our watersheds is becoming more and more important. Particularly in countries with a deficiency in usable water, this problem constitutes one of the most important preoccupations of the administrators.

Almost always the problems of soil erosion and flood control are closely related to that of water production. Usually, increase of water yield and soil erosion-flood control are quite controversial items. Furthermore, in some countries one of these two items is the predominant one and the decisive factor in policy making. There are also cases (countries of Mediterranean-like climate) in which the critical thing may be the timing of water production throughout the year rather than the absolute increase of good quality water.

Long experience and detailed studies have established firmly the belief that the form and type of vegetation on the watersheds as well as how they are managed greatly affects water yield, soil erosion and flood control.

Numerous comparative studies have been made and a great deal has been written to date about the beneficial effect of forest, brush and herbaceous vegetation on water yield, timing of water production, soil erosion, and flood control.

The attention of research

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[1] *The present study was carried out under the sponsorship of the National Academy of Sciences, Washington, D. C., Worldwide Research Program to which I express my acknowledgement.*

FIGURE 1. Soil profile taken with the aid of a metallic box.

workers has been mainly concentrated on the relative effect of the forest versus brush versus herbaceous vegetation, and there has been particular interest in the effect of forest manipulation upon water production, soil erosion and river regimen.

Relatively little has been done about the effect of grassland management practices upon water yield. Attention has been mainly centered around the hazard of soil erosion and range deterioration caused by overuse or misuse of grass cover by grazing animals. Particularly poor is the literature on annual rangelands, a characteristic formation of the Mediterranean climate.

The purpose of the present study was to contribute a better understanding of degree of grazing effects in the annual type upon soil, water storage and use by plants, and the opportunities for increased water yield.

Methods

In the Berkeley hills, just east of San Francisco Bay in California, a cluster of three experimental plots, 6 x 6 m each, was established in October 1959, one on range heavily grazed since at least 1925, another on range grazed lightly since 1928, and the third on range not grazed since 1935.

The plots were about 15 m apart and each was divided into 225 sub-plots 40 x 40 cm. In each large plot seven groups of five subplots each (35 in total) were randomly selected for seven soil samplings taken throughout the year 1959-60, with the provision that no two subplots would be touching on a side. From each subplot four soil samples were taken with an auger, representing four depth layers: a) 1-10 cm; b) 10-25 cm; c) 25-40 cm, and d) 40-90 cm.

On the same date, seven times during the year, 5 subplots x 4 (depths) soil samples were taken from each plot for soil moisture determination. At the second sampling, December 4, 1959, an additional series of soil samples was taken for soil moisture equivalent determination. In August complete soil profiles were taken with the apparatus shown in Figure 1. At the same time samples were carefully taken for bulk density determinations by the zinc chloride solution method (Perry 1949).

Water retention by mulch (dead plant material), left on the ground the year before, was evaluated. This is called rain interception in the following discussions.

Mulch collected separately from each of the three plots was used for a laboratory study as well as field study. In the laboratory, mulch proportional to the amount found on the ground for each plot, was placed in a 3 mm soil sieve with filter paper in the bottom and then thoroughly wetted by watering it for 30 minutes. By weighing the mulch before and after watering the

FIGURE 2. Wooden frame with mulch for testing rain interception losses.

percent by dry weight water interception was determined. The mean of three replications was used as the interception figures.

The field test was run to simulate natural conditions. Plastic screen of 5 x 5 mm mesh was put on three 40 x 40 cm frames. These were painted for waterproofing. After taking the tare of each screen, mulch was placed proportionally to the amount of mulch in each plot and the top of the frame was covered with a net of plastic string. So prepared, the frames were placed in the respective plots in direct contact with the ground (Figure 2). Twice, early in the morning after continuous night rains, the frames were weighed in the field. The difference of dry and wetted mulch weights was used to determine the percent field rain interception.

The weight of mulch cover in each plot was determined by collecting it very carefully from 40 x 40 cm squares. The means of five such squares taken on October 24, 1959 and May 17, 1960 were used in making a regression (mulch decomposition) line, relating the amount of mulch to time of year.

Local Climate and Soil

The climate is typically Mediterranean. The annual precipitation, all rain, amounts to 595 mm (23.35 inches, Berkeley long term average). This comes mainly during 8 months, October to May. Summer through the month of September is dry almost every year and herbaceous vegetation, except some late growing weeds and perennial grasses, is dry. The soil moisture, at least in the upper part of the profile, falls to or below permanent wilting percentage (PWP). This occurs at a depth of 15 to 25 cm and evaporation is very intensive during the summer.

Temperatures are very even throughout the year. Normal mean in Berkeley is 9.5°C (49.2°F) for January, the coldest month, and 17.3°C (63.2°F) for September, the warmest month. In the main growth period, (March through May) temperature varies from 12.9°C (53.9°F) for March to 15.6°C (60.1°F) for May.

The soil is a clay loam residual developed on sandstone in the Los Osos series. It is classified as a non-calcic brown grassland soil with some rendzina-like characteristics. The relief, on all three plots, is a gentle north facing slope (8 percent). The soil forming factors seem to have been the same for all three plots, with the exception of the different degrees of grazing by domestic livestock during the past 35 to 50 years.

Findings-Discussion

Soil Properties

Soil profile characteristics (Table 1) indicate the effects of grazing during the last 30 to 40 years on soil development.

Under protection from grazing, the undisturbed vegetation, microflora and microfauna of the soil apparently contributed to a granular structure and increased porosity of the soil. There also was evidence of an increase in infiltration, percolation and water storage capacity. These factors in turn affected vegetational changes, maybe a secondary succession towards the perennial grass climax. Thus, that portion of the soil profile which is actually utilized by the plants is deep under protection from grazing. The abundant roots go down more than 90 cm., permeating the soil very extensively throughout the profile and so improving greatly the porosity and aeration of the soil. At the same time the improvement of infiltration and percolation has increased the clay migration.

Under heavy grazing the soil

Table 1. Soil Profile Characteristics.

Soil Profile Plot	Layer from - to cm	Bulk density	Soil Structure	Color	pH
Ungrazed	0-10	1.40	Granular weakly block .5-1.5 cm	light brownish gray	5.4
	10-40	1.50	Blocky angular in squares .5-4 cm	light brownish gray	5.5
	40-72	)	Blocky angular 2-7 by 4-14 cm	light gray	6.0
	72-80	)2.00	Lightly blocky angular 2-5 cm	light olive gray	6.2
	80-90	)	Blocky angular 2-4 cm	light gray	6.5
Moderately to lightly grazed	0-18	1.50	Granular weakly blocky .5-4 cm	light brownish gray	5.5
	18-48	1.65	Blocky angular columnal 2-3 by 4-8 cm	light brownish gray	5.4
	48-80	1.60	Blocky angular columnal 3-4 by 10 cm	olive gray	5.6
	80-90	......	Decomposed bed rock (sandstone)	olive	6.0
Heavily grazed	0-15	1.60	Blocky more or less rounded 1-5 cm	grayish brown	5.7
	15-40	1.55	Blocky angular columnal 3-6 by 10 cm	grayish brown	5.6
	40-75	1.25	Blocky angular 2-4 by 10 cm	dark grayish brown	5.7
	75-90	......	Bed rock more or less decomposed	olive brown	6.4

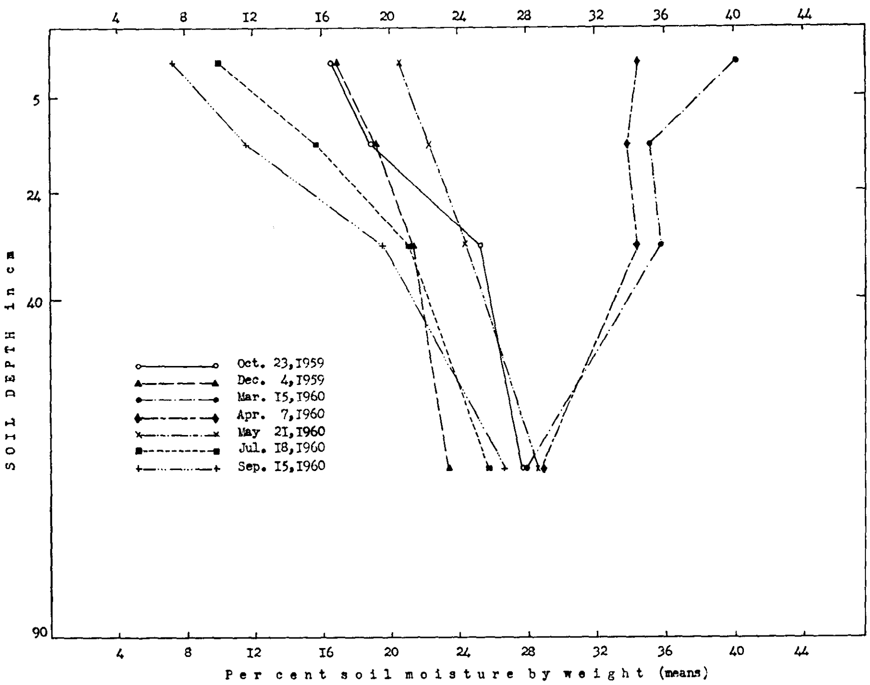

FIGURE 3. Heavily grazed plot. Soil moisture profiles throughout the hydrologic year 1959-60.

is shallower. Plant roots decrease greatly with depth. Trampling by the animals increased the bulk density of the upper layer. Water infiltration and precolation rates were apparently lowered and aeration was reduced. Earthworm activity was markedly lower than in ungrazed soil. The uppermost layers were darker in color, apparently because of the slow plant material decomposition process.

Under light grazing the situation was something between, but closer to the plot under no grazing (Table 1).

Soil Water Regime

The differences in soil physical properties were correlated with striking differences in the water regime in the three grazing treatments. Figures 3, 4, and 5 show the soil moisture profiles throughout the year for all three plots examined.

Under heavy grazing soil water storage was always low; its field maximum, reached by March 15 (end of the winter rainy season), amounted to 403 mm. The reason for that low moisture content must be the low rate of water infiltration and percolation. The soil moisture in the lower half of the profile practically did not vary during the year. It remained around 26 percent by weight. The water percolation was so slow that an increase of only about 3 percent was noticed. On the other hand the amount of plant roots was so small in the lower half of the profile that a moisture depletion of only 6 percent occurred.

The soil moisture content in the upper layers varied greatly, from 40 percent (very close to moisture equivalent=field capacity) at the end of the rainy season, down to permanent wilting percentage which was calculated to be around 15 percent. However, the moisture content of the uppermost layer went down to about 7 percent as a result of the intensive summer evaporation; this low soil moisture content of the uppermost layers—lower than the PWP—was a common phenomenon in all three plots. Moisture content of the third layer (24-40 cm) on October 23, 1959, was high. This was probably due to the good water storage during the first big storm

Table 2. Rain interception Losses by Mulch.

	Heavily grazed plot				Lightly grazed plot				Ungrazed plot			
		Interception Loss				Interception Loss				Interception Loss		
Month	Mulch	by evapo-transpiration	Total amount	Period of water surplus	Mulch	by evapo-transpiration	Total amount	Period of water surplus	Mulch	by evapo-transpiration	Total amount	Period of water surplus
	Kgr/ha	— — — mm	— — —		Kgr/ha	— — — mm	— — —		Kgr/ha	— — — mm	— — —	
September	688	0.182			1,399	0,369			3,837	1.013		
October	688	......			1,399	......			3,837	......		
November	600	......			1,250	......			3,580	......		
December	525	0.257		)	1,050	0.277		)	3,262	0.861		)
				)				)				)
January	455	1.676		)	855	2.662		)	2,965	4.977		)
				)2.959				)5.055				)9.270
February	332	0.694		)	662	1.400		)	2,585	2.140		)
				)				)				)
March	315	0.332			470	0.716			2,250	1.292		
April	245	0.195			275	0.219			1,920	1.163		
May	165	0.129	3.465		68	0.954	5.697		1,555	1.072	13.018	

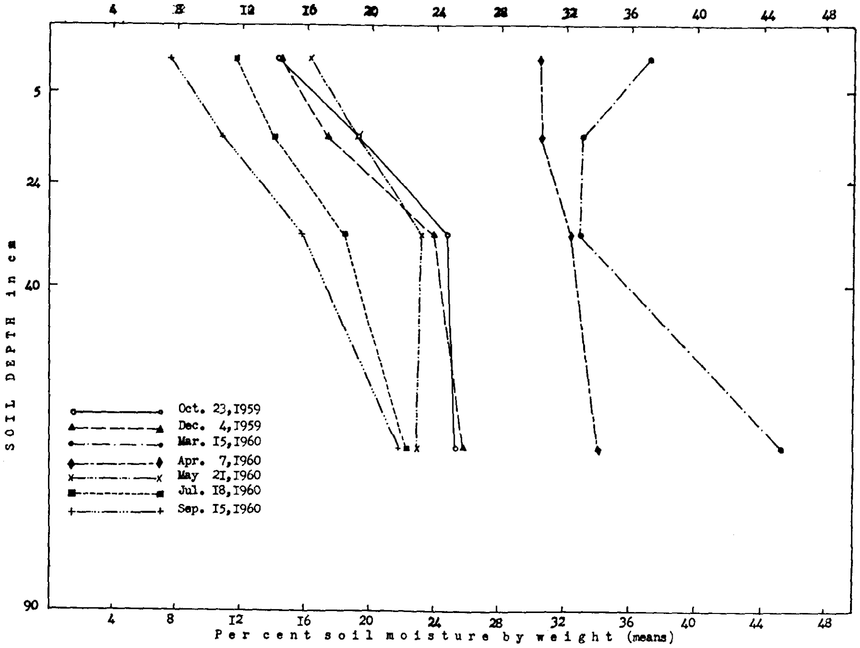

FIGURE 4. Lightly grazed plot. Soil moisture profiles throughout the hydrologic year 1959-60.

in September (Figure 6), facilitated by the deep fissures in the soil late in the dry season. The shallow rooted new seedlings had used the moisture of the upper layer only thus far, but the roots had not yet reached the 24 cm depth.

The soil water regime of the ungrazed plot was very much different, and soil moisture changes were equally drastic throughout the whole profile (Figure 5). A range in variation of 24 percent was found in all soil layers. The unexpectedly high moisture content in the lowest layer in May and July 1960 was due to a very high clay content in two of the five samples taken for each of them.

The ungrazed plot had high infiltration and percolation rates on the one hand, and heavy use of the stored moisture by abundant, deeply rooted plants (a considerable number of perennials) throughout the whole profile on the other hand. This can very easily explain the differences in its soil water regime and that of the heavily grazed plot.

As can be expected, the soil moisture regime of the lightly grazed plot showed a very similar picture. Soil moisture varied throughout the whole profile, but not as much as in the ungrazed plot (Figure 4). It is important to note, however, that in the lowest layer the percent soil moisture was not lowered very much, remaining around 23 percent at the end of the dry summer season. Thus, the lightly grazed plot was similar to the ungrazed one in soil moisture accretion and similar to the heavily grazed plot in soil moisture depletion. The very high soil moisture content in the lowest layer in the March sampling was due to the clay content of samples.

Rain Interception

Studies of rain interception by grasses, especially annual grasses, are rather limited (Burgy and Pomeroy 1958; Burgy 1958; Clark 1940). In a recent one, W. D. McMillan and R. H. Burgy (1960) found that rain interception by green grass leaves did not represent a net loss. Differences in evapotranspiration losses were very small under dry or wetted grass canopy (dry or wet leaf). In contrast, interception represented a net rain loss in the case of dry or wetted dead plant material.

Table 2 shows the amount of mulch in each plot for every month from September to May. The amount of mulch for Sep-

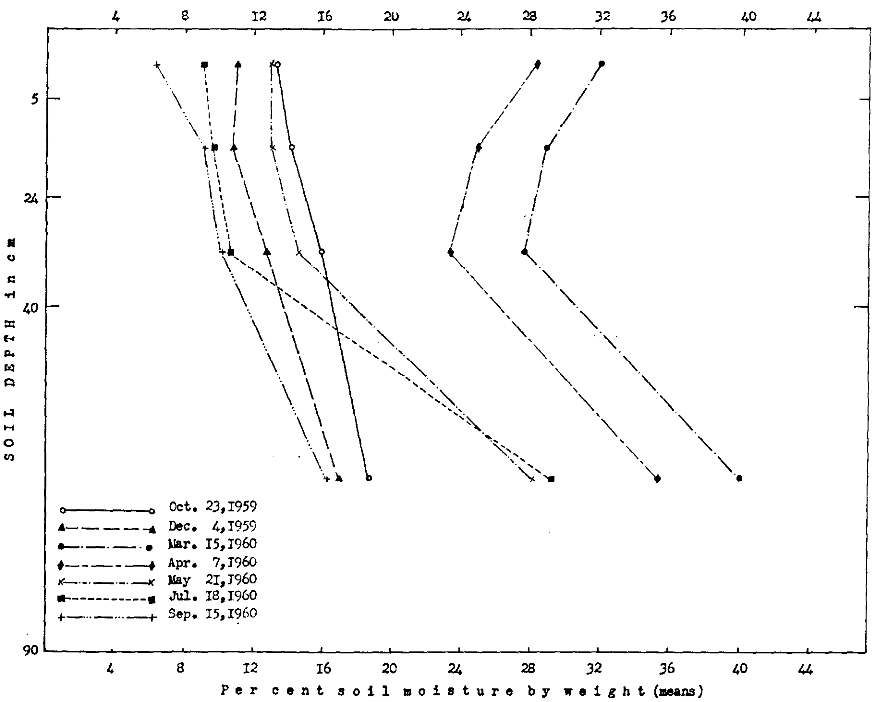

FIGURE 5. Ungrazed plot. Soil moisture profiles throughout the hydrologic year 1959-60.

tember was considered equal to that of October.

The mulch rain interception losses as a mean of the laboratory and field tests were found to be (percent by dry weight of mulch) as follows:

a. Heavily grazed plot 271 percent
b. Lightly grazed plot 260 percent
c. Ungrazed plot 261 percent

These figures are close to the results of other investigators (Kittredge 1955).

Based on the findings of McMillan and Burgy (1960) and taking as rain interception percentage for all three plots, 264 percent of dry mulch weight (mean of the above three figures), the net interception losses were calculated for each individual storm; the time interval between storms was taken into consideration for such calculations. The monthly net interception loss is given in Table 2. The net rain interception loss was about 10 mm greater in the ungrazed plot than in the heavily grazed one, and 7.5 mm greater than in the lightly grazed plot. (Although lightly grazed the cattle took a considerable amount of mulch during the early winter grazing).

Water Balance

It would appear from this study that intensity of grazing has a great effect upon the hydrology of a watershed. Although soil moisture differences may occur even at greater depth than the 90 cm (3 ft.) considered here, we can evaluate the hydrologic effect of grazing and its degree of intensity.

Figure 6 shows the trend in soil moisture content or water yield (depth of water in mm) throughout the year for each plot. The period of soil moisture accretion coincides, mainly, with the winter season of precipitation. Certainly, there is a variability from year to year but this does not greatly affect the general picture of soil moisture trend.

During the year 1959-60, when the experiment was carried out, the distribution of rain was very close to the "normal" one, based on weather record means, particularly during the period of soil moisture accretion (Figure 7).

Most of the rain comes during the period of seed germination and low growth. This is the period of soil moisture storage. By the middle of March, in general, soil reaches its maximum field moisture content, which is, we can say, the field capacity. Following the middle of March plant growth is very fast and a depletion of soil moisture begins. The small and scattered rain storms in the spring are ineffective in recharging the soil. All the rain coming during that period can be used by the plants at a faster rate than it is received.

In order to check the findings from field samplings, a daily water balance has been computed according to Thornthwaite's method (C. N. Thornthwaite and J. R. Mather 1957). The results of such water balance computations were rather close to those of actual sampling (Figure 6). It is important, I think, to notice that in the face of soil moisture depletion the method of Thornthwaite gives a smaller rate than the actual one in the case of the lightly and the ungrazed plots; in contrast this rate is higher in the case of closely grazed plots. In the face of soil moisture accretion the rate does not vary; the small differences, especially in the level of the accretion lines, are the result of similar variation in the rate of depletion during the late fall and early winter period (Figure 6). The low rate of soil moisture depletion in the early dry winter period in the case of the lightly grazed plot is actually due to heavy grazing by calving cows during that period, which

Table 3. Water yield under different intensities of grazing.

	Calculated by simple arithmetic						Computed by Thornthwaite's daily water balance method			
	Soil Moisture Storage									
Plot	On Dec. 4, 1959	On March 15, 1960	"Accretion" Difference in storage between the two dates	Actual evapotranspiration losses between dates	Rain received between the two dates	Water yield	Surface runoff	Gravitational water yield	Total water yield	Differences in water yield because of biased computed soil moisture content at the beginning of soil moisture accretion period
	(mm)									
Heavily grazed	266	401	135	98	468	235	59	226	285	+12
Lightly grazed	328	578	250	116	468	102	....	158	158	+33
Ungrazed	237	570	333	89	468	46	....	136	136	− 8

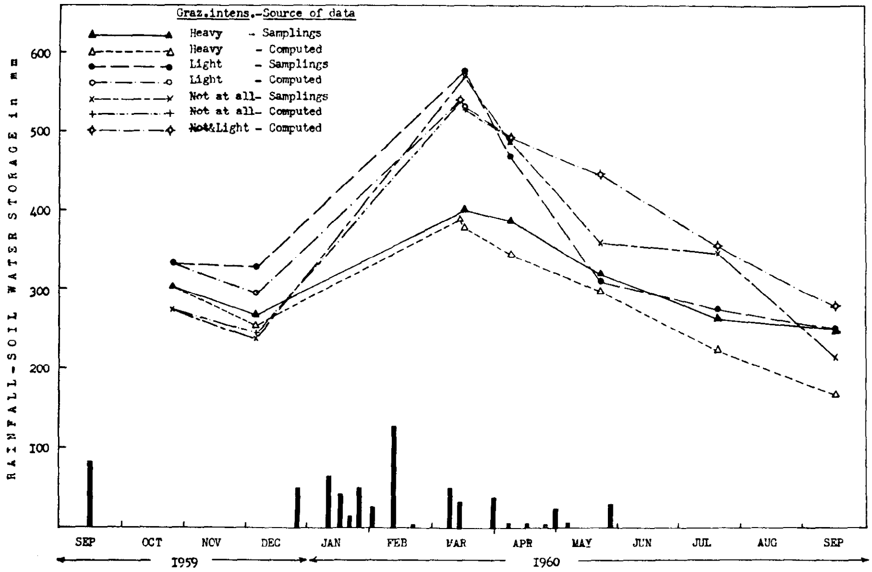

FIGURE 6. Rainfall and soil moisture trend throughout the year.

supports the statement made above.

Thus, we can say that the Thornthwaite's method is not a good one for water balance calculations in the case of grasslands subjected to different intensities of grazing. It can only be used for a general and average picture of the problem.

Coming back to the case of soil moisture accretion, we can see quite striking differences in the water regime from one plot to another. By substracting from the total rain received from December 4, 1959 to March 15, 1960 (period of soil moisture accretion) the difference of soil moisture between the above dates of sampling plus the evapotranspiration losses, one can easily find the water yield from each of the three plots. Table 3 summarizes the computations. For evapotranspiration losses, those computed by the Thornthwaite's method were taken. Although it may be argued that a portion of the soil water found on March 15 could be classified as gravitational water produced gradually later in the spring, yet nothing was added, considering the soil, on that date, to its field capacity. The soil samples were taken on March 15, and the last big storm was received on March 12, in other words, allowing some time for drainage. Table 3 also shows (see also Figure 7) the water yield from each plot according to the computations by the Thornthwaite's method. It must be noticed that, if the daily water balance computations had as starting point the sampling of Dec. 4, 1959 and not Oct. 24, 1959, the water yield would be increased for the heavily and lightly grazed plots and decreased for the ungrazed one; the last column of Table 3 shows the respective amount of increase or decrease in water yield.

The intensity of grazing, therefore, greatly affects the hydrology of our watersheds. Heavy grazing is responsible for more water production in areas similar in physical conditions to those of the Berkeley hills. The present study thus shows that the greater the grazing intensity the higher the water production. The figures in Table 3 also show that under heavy grazing a considerable amount of water produced down hill comes in the form of surface run-off (Martin and Rich 1948). That means that soil erosion hazard increases with the intensity of grazing, which is in accordance with the already well established experience. Although we have not noticed any erosion of soil on the heavily grazed plot, one feels that such a phenomenon will inevitably occur, especially when heavy grazing is practiced on steeply sloping grasslands. However, in case of heavy montmorilionite clay soils where shrinkage occurs, deep fissures open in the soil during the dry summer period which accept the rain water of the first storms in the fall very rapidly and so re-

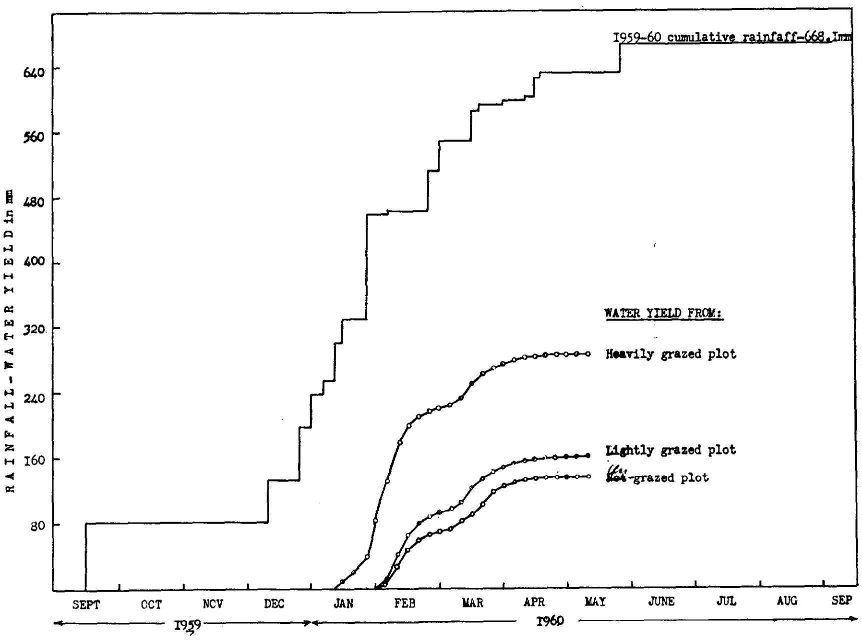

FIGURE 7. Water yield as related to degree of grazing by livestock.

duce greatly the erosion hazard on the soil surface. In that case internal soil erosion takes place during which soil particles are detached from the side walls of the open fissures and transported down to the bottom; this kind of erosion is not damaging. Following the first rains with favorable soil moisture and moderate temperature, many new seedlings (facilitated partly by the fact of low mulch cover), provide a very dense cover, especially when grazing is excluded for an adequate period of time. It is evident that in case of light and shallow soils, soil erosion with the first storms, when the soil is barren and with very poor litter cover, becomes the key problem in land management practices. In the case of the present study the surface run-off from the heavily grazed plot came during the main rainy period, when a good new growth provided cover to the soil. But the heavy trampling of the soil by livestock must reduce considerably the infiltration and percolation rates, thus causing the surface run-off.

The reduction of the infiltration and percolation rates is responsible, in the case of the heavily grazed plot, for the very low storage of rain water in the lower soil layer (Figure 3). On the other hand, the low, almost insignificant withdrawal of soil moisture from this lower layer by the shallow rooted plants does not create great opportunities for new storage.

The soil properties of the lightly grazed plot present good conditions for storage; the infiltration and percolation rates being high, facilitate the storage of the rain water even in the lowest soil layers. The more effective use of this water, on the other hand, by relatively deeper rooted plants creates good opportunities for water storage (Figure 4).

Finally, the soil water storage opportunities in the ungrazed plot are really very high, especially because of the total depletion of the soil moisture at the end of the summer by deeply rooted perennial plants. The soil moisture by the end of the dry season is at the P.W.P. (Figure 5). The extremely high infiltration and percolation rates prevent surface run-off. Thus, all the rain water is stored in the high storage capacity soil profile.

The total water production is also affected differently by interception losses. Those losses are significant in the case of the ungrazed plot (Table 2). Thus, if we took the most representative results of the simple arithmetic calculations (Table 3) and subtracted from them the respective mulch interception losses (from Table 2), the water yield from each plot would be as follows:

a. Heavily grazed plot 232 mm
b. Lightly grazed plot 97 mm
c. Ungrazed plot 33 mm

It is very reasonable to believe that under moderate grazing the water yield would be between 97 and 232 mm.

Thus, range managers have a very good tool in their hand to affect water production in quantity and quality.

Conclusion

1. When heavy grazing is practiced for a long time, the soil forming process is slowed down. Light or no grazing results in deeper soil, with good physical properties and high soil moisture storage capacity.
2. Water yield is many times greater from grassland under heavy grazing than under protection, when the major part of the rainfall comes during the winter period which coincides with very low growth.
3. The amount of net interception loss is about 6 mm higher in grasslands under no grazing than under heavy grazing and 4 mm higher than under light grazing.
4. The gravitational water does not seem to vary much with the degree of grazing.
5. The degree of grazing may be a practice for regulating water run-off. Protection from grazing may reduce the run-off and control the floods in small watersheds. In contrast, increased grazing intensity may be the right practice for increased water yield.
6. Where light to moderate grazing is implied, intense early winter grazing cuts down the evapotranspiration and reduces the soil water storage opportunity, resulting in increased water yield during the period of soil moisture accretion.
7. Thornthwaite's method gives higher evapotranspiration losses in the case of closely grazed grassland and lower in the case of ungrazed grassland.
8. Range managers must pay more attention to range influences and particularly to watershed management as affected by grazing management.

Summary

An experiment was established on the Berkeley hills, California, in 1959-60 to check the effect of the intensity of grazing upon the water balance.

Heavy grazing for more than 35 years had resulted in a shallower soil than where ungrazed during the same time.

Reduction of infiltration and percolation rates and increased shallow rooted plants, caused by heavy grazing, resulted in a considerable increase of water yield. Against only 33 mm, produced from the ungrazed plot there were produced 97 mm and 232 mm from lightly and heavily grazed plots, respectively.

The net interception losses from dead plant material (litter) were 3, 5, and 9 mm from heavily, lightly and ungrazed plots respectively.

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Fertilizers Increase Range Production

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Livestock grazing on California ranges dates from the arrival of the first Spanish colonists in 1769 (Burcham, 1957). Before that date only wild game and range rodents made limited use of these vast areas. Today, as during the past 70 years at least, these ranges are fully stocked if not overstocked with livestock. In addition, the big game population, mostly deer, is higher now than during any previous period. These factors plus drought, fire, and man's numerous devastating activities, have reduced the production of California's remaining range acres to perhaps half or less of their potential capacity (Burcham, 1957).

In the face of expanding human populations and increasing demands of other uses on the grazable acres it is imperative that every acre be wisely used for sustained high level production.

A large segment of the pristine Central Valley prairie, commonly known today as the foothill-annual range type, is the State's largest and most important range area. It encircles the Sacramento and San Joaquin valleys in a broad band between the low-lying agricultural lands and the brushfields situated just below the timber in the Sierra Nevada and Coast Range. It extends, too, into the valleys of the Coast Range and throughout the minor mountain ranges of southern California. Because of greater accessibility and milder climate, this range type has a longer and perhaps more critical grazing history than other range types in California. Aids to and management for improvement and increased production on these ranges are highly important.

Early Research

Interest in the possibilities of increasing annual type range production by fertilization was first shown by researchers and ranchers in the early 1940's. Bentley (1946), working at the San Joaquin Experimental Range near Fresno, found that pit-run gypsum gave greater increases in herbage production than either single superphosphate or sodium nitrate. About the same time the California Agricultural Extension Service and individual progressive ranchers reported good success with gypsum on range areas in several counties.

In many of these early trials the first response to fertilizers was shown by native clovers and other leguminous plants. Increased vigor and herbage growth in these species apparently added significantly to soil nitrogen through natural assimilation which stimulated grass and non-leguminous herbs to greater growth in the second years after fertilization. Bentley (1946), Bentley et al. (1958), Hoglund et al. (1952), Conrad (1950), and later Green et al. (1958) showed that the beneficial effects of the gypsum carried through three growing seasons. This finding led to a 3-year fertilization cycle and fall application. These same workers determined that plant growth started earlier, maintained a more rapid rate through the winter, and produced earlier grazing on fertilized than on unfertilized range.

Various workers in the California Agricultural Extension Service (Martin et al., undated) and the University of California (Williams et al., 1956) as well as ranchers and others, conducted numerous tests throughout the past decade with a large number of fertilizers on annual-type ranges. In general, these tests confirmed earlier findings, extended knowledge concerning several kinds of fertilizers, and gave some indications of the economics of range fertilization. None, however, was primarily concerned with proper management of fertilized ranges or the correlation of such areas with unfertilized range in terms of a yearlong practical range-livestock operation.

The San Joaquin Study

Research on these management problems was started at the San Joaquin Experimental Range in 1958 after several years of research and experience with range fertilization (Bentley and Green, 1954; Wagnon, Bentley, and Green, 1958; and Green, Wagnon, and Bentley, 1958). New studies were designed to determine proper grazing management of fertilized ranges and how to correlate their use, yearlong, with unfertilized range. Two series of six range areas were fenced for this purpose. In each series, two units were fertilized with 60 pounds per acre of sulfur, two with 60 pounds of sulfur plus 80 pounds of nitrogen per acre, and the remaining two were unfertilized. One series was designed for green-season grazing (February to May usually), the other for use during the dry season, from May or June until the occurrence of substantial (1 inch or more) fall rain. The dry season units were fertilized in the fall of 1958 and treated again in 1961. Green season units were treated in 1959 and will be refertilized in the fall of 1962.

The cattle used in this study start out as weaned steer calves and finish about 10 months later as yearling feeder steers (Figure 1.) A new group is used each year. The basic experimental group in each unit is nine animals. Additional animals are added as needed to effect moderate utilization of the range herbage during the designated season. The grazing year starts in June or July with the dry season. When enough fall rain occurs to germinate seed and severely leach old range herbage, all animals are moved to winter range and given uniform treatment unil range readiness occurs in the green-season units. At this time each basic experimental group of nine steers is divided into three sub-groups of three. One sub-group is placed in each fertilizer treatment. This cross-over design or arrangement subjects sub-groups of animals to each fertilizer treatment and every combination of treatments. Animals are weighed individually with a light shrink at 28-day intervals and grazing use by units is recorded. Herbage production is determined annually by units as is level of utilization at the end of each grazing season.

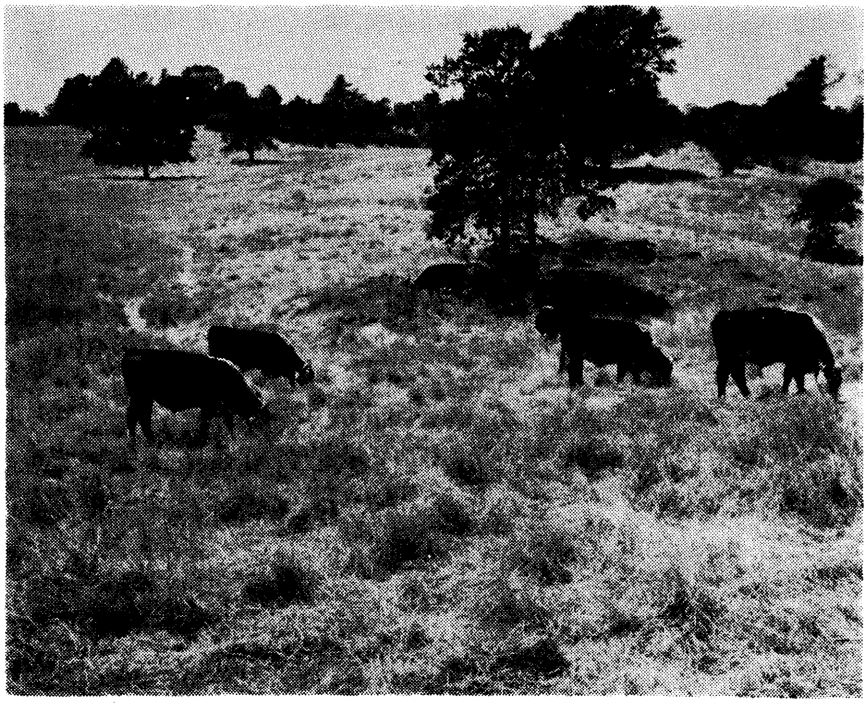

FIGURE 1. Yearling steers on fertilized annual type range late in the green season.

Results

Dry Season, 1959 and 1960

Unseasonal weather and the difficulties of starting a new procedure resulted in more variation in the first two dry seasons than was expected. At the outset, 1959 was extremely droughty and range herbage production less than half of the longtime level (Table 1). The dry-season ranges were stocked on June 1, but the short supply of herbage was soon consumed on all units and the season ended on September 9. Nine days later 3.5 inches of rain induced seed germination and plant growth, thus terminating the dry season. More than 100 days of drought following this September 18, 1959 rain proved disastrous to a high proportion of new grass seedlings on the range, thus affecting composition of the 1960 herbage (Table 2) and, of course, greatly reducing the amount of herbage avail-

Table 1. Herbage production on unfertilized and fertilized annual-type range.

Year	None	Fertilized with Sulfur	Fertilized with Sulfur plus nitrogen
	— — — — — (Pounds per acre) — — — — —		
1959	692	884	2,513
1960	1,662	2,066	3,485

Note: Preliminary estimate 1961, unfertilized range, 1,500 lbs./acre.

Table 2. Composition of herbage on unfertilized and fertilized annual-type range (based on hand sorted, clipped material).

	Fertilizer treatment					
	1959			1960		
Species	None	Sulfur	Sulfur plus nitrogen	None	Sulfur	Sulfur plus nitrogen
	(Percent)					
Grasses	54.9	66.0	69.5	25.0	27.5	40.5
Grasslikes	3.3	5.0	1.6	2.0	1.2	0.0
Broadleaved herbs						
Erodium	39.3	25.5	27.1	60.9	63.7	52.1
Clover	1.2	1.2	0.5	1.6	2.9	0.1
Others	1.2	2.2	1.3	10.5	4.6	7.2
All herbs	41.7	28.9	28.9	73.0	71.2	59.4

Note: Preliminary 1961 estimate of herbage composition by foliar hit method; 54, 0, 37, 3, 6, and 46 percent, respectively.

able for winter grazing, Reppert and Duncan (1960). Animal days of grazing use obtained per acre of grazable range during the 1959 dry season were low, as expected, but proportionately greater on the sulfur-and sulfur-plus nitrogen-fertilized units than on unfertilized range (Table 3). Animal performance, too, although much lower than expected was greater from fertilized range, on both an animal and an acre basis, than from unfertilized range (Table 4).

The 1960 dry season was even shorter than that of 1959. Animals intended for the study required recuperation from prior rough handling and this held up the start of grazing until July 20. Herbage production was about normal on unfertilized range (Table 1), but herbage composition was considerably out of balance (Table 2) because of the previous fall's drought effects. The heavy proportion of broadleaved species compared to grasses in the 1960 vegetation composition was tempered somewhat by both fertilizer treatments. Grazing use in animal days, both total and per acre, was considerably above the 1959 level because more animals were available and all units produced more herbage than in 1959. Condition of the cattle at the start of the 1960 dry season affected their performance on the sulfur- and unfertilized units. Only a slight change in weight occurred on the sulfur-plus-nitrogen units. The effects of branding, castrating, and vaccinating combined with a truck ride all in one day contributed to the very poor condition of these cattle throughout the dry season.

These data for two dry seasons, one following severe growing season drought, the other after a usual growing season, indicate some of the benefits of range fertilization. Sulfur alone increased individual animal gain by 48 percent for the 1959 dry season, and animal gain per acre by 37 percent. Sulfur-plus-nitrogen doubled animal gain and increased gain per acre by more than six times. Compared to the sulfur-fertilized areas, sulfur-plus-nitrogen increased animal gain by 36 percent and gain per acre by 440 percent. Neither individual animal gain nor gain per acre was enough different between treatments in the 1960 dry season to warrant comment. The reason has already been cited.

Dry season, 1959, grazing use, in animal days per acre, was about 10 percent greater with sulfur-plus-nitrogen. The use on sulfur-plus-nitrogen units was 230 percent above the sulfur units. During the 1960 dry season, grazing use on the fertilized units was 60 to 190 percent more than on the unfertilized, and on the sulfur-plus-nitrogen units it was 80 percent above the sulfur units.

Green Season, 1960 and 1961

The 1960 and 1961 green seasons were very similar in total herbage production but very unlike in herbage composition. Because of the fall 1959 drought, 1960 was a "filaree" year. Broadleaved herbs were very abundant, with *Erodium* spp. (filaree) composing a high percent-

Table 3. Livestock grazing use in animal days on unfertilized and fertilized annual-type range by seasons.

	Fertilizer treatment								
	None			Sulfur			Sulfur plus nitrogen		
Item	1959	1960	1961	1959	1960	1961	1959	1960	1961
Dry season ranges:									
Acres grazed	130.5	130.5	....	58.9	58.9	....	54.5	54.5	....
Total animal days	1,020	2,573	....	502	1,870	....	1,530	3,123	....
Animal days/acre	7.8	19.7	....	8.5	31.7	....	28.1	57.3	....
Green season ranges:									
Acres grazed	....	141.3	141.3	......	50.4	50.4	....	52.6	52.6
Total animal days	....	2,876	3,410	......	2,043	2,187	....	3,514	2,648
Animal days/acre	....	20.4	24.1	......	40.5	43.4	....	66.8	50.3

Table 4. Pounds of animal gain produced on unfertilized and fertilized annual-type range by seasons.

	Fertilizer treatment								
	None			Sulfur			Sulfur plus nitrogen		
Item	1959	1960	1961	1959	1960	1961	1959	1960	1961
Dry season ranges:									
Total	787	−40	....	486	−156	....	2,429	47	....
Avg./animal	66	− 2	....	97	− 9	....	132	3	....
Avg./acre	6	−0.3	....	8	− 2.6	....	45	0.8	....
Green season ranges:									
Total	....	4,558	8,167	......	3,294	5,477	....	5,665	5,690
Av./animal	....	191	213	......	165	205	....	209	220
Avg./acre	....	32.3	57.8	......	65.3	108.6	....	107.7	108.2

age of the herbage in this group (Table 2). Grasses made up half or less of their usual composition in the herbage. This shift in composition shortened the 1960 green season and, as already indicated, reduced the value of annual-type ranges for dry season grazing. Both of the fertilizers tended to cushion the effect—forbs were considerably less abundant and the grasses more abundant on the fertilized than on the unfertilized units (Table 2).

The effects of the fertilizers were very noticeable in terms of grazing use and weight of animal gain produced. In 1960 grazing use per acre on the sulfur units was nearly double, on the sulfur-plus-nitrogen units more than three times that of the unfertilized units. Use on the sulfur-plus-nitrogen units was 65 percent more than the use on the sulfur units that year. During the 1961 green season the same trend held but was somewhat scaled down. Use per acre on the sulfur units was up 80 percent; on the sulfur-plus-nitrogen units, 108 percent over the unfertilized units. Sulfur-plus-nitrogen units gave only 16 percent more grazing per acre than sulfur alone during 1961, the second green season after fertilization.

Livestock gains per acre on fertilized range held almost exactly the same advantages over the unfertilized as did grazing use. Gains per acre in 1960 on the sulfur and sulfur-plus-nitrogen units were 102 and 233 percent greater than on the unfertilized units. The sulfur-plus-nitrogen acres produced 65 percent more than the sulfur-fertilized acres. In the 1961 green season, animal weight production per acre was even for the two fertilizer treatments and 87 percent above production from the unfertilized acres.

Conclusions

The experience reviewed and data presented indicate rather conclusively that range herbage production, grazing use, and weight gains of grazing animals can be effectively increased on California annual-type range by fertilization. The greatest benefits came from the application of 60 pounds of sulfur and 80 pounds of nitrogen per acre. Sulfur alone, 60 pounds per acre, was less beneficial.

The benefits of sulfur-nitrogen fertilization were evident in the dry season as well as in the green season and in drought as well as in normal years. This fertilizer minimized the effects of weather on vegetation composition. It also induced earlier plant growth and sustained growth at a more rapid rate during winter when temperatures are minimal. Range livestock operators in the annual type can well afford to take advantage of a fertilizer program for greater production.

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BOOK REVIEWS

Edited by Lowell K. Halls, Forest Service, U. S. Department of Agriculture, New Orleans, Louisiana

Audubon and His Journals. By J. J. Audubon, edited with a biography by Maria Audubon, and other notes by Elliott Coues. Complete, unabridged reprinting of the 1897 edition. *Dover Publications, Inc., New York, New York. Two volumes, total of 1086 pages. 1960. $4.00.*

This review is not for the purpose of discussing the subject matter contained in Audubon's Journals. These Journals have been used for many years by working scientists, naturalists, and others since the original publication in 1897, and are well known. The important fact is that they are again available, and at a reasonable price, in an unabridged edition.

To refresh the memories of those who may not have had the opportunity to peruse the original works lately, the Journals consist of: (1) The Missouri River Journals (1843); (2) The Labrador Journal (1833); and (3) the European Journals (1826-29). These Journals tell of the Audubons' encounters with frontier folk, Indian tribes, and contain hundreds of descriptions of the bird and animal life of the regions. The European Journal tells of Audubon's sudden rise to fame as the American backwoodsman.

To these Journals, Dover has added the famous "Episodes," 58 in number, which are in reality vividly written short stories of Audubon's experiences in backwoods living. These experiences reach from the Florida Keys to Labrador and in subjects from pitting wolves to squatters of the Mississippi.

Finally, the edition includes a biography of Audubon by his granddaughter.

Do not be misled by the quality of this paper bound edition. The Dover edition will stand many years of use. The paper is of the quality used in more expensive editions and the binding sewn in signatures. The books will open flat for easy reading without damage. Finally, the type is legible and margins sufficiently wide to permit cloth rebinding, should one feel this to be necessary.

For those who could not find the original edition, or afford one when he did, now is the time.—*Howard A. Miller,* U. S. Forest Service, Atlanta, Georgia.

Elements of Photogrammetry. By Wilfred H. Baker, *The Ronald Press Company. New York, New York, 199 pages. 1960. $5.00.*

This book presents basic principles of photogrammetry in fairly logical sequence beginning with a brief discussion of the development of photogrammetry as a science.

Coverage of essential subject matter, while on an elementary level, is reasonably complete. The first six chapters include material on aerial photographs, photo indexes and mosaics, interpretation and control, vertical photographs, and radial line mapping. Chapters 7 through 11 cover stereoscopic principles, tilt analysis, precise determination of tilt, the use of tilted photos, and stereoscopic plotting instruments. Chapter 12 discusses oblique and terrestrial photographs, with a final chapter on applications of photogrammetric techniques and use of aerial photos. Each of the chapters on principles includes a set of numerical problems and suitable laboratory assignments which should be very helpful in teaching an elementary photogrammetry course.

Since the purpose is to provide an introduction to photogrammetry, and the range of material covered is fairly extensive, many subjects are treated rather briefly. For example, sections on aerial surveys, flight planning, scale of photography, and photo interpretation are not sufficiently detailed to make this a satisfactory reference for persons interested in resource surveys and evaluation.

Examples and illustrations throughout the book are oriented toward the field of surveying and mapping. The chapter on application of techniques and uses of aerial photos is short and very general. In this section, where one might expect to find material of special interest to foresters and range technicians, there is only a brief discussion of the uses of aerial photos as applied to forestry. No mention is made of their use in range work.

The book should be valuable and popular as a text for introductory photogrammetry courses in engineering, forestry, and range schools. However, examples and illustrations for specific application to forestry, range, and other resource problems will have to be taken from supplementary sources. It is not meant to be a reference for persons familiar with the field, but should be a worthwhile acquisition for anyone interested in becoming acquainted with the basic principles of photogrammetry.—*Lynn Rader,* Pacific Southwest Forest and Range Experiment Station, Susanville, California.

Our National Park Policy: A Critical History. By John Ise. *Published for Resources for the Future, Inc. John Hopkins Press, Baltimore, Md. 701 pages. 1961. $10.00.*

A national park book with no pictures! Maps show only 10 of the most important or controversial national parks. Outline maps of the United States and the Virgin Islands, inside front and rear covers, locate the 29 existing national parks.

Books describing our national parks and monuments are many. New ones appear annually. Most of them emphasize those spectacular attractions which lure tourists. Recent publications follow current trends toward more pictures and less reading. A few subordinate natural scenes behind groups of happy visitors—often of the "cutie" type. But despite such literary and pictorial competition, Professor Emeritus Ise (University of Kansas) has written an historic and legislative chronology which long will be valued within national park literature. Though its record ends with 1961, the book cannot soon be superseded, because few can equal the author's scholarly patience in reviewing, digesting, and chronicalling events and opinions which shaped the establishment and administration of our national park and monument areas.

Part One of the book—The Early Parks: 1872-1916—could be termed Pre-Park-Service Parks. Nine chapters deal chronologically in 169 pages with Yellowstone, Yosemite, Sequoia and General Grant, Mount Rainier, Crater Lake, Three Inferior National Parks (Wind Cave, Sullys Hill, and Platt), the Antiquities Act (The National Monuments), Mesa Verde, and Glacier Park. (Rocky Mountain National Park, 1915, oddly is included within Part Two.)

Part Two—The National Park Service: 1916-1959—divides 384 pages into 17 chapters named for administrations of the six Park Service Directors: Mather, Albright, Cammerer, Drury, Demaray, and Wirth. Titles could imply primarily a characterization of the successive directors, but such discussions are brief, incidental, or incomplete. Several of the directors still are alive. Most men are ably characterized and compared only after their deaths. Instead, Part Two continues the long chronology under which this nation has set aside from ordinary use—under the impetus of its national character—various superlative natural areas.

Part Three—Special Park Problems—employs 96 pages to deal more specifically with key national park policies. There are chapters on Wildlife, Concessions, Financing, Wilderness Areas, and National Parks in Other Countries.

The book proves most valuable as a reference for those who seek clues to or descriptions of events creating or related to one-time or remaining national parks. Professional men responsible for public land management policies find it helpful. General readers find it tedious. Thirty one pages of fine-print index help the well-informed reader to find items sought, but the text is so voluminous and detailed that most readers can jot additional page numbers after index captions, or supplement the regular index with a few pages of their own.

The book engrosses me because since 1937 I have taught a course in National Park Management and have been privileged to work with many national park managers. It serves as an important reference, but not as a text, for which at least a few pictures, more descriptions of individual park characteristics, and discussions of individual park problems and their solutions are essential.

Professor Ise is ablest when reporting events and references, and the places of men in history. His coverages of the Hetch-Hetchy dam and early 1920's attempts to impound Yellowstone waters are excellent examples. His comments upon administrative, cabinet, and congressional officials are illuminating, and transcend traditional concepts of well-known persons like Fall, Graves, Lane, and Pinchot.

Ise is least able when interpreting and evaluating natural resources. Of Crater Lake he opines: " . . . no other lake could be so beautiful." Glacier's Going-to-the-Sun highway is dubbed "glorious." Wildlife managers ponder his distinction between wildlife (wild ruminants in his usual thinking) and predators.

The reader wonders why the man who wrote *United States Forest Policy* in 1920, now writes of Forest Service opposition to creation of Grand Teton and Rocky Mountain National Parks without mentioning that lands coveted were under Forest Service jurisdiction, and why he interprets Forest Service responsibility for primitive and wilderness areas as a device for "undercutting the demand for more parks."

The Lane Letter dictum that "parks need not be large" is not related to small sizes of one-time Abraham Lincoln, Casa Grande, Fort McHenry, General Grant, and Sullys Hill National Parks. Yet Ise overlooked values accruing to small areas when a part of larger complexes within which the Park Service is properly represented. Examples are Wind Cave (which Ise termed inferior) within South Dakota's Black Hills, and Theodore Roosevelt National Memorial Park within North Dakota's Bad Lands, Medora, Marquis de Mores, Theodore Roosevelt ranches complex.

The advanced reader will be challenged, or slightly irked, by a myriad of minor questionable explanations, but he will enjoy them all and will be grateful for this one-volume, indexed key to national parks policy.—*J. V. K. Wagar*, Colorado State University, Fort Collins, Colo.

Animal Husbandry Heresies. By Allan Fraser. *Philosophical Library Inc., New York, New York, or Crosby Lockwood, & Son Ltd., London, 200 pages. 1961. $6.00.*

An interesting and unusual book that the reader will find difficult to lay aside before it is read cover-to-cover. The author is outspoken, frank, and stimulating. In many instances the sarcasm is thinly veiled.

Dr. Fraser discusses three phases of animal production—Inheritance, Environment, and Husbandry. A qualified and widely read philosopher with considerable practical experience, he denounces the geneticist and the animal breeder in their attempts at livestock improvement.

The denunciation reveals somewhat of an inconsistency in the author's reasoning. Although he never outright denies the principles of Medelian genetics, he does not accept the theories of linkage, crossing-over, and blended inheritance. Such hypotheses, he feels, are mathematical manipulations made to fit principles with unexpected population ratios.

Breed societies, pedigrees, and livestock shows are included in his attack on the over-emphasis of breeding in livestock improvement. He is critical of the breeder of purebred beef cattle, who suckles the promising bull calf on the Holstein cow. Dr. Fraser is critical of inbreeding and close line-breeding because it tends to concentrate undesirable characteristics. He must realize, however, that it may also intensify desirable traits in livestock.

The author champions the philosophy that a favorable environment will contribute more to the improvement of farm animals than will breeding. In support of his thesis he leans heavily upon the thinking of Voisin.

The importance of the environment in animal welfare isn't denied by the geneticist or the agricultural scientist. However, there may be some question to the author's suggestion that evidence indicates effect of feeding may persist over a number of generations.

Certainly the most valuable contribution of the book is the searching questions Dr. Fraser poses relative to livestock feeding. He champions the peasant farmer who keeps his animals well-fed without a knowledge of the principles of scientific feeding. Inadequacies of the current knowledge of food-stuff analyses and their relation to livestock nutrition are frankly and openly discussed.

Some of the discussion will be of minor interest to American scientists, since it is developed to initiate activity for progressive changes in English agricultural legislation.

In the portion of the book covering aspects of husbandry, the author philosophizes on many subjects, ranging from economics to grazing management systems. He recognizes the current trends toward intensive operation in 20th century agriculture. Much of this section seems to be an attempt to prepare his peasant friends for the consequences of these inevitable but possibly undesirable changes.

This book should be required reading for every graduate student in the field of Animal Husbandry. Challenging and searching questions are asked throughout. These must be answered if modern agriculture is to keep pace with competitive industries.—*Donald F. Burzlaff*, University of Nebraska, Lincoln, Nebraska

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Edited by Lee A. Sharp and E. W. Tisdale, College of Forestry, University of Idaho, Moscow, Idaho

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CHANGE OF ADDRESS

To Members: The Post Office Department has doubled the cost of notifying us of your change of address when Journals are not deliverable. We cannot supply you with Journals you miss because you have failed to notify us of a change of address on time. We ask you, please, to notify us on an official change of address postcard (obtained from any post office free of charge but postage will cost you 3 cents) as soon as you known your new address.

EXECUTIVE SECRETARY

Former ASRM President Retires

FRED G. RENNER, Head Range Conservationist of the Soil Conservation Service, retired September 1, 1961. Mr. Renner has been with the SCS since 1936. His guidance, wisdom, leadership and dedication to range management are acknowledged and appreciated by all.

B. W. ALLRED, Utah State University graduate, will succeed Mr. Renner as Head Range Conservationist for the SCS. Mr. Allred has been with SCS since 1934 and is well known for his contribution in range management.

Avery in France

CHARLES C. AVERY, a graduate in Range Management at Utah State University, and recently with the U.S. Forest Service in Ellensburg, Washington is in France for one year on a Fulbright Grant to study French Methods of Mountainous Erosion Control. He is at the French National Forestry School — Ecole Nationale des Eoux et Forets at Nancy, France.

Bradley Promoted

GEORGE E. BRADLEY, widely known charter member of the ASRM and for several years staff assistant to the Administrator of the Agriculture Conservation Program Service, USDA, has been promoted to Western Area Field Representative, Office of Rural Areas Development, USDA. This change in assignment came to George in May 1961.

George has served the Society and the National Capital Section in many ways. He helped organize the Section and became it's first chairman. Presently he is chairman of the Section's membership committee. At the Society level George has been active on the research committee and with the committee on Cooperation with Organizations in other Countries. He is presently co-chairman of the latter.

As western field representative for ORAD, George travels Hawaii, Alaska and nine western mainland states.

Foreign Assignment

ALEX JOHNSTON, well known range researcher with the Canada Department of Agriculture and member of the Society's Editorial Board, left November 1 for a Technical Assistance Mission with FAO to the government of Pakistan. This assignment will include surveys of rangelands, determination of grazing capacity and counsel to the government on range improvement and potential. Alex expected to travel via Rome to Karachi where his headquarters will be established.

Cliff Appointed Chairman

EDWARD P. CLIFF, assistant chief of the U. S. Forest Service, has been appointed Chairman of the Board on Geographic Names for the two-year term ending September 30, 1963.

Stressing Mr. Cliff's important contributions to the work of the Board, Secretary of the Interior Stewart L. Udall wrote, "Your nomination by the Board reflects the high regard in which you are held by your colleagues, and their confidence in your leadership."

The Board on Geographic Names is interdepartmental and is made up of representatives of 11 agencies. Mr. Cliff has been a member of the Board since 1953.

Mr. Cliff is a member of the Society of American Foresters, the Wildlife Society, the American Society of Range Management, the Wilderness Society, and the American Forestry Association.

Beetle to Mexico

ALAN A. BEETLE, ASRM, Historian and Wyoming University range-management scientist, will study range vegetation in central and northern Mexico December 1 to June 1, 1962 under a $3000 grant from the Rockefeller Foundation and a sabbatical leave from U.W.

Aim of the study is to develop new knowledge about drought-resistant livestock forages growing at high elevations similar to some Wyoming conditions. Plants under study will include range grasses and dryland shrubs.

Appearance of Pampean Brome on Wyoming certified-seed lists resulted from an earlier study by Beetle in the southern Andes Mountains in South America. The scientist found the plant there and introduced it for trial in Wyoming as "promising for many of the state's dry and sterile soils."

Beetle began collecting and studying plants in Latin America in 1938-39.

His wife, Dorothy, son John, and daughter Karen, will accompany him on the trip.

Tulley in Haiti

HARLAN N. TULLEY, a soil conservationist from Sheridan, Wyoming, has been helping Haitian farmers combat soil erosion, one of their most serious agricultural problems.

Tulley recently returned on home leave. He was accompanied by his wife, the former Agnes Smith of Buffalo, Wyoming. Their sons, Bill and Fritz, preceded their parents to the United States and are attending school in Buffalo. Mr. and Mrs. Tulley will return to Haiti after home leave.

Most of the topsoil in Haiti has been washed away from the land, leaving loose rocks and infertile soils on which crops are now raised. It is with this problem of trying to save the remaining soil and increase its fertility that Tulley has been working. This work is integrated into a watershed program where reforestation, pasture planting, water storage, and crop improvement are coordinated with soil conservation activities to provide proper use and treatment of the land.

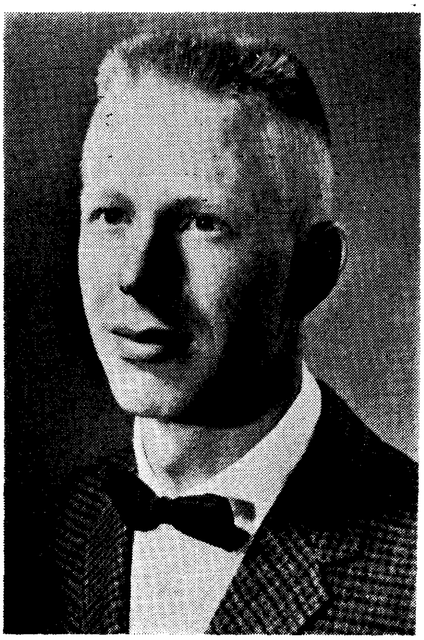
In addition to training Haitian technicians, trials have been made to determine the adaptability of many grass and legume species and the amount and type of fertilizer best suited for the soil. Field demonstrations were held to show farmers how to fence their land to exclude livestock from planted areas, how to plant Guatemala grass for better hay crops and how to plant various other grass and legume species on eroded land.

Tulley was graduated from the University of Idaho, receiving a B.S. degree in forestry in 1941. He is a member of the American Society of Range Management.

Scholarship

JON MICHAEL GEIST is the 1961-62 recipient of the Colorado Section, American Society of Range Management Scholarship. Jon is a junior student majoring in Forest-Range Management at Colorado State University.

In high school Jon was active in band, dance band, chorus, and rifle team. He is a transfer student from the University of New Mexico where he was Vice-President and Social Chairman of Tau Kappa Epsilon and Treasurer of the Junior Fraternity Council.



In Memoriam

KENNETH CONRAD, prominent northeastern Colorado rancher and farmer died of a heart attack at Wray, Colorado on November 17, 1961. "Kenny" was well known throughout the state for his interest and work in Hereford cattle performance testing and range management.

Kenny was Past Director of American Society of Range Management, Past Supervisor Northeastern Yuma County Soil Conservation District, and member of various Cattlemen's Associations and the Wheatgrower's Association.

Kenny was the son of J. O. and Luella G. Conrad, early day pioneers who homesteaded in the Idaho community south of Wray and who later acquired extensive agricultural interests in Yuma County. Survivors are wife, Margaret and three sons, Joe, Mike and Chris; a sister, Mrs. Carl O. Peterson; and a brother, Lawrence L. Conrad, all of Wray.

Kenneth was 57 years old.

World Forestry Information To Be Published

Proceedings of the Fifth World Forestry Congress, the most comprehensive compilation of world forestry knowledge in existence, are to be published according to DR. V. L. HARPER, Chairman of the Executive Committee of the Congress. The Forest Service, U.S. Dept. of Agriculture, is directing the compilation and editing.

The Congress, which was held in Seattle, Wash., Aug. 29 to Sept. 10, 1960, attracted 2,000 men and women responsible for management and protection of the world's forest resources. Of the governments invited to the Congress by the Department of State, 71 had nationals in attendance. This was the largest World Forestry Congress ever assembled, and the first held in the Western Hemisphere.

The Proceedings cover a wide variety of forestry subjects, ranging from multiple use of forest lands and progress in world forestry to silviculture and management, genetics and tree improvement, forest protection, forest economics and policy, forestry education, forest products, forest and range watersheds, logging and forest operations, and tropical forestry. Also included are accounts of special events such as the planting of the International Friendship Grove on the University of Washington Campus, key speeches, a list of participants and other features.

In almost 2 million words, 449 of the world's most esteemed foresters presented papers which will be included in 3 volumes. They cover 1,800 pages—1,386 in English, 234 in French and 180 in Spanish—the 3 official languages of the conference. In addition to the full text of each technical paper in the language in which it was delivered, a resume will be included in the other two languages.

All three volumes may be purchased for $25, the cost price, through advance order only, placed prior to January printing with delivery later in 1962. There will be no bookstore sales. Payment must be in U.S. dollars. Postage is included in the purchase price. A special folder describing the Proceedings and their contents will be distributed here and abroad to libraries, trade journals, public agencies and schools. Others who wish to order may obtain the brochures with blanks from DR. V. L. HARPER, Chairman of the Executive Committee, Fifth World Forestry Congress, c/o Forest Service, U.S. Department of Agriculture, Washington 25, D.C.

Let Romance Reign Supreme

The U. S. Department of Agriculture has moved to bring romance back to the ranges. Instead of calling grasslands conservation efforts "Land Utilization Projects" and identifying them by abbreviations and numbers, the Department now uses names befitting the locale. Some run to the picturesque:—Thunder Basin, Buffalo Gap, Cross Timbers, Curlew, etc., while others are named for Indians who hunted and fought their battles in the areas:—Pawnee, Cheyenne, Kiowa.

Ducks Top Rice in Land Value

An acre of land is worth much more for a duck landing field than it is for growing rice judging by a recent transaction in California's Sacramento Valley. A 165-acre marsh, with no important income, was sold to a group of duck hunters for $165,000. Developed California rice acreage sells for about $450 to $650. Good Golden State duck land is worth more today than any agricultural land except that in developed orchards.

27th Wildlife Conference

Outdoor recreation will be the principal topic for consideration at the general sessions of the 27th North American Wildlife and Natural Resources Conference, scheduled for the Hilton Hotel, Denver, Colorado, next March 12-14, according to the Wildlife Management Institute, sponsor of the large international meetings.

"New Horizons for Outdoor Recreation" is the overall conference theme. The program for the three day meeting consists of two general sessions at which broad policy questions will be discussed and six technical sessions where last-minute research findings and management techniques will be aired.

"Strength Through Recreation" is the theme of the opening general session on Monday morning, March 12. Session topics will be Recreational Needs in the Years Ahead, Recreation for Young America, Recreation Builds National Health, and Getting on With the Job.

Arthur S. Flemming, president, University of Oregon, and former Secretary of Health, Education, and Welfare, will be the chairman of the second general session on Wednesday, March 14. The theme will be Recreation's Future—Whose Responsibility?

Two technical sessions will be held on each of the three days of the conference. The session topics include Wetlands and Inland Water Resources, Disease, Nutrition and Controls, Field and Farm Resources, Coastal and Marine Resources, Conservation Information and Education and Forest and Range Resources.

Seth Gordon, vice president, North American Wildlife Foundation, will be the conference summarizer.

WITH THE SECTIONS

COLORADO

The Annual Meeting was held in Denver, November 18, 1961. Installed as officers for 1962 were William J. Hoffman, Chairman; Lyman Linger, Vice-Chairman; Harold F. Kerst, Councilman; and Elwin W. Stevens, Councilman. Additional Councilmen holding over from 1961 are Paul Gilbert and George Weaver. Carl Herzman, as past-Chairman, will also serve on the Council. Hoffman operates a sheep ranch near Montrose, Linger a cattle ranch near Loveland, Kerst a cattle ranch near Wray, and Stevens is Supervisor of the Rio Grande National Forest.

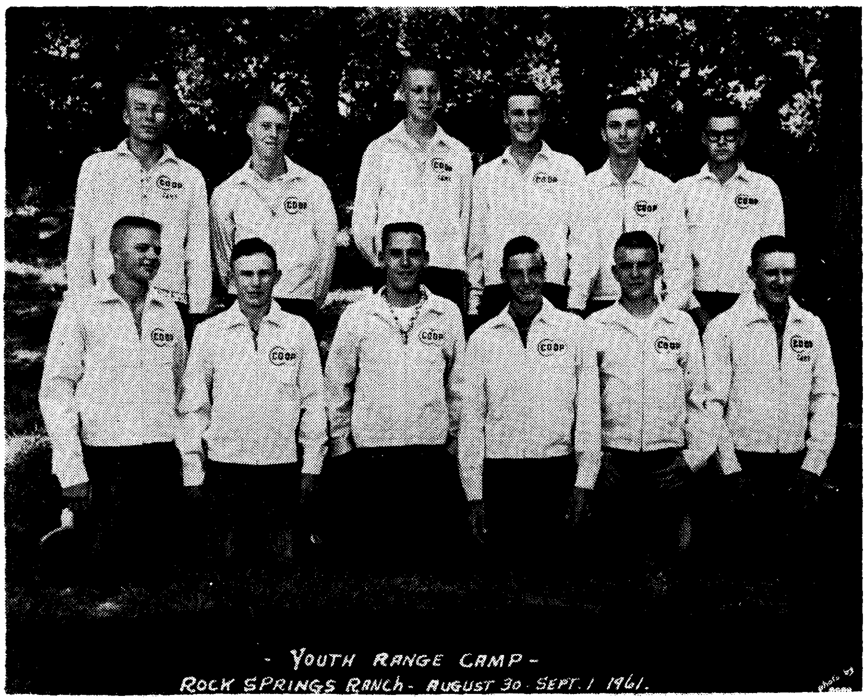
C. H. Wasser, Dean of the College of Forestry and Range Management at Colorado State University, acted as Master of Ceremonies for a wide-ranging program that covered talks by Roy Bean on the pilot Range Resources Review, Professor J. V. K. Wagar on a proposed Nation Grasslands Monument, Mrs. Lorean Gawel on what the Great Plains Program has meant to her ranch operations, Dr. Don Hyder on grazing management of crested wheatgrass, and Con Tolman on "Operation Respect." Approximately 60 people attended this day-long meeting with the noon luncheon as the social highlight.

Two field meetings were held by the Colorado Section during the summer. On June 9, 1961 the Section assembled at Springfield, Colorado, for a tour of the Carrizo ranger district of the Commanche National Grassland and of the Southeastern Colorado Branch Experiment Station (Colorado State University). The tour led to Lamar for an evening banquet with an interesting program on the past, present, and future of ranching in southeastern Colorado. On Saturday morning, June 10, the group saw sand dune stabilization along the Santa Fe Railway.

The second field meeting was held in the vicinity of Durango on September 8 and 9. The Friday afternoon tour on the San Juan National Forest took the group to an area where big game-livestock competition is a problem, and to one where intensive range restoration work has been done to stop severe erosion. At the evening banquet in Durango Dr. John Norris of New Mexico State University showed slides of range and livestock work in Pakistan. On Saturday the group travelled to the Southern Ute Indian Reservation to see extensive areas of juniper control and range seeding.

KANSAS-OKLAHOMA

The first Kansas youth camp, sponsored jointly by the Kansas-



- Youth Range Camp -
Rock Springs Ranch - August 30 - Sept. 1 1961.

Oklahoma Section ASRM and the Consumers' Cooperative Association, was held August 30-September 1 at the Rock Springs Ranch, Headquarters of the Kansas 4-H Foundation, south of Junction City, Kansas.

Attendance was limited to one young man from each of the 12 counties, Smith, Barber, Marshall, Clark, Hodgeman, Chase, Greenwood, Elk, Logan, Wallace, Gove, and Chautauqua.

Participants were selected by local committees headed by the chairman of the board of supervisors of the soil conservation district and assisted by local county agents, work unit conservationists, high school agriculture teachers, service clubs, Coop. representatives, and members of the Range Society, the local ASC Committee, and the Soil Conservation Society. Only young men who had graduated from high school in 1961 or were members of the 1962 graduating class were selected.

The delegates gathered at Rock Springs Tuesday evening and all were ready for instruction at 8:00 the next morning. The Consumers' Cooperative Association furnished portfolios and sports jackets, appropriately marked to identify the young men with the range camp, and visual materials describing the camp and its work. In addition to the lecture and field trip study, each member of the group was given literature about pertinent range subjects accumulated by the committee and the instructors.

Mr. Ted Furtak, SCS, Manhattan, served as camp counselor and chaperon, with the approval of the State Conservationist. Mr. Furtak had a fine influence on the entire camp and his presence proved very worthwhile.

Both Howard Cheney, Chairman of the Kansas-Oklahoma Section of ASRM, and Kenneth E. Johnson of the Consumers' Cooperative Association were also present throughout the period and with Mr. Furtak provided guidance.

At the close of the camp each participant was asked to evaluate his experience in terms of what he had learned and what changes he would suggest. Their written comments are being sent to the section officers along with the 1961 correspondence. It was their unanimous opinion that the camp should be continued and expanded.

Selection of participants and scheduling of dates at the Rock Springs Ranch for 1962 are already being planned. The committee will probably consist of John L. Launchbaugh, G. W. Tomanek, and H. Ray Brown, all of Hays, Kansas.

NEBRASKA

The 1961 Annual Meeting was held at Broken Bow, the day before the State Range Judging Contest. A record crowd attended both occasions.

Approximately 150 were in attendance at the indoor meeting and field tour Friday, September 15th. Chairman Richard Dunn extended a welcome to every one and told about the American Society of Range Management and its program. A special welcome was extended to Professor Thadis Box and his class of 26 senior students in range management from Utah State University. Elmer Vogel, Atkinson rancher told how he reduced hay requirements by reorganizing his ranch operation to graze wet and subirrigated meadows formerly mowed for hay. He credited his program of range management and herd culling as governed by production testing for much heavier weaning weights.

Dick Whitsel, Range Manager, Foraker, Oklahoma made a hit with the audience by his congenial presentation of the principles of range management. Dick could cite ample results from experience to support the soundness of proper range use and other simple range management practices.

Lorenz Bredemeier, SCS Range Conservationist of North Platte, presented data showing that weaning weights increased 5 consecutive years with a program of proper range use and deferred grazing. Costs were lowered and profits increased.

The first stop on the afternoon tour was at a range seeding made in the spring of 1960. A mixture of big bluestem, little bluestem, switchgrass, sideoats grama and western wheatgrass was seeded. The last stop was at a similar seeding made in 1959. Here the group viewed an excellent stand of the native grasses 3 to 4 feet high.

On the Henry Haumont ranch north of Broken Bow ranchers and scientists alike marveled at the pro-

First place winners at the 1961 Nebraska State Range Judging Contest. Left to right—front row: Larry Leistritz, Walter Fick, Mrs. Raymond Andrews, Don Harford, Rance Rollins.

Second row: First Place 4-H team—Gary Glendy, Dale Estergard, Jerry Glendy and Vaughn Helberg.

Third row: First place FFA team—Dale Seidler, D. H. Lovejoy, Duane Goodin and Bill Price.

fusion of big bluestem and other tall grasses on the silty and thin loess range sites. This stop vividly demonstrated excellent range condition on such land.

Banquet speaker, DR. JERRY TOMANEK, Professor of Botany, Fort Hays State College, Hays, Kansas, entertained and told the group of range management in Argentina. WM. J. STUART, Work Unit Conservationist from Rushville, served as Toastmaster.

HARVEY JORGENSEN, County Agent, Broken Bow headed local arrangements.

CHAIRMAN DUNN conducted the annual business meeting after the banquet program.

Range Judging Contest

Participation in the State Range Judging contest reached a new high with 204 registered contestants competing in five divisions; 4-H, FFA, Women's division, Men's division, Professionals, and Out-of-State.

The 4-H teams placed in the following order; Custer County, Cheyenne County, and Box Butte County. Individual honors went to LARRY LEISTRITZ, Sheridan County; VAUGHN HELBERG, Custer County; and LARRY HARDESTY, Logan County.

In the FFA division Curtis High School placed first, North Platte High School second, and Keya Paha County High School, third. Individuals placing were; DUANE GOODIN, first; JIM GARNER, second; and BOB MCCORMICK tied with TOM HOFFMAN for third.

In the Women's division, MRS. RAYMOND ANDREWS placed first, MRS. RAY ATKINS second, and MRS. CHARLES EMPKEY third.

DON HARFORD was first in the Men's division with an individual score of 405 out of a possible 430 points. EDWIN ESTERGARD was second and MYRON BAKEWELL third.

The Professional placings in 1, 2, 3 order were WALTER FICK, former state winner, top individual at Oklahoma City last April, and coach of the first place team at Oklahoma City; WESTON WHITWER, and JOHN HENRY.

In the Out-of-State division the first three place winners were students at Utah State University; RANCE ROLLINS, KEN BAYER, and K. LYNN BENNETT.

NEVADA

In response to our article on "Big big-sage," DR. JOSEPH H. ROBERTSON, Chairman, Department of Plant Science, University of Nevada, Max Fleishmann College of Agriculture, wishes to enter the big-big sagebrush competition. He reports that on the White Pine Division of the Nevada National Forest near the Ellison Ranger Station, Ranger FOYER OLSEN and he found, measured, photographed, and cut down a big sagebrush tree 11 feet, 10 inches tall and 30 inches, c.a.h. The 20-acre patch was then wheatland plowed and seeded.

On returning a year or so later to rate the seeding, the late BILL WHITE of the B.L.M., KEN BRADSHAW of the SCS, and DR. ROBERTSON were stumbling among the down "timber" when they noticed an extra large specimen. Only the bole remained but it was quite sound. It measured 18 inches through at the thickest point and 40 inches, c.a.h. (circumference ankle high). A photo of this 50-year-old trunk appeared in the Salt Lake Tribune on November 4, 1946.

PACIFIC NORTHWEST

TOM WILLIS, Superintendent of the Dominion Range Experimental Farm at Kamloops, was chosen this summer to fill the position of Executive Assistant to the Assistant Deputy Minister (Research), Canada Department of Agriculture, Central Experimental Farm, Ottawa. This new assignment entails working out policy on research programs between the Dominion Research Branch and Provincial organizations, and between the Research Branch and the universities. Tom's first job will be to become thoroughly acquainted with all Research Branch stations across Canada and, as he says, "Kamloops will therefore be the last place that I should visit officially." Notwithstanding this, Tom misses the many friends and acquaintances he has made in this Pacific Northwest region and will certainly drop in as occasion permits. Tom left Kamloops by car August 28 via Lethbridge and Winnipeg to arrive at Ottawa in time to meet Betty and the children who traveled by plane. They were fortunate to find a vacant house on the Central Farm to use until they've "looked around a bit."

DR. HUGH NICHOLSON, Animal Husbandman at Kamloops Range Experimental Farm, was involved in a rather serious accident while returning from an Animal Production meeting at Lethbridge in the company of 3 other colleagues from B.C. on the night of Wednesday, September 13. It seems they had been plagued with car trouble all day and were just in the process of being towed into Calgary when a 3-ton truck rammed their car. Hugh suffered severe concussion and some spinal injuries. He was only partially conscious in Calgary Hospital for 6 days. Don Waldern of Prince George, the only other man in the car at the time, received minor injuries. Hugh has been back in Kamloops since October 6 and is gradually getting back into his old form.

For the first time in many years, British Columbia sent two candidates to the Washington Natural Resources Youth Camp at Camp Heyburn, Idaho, this summer. We don't know whether B.C.'s absence has acted as a ripening period or not, but BARRY BRADY stood 5th in the group while RENO DE MARNI came first. Both boys were sponsored by the Kamloops Stockmen's Association.

The Bureau of Land Management received an emergency appropriation of $1,250,000 for rehabilitation of recently burned-over public lands under its administration. Oregon received $562,000 for range and forest reseeding. We all recognize that thousands of acres need rehabilitation. George Lea, officer in charge of this work in Oregon, is hoping for a long, mild fall. You will recall that our Pacific Northwest Section passed a resolution last year recommending the government provide emergency funds for such action.

WARREN SANDAU recently transferred from the Burns District to the BLM Oregon State Office where he is serving as Soil Specialist. RON YOUNGER moved from Baker to Burns to fill in behind Sandau as Range Conservationist.

FRANK STANTON, with the Oregon State Game Commission for 20 years, has been appointed to the new position of Wildlife Specialist with the BLM at the Oregon State Office.

Youth Camps

On September 29, the 1961 Washington Natural Resources Youth

Camp Committee for the Inland Empire had a meeting in Pullman to discuss last summer's camp and organize the 1962 Committee. This camp is sponsored jointly by the Society of American Foresters, Soil Conservation Society of America, and the American Society of Range Management. FRED HALLER and MARK STEVENS represent the Range Society on the 1962 Committee. DILLARD GATES is outgoing Committee chairman. There were 58 boys who attended camp last summer; 46 from Washington, 10 from Idaho, and 2 from British Columbia. The boys were given a good course in wildlife, soil and water, range and woodland conservation. The facilities at Heyburn Camp will accommodate 100 boys and the 1962 Committee is going to have one hundred boys in camp next summer. This will put a heavier responsibility on our Society members because this means more of us will be called on for instructor and committee jobs. Remember when you as a Society member raised your hand in support of this camp, you also pledged your help and cooperation in carrying out the youth program.

BILL CURRIER reports that 48 boys from 16 eastern and southwestern Oregon counties attended the 12th Oregon Range Camp for boys. The camp was held at Malheur Wildlife Refuge, July 31-August 5. RAY NOVOTNY ran the camp with ELGIN CORNETT putting on the formal program. Elgin called upon outstanding youth workers in range management to assist him in his varied program. Instructors included GARY REID, Madras High School teacher; BILL FARRELL, MRS. JERRY BEERY, ART SAWYER, E. R. JACKMAN, RUBE LONG, ANDY LANDFORCE, JACK FINE, JOHN SCHARFF, EUGENE KRIDLER, and other members of JOHN SCHARFF's staff at the Refuge. ROGER THOMPSON of Wasco County was grand contest winner. Roger will be given an expense-paid trip to the fall meeting at Yakima.

SOUTHERN

The 1961 Annual Meeting was held at Gulfport, Mississippi on October 30 and 31.

The meeting got underway at 1:15 P.M. on Monday, October 30 at the W. LUTHER BLACKLEDGE Polled Hereford Ranch, Saucier, Mississippi with a tour sponsored by the Commissioners of the Harrison County Soil Conservation District. MR. SAM LANGENWALTER, Chairman, assisted by Soil Conservation Service technicians from the Hattiesburg office and personnel from Blackledge Ranch and the County Agent's office, did a bang-up job of showing and explaining the land use program of the 1,800-acre operation.

Section members and a number of other guests were given a firsthand look at how MR. BLACKLEDGE coordinates cattle production with forest management. Purebred Polled Herefords and commercial cattle graze both native range and improved pasture under longleaf and slash pine stands. In the winter corn silage and oat pasture provide supplemental forage, and cottonseed meal makes up for the protein deficiency of dormant range grass.

Moderate stocking, controlled burning of forest rough, alternate grazing of native range and improved pasture, half-day or budgeted use of winter temporary pasture, planned timber harvests, and intensive control of cattle parasites are skillfully integrated for the production of commercial beef, pure-bred breeding stock, gum (turpentine), and sawlogs.

Interesting discussions of range plants, range condition classes, forage production capabilities, proper stocking, and supplemental feeding were held at various stops along the route.

On Monday evening the group met at Hotel Markham in Gulfport for a fine meal followed by a half-hour of well-received entertainment. The annual business meeting, presided over by Chairman Wayne West, rounded-out the evening's activities.

Tuesday morning was devoted to a panel discussion dealing with various aspects of coordinated land use. Vice-Chairman RALPH HUGHES served as moderator. Discussion leaders and their topics were:

CLYDE BLOUNT, Agronomist, South Mississippi Branch Station, Poplarville, Miss. Improved Pasture Management.

HENRY LEITHEAD, Range Conservationist, Soil Conservation Service, Athens, Georgia. Farm-Ranch Planning in Relation to Forest Grazing.

WILLIAM H. TURCOTTE, Chief, Game and Fish Division, Mississippi Game and Fish Commission. Game Potential of Mississippi Forests.

VINSON DUVALL, Range Conservationist, Southern Forest Experiment Station, U. S. Forest Service, Alexandria, Louisiana. Economics of Forest Grazing.

TEXAS

The 7th Texas Section Range Camp was held at the A & M Adjunct at Junction with 36 boys attending from all over Texas. The

Range Campers were given a full week's training in range, wildlife, and livestock management. The program was well rounded with technical instructions and recreational activities. Experts in the range field were instructors at the camp. DR. V. M. HARRIS, President of the Texas Section, presented awards and encouraged the boys to obtain further education. Each of the Range Campers will receive the Newsletter for one year, beginning with this issue. The Campers, and their home towns, are as follows: RANDY ANDERWALD, Pierce; JOHN CHARLES BENDELE, D'Hanis; BILL BENSON, San Angelo; JON BOTTER, Lockhart; PLEAS CHILDRESS, III, Ozona; HARRELL CLARY, Lampasas; EDGAR DOHMANN, Yorktown; DON DUNLAP, Ozona; NEILL EDWARDS, Graham; JOHN FISHER, Hunt; JOHN FOCKE, Bandera; JOE FRERICH, Brackettville; TOM GLASSCOCK, Sonora; LEONARD GRENWELGE, Valley Springs; STANLEY HARVEY, Lueders; JIM HIGGINS, Hereford; JOHNNY KINSTON, Toyahvale; RAY LANFORD, Uvalde; RANDY LEIFESTE, Castell; JOE MCADAMS, Brownwood; LESLIE MEZGER, Kempner; JAY MILLER, Ozona; EDGAR OHLENDORF, Lockhart; W. B. PATTERSON, III, Rio Frio; JIMMIE RANDOLPH, Cleburne; BURT RICHARDS, Fairfield; JOHN H. ROGERS, Montell; MILTON SCHULTZ, JR., Godley; TIM SHAUNTY, Houston; CLAYTON STEWART, Sterling City; RONALD SUTTON, Junction; JACKIE RAY TAYLOR, Midland; ROBERT TIDWELL, Brackettville; GEORGE WALKER, London; GARY WESTMORELAND, Walnut Springs, and CAREY WILSON, Pyote.

UTAH

The Utah State Student Chapter opened its fall activities under its new officers by announcing that the chapter will publish a quarterly newsletter to carry news and articles for the professional improvement of its members. The publication will be sent to non-members who make a donation to help send a student delegation to the international meeting. Officers for the 1961-62 school year are GARY OLIVERSON, Preston, Idaho, chairman; NORMAN HUNTSMAN, Cedar City, Utah, vice-chairman; and LEW MUNSON, Las Vegas, Nevada, secretary; JIM BOWNS, Castle Gate, Utah, director; RICHARD DEE, Amarillo, Texas, director; THADIS W. BOX, advisor, and JOHN F. VALLENTINE, advisor.

DARWIN ANDERSON, range management senior, won the Daniel Boone Hunter's Club scholarship for the outstanding senior in conservation. The scholarship is given on a national competition basis, by the Wisconsin group to encourage excellence in the general conservation field.

Twenty-seven range management seniors visited several ranches, research stations, and demonstration areas in the states of Utah, Colorado, Nebraska, and Wyoming during September as part of the field course taught by DR. THADIS W. BOX. Some of the stops included the Black Mesa Experimental Range where GEORGE TURNER and GENE SPAIN acted as hosts; Manitou Experiment Station with Pat Currie; Banning-Lewis Hereford Ranch with CARL FONTE; Eastern Colorado Experiment Station with BILL DAHL; North Platte area with LORENZE BREDEMEIR; Nebraska Section ASRM meeting at Broken Bow; Nebraska range judging contest; and DON COX's U-Half Circle ranch at Mullen, Nebraska. The seniors attended the professional meetings and banquet of the Nebraska section. They also entered the out-of-state division of the Nebraska range judging contest where RANCE ROLLINS, Beaver, Utah won first place; KEN BOYER, Coalville, Utah, second; and KLYNN BENNETT, Delta, Utah, third. The fine hospitality of the hosts on the field trip made the class a pleasant and memorable experience.

A preliminary check of registration records shows that range majors at Utah State come from many places in the U. S. and abroad. There are 46 students from Utah, 8 from Idaho, 7 from California, 4 each from Texas, Wyoming, and South Dakota, 3 from Arizona, 2 each from Nebraska, Colorado, Connecticut, and Kansas and one each from Nevada, Washington, Maryland, Indiana, Illinois, Pennsylvania, and New York. Four students come from Canada, 2 from India, and one each from Mexico, Argentina, Sudan, Egypt, and Iraq. In addition, there are many range students in the freshman and sophomore years who are still carrying a general program in the College of Forestry and have not been identified as range management students.

New members of the student section include MEL BROMLEY, Phoenix, Arizona; DAN BROMLEY, Phoenix, Arizona; JERRY LEE CALLEY, Williams, Arizona; LYNN FINDLAY, Kemmerer, Wyoming; RICHARD FARRAR, Connecticut; GERALD GIFFORD, Chanute, Kansas; VAL GIBBS, Laramie, Wyoming; BRENT JENSEN, Emery, Utah; WENDELL LOWERY, Arimo, Idaho; DANIEL MORGAN, Pocatello, Idaho; DONALD SCHMIDTLEIN, Logan, Utah; SHERRIL SLACK, Logan, Utah; RALPH RAWLINSON, Delta, Utah; LARRY RITTENHOUSE, Lewellen, Nebraska; ERL SIMPSON, Salt Lake City, Utah; and DOUGLAS WOOD, Lyman, Utah.

The student section has chosen several projects for the professional improvement of the group. These include sponsoring outstanding speakers, sponsoring a plant identification team, publishing a newsletter, building displays for state and national meetings, sending a delegation to the international meeting, advising the range department on curriculum needs, serving on state section committees, and selecting Utah's outstanding rancher of the year.

In addition to professional improvement projects, the section will sponsor a fall social for students and faculty and a spring bar-b-que.

Range Management Theses for 1960 and 1961

COMPILED BY FLOYD E. KINSINGER AND RICHARD E. ECKERT, JR.,
FORT HAYS KANSAS COLLEGE AND UNIVERSITY OF NEVADA.
* INDICATES PH.D.

UNIVERSITY OF ARIZONA

***Dalton, Patrick K.** 1961. Ecology of the creosotebush.

Johnson, Donald E. 1961. Distribution of creosotebush *(Larrea tridentata)* as affected by certain soil characteristics.

Mukhtar, Hashim A. M. 1961. Factors affecting seed germination of some important desert plants.

BRIGHAM YOUNG UNIVERSITY

Cline, Morris G. 1961. A comparison of the root systems of bitterbrush and cliffrose.

Erdman, Kimball Stewart. 1961. Classification and distribution of the native trees of Utah.

Nixon, Elray S. 1961. An ecological study of an exclosure in the mountain brush vegetation of the Wasatch Mountains, Utah.

Shumway, Lewis Kay. 1961. An analysis of a hybrid complex involving *Agropyron subsecundum, Agropyron trachycaulum,* and *Elymus glaucus.*

UNIVERSITY OF CALIFORNIA

Adams, Theodore E. 1961. Reaction of the Sacramento Valley pocket gopher *(Thomomys bottae navus* Merriam) to two perennial forage grasses.

***Landers, Roger Q., Jr.** 1961. The influence of chamis *(Adenostema fasciculatum)* on soils and vegetation at chamise-grassland boundaries.

***Marsh, Michael.** 1961. Food as a factor regulating the numbers of the California vole, *(Microtus californicus).*

Ratliff, Raymond D. 1961. Seasonal changes in herbage weight and species composition in an annual grass community.

Robinson, John P. 1961. Measurements of ecotypic variation in medusahead *(Elymus caput-medusae* L.) and introduced annual grass.

Stechman, John V. 1961. Some responses of four annual range grasses to foilage removal.

Tothill, John. 1961. Autecological studies in *Ehrhanta calycina.*

COLORADO STATE UNIVERSITY

Anderson, Allen E. 1960. Distribution and abundance indices of selected biota in western Colorado before and two months after 2,4-D application.

Crouch, Glenn L. 1961. Wildlife populations and habitat conditions on grazed and ungrazed bottomlands in Logan County, Colorado.

Hylton, Lynn O. 1960. Effects of environment on germination and occurrence of six-weeks fescue *(Festuca octoflora* Wall).

Lovell, Gilbert R. 1961. The trend of forage and nutrient production of grasses on sandhill and sandy plains sites in northeastern Colorado.

FORT HAYS KANSAS STATE COLLEGE

Hischke, Herbert Jr. 1961. Carbohydrate root reserves of three native prairie grasses.

Modha, V. V. 1961. Vegetation cover, composition, and yield as influenced by soil, litter, and grazing intensity.

Nichols, James T. 1961. Variation in vegetation and microclimate on north- and south-facing slopes in the mixed prairie near Hays, Kansas.

Patel, K. R. 1961. Responses of big bluestem to habitat factors in a relict prairie.

Saxton, Sheldon E. 1961. The development of first year grass seedlings on an upland site under unmowed and mowed conditions in Pawnee County, Kansas.

UNIVERSITY OF IDAHO

Orkney, George Dale. 1961. The seedling anatomy of *Opuntia polyacantha* Haw.

Chugg, Jack Claude. 1961. Characterization and genesis of some soils derived from loess in the central Snake River plain of Idaho.

Dhindsa, Satwant Singh. 1961. Genetic variability in Russian wildrye *(Elymus junceus* Fisch.)

Henry, John Edward. 1961. The biology of the sagebrush defoliator, *Aroga Websteri* Clarke, in Idaho (Lepidoptera: Gelechiidae).

Knapp, Jerry Wilson. 1961 An econometric approach to the least cost ration for fattening steers.

Swenson, Charles Frederick. 1961. Phasic aspects of seedling development, vernalization, mineral accumulation and herbicide resistance in *Elymus caput-medusae* L.

MONTANA STATE COLLEGE

Fisser, Herbert G. 1961. A comparison of line intercept, inferred point contact, and weight measurement methods of foothill grassland vegetation.

Smoliak, S. 1961. Use of regression equations to determine utilization of "shortgrass" rangeland.

Vogel, Willis G. 1961. A comparison of three range measurement techniques and a study of the response of native vegetation to protection from sheep grazing.

UNIVERSITY OF NEVADA

Lesperance, A. L. 1960. The development of techniques for evaluating grazed forage.

NEW MEXICO STATE UNIVERSITY

Baca, Edward C. 1961. The accuracy, precision, and efficiency of the point series method of vegetation sampling with reference to the low vegetation cover of the semi-desert grassland.

DeOliviera, Ralph Rhea. 1961. Survey of the vegetation of the eastern base of San Augustin Peak and vicinity, San Augustin Mountains, Dona Ana County, New Mexico.

Knipe, Oren D. 1960. The effect of aqueous extracts of creosotebush on germination and growth of some desert grassland plants.

Leven, Andrew A. 1961. An investigation of eleven Zuni Mountain Forest soils.

Niles, Wesley E. 1961. A winter key to the trees and shrubs of the Chiricahua Mountains and adjacent areas of southwestern Arizona.

Snyder, Walter A. 1961. A chemical analysis of thirteen major deer forage plants from the Guadalupe Mountains of New Mexico and their adequacy for maintaining deer.

Wright, Robert A. 1960. Increase of mesquite on a southern New Mexico desert grassland range.

OREGON STATE COLLEGE

***Hyder, Donald N.** 1961. Growth characteristics of crested wheatgrass, *Agropyron desertorum* (Fisch.) Schult., in the big sagebrush-bluebunch wheatgrass province of southeastern Oregon.

Walton, Richard L. 1961. The seasonal yield and nutrient content of native forage species in relation to their synecology.

Wullstein, Leroy H. 1961. The ammonifying, nitrifying, and respiration power of certain soils found in three habitat types in the Columbia Basin rangelands.

TEXAS A. & M. COLLEGE

Avant, Herman Dale. 1960. Responses of yaupon and associated vegetation to burning, herbicidal application and phosphate fertilization.

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A Study of Range Condition In A Fescue Grassland In Western Montana

Abstract of thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Forestry, School of Forestry, Montana State University, Missoula, August, 1961.

In western Montana the rough fescue (*Festuca scabrella* Torr.) grasslands are an important source of forage for domestic livestock. Misuse of these grasslands results in range deterioration and lowering of economic values. The purpose of this study was to evaluate the effects of different degrees of livestock grazing on the vegetation and soil of an upland site in the fescue grasslands.

Three contiguous pastures, near Philipsburg, Montana, with similar soil, slope, and aspect were pre-classified into excellent, fair, and poor range condition. The area was selected for study because of the apparent vegetation differences between the three pastures and because the soil had a texture which permitted measurement of certain soil physical characteristics not easily studied in most ranges.

The results indicated that livestock grazing had a pronounced effect on the vegetation and certain soil physical properties such as bulk density and penetrability, while soil chemical properties studied were only slightly affected. Difference in range condition were associated with reductions in coverage, yield, and vigor of rough fescue, total grass cover, total herbage yields, litter production, and infiltration rate of water. This was accompanied by increases in the total forb cover, shrub abundance, bulk density, and penetrability. Differences between pastures in regards to soil pH, total nitrogen, available phosphorus, organic matter, exchangeable sodium and potassium, and soil texture did not reveal trends consistent with differences in range condition.

Some of the more important data illustrating the effects of grazing follow. Rough fescue was reduced by grazing to 4.3 and 0.6 percent in the fair and poor treatments, respectively. On the excellent range it composed 33.9 percent of the total vegetation. *Phlox muscoides* composed 3.1 percent of the vegetation in the excellent pasture and 27.1 and 40.3 percent, respectively, in the fair and poor units. Total herbage yield varied from 592.2 and 909.9 pounds per acre the

first and second years on the excellent range to 303.2 and 353.1 pounds on fair range and 216.9 and 280.8 pounds on poor range for the two years respectively. In the 0-2 inch soil horizon bulk density was 0.71, 0.92, and 0.94 grams per cubic centimeter, on the excellent, fair, and poor range, respectively. Pentration values were 95.5, 77.2, and 74.8 millimeters. Applications of 2 inches of water revealed infiltration rates of 7.3, 16.2, and 22.0 minutes for the first application and 13.4, 26.1, and 29.1 minutes for the second application on the three condition classes. The differences between the first and second applications on all ranges were significant at the 5 percent level. The infiltration rate on the excellent range was significantly different from the fair and poor ranges for the 6 applications, while the latter two were not significant from each other.

It was concluded that (1) grazing effects are most readily measured in the condition of vegetation soil bulk density and penetrability, (2) soil physical characteristics are more strongly influenced by current grazing than are chemical aspects, and (3) vegetation changes do not necessarily result in loss of soil chemical constituents.

ROBERT B. MURRAY JR.

The Effect of Leaf Age and Abscission Zone Formation on the Absorption and Translocation of 2,4,5-trichlorophenoxyacetic acid by Blackjack Oak (*Quercus marilandica* Muenchh.)

Arlo V. Dalrymple
Abstract of dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Agronomy, Oklahoma State University.

A study was started in 1958 near Stillwater, Oklahoma, to determine the effects of leaf age and abscission zone formation on the absorption and translocation of one rate of 2,4,5-trichlorophenoxyacetic in blackjack oak. Three trees were selected at anthesis for each treatment date. When the leaves were one-half normal size, the treatments were started and continued throughout the growing season. Leaves to be analyzed were enclosed in plastic bags while the entire plant was sprayed with a 2,4,5-T emulsion (4 pounds acid equivalent per 100 gallons of water). The plastic bags were removed in approximately 10 minutes and these leaves were treated with 10 microliters of emulsion containing 36 micrograms of radioactive 2,4,5-T with a specific activity of .95 microcurie of C^{14} per millimole. Two leaves were collected from each of the trees at 12, 24, and 36 hours after treatment and absorption and translocation determinations were made by the analysis of C^{14}. The abscission zone was studied microscopically.

The absorption and translocation of 2,4,5-T in blackjack oak were both found to be fairly high in the early spring. There was a rapid decrease in absorption and translocation occurring in May and June so that during the summer months of July and August the absorption and translocation occurred at comparatively low rates. Apparently the decrease in rate of both absorption and translocation may be factors responsible for the low degree of kill of blackjack oak observed in this area during these months. However, translocation appears to be the more important factor since it seems to be reduced during July and August to a greater extent than absorption. Both absorption and translocation increase during the early fall months of August and September, and it has been observed that brush may be successfully controlled at times by applications during the late growing season.

There were obvious processes of abscission zone formation occurring in treated plants since leaf fall was fairly high after treatment. Only slight pressures were necessary to remove treated leaves from the stem by separation in the pulvenoid section of the leaf. However, these effects were not apparent upon microscopic examination of the pulvenoid tissues. There were no indications of whole cell wall hydrolysis, cell division or clogging of phloem cells with tallous formations.

The age of the treated leaf may be an important factor responsible for the variability in absorption and translocation of 2,4,5-T in blackjack oak. However, it was not possible to determine if abcission zone formation was influencing the translocation of 2,4,5-T from the leaf tissues.

THE HEREFORD IN AMERICA—MR. DONALD R. ORNDUFF's book of the above title isn't exactly a new publication but one which will be new to many readers of this Journal. In the fall of 1960 it was reprinted in the second edition. The first edition appeared in 1957.

Making the acquaintance of the author may also be a new experience for many Journal of Range Management readers. MR. ORNDUFF, editor of The American Hereford Journal, has been a Hereford man for more than 30 years. He joined the staff of The American Hereford Journal in 1930, became its managing editor in 1934, and editor in 1944. Many of his writings on breed history have appeared in publications throughout the United States, Canada, England, Australia, and South America.

THE HEREFORD IN AMERICA is the first new history of the Hereford breed to appear in more than 30 years. In the preface, the author indicates that nearly 40 years of interest in Herefords and more than 20 years of effort have provided a basis for the volume. It contains something of the breed's origin, its beginnings on this side of the Atlantic, and the subsequent westward expansion which laid a broad foundation for all that was to follow. Also contained is a broad sweep of the breed's progress in America through a panoramic presentation of its major lines of inheritance.

The 23 chapters and 8 appendices provide a wealth of source material for the student, researcher, breeder, or interested reader. MR. ORNDUFF's thorough knowledge of the subject and clear, easy style of writing have produced this valuable history which should be available to every conscientious Hereford breeder and admirer of white-faced cattle. Range men will find here, too, the Gudgell and Simpson story about buying a "bull with a rear end," told to many by college professors. The bull selected, Anxiety 4th 9904, has been well known in Hereford circles as the foundation for a good deal of the breed improvement experienced in America. An entire chapter has been devoted to the role of these pioneer breeders in the development and improvement of the Hereford on this side of the Atlantic.

Another chapter sets forth the influence of Gudgell and Simpson bulls as breed builders. It also contains some chronology of the Gudgell and Simpson operation. Students of Hereford breeding and improvement will find here many of the familiar names which have made the breed famous. Our famous breeders and the animals they developed have been included elsewhere.

From the chapter on breeder organization comes an interesting item. Forty years were required to reach the 1,000,000-mark in Hereford registrations. This point was reached in the spring of 1921. In the next 39 years 10,000,000 more Herefords were recorded and most of these were produced in the latter part of the period.

Herefords without horns are in this book, too. The winners of National Polled Hereford shows from 1922 through 1959 are contained in appendix II. Appendix I has Winners of the Purple from 1893 through 1960.

Range men regardless of assignment—teaching, ranching, administering range land, doing research or whatever else—must know something about grazing animals, their history and development. THE HEREFORD IN AMERICA contains all, perhaps a good deal more than most of us need to know about white-faced cattle.

E. J. WOOLFOLK

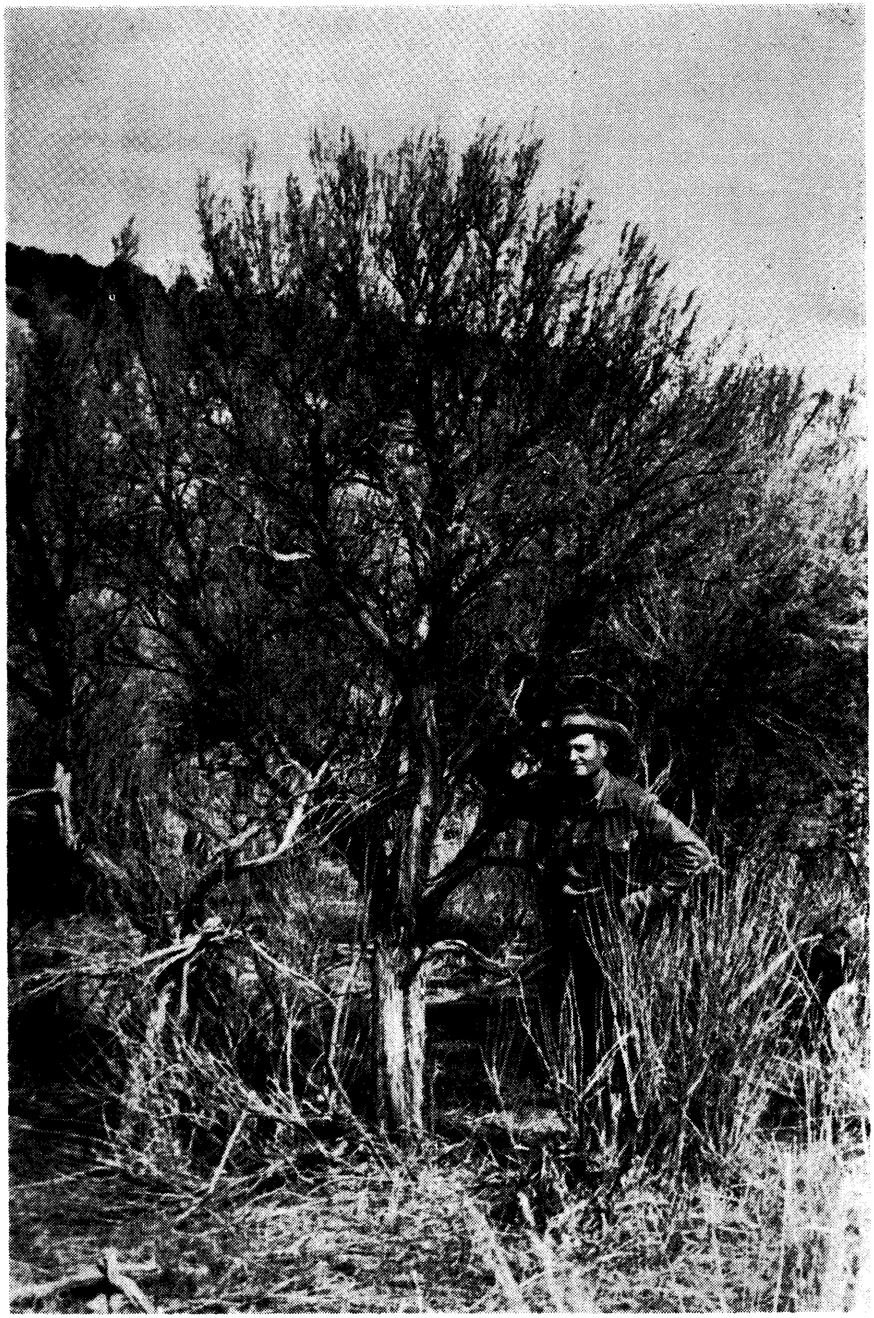
USDA CENTENNIAL

SECRETARY ORVILLE L. FREEMAN has announced that the Department of Agriculture will observe in 1962 the Centennial anniversary of its establishment. President Lincoln signed the act creating the Department on May 15, 1862.

Official recognition of the anniversary was obtained when President Kennedy, on August 25, signed into law a Joint Resolution of the Congress which declared "That it is fitting and proper to commemorate the centennial of the establishment of the Department of Agriculture by appropriate celebration." In keeping with a provision of the Resolution, the President issued a proclamation designating 1962 as the United States Department of Agriculture Centennial Year.

The observance of the Department's Centennial is not an occasion for self-praise. The Department has made significant contributions to the development of American agriculture, but others have also contributed: Our land-grant colleges and State universities, State departments of agriculture, farm organizations, agricultural societies, individuals, trade groups, commodity groups, and industries associated with agriculture. The great architects of America's productive and efficient agriculture, however, are the individual farmers and ranchers who have put into constructive use the research, service, and educational work of the Department and others.

BIGGER BIG SAGEBRUSH



Very tall growth in *Artemisia* is a morphological characteristic confined not only to the section Tridentatae, but within that section to a single subspecies, *Artemisia tridentata* subsp. *tridentata* (see Wyo. Agric. Exper. Sta. Bul. 368: 1960). These tall forms have fascinated writers for many years. In 1917 Cary (U. S. Dept. Agric., Bur. of Biol. Survey, North American Fauna, No. 42, see pg. 80) illustrated plants ten feet high from the Wind River Valley in Wyoming.

In 1956 Pase located a plant east of Kanab, Utah, height 15′7″, circumference 2.33 feet. While the height of this plant seems to remain an unchallenged record, the circumference was soon challenged by the Idaho Section Newsletter (November, 1960) which reports a plant in Blaine County, Idaho, circumference 2.78 feet.

Now the author and Alvin Young (U. of Wyo. Range. Mangt. Major) have found basin big sagebrush in Park County, Wyoming, 3.6 miles east of Wapiti Post Office, which is 3′5″ in circumference at the base, and 20 inches above the base is 2′10″.

Ellis Sedgley (Work Unit Conservationist, S. C. S.) contributes the accompanying picture of a tall plant (about 13′ tall, circumference 26″) on Dutch Creek in Rio Blanco County, Colorado.

Size and age are unrelated. Large plants have large, annual rings and are not very old. Ferguson (Bul. Ecol. Soc. Amer. 38 (3): 72) reports plants over 200 years old, but these are not exceptionally tall, nor do they have exceptionally large trunks.—A. A. Beetle

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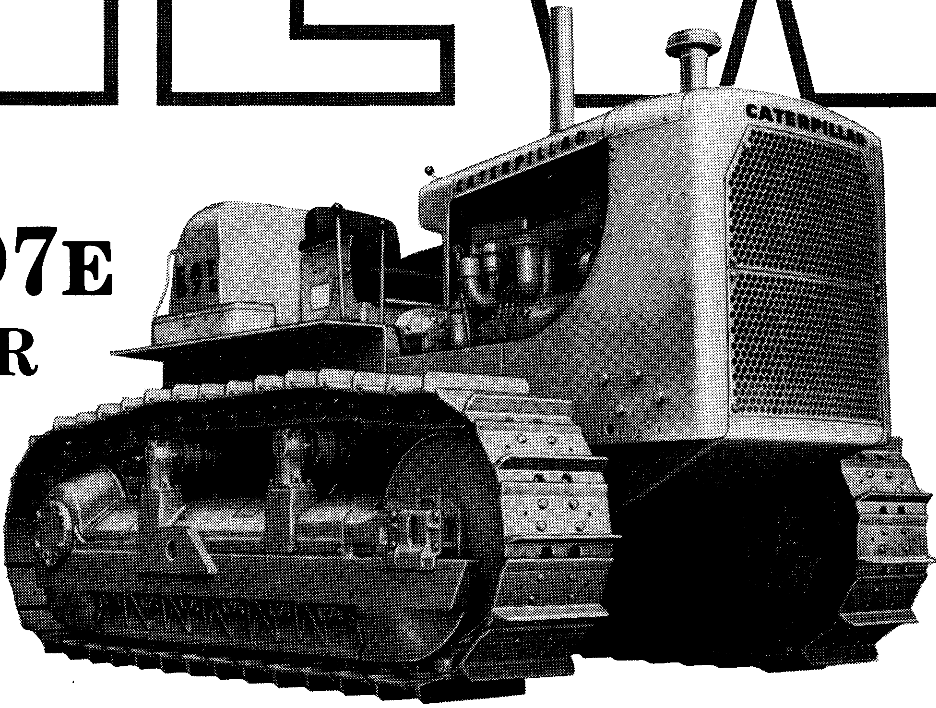

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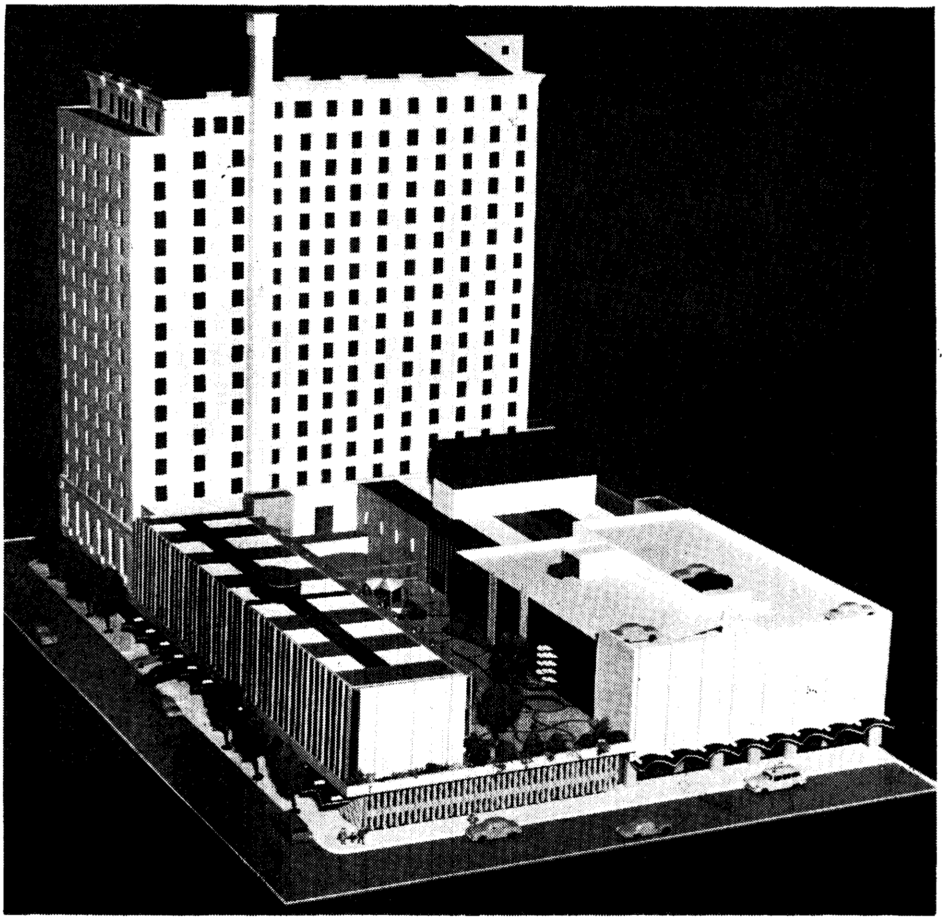

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