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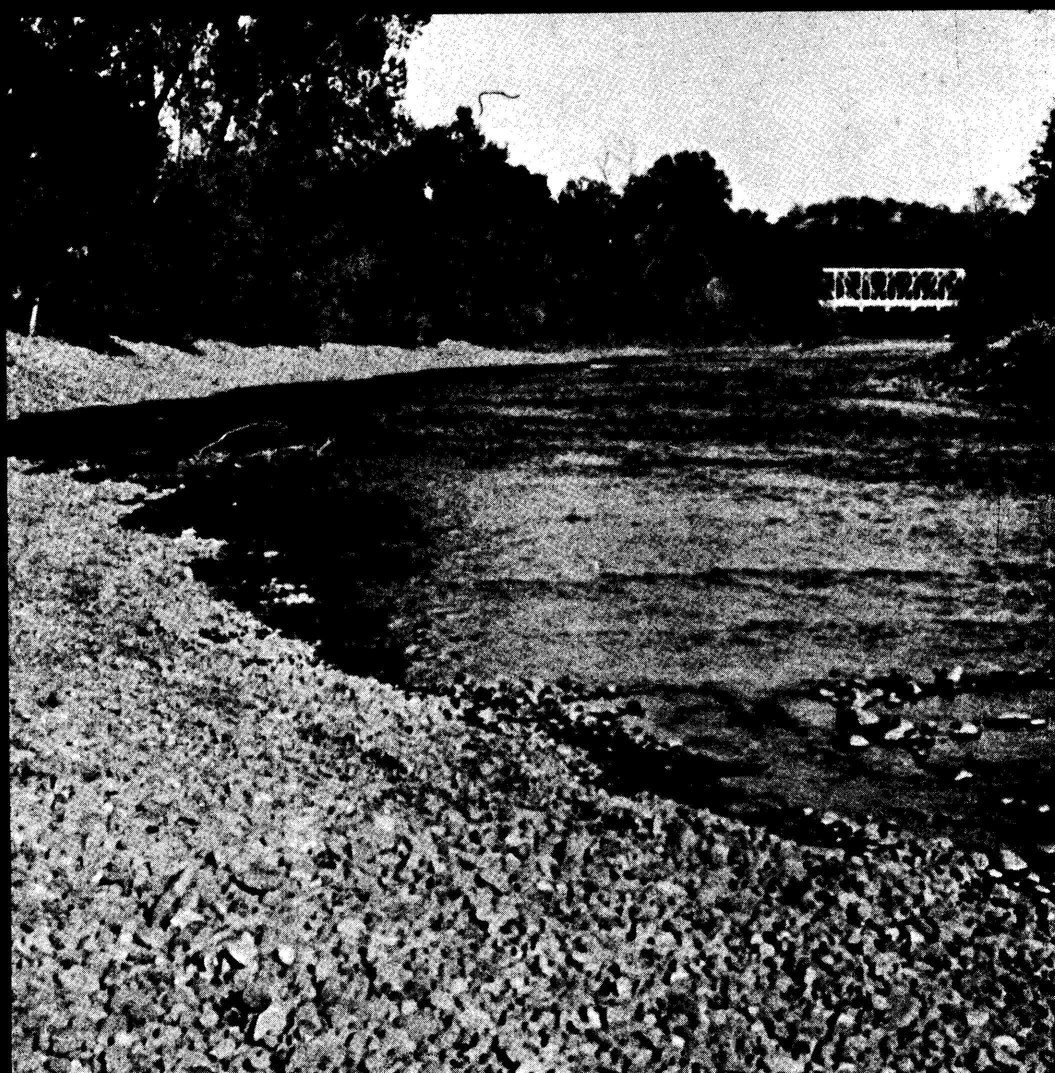

The Trail Boss ®

American Society of Range Management

The American Society of Range Management was created in 1947 to advance the science and art of grazing land management, to promote progress in conservation and sustained use of forage, soil and water resources, to stimulate discussion and understanding of range and pasture problems, to provide a medium for the exchange of ideas and facts among members and with allied scientists, and to encourage professional improvement of members.

Membership: Persons shall be eligible for membership who are interested in or engaged in practicing range or pasture management or animal husbandry; administering grazing lands; or teaching, or conducting research, or engaged in extension activities in range or pasture management or related subjects.

JOURNAL OF RANGE MANAGEMENT

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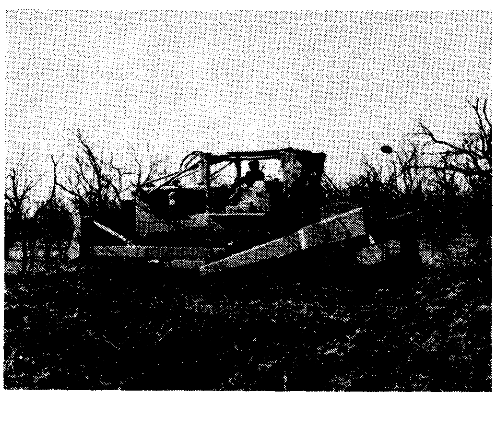

Journal of RANGE MANAGEMENT Volume 20 Number 4 July, 1967

Cover Photo—Salmon and Steelhead Production Affected by Range Use. Gover Ranch, Anderson, California.

See Management Note by W. C. Gover, page 263.

Editorial

Range Management's Share of Agricultural Research

THADIS W. BOX

Professor of Range Management, Texas Technological College, Lubbock.

The front cover of our Journal carries a statement of the purpose of our Society. Among other things, we are challenged to advance the science and art of grazing land management and to promote progress in conservation and sustained use. This is quite a challenge.

Grazing is still the largest single agricultural use of land in America. Over one billion acres are devoted to grazing by domestic animals and wildlife (Thomas and Ronnigen, 1965). A national survey conducted in 1962 (USDA, 1962) indicated that these lands were producing only about half their potential.

My association with people in the range management profession has convinced me that there are no more devoted or able scientists in any group in the world than in the American Society of Range Management. Yet with these dedicated men working long and hard, our ranges still are producing only about half of the potential.

One of the major reasons we are barely holding our own is shown graphically in a recent report jointly sponsored by the U. S. Department of Agriculture and the Association of State Universities and Land Grant Colleges entitled "A National Program of Research for Agriculture" (Agriculture Research Institute, 1966). There simply are not enough people working in the range management research area.

Although the figure of 146 man years annually conducting range research does not include those working at non-land grant universities and for private organizations, it can be used as a basis of comparison with other fields. For instance in a "closely related" area of timber and forest products there are 1004 annual man years of research to our 146. There is one more man year, 147, devoted to potato research each year than to research on the entire billion acres of rangeland.

Cotton, our major surplus commodity, has 467 man years annually devoted to it. Tobacco, with all its recent publicity as a man killer, has 151 man years of research. Several other individual crops have more man years of research than the entire range management field: citrus fruit 242 man years, small fruit and tree nuts 527, ornamentals and turf 245, corn 298, wheat 304.

Each major species of domestic animal produced in this country has far more annual man years of research than the entire range field. The man years for each animal are poultry 469, beef cattle 514, dairy cattle 601, swine 259, and sheep 203.

Not only does the report show we have fewer people working in range than in many less important agricultural areas, but the projected growth in our field is behind other agricultural areas. The projection shows that 175 man years will be needed in range in 1977, while 1550 men will be needed in the area of improving biological efficiency of field crops.

These figures should say something to us as a profession and as concerned individuals charged with the "wise use" of the largest block of our nation's agricultural land. Either we have not made our needs known, or we are politically ineffective in getting the support our resource deserves. In either case, we must re-examine our position and improve our tactics if we are to meet our responsibilities.

We must make our needs known at all levels. We must not be reluctant to tell our story in the popular press or spend funds on advertising. We may or may not agree with the Sierra Club and the Audubon Society, but I dare say more congressmen know them and their objectives than know the American Society of Range Management.

If we are to truly live up to the aims of our Society, we cannot be content when only 146 man years of research each year are devoted to one billion acres of grazing land. We need to act as individuals, and corporately through our Society, to ensure that range management research is put in its proper perspective.

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Editorial

The Use of Common Names in The Journal of Range Management

ALAN A. BEETLE

Range Management Section Head, Plant Science Division University of Wyoming, Laramie

In the early decades of the Twentieth Century, American literature developed a wealth of common names for plant species. In fact so many sprang into use that the American Joint Committee on Horticultural Nomenclature sponsored the first compilation called "Standardized Plant Names" (1917). This list was enlarged, revised, and republished in 1941. Now that this, also, is out of print, more and more splinter lists (Bureau of Land Management, Forest Service, Weed Society of America, and the like) are appearing. Does the range management

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One can easily see that common names add interest and color to a world that would be, for many, coldly scientific and remote if only Latin designations were available. A scientific name usually tells a story, reflecting origin *(virginiana)*, size *(gigantea)*, color *(rosea)*, or form *(squarrosa)*. The same is true of common names, and where they have a useful and significant meaning, some thought should be given to their preservation. A good example is the unfortunate shortening of the Old World "goatfacegrass" to "goatgrass". The first is descriptive, the second is meaningless.

Neither authority nor administration should force upon the literature the common name "centaurea" (cf. Standarized Plant Names) when general usage has brought acceptance to "knapweed" and "starthistle" (see list of Weed Society of America). Acceptance of a standardized list, reserving the right to make changes, is a compromise for both extremes.

Range science needs common names, just as it needs scientific names. Neither should be straight-jacketed into a status quo. Evolution and synthesis of lists will reflect a healthy growth in range science and related fields. Let's "standardize", but let's not overdo it.

(Editor's Note: Dr. Beetle is a member of the Editorial Board of Journal of Range Management and has accepted the assignment of preparing a preliminary Range Plant List of the American Society of Range Management. Those interested in this subject should correspond directly with Dr. Beetle.)

How Heavy Grazing and Protection Affect Sagebrush-Grass Ranges

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Highlight

Heavy late-fall grazing by sheep following spring deferment improves deteriorated sagebrush-grass ranges by reducing sagebrush and increasing the production of grasses and forbs. Fall grazing as a method for range improvement is more effective and practical than complete protection from grazing and is less expensive than mechanical or chemical means of sagebrush control. Heavy spring grazing damages good-condition ranges by increasing sagebrush and reducing herbaceous production.

Since 1924, researchers at the U.S. Sheep Experiment Station[2] near Dubois, Idaho, have been studying the sagebrush-grass ranges which provide the primary source of forage for sheep in both spring and fall on the Upper Snake River plains of southeastern Idaho. As they have reported previously, heavy spring grazing by sheep followed by fall grazing results in dense stands of sagebrush and low production of palatable grasses and forbs. Craddock and Forsling (1938) reported results of this study through 1932; Mueggler (1950) continued the report through 1949, and Laycock (1961) summarized results through 1957. All these reports showed that grazing only in the late fall maintains an open stand of sagebrush. This paper reports continuation of these studies through 1964; objectives of this continuation were to determine the effects on good and poor sagebrush-grass range of (1) complete protection, (2) heavy grazing in the spring only, and (3) heavy grazing in the late fall only.

The Study

This study was conducted in two 80-acre native range pastures. From 1924 to 1949 the two pastures were grazed at different seasons—one in the fall only, the other in both spring and fall. Stocking rates for the fall-grazed pasture averaged 43 sheep-days/acre; stocking rates for the spring-fall pasture averaged 19 sheep-days/acre in the spring and an additional 10 in the fall.

In 1924, both pastures were in good condition when rated by the standards published by Pechanec and Stewart (1949). Both pastures had open stands of threetip sagebrush (*Artemisia tripartita*)[3] and were producing abundant grasses and forbs. In 1949, the pasture grazed in the fall was still in good condition. The spring-fall pasture, however, dropped from good to poor condition during this period; sagebrush increased and grasses and forbs decreased. This deterioration was attributed primarily to the heavy spring use during the first few years of the study when

[1] *At Forestry Sciences Laboratory, maintained in cooperation with Utah State University.*

[2] *Cooperative research by the Intermountain Forest and Range Experiment Station, Forest Service; Animal Husbandry Research Division, Agricultural Research Service; and the University of Idaho.*

[3] *Nomenclature follows Hitchcock et al. (1955-1964) for dicotyledons and Hitchcock (1951) for grasses.*

the spring stocking rates were as high as 34 sheep-days/acre. Because of the combined seasons of use, however, the separate effects of spring and fall grazing could not be determined. The pasture arrangement and the study therefore were changed somewhat in 1950.

First, 10 acres of the spring-fall pasture were fenced off so that their rate of recovery could be compared with that of an exclosure in the fall-grazed pasture that had been protected from grazing since 1941. Then the remainders of both the spring-fall and fall-grazed pastures were bisected with a fence. The former grazing practices, with some modification (Fig. 1), were continued in one half of each of the original pastures. The two remaining halves, however, were put to new use. One was grazed in the spring only (May) at the heavy stocking rate of 40 sheep-days/acre, and the other was grazed in the fall only (November and December) at the heavy stocking rate of 60 sheep-days. Craddock and Forsling (1938) and Laycock (1962) all show that moderate grazing rates for fair to good ranges in this area would be 10 to 20 sheep-days/acre in the spring and again in the fall.

These modifications, made in 1950, have enabled us to determine whether heavy grazing solely in the spring damages the range as much as the heavy spring-fall grazing did prior to 1950. Similarly, the addition of the exclosures has provided for a comparison between fall grazing and protection as methods for improving range in poor condition and for maintaining range in good condition.

Fig. 1 shows the layout and grazing history of the pastures and exclosures. For convenience of discussion, the following terms are used to describe the grazing treatments:

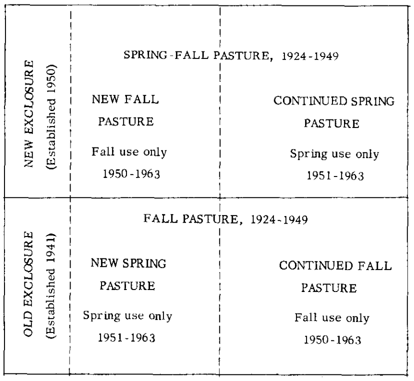

FIG. 1. Layout and grazing history of the pastures and exclosures, U.S. Sheep Station Experimental Range, Dubois, Idaho, 1924-1963.

Continued Fall — fall grazing 1924-1949; fall grazing continued 1950-1963.

Continued Spring — spring-fall grazing from 1924-1949; spring grazing continued 1950-1963.

New Fall — spring-fall grazing from 1924-1949; use changed to fall only 1950-1963.

New Spring — fall grazing 1924-1949; use changed to spring only 1950-1963.

Old Exclosure—fall grazing 1924-1941; protected from grazing 1941-1963.

New Exclosure — spring-fall grazing 1924-1949; protected from grazing 1950-1963.

Vegetation Sampling. — Each pasture contains 30 permanent 100-square-foot plots located on a grid. In the exclosures, the number and size of plots vary. The new exclosure contains fifteen 100-square-foot plots; the old exclosure contains fifty 50-square-foot plots.

Vegetation on the plots in each area was sampled by the weight estimate method (Pechanec and Pickford, 1937a) in 1950, 1957, and 1964. The pastures were not grazed in the spring during these years to permit sampling at the end of the spring growing season. The pastures were also sampled in 1953 and 1960 without interrupting the planned grazing treatments. In 1964, additional information on plant density was obtained from the sample plots by counting the number of plants in the following categories: arrowleaf balsamroot (*Balsamorhiza sagittata*), mature threetip sagebrush (6 in. or taller), and sagebrush seedlings and young plants (less than 6 in.).

Utilization of the major species was estimated on the plots after spring grazing every year from 1951 to 1956, and in 1958. Estimates of fall utilization of the grasses and shrubs were made only in 1955 and 1956. Estimates were made by the ocular estimate-by-plot method (Pechanec and Pickford, 1937b).

Results and Discussion

Trends Under Spring Grazing, 1950-1964.—The range condition of the continued spring pasture, poor to begin with, declined further between 1950 and 1964. Sagebrush production increased more than 60%, and cheatgrass brome (*Bromus tectorum*) also increased (Table 1). Production of perennial grasses and forbs remained about the same.

In the new spring pasture, where the heavy grazing treatment was changed from fall to spring, the range condition declined from good to poor just as Mueggler (1950) reported it previously had declined in response to use in both spring and fall. Sagebrush production increased 78%, and cheatgrass brome increased more in this pasture than in any other. Total grass production decreased 22%; bluebunch wheatgrass (*Agropyron spicatum*) decreased 48%. Total forb production decreased 73%. The forbs most palatable to sheep—arrowleaf balsamroot, common comandra (*Comandra umbellata*), tapertip hawksbeard (*Crepis acuminata*), and eriogonum (*Eriogonum heracleoides* and *E. ovalifolium*) — decreased more than 85%.

The response of comandra is interesting because increases in comandra on overgrazed ranges have been cited as a possible cause of increased incidence of rust in lodgepole pine (Mielke, 1961). At the Sheep Station, comandra decreased rather than increased on overgrazed ranges because sheep eat it heavily in the spring (see Table 1; also Mueggler, 1950).

The downward trend in the new spring pasture could be seen and measured 3 years after the treatment was changed from fall to spring grazing. Fig. 2 shows some of the changes that took place during the study on one of the plots in this pasture.

Trends under Fall Grazing and under Complete Protection.—The pasture in which fall grazing was continued remained in good condition from 1950 through 1964 just as it had during the previous 25 years (Mueggler, 1950). Production of sagebrush, grasses, and most forbs remained about the same. Production of annuals, mainly cheatgrass brome, was higher in both fall-grazed pastures and in both exclosures in 1964 than in 1950—presumably in response to precipitation; but the differences

Table 1. Herbage production (lb/acre, air-dry) in spring- and fall-grazed pastures and in exclosures, U. S. Sheep Experiment Station, 1950 and 1964.

Species	Good condition in 1950 (Fall-grazed, 1924-1949)						Poor condition in 1950 (Spring-fall grazed, 1924-1949)					
	Continued fall-grazed		New spring-grazed		Old exclosure		Continued spring-grazed		New fall-grazed		New exclosure	
	1950	1964	1950	1964	1950	1964	1950	1964	1950	1964	1950	1964
Perennial grasses												
Agropyron spicatum	127	124	93	48	72	87	88	67	77	110	72	127
Koeleria cristata	22	11	27	5	22	10	10	4	8	6	12	8
Oryzopsis hymenoides	26	17	14	6	27	8	17	13	14	9	13	2
Poa secunda and *P. nevadensis*	31	81	23	68	23	80	22	77	25	80	20	70
Stipa comata	32	26	18	12	64	24	18	13	13	9	16	8
Other grasses	23	16	24	16	27	7	31	22	17	12	27	8
Total perennial grasses	261	275	199	155	235	216	186	196	154	226	160	223
Perennial forbs												
Balsamorhiza sagittata	164	226	176	9	132	167	1	1	1	9	5	25
Comandra umbellata	18	18	20	1	10	10	1	0	0	1	1	1
Crepis acuminata	28	25	24	3	25	16	2	2	3	11	6	12
Erigeron spp.	11	19	11	20	9	14	5	21	5	10	11	10
Eriogonum spp.	12	14	20	2	18	10	7	1	7	4	4	5
Penstemon spp.	7	6	5	1	5	5	3	2	3	4	3	3
Phlox hoodii	10	12	12	19	20	24	10	17	11	8	7	8
Other forbs	44	38	53	32	63	39	36	24	38	29	39	24
Total perennial forbs	294	358	321	87	282	285	65	68	68	76	76	88
Shrubs												
Artemisia tripartita	94	84	126	224	158	127	152	248	137	107	204	166
Chrysothamnus viscidiflorus var. *puberulus*	45	24	17	6	33	16	24	6	31	26	58	27
Gutierrezia sarothrae	4	3	6	4	7	8	19	17	13	8	6	6
Leptodactylon pungens	7	2	6	4	9	4	8	7	12	5	9	5
Purshia tridentata	17	3	52	5	15	4	28	9	39	3	64	13
Tetradymia canescens	33	16	18	14	15	9	26	11	21	12	19	19
Other shrubs	3	2	2	1	6	19	6	5	6	3	9	5
Total shrubs	203	134	227	258	243	187	263	303	259	164	369	241
Annuals												
Bromus tectorum	2	9	2	53	2	10	3	33	7	12	2	7
Annual forbs	2	4	2	6	4	6	4	7	3	8	3	6
Total annuals	4	13	4	59	6	16	7	40	10	20	5	13
Cactus												
Opuntia polyacantha	75	31	13	19	33	17	22	30	62	31	36	9
TOTAL VEGETATION	837	811	764	578	799	721	543	637	553	517	646	574

FIG. 2. This plot in the new spring pasture shows the damaging effects of heavy spring grazing by sheep on native sagebrush-grass range. Upper left, 1952, Arrowleaf balsamroot plants were vigorous following the favorable fall-grazing treatment before 1951. Upper right, 1955, The balsamroot plants are less vigorous, and more bare soil is evident. Lower left, 1958, The balsamroot plants have died, and the sagebrush plants have grown larger. Lower right, 1964, Sagebrush has obscured the plot stake. The bitterbrush plant in the upper left was killed by tent caterpillar defoliation, not by grazing. Much of the grass is cheatgrass brome.

were comparatively smaller than those in the spring-grazed pastures.

Significantly, the deteriorated pasture improved under fall grazing (the new fall pasture—Fig. 3) and under protection (the new exclosure). The increase in total grass production, expressed mainly as increases in bluebunch wheatgrass and bluegrass (*Poa secunda* and *P. nevadensis*), was 47% in the new fall pasture and 39% in the new exclosure. Sagebrush production decreased about 20% in both areas (Table 1). Total forb production increased only slightly. After palatable forbs have been reduced or removed by heavy spring grazing, they recover slowly, even under favorable conditions.

Some forbs, such as tapertip hawksbeard, increased fairly uniformly throughout the new fall pasture. This species becomes established quickly because it has a light, wind-carried seed. In contrast, almost all the increase of arrowleaf balsamroot occurred in the south end of the new fall pasture. Balsamroot has a comparatively heavy seed, which is not dispersed over a very wide area. Most plants in the south end of the new fall pasture probably started from seeds produced in the adjacent new spring pasture (Fig. 1), which had an abundance of balsamroot in 1950. Seeds could have been carried short distances by the prevailing southwesterly winds or possibly by rodents. This seed source has been largely elimi-

FIG. 3. These two photographs on a plot in the new fall pasture show the increase in production of grasses and forbs and the decrease in sagebrush from 1952 (left) to 1964 (right) as a result of heavy fall grazing.

nated because few of the remaining balsamroot plants in the new spring pasture now produce flowers or seed. However, balsamroot plants now present in the new fall pasture should insure further increases as long as the favorable fall-grazing treatment is continued.

Number and Average Weight of Plants, 1964.—The number of arrowleaf balsamroot plants was not correlated with production in the new spring and new fall pastures in 1964. Production was 9 lb/acre in both pastures (Table 1), but the new spring pasture had 8 times as many plants (Table 2). The air-dry weight of plants in both spring-grazed pastures averaged 2 to 4 g compared with 13 to 17 g for the plants in the fall-grazed pastures and the exclosures.

Plant numbers and productivity of mature sagebrush were highest in the two spring-grazed pastures and lowest in the continued fall-grazed pasture. The mature sagebrush plants in the continued fall pasture also had the lowest average weight. The number of sagebrush seedlings and small plants (less than 6 in. tall) was not affected by grazing treatment.

Table 2. Average number and weight of arrowleaf balsamroot and mature (taller than 6 in) sagebrush plants in 1964.

Item	Fall-grazed, 1924-1949			Spring-fall grazed, 1924-1949		
	Continued fall	New spring	Old exclosure	Continued spring	New fall	New exclosure
Ave. no. plants/100/ft^2						
Balsamroot	14.5	5.8	13.1	0.2	0.7	1.5
Sagebrush	7.7	15.4	10.8	19.3	10.0	11.0
Ave. plant weight (g. airdry)						
Balsamroot	16.2	1.6	13.3	3.6	13.9	17.5
Sagebrush	11.5	15.1	12.3	13.3	11.2	15.8

Statistical Analysis.—Analysis of variance was used to compare changes in production from 1950 through 1964 for bluebunch wheatgrass, arrowleaf balsamroot, threetip sagebrush, and total perennial grasses and forbs. Counts of the number of balsamroot and sagebrush plants in 1964 were also analyzed. Each of these categories was analyzed separately using the six pastures and exclosures as six treatments in a completely randomized design with the individual sample plots as subplots within each treatment. In each analysis, the treatment sum of squares was subdivided into various single degree of freedom comparisons between pastures or groups of pastures. The three comparisons of greatest value in interpreting results are shown in Table 3.

In the overall analysis for each category, the "F" test for "Treatment" was highly significant ($P < .01$). As might be expected, a large part of the treatment sums of squares for each category resulted from the difference between the average of the spring-grazed areas on the one hand, and the average of the fall-grazed and protected areas on the other (Comparison A, Table 3). The main comparisons of interest were those between fall grazing and protection from grazing on range initially in good condition (continued fall pasture vs. old exclosure—Comparison B, Table 3) and on range initially in poor condition (new fall pasture vs. new exclosure—Comparison C, Table 3). In general, only two

Table 3. Comparisons between pastures and exclosures of change in production from 1950 through 1964 and number of plants in 1964.

Item	A			B			C		
	Spring grazing	Fall grazing & protection	F	Continued fall	Old exclosure	F	New fall	New exclosure	F
Average change in prod. (lb/acre), 1950-1964									
Agropyron spicatum	−33	+25	**19.2	− 3	+15	ns	+33	+55	ns
Balsamorhiza sagittata	−84	+31	**48.5	+62	+35	ns	+ 8	+20	ns
All grasses and forbs	−132	+54	**19.7	+78	−16	*5.8	+80	+75	ns
Artemisia tripartita	+97	−27	**77.5	−10	−31	ns	−30	−38	ns
Ave. no. of plants (per 100 ft.^{2}) in 1964									
Balsamorhiza sagittata	3.0	7.0	**12.6	14.5	13.1	ns	0.7	1.5	ns
Artemisia tripartita	17.4	9.9	**70.8	7.7	10.8	*5.6	10.0	11.0	ns

* Difference significant at the 5% probability level.
** Difference significant at the 1% probability level.
ns Difference not significant at the 5% probability level.

of these comparisons were significant. First, from 1950 through 1964 production of all grasses and forbs increased in the continued fall-grazed pasture; however, it decreased slightly in the protected old exclosure. Moreover, the continued fall pasture contained significantly fewer sagebrush plants in 1964 than did the old exclosure.

Vegetation Changes not Related to Grazing Treatment.—Results discussed thus far were for the major species and those that showed definite responses to the experimental treatments. Precipitation may have had a greater effect than treatment upon some of the other species. Precipitation in 1950 and 1964 was:

	1950	1964
Before the growing season (July-March)	7.16	7.14
Growing season (April-June)	3.20	7.52

Blaisdell (1958) found that *total* production of grasses and forbs at the Sheep Station was most closely correlated with precipitation prior to the growing season. However, precipitation during the growing season also affected the production of some individual species in this study. Cheatgrass brome and other annuals, for example, were scarce in 1950; but they were relatively common in all areas in 1964 as a result of the abundant spring moisture.

The perennials most obviously affected by variations in precipitation were the Nevada and Sandburg bluegrasses; in 1964 they produced two to three times more in all pastures and exclosures than they had in 1950. These grasses generally start growth, mature, and become dry earlier than most other grasses. In 1964, the abundant and prolonged spring moisture evidently favored extended growth and therefore relatively high production. The large decrease in the production of antelope bitterbrush *(Purshia tridentata)* in all areas was probably caused by damage from tent caterpillars in 1958-1960. When several pastures were sampled in 1960, almost all bitterbrush plants were completely defoliated. By 1964 many were partly or completely dead (Fig. 2).

Utilization. — In the spring, grasses and forbs made up the bulk of the diet of the sheep. Average use of the highest producing grass, bluebunch wheatgrass, ranged from 20 to 40% of the current year's growth in the new spring pasture and from 40 to 60% in the continued spring pasture. Most other grasses were consumed in about the same quantity, or slightly less, as bluebunch wheatgrass; however, Indian ricegrass *(Oryzopsis hymenoides)* and needle-and-thread *(Stipa comata)* were usually grazed more heavily.

The average spring use of tapertip hawksbeard and arrowleaf balsamroot ranged from 40 to more than 90%. Use of other forbs usually was less and varied considerably from year to year. Antelope bitterbrush was the main shrub utilized in the spring, with use ranging up to 60% of the growth at the time of grazing. Other shrubs received only light use in the new spring pasture, but up to 40% of the downy rabbitbrush *(Chrysothamnus viscidiflorus* var. *puberulus)* and the broom snakeweed *(Gutierrezia sarothrae)* was used in the continued spring pasture. Evidently, the low production of palatable grasses and forbs in the continued spring pasture caused heavier use of the shrubs.

In the fall, the amount of sagebrush and other shrubs eaten by the sheep varied considerably from year to year. In 1955 and 1956, the only years for which fall utilization data are available, the sheep consumed the following percentages of the current year's growth of threetip sagebrush:

	Continued fall pasture	New fall pasture
1955	26	19
1956	7	6

The greater utilization in 1955 probably was the result of deeper snow cover. Little snow was present at any time in 1956, and in that year the use of sagebrush and other shrubs was light. In 1955, 5 to 8 inches of snow covered the ground during the last month of fall grazing. Thus many of the grasses and forbs were buried, and heavier use of sagebrush and other shrubs resulted.

Continuous snow cover of 5 inches or more during the last half of the fall grazing period occurred in 6 of the 14 years of the study. In 1951, the sheep were removed from the fall-grazed pasture about 10 days earlier than had been planned because the snow was about 15 inches deep. Portions of sagebrush and other shrubs above the snow were used heavily, but accurate estimates of total utilization could not be made because of the deep snow.

Causes of Varied Response.— As Mueggler (1950) previously reported, heavy spring grazing followed by fall grazing caused sagebrush-grass range in good condition to deteriorate quickly. During the present study, heavy grazing only in the spring had the same result: sagebrush increased, and the more desirable grasses and forbs decreased. By contrast, late fall grazing improved range in poor condition; it reduced sagebrush and increased the production of grasses and forbs.

Why does spring grazing damage the range while heavy fall grazing improves it?

The best answers seem to be that the spring grazing period is also the active growing period for the native grasses and forbs. Grazing during this period, and particularly heavy grazing, removes photosynthetic material from grasses and forbs at just the time when it is needed for the repair of winter damage and for renewed growth. When protected in the spring, however, the grasses and forbs can reach full maturity unhindered and increase in vigor. Then in the fall, when their root systems are well established and their foliage is dry, they can be grazed without significant damage. Sagebrush, on the other hand, is not dormant in the fall; so utilization by sheep results in a decline in vigor. The established grasses and forbs, vigorous as a result of spring deferment, can then increase while the sagebrush decreases.

Moreover, fall grazing probably helps to promote the establishment of additional grass and forb seedlings during the following spring. The sheep scatter the newly shed seed and often cover it by trampling (Pechanec and Stewart, 1949). Then, if the area is again protected in the spring, many of these grass and forb seedlings become established.

An area containing an open stand of sagebrush resulting from heavy fall grazing is probably better sheep range than an area from which sagebrush has been eliminated. Sagebrush and other shrubs constitute an important part of the diet of sheep in the fall because they supply much more crude protein and phosphorus at that time than do the native grasses and forbs (Blaisdell et al., 1952). The shrubs also provide emergency feed when early snows bury herbaceous vegetation.

Thus, both fall grazing and protection improved range in poor condition. However, fall grazing probably reduces sagebrush more than protection from grazing: (1) after prolonged fall grazing, there were significantly fewer sagebrush plants in the continued fall pasture than in the old exclosure (Table 3), and (2) the average weight of sagebrush plants was lower in the new fall pasture than in the new exclosure (Table 2).

Application of Results. — The results of this study indicate that depleted sagebrush-grass ranges can be improved by use of a properly planned grazing program. The commonly used methods of reducing dense stands of sagebrush (burning, spraying, or mechanical treatment) are costly and eliminate grazing for one or more years following treatment. A program of spring deferment combined with heavy fall grazing offers an alternative method of improvement. Its advantage is that it requires only management of the sheep and not costly cultural practices.

Fall grazing should be an effective method of improving sagebrush-grass ranges if:

(1) The sagebrush has a good understory of herbaceous perennials, especially grasses. (If the native grasses and forbs have been replaced by annuals, little improvement can be expected.)

(2) The sagebrush is grazed in the late fall when snow is on the ground so that utilization is as heavy as possible. On fairly level ground, the condition of the sheep should determine the time of removal in the fall rather than any certain level of utilization. (Sheep were not weighed in this study, but fall grazing caused no observable decline in weight or condition.) On steep slopes, however, grazing rates should be lower than on level ground to prevent excessive soil disturbance by

sheep and the resulting acceleration in erosion.

During this study, heavy fall grazing had noticeably improved the new fall pasture by 1953, only 3 years after the treatment was started. Such a rapid rate of improvement indicates that the combination of spring deferment and heavy fall grazing is a very practical method for range restoration. Because only 2 or 3 years are necessary to effect marked improvement, this program could be applied on a rotation basis to one range unit at a time, and it should thus upgrade the entire range over a period of years.

Whether this system could be used on a given range without reducing the number of sheep grazed in the spring would depend upon the condition of the range and the present grazing intensity. If the present grazing rate is quite heavy, deferment of one unit and thereby increasing the spring grazing pressure on the remainder of the range might cause considerable damage. In such a situation, additional spring range or supplemental feed might be necessary until the carrying capacity of part of the range is increased. If the present grazing rate is moderate, the system might be used without serious damage, especially if the spring-grazed units were rotated so that a given unit would be grazed at a different time each spring (Laycock, 1962).

The only known test of fall grazing as a method of range improvement is being conducted on the Benmore Experimental Area in Utah, where heavy fall grazing by sheep appears to have reduced the amount of big sagebrush *(Artemisia tridentata)* in seeded cattle pastures.[4]

[4] *Personal communication, Neil C. Frischknecht, Intermountain Forest and Range Experiment Station, Provo, Utah.*

Summary

At the U.S. Sheep Experiment Station near Dubois, Idaho, one pasture, grazed only in late fall from 1924 to 1949, remained in good condition with an open stand of threetip sagebrush and a good understory of perennial grasses and forbs. An adjacent pasture, grazed in both spring and fall, deteriorated to poor condition as grasses and forbs decreased markedly and sagebrush increased.

In 1950 additional fences were erected and grazing treatments were applied from 1950 through 1963 to determine the effects of spring grazing only, fall grazing only, and protection from grazing on some range in good condition and some in poor.

Heavy spring grazing caused rapid deterioration of good-condition range; production of sagebrush increased 78% and production of grasses and forbs decreased more than 50%. Arrowleaf balsamroot and some of the palatable forbs decreased more than 85%. Heavy spring grazing on range already in poor condition maintained the low productivity of palatable forage species and further increased sagebrush.

Heavy late-fall grazing and complete protection maintained the range in good condition with an abundance of balsamroot, other forbs, and grasses. Likewise, both heavy fall grazing and protection improved poor-condition range; production of the desirable forage species increased more than 30% while sagebrush decreased 20%. Fall grazing, however, reduced sagebrush more than protection because the sheep browsed on the sagebrush in the fall. Grasses and forbs were not damaged by fall utilization because they are essentially dormant at that time.

Thus sagebrush-grass ranges can be improved by proper grazing rather than by costly spraying, burning, or mechanical treatments. Spring deferment combined with heavy grazing in the late fall offers an alternative method of improvement. The loss of grazing in the spring is more than offset by the increased grazing rate allowable in the fall.

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Beef Production on Lodgepole Pine-Pinegrass Range in Southern British Columbia

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Highlight

Yearling steers on lodgepole pine-pinegrass summer range in British Columbia had an average daily gain of 1.75 lb for 103 days per year over a 5-year period. The average gain per acre was 19.3 lb for the season and the average stocking rate was 4.8 acres per AUM. Pinegrass, which provided over 50% of the forage yield, was readily accepted by cattle during early summer but became unpalatable by mid August.

The most important and characteristic range vegetation zone in interior British Columbia is the douglasfir zone. It comprises about 15 of the 19 million acres of grazing land in the Interior. The zone has been described by Tisdale and McLean (1957). The major plant association within the zone is douglasfir-pinegrass, the principal grazing species being pinegrass *(Calamagrostis rubescens* Buckl.). Lodgepole pine *(Pinus contorta* Dougl.) is the main seral tree species in the zone.

Few grazing studies have been made in the zone and yet this step is necessary if accurate grazing values are to be assigned.

The Eastern Oregon Experiment Station is conducting grazing studies on pinegrass-dominated range in eastern Oregon (Hedrick, 1966). Indications are that early-summer grazing is the best time of use while the forbs are at peak production and the pinegrass is immature.

The Oregon pinegrass range is markedly different from ours in that the climax tree is grand fir *(Abies grandis* L.) and the understory contains a higher proportion of shrubs which make up 40% of the forage under moderate shade and about 20% in open areas.

FIG. 1. Plant cover in the experimental fields, Pass Lake, B. C. Dominant tree is lodgepole pine with understory mostly of pinegrass.

Grazing trials were started in 1960 at the CDA Research Station, Kamloops, B.C. The work during 1960 and 1961 was supervised by Dr. H. H. Nicholson, then Animal Scientist at the research station, and for the remainder of the time by the author. The results must be interpreted with caution since there is no assurance that they are representative of the region as a whole. The trials are being continued, however, and extended to other grazing districts.

Study Area and Procedures

The experimental fields lie within the holdings of the Research Station near Pass Lake about 14 miles northwest of Kamloops. They are located in the douglasfir zone between 3400 and 4000 ft elevation. The present tree cover is a medium-dense stand of lodgepole pine alone or mixed with aspen *(Populus tremuloides* Michx.) (Fig. 1). Throughout the fields there is sufficient douglasfir to indicate a successional trend to that species. Pinegrass is the dominant ground-cover species. Plot records indicate that the species dominates about 80% of the ground area. It is the only grass to contribute significantly to the forage yield. Plots clipped in 1966 indicated that the grasses, forbs, and shrubs had an average distribution by weight of 56, 29, and 15% respectively.

The principal associated shrubs are rose *(Rosa nutkana* Presl), oregongrape *(Mahonia repens* (L.) G. Don), whitetop spiraea *(Spiraea betulifolia* Pall.) and russet buffaloberry *(Shepherdia canadensis* (L.) Nutt.). The most commonly occurring forbs are heartleaved arnica *(Arnica cordifolia* Hook.), showy aster *(Aster conspicuus* L.) timber milkvetch *(Astragalus miser* Dougl. var. *serotinus* (Gray) Barneby), creamy peavine *(Lathyrus ochroleucus* Hook.), and strawberry *(Fragaria glauca* (Wats.) Rydb.).

Plot records indicated that dominant trees of lodgepole pine had an average diameter at breast height of 9.2 inches, an average age of 72 years and site index of 75.

The topography is rolling and cattle can graze over the entire

Table 1. Number of days on pasture, number of yearling steers on each field, and their average starting weights in a grazing trial on the Pass Lake experimental fields 1960 to 1964.

	No.	No. of days on pasture						No. of yearlings on field					Avg starting weights (lb)				
Field	acres	1960	1961	1962	1963	1964	Avg	1960	1961	1962	1963	1964	1960	1961	1962	1963	1964
1	105	106	112	98	100	112	106	6	12	12	8 + 11*	15	648	508	571	486	459
2	81	106	112	98	72	98	97	6	9	8	11	12	634	537	637	484	476
3	90	106	112	98	100	112	106	6	9	9	12	12	630	532	628	505	479
Avg.	92	106	112	98	91	107	103						637	526	612	492	471

* Eleven animals were moved from Field 2 to Field 1 after 72 days when the former became overgrazed.

Table 2. Average daily gain of yearling steers, gain per acre, and average carrying capacity of three Pass Lake experimental fields for 5 years (1960 to 1964).

	Avg daily gain (lb)				Gain per acre (lb)				Stocking rate (ac/AUM)			
Year	1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
1960	1.85	1.98	1.78	1.87	11.2	15.5	12.6	13.1	8.2	6.4	7.1	7.2
1961	1.89	1.85	1.98	1.91	24.2	23.0	22.2	23.1	3.9	4.0	4.5	4.1
1962	1.82	1.36	1.60	1.59	20.4	13.2	15.7	16.4	4.5	5.2	5.1	4.9
1963	1.53	1.79	1.61	1.64	13.0	17.5	21.5	17.3	4.7	5.1	3.7	4.5
1964	1.81	1.85	1.60	1.75	29.0	26.9	24.0	26.6	3.1	3.4	3.3	3.3
Avg	1.78	1.77	1.71	1.75	19.6	19.2	19.2	19.3	4.9	4.8	4.7	4.8

The averages joined by lines are not significantly different at the 5% level expressed by Duncan's Multiple Range Test.

1.91 1.87 1.75 1.64 1.59 26.6 23.1 17.3 16.4 13.1 3.3 4.1 4.5 4.9 7.2

area without having to climb steep slopes. Water is available in several places in each field. The fields are fairly similar in their forage cover and topography. The chief differences are that Field 3 contains a small, swampy meadow (about 2 acres) and Field 1 has a few more open patches dominated by Kentucky bluegrass.

Three fields were fenced in the fall of 1959 and continuously grazed during each pasture season from 1960 to 1964. Grazing of the area had been light for a number of years prior to the start of the experiment and there was a good cover of forage species.

There was no fixed grazing period, animals being grazed for as long as possible depending on the forage growth and weather conditions. Yearling steers averaging 548 lb at turn out (Table 1) were used in the test and weighed every 2 weeks throughout the season. The animals were kept on pasture in the fall until the average gain became less than 1 lb/day. In 1960 the fields were obviously undergrazed so that stocking rate was increased the following year and adjusted as available forage dictated thereafter (Table 1). For reporting, yearling steer units were converted to animals units (AU) by multiplying the former by 0.6.

The turn out dates for 1960 to 1964 inclusive were June 30, June 16, July 6, July 3, June 5. The closing dates were October 14, 6, 12, 11, and September 25, except that Field 2 was closed on September 13 and 11 in 1963 and 1964 respectively because of overgrazing.

The plant cover was estimated from sample plots using the method of Daubenmire (1959). Forage yield was determined in 1966 by clipping five 9.6 ft^2 plots at random at each sample-plot site.

Plant nomenclature follows that of Hitchcock et al. (1955).

Results and Discussion

The fields compared well both as to animal performance and carrying capacity. The 5-year average daily gain of 1.75 lb for 103 days (Table 2) compares favorably with the 1.40 lb average for 74 days obtained over 7 years on a sedge meadow in the same district (McLean, Nicholson, and van Ryswyk. 1963).

The time of removal of the animals from the range greatly influenced the seasonal average daily gain because of reduced gains in the fall (Table 3). On the test fields the dates of first loss of weight of any animal in the fall was recorded on October 14, 6, 12, 11 and September 11, for the years 1960 to 1964 respectively. There was no significant difference in the average daily gain between years (Table 2).

On a nearby similar range on which yearling steers were weighed on and off, the average daily gains were 1.5, 1.3, 1.6, and 1.9 lb. The dates the latter range was closed in the fall were October 1, 6, September 15, and 16 respectively.

Table 3. Average daily gains (lb) of yearling steers on Pass Lake experimental fields by 14-day weigh periods for 5 years (1960 to 1964).

Weigh per.	1960	1961	1962	1963	1964
1	3.70*	3.71	2.45	3.00***	3.29
2	2.62	0.85	2.49	2.20	2.35
3	1.67	3.36	1.36	1.73	2.24
4	2.83	2.33	1.59	1.53	1.46
5	1.34	1.60	1.64	0.92	2.17
6	1.96	1.06	0.89	0.66	2.01
7	1.07	1.77	0.75	0.29	−0.17
8	−.86**	0.57			0.30

* Weigh period 15 days; ** 7 days; *** 16 days.

The decline in daily gain as the season advances is most likely largely a result of the drop in nutrient value of the feed available. A decline in crude protein and phosphorus was demonstrated by McLean and Tisdale (1960) who collected most of their samples from the same general area in which the grazing trial was conducted. The lower feed value of pinegrass as compared with associated forbs and shrubs was especially marked. Dr. D. M. Bowden, Animal Scientist, CDA Research Station, Agassiz, B.C. carried out in vitro digestibility analysis on a series of pinegrass samples collected in 1965 from the experimental fields. The digestibility values dropped from about 65% at the end of May to 57, 53, 48, and 37% at the end of June, July, August, and September respectively.

The above results suggest that animals that are to be sold in the fall should be taken off forest range in early September or have their diets supplemented if they are to maintain their rate of gain.

The average carrying capacity of 4.8 acres/AUM is considered to represent a realistic figure for the fields. In interpreting this value for range management purposes, however, it must be remembered to allow for such factors as distance from water and accessibility.

Understocking of the fields in 1960 accounts for the lower gain per acre and the greater number of acres required per AUM for that year (Table 2).

The average gain per acre over the 5 years for the 300 acres was 19.3 lb for the season which, if beef was sold for 25¢/lb would return nearly $5.00/acre.

The fields were rotationally grazed during 1965 and 1966 by yearling heifers, starting dates being June 1 and 3 respectively. The fields were grazed for 108 and 112 days and produced average daily gains of 1.68 and 1.69 lb. The average gains per acre were 24.6 and 26.8 lb for the two years respectively.

Much better utilization of pinegrass was obtained by the earlier turnout in the past 2 years as it was readily acceptable throughout June. On the other hand it became very unacceptable by mid August. Despite the earlier season of use, the average daily gains were not appreciably better than those from the first 5 years.

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Fertilization and Its Effect on Range Improvement in the Northern Great Plains

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Highlight

Application of nitrogen fertilizer to a deteriorated range site changed the botanical composition from predominantly forbs and shortgrass species to a western wheatgrass and shortgrass composition. Nitrogen fertilization increased both forage and crude protein yields.

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Research and practical experience indicate that much rangeland has a potential for greater forage production. Practices such as reseeding, control of undesirable species, proper management and mechanical treatments all aid in range improvement. Range pitting, for example, on the shortgrass plains of Wyoming (Barnes, 1952; Rauzi and Lang, 1956) increased carrying capacity and forage production.

Use of fertilizer on dryland ranges is also a practical means of increasing forage production in certain situations. However, some range fertilization studies have shown erratic or undesirable effects. Huffine and Elder (1960) in Oklahoma found that fertilized native pastures produced 2 to 5 times more weeds (by weight) than did unfertilized pastures. On the other hand, in southeastern Arizona blue grama responded consistently to fertilizer applications (Honnas et al., 1959). Similarly, results from a 6-year study in North Dakota showed that 2 years of fertilization, with 90 lb of nitrogen on a heavily grazed pasture, did more to improve range condition and production than did 6 years without grazing (Rogler and Lorenz, 1957). Studies in western South Dakota indicated that maximum forage production from utilizing runoff water could not be obtained without fertilization (Cosper and Thomas, 1961).

In the Northern Great Plains, forage yields from native ranges in poor to fair condition seldom exceed 600 lb/acre even in years of 15 inches or more precipitation. Little information is available on the effect of fertilizer on species composition and nutrient uptake on native rangeland. Generally, cool-season grasses responded to nitrogen fertilizer (Rogler and Lorenz, 1957). In order to evaluate potential forage production, in addition to other effects of fertilization, two native ranges in northeastern Wyoming were selected for study. The economics of rangeland fertilization was not investigated.

Experimental Area and Procedure

Site A was located approximately 11 miles north and site B, 6 miles east of Sundance, Wyoming. Due to the influence of the neighboring Black Hills, precipitation at the two sites varies somewhat from that recorded at Sundance (Table 1). Normally, 45% of the annual precipitation comes in April, May and June. Day temperatures in the summer very often reach 90 to 100F. Winter temperatures may go as low as minus 30F. Drouths are frequent. In 1961 lack of precipitation limited plant growth and forage yields were not taken.

The soils at the two locations were similar in that each developed from very fine sandy and silty parent materials weathered from fine-grained sandstones. At site A the surface 2 inches of soil was a very fine sandy loam with a pH of 6.8 to 7.0. At 2 to 9 inches the soil graded into a silty clay loam (35% clay) with a pH of 7.2. The soil at site B, from the surface to the 16-inch depth, was a silt loam with a pH of 8.0. Topography at both locations is gently sloping.

Table 1. Annual and seasonal (April 1 to June 30) precipitation in inches, 1957-1962, at Sundance, Wyoming.

Year	Annual	Seasonal
1957	24.59	13.12
1958	18.86	8.37
1959	18.10	8.48
1960	15.96	5.67
1961	17.91	4.84
1962	33.63	19.65
Mean	21.51	10.02
19-Year Mean	21.22	9.66

Native grass species at site A in 1958 accounted for 54.6% of the vegetation by weight and other plant species made up the remainder. Principal grass species present before the study was initiated were western wheatgrass (*Agropyron smithii* Rydb.), blue grama (*Bouteloua gracilis* H.B.K. Lag. x Steud.), buffalograss (*Buchloe dactyloides* [Nutt] Engelm.) and sandberg bluegrass (*Poa secunda* Presl.). Other principal species were horseweed (*Conyza canadensis* [L.] Cron.), fringed sagewort (*Artemisia frigida* Willd.), woolly plantain (*Plantago purshii* R. & S.), threadleaf sedge (*Carex filifolia* Nutt.), needleleaf sedge (*Carex eleocharis* Bailey), green sagewort (*Artemisia glauca* Pall.), and downy brome (*Bromus tectorum* L.). Numerous other species were represented but in relatively small amounts. Grass species at site B before the study began accounted for 91% of the vegetation by weight. In addition to the same grass species that were present at site A, a small amount of green needlegrass (*Stipa viridula* Tren.) was found at site B. Other species included sixweeks fescue (*Festuca octoflora* Walt.).

Three variables, nitrogen, phosphorus, and season of fertilizer application, were included in a factoral design with three replications at both sites A and B. Each fertilizer treatment was applied to an area 5 by 24 ft. Nitrogen as ammonium nitrate (33.5% N) was applied at rates of 0, 40, 80, and 160 lb/acre and phosphorus as superphosphate (43% P_2O_5) was applied at rates of 0, 80, and 100 lb/acre. The fertilizer was placed in bands 10 inches apart to a depth of 2 to 3 inches in the soil by means of small chisels. The nonfertilized treatments were also chiseled. The experimental sites were protected from grazing.

Fertilizer was applied at three seasons of the year, fall (October, 1957), spring (April, 1958), and summer (first week of June, 1958) at site A; and two seasons, spring (April, 1957) and summer (June, 1957) at site B. Fertilizer was applied only at the initiation of the study at each location.

The forage from 2 randomly selected areas (total of 28 ft^2) in each fertilizer treatment was clipped 1 inch above ground level late in June. The plant material was separated into 3 categories; intermediate grasses, short grasses, and other species which included nongrasses and summer annual grasses. Dry matter yields in each category were determined. Yields were measured in 1958 through 1960 and in 1962 at site A. At site B, yields were taken in 1957 and 1958.

Protein was determined by the A.O.A.C. method (1960). Plant phosphorus was determined by the methods of Bolin and Stamberg (1944) and Barton (1948).

Vegetative composition at each site was determined by the point frame method. The procedure was similar to that first described by Levy and Madden (1933). Points of contact were spaced 1 inch apart along a 2-foot frame. Two frames were counted per individual plot to determine vegetative composition and plant cover.

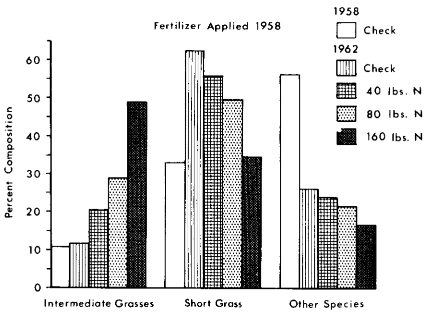

FIG. 1. Botanical composition of a deteriorated range fertilized in 1958. Averaged for all phosphorus rates and seasons of application.

Results and Discussion

Botannical Composition

Heavy grazing had deteriorated site A to such an extent that grasses made up only 43.7% of the total plant population, of which shortgrass and intermediate grasses comprised 33.0 and 10.7%, respectively. Five years of deferred grazing without fertilizer produced a marked change in botanical composition (Fig. 1). Vegetative composition in 1962 showed that shortgrass species, blue grama and buffalograss, had about doubled; intermediate species, mainly western wheatgrass, had remained approximately the same; and the other species had decreased from 56.0 to 25.9%.

Fertilizer applied in 1958 also produced botanical changes in 1962 (Fig. 1). Phosphorus had no significant effect on botanical composition. Point frame sampling showed that all nitrogen levels significantly increased the intermediate grasses but decreased shortgrass and other species. The 160-lb nitrogen application in combination with phosphorus increased the population of intermediate grasses in 1962 from 11.6% of total plant population for the check treatment (no nitrogen applied) to 48.3%. The corresponding nitrogen fertilizer treatments decreased shortgrass species composition from 62.3 to 34.5%, and other plant species from 25.9 to 16.7%, of the total plant population.

The differences in species composition due to season fertilizer was applied were small when measured in 1962. Fall-applied fertilizer slightly increased the intermediate grasses over that obtained from spring or summer applications.

Botanical composition at site B was not significantly altered by the fertilizer applications. This may reflect the short time over which measurements were taken (2 years) or the difference in species composition at sites A and B. Shortgrasses made up 80% of the total plant population at site B compared to 33% at site A.

Forage Production

Site A.—Total forage yields for the 4 years, (1958, 1959, 1960, and 1962) were affected significantly by both the time of year applied and rate of application of nitrogen and phosphorus fertilizer (Table 2). Summer application had the least effect on yields. Lack of moisture limited plant growth in 1959, 1960, and 1961.

In 1958 total forage production increased significantly with nitrogen applications and with phosphorus when applied with nitrogen. All of the yield response was due to the increased growth of other species (annuals and browse). Fertilizer application had no significant effect on growth of the intermediate or shortgrass species (Fig. 2). The significant yield response in 1959 was due mainly to residual nitrogen from the 160-lb nitrogen additions. The low amount of precipitation in 1959 restricted growth of the other species to a greater extent than that of the grasses. In response to the residual nitrogen from the 0-, 40-, 80-, and 160-lb nitrogen additions of 1958, the other species con-

Table 2. Dry matter forage yields (lb/acre) on a deteriorated native range (site A) as influenced by rate (lb/acre) and season of N and P fertilizer application (1958) and residual fertilizer (1959-1962).

Fertilizer applied in 1958		Fall applied				Spring applied				Summer applied			
N	P_2O_5	1958	1959	1960	1962	1958	1959	1960	1962	1958	1959	1960	1962
0	0	928d*	277d	374d	490d	945d	326d	547c	458d	744d	415cd	626bc	681d
40	0	1710d	443cd	543c	920c	1767d	522bcd	538c	827cd	1086d	364d	533c	863c
80	0	2570c	579bc	866a	1263b	2450c	662ab	697b	1081bc	1100d	634b	568bc	998c
160	0	3446b	646ab	818ab	1380b	2521c	859a	800ab	1514b	1468d	501bc	788b	1814a
0	80	762d	454cd	381d	477d	1099d	487bcd	481c	690cd	857d	466cd	382d	382d
40	80	1911d	459cd	469c	930c	2014c	546bc	658b	1047bc	1060d	499bcd	462cd	649d
80	80	3325b	534bcd	531c	1166bc	2281c	478cd	656b	1069bc	1381d	489bcd	824a	739c
160	80	2867c	812a	824a	2011a	4019b	700ab	872a	1605b	1633d	601bc	691b	1582b
0	160	963d	378d	466c	652d	1061d	388d	496c	482d	995d	324d	456cd	732cd
40	160	1404d	376d	523c	844c	2145c	482bcd	513c	927cd	1192d	449cd	660b	746cd
80	160	2895c	601bc	597bc	1053bc	3270b	494bcd	744b	1048bc	1592d	605bc	619bc	910c
160	160	5704a	827a	636bc	1746ab	3282b	733ab	722b	1702ab	1203d	698ab	686b	1501b

* Values in same year, column or row followed by the same letter not significantly different at 5% probability level by Duncan Multiple Range Test.

stituted 23.4, 25.9, 27.6, and 34.9%, respectively, of the total forage yield. In 1960 other species responded to a greater extent than the grasses to residual nitrogen. Other species made up 63.2, 62.0, 58.7, and 50.7% of the total yield in response to residual nitrogen from the 0-, 40-, 80-, and 160-lb nitrogen applications of 1958. The difference in response by grasses in 1959 and 1960 may be due to rainfall distribution.

Increased yields from residual N in 1962 were due to intermediate grasses (Fig. 2). These native grasses accounted for 46 and 62% of the total yield (by weight) of the nonfertilized and the previously fertilized (160 lb/acre N) forage, respectively. Shortgrass species such as buffalo and blue grama contributed 44 and 32% of the total yield at the same nitrogen additions, respectively.

Site B.—Applications of nitrogen and phosphorus to a predominantly shortgrass range significantly increased forage production. Forage yields for two seasons are presented in Table 3. Forage yields the first season increased as the rate of nitrogen application increased. The largest yield was obtained with the 160-lb nitrogen addition in combination with 80 lb of phosphorus. The greatest increase per pound of nitrogen applied, however, was from 40 lb.

In contrast to the initial plant species response on Site A, the increased yields at Site B were due to greater production by native grass species rather than by other species. Nonfertilized other species accounted for 45 and 9% of the total yield at Sites A and B, respectively. Following the application of 160 lb of nitrogen, the nongrass yields at Sites A and B constituted 88 and 19% of the total yield, respectively.

The time of fertilizer application significantly affected forage production (Table 3, Fig. 3). Spring applications (April, 1957) increased growth of other species

Table 3. Dry matter, total protein yields (lb/acre) and mean phosphorus content (%) of forage on a short grass range (site B) as affected by rate (lb/acre) and season of N and P application (1957) and residual fertilizer (1958).

Fertilizer applied in 1957		Spring applied		Summer applied		Spring		Summer	
N	P_2O_5	1957	1958	1957	1958	Crude prot.†	Phosphorus	Crude prot.	Phosphorus
0	0	1345ghi*	669	1128hi	886	165	0.145	165	0.145
40	0	2205cd	1111	1390fg	960	274	.133	221	.127
80	0	2118cd	1198	1483fg	1019	324	.115	245	.118
160	0	2066cd	1013	1644ef	1240	337	.114	294	.124
0	80	1220hi	1098	1081hi	945	189	.156	175	.175
40	80	2401c	1519	1411fg	1214	337	.155	221	.167
80	80	3208a	1417	1581eg	1084	437	.158	264	.152
160	80	3157a	1278	2720b	1504	481	.164	458	.161
0	160	1372fgh	932	1027hi	750	203	.178	147	.176
40	160	1993d	1064	1570eg	1141	267	.167	248	.175
80	160	2201cd	1095	1809de	1035	320	.188	284	.161
160	160	2906b	1503	2215cd	1503	483	.211	459	.201

† L.S.D. 5% Crude protein—Fertilizer, 58 lb/acre; Season, 49 lb/acre.

* Values in same year, column or row followed by the same letter not significantly different at 5% probability level by Duncan Multiple Range Test.

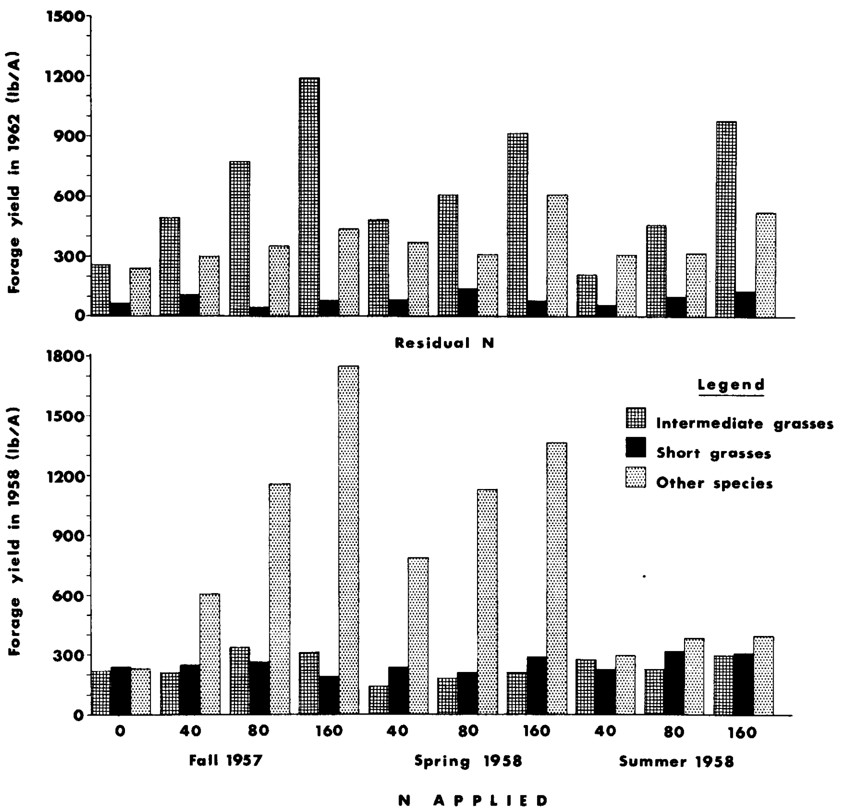

FIG. 2. Forage yields by species on a deteriorated range as affected by applied and residual nitrogen fertilizer.

Table 4. The effect of nitrogen fertilizer (applied in 1958) on the 1962 production and germination of western wheatgrass seed (site A).

Nitrogen lb/acre	Seed heads No./ft^2	Weight g/head	Germ. %[1]
0	1.2	0.251	80
40	2.3	.248	—
80	5.3	.235	91
160	5.5	.237	91

[1]Standard germination — KNO_3 (0.2% solution) diurnal temperature 15 to 30C.

Table 5. Total protein yields (lb/acre) and mean phosphorus content (%) of forage on a deteriorated native range (site A) as influenced by rate (lb/acre) and season of N and P fertilizer application.

Fertilizer applied in 1958		Fall applied		Spring applied		Summer applied	
N	P_2O_5	Crude protein	Phosphorus	Crude protein	Phosphorus	Crude protein	Phosphorus
0	0	170	0.193	175	0.170	184	0.179
40	0	312	.183	310	.201	273	.186
80	0	476	.174	489	.167	286	.179
160	0	711	.180	589	.171	497	.189
0	80	160	.194	230	.200	165	.190
40	80	284	.188	347	.187	280	.200
80	80	471	.172	416	.178	352	.202
160	80	637	.181	749	.188	474	.194
0	160	198	.185	206	.217	203	.214
40	160	302	.192	317	.204	284	.202
80	160	483	.177	485	.197	386	.207
160	160	883	.188	719	.181	447	.220

L.S.D. 5% Crude protein—Fertilizer, 63 lb/acre; Season, 52 lb/acre.

and intermediate grasses more than summer (June, 1957) fertilizer additions. The shortgrass species were not affected by the time of fertilizer application.

A marked response by the different plants to fertilizer was noted. The application of 160 lb of nitrogen resulted in yield increases over the nonfertilized plants of 58, 129, and 199% by the shortgrasses, intermediate grasses (chiefly western wheatgrass and sandberg bluegrass), and other species, respectively. Eighty pounds of phosphorus increased the yields of other species, intermediate grasses, and shortgrasses by 71, 30, and 9%, respectively.

Forage yield response to residual fertilizer from the 1957 applications was obtained only in 1958. All fertilizer treatments produced substantially more forage than the nonfertilized treatment. However, differences in yields among fertilizer treatments were small and nonsignificant.

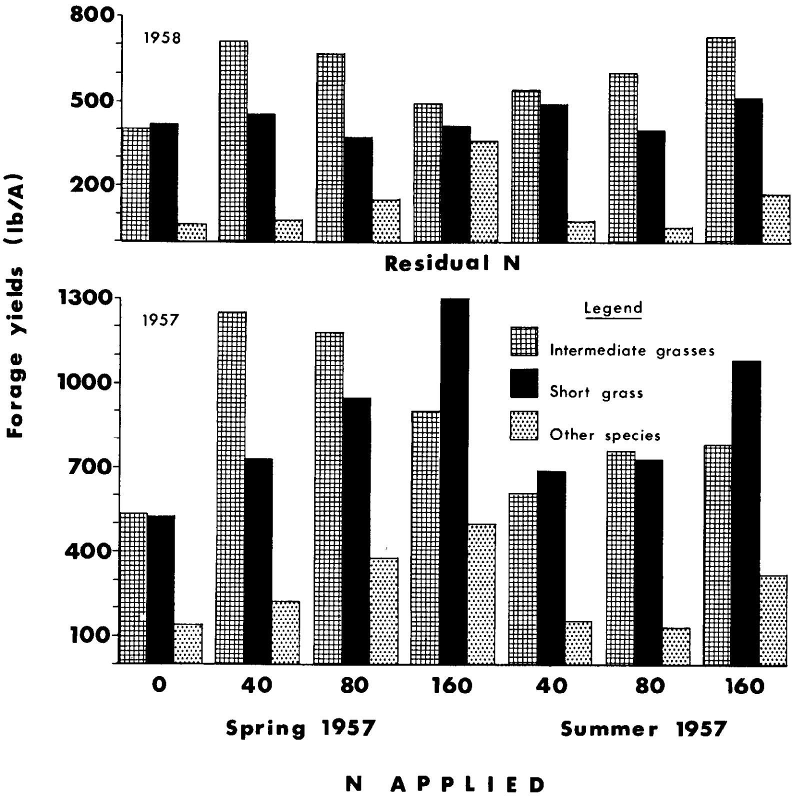

FIG. 3. Forage yields by species on a shortgrass range as affected by applied and residual nitrogen fertilizer.

Seed production.—Nitrogen increased both plant vigor and seed production of western wheatgrass. Forty pounds of nitrogen applied at site A in 1958 nearly doubled the number of seed heads and amount of seed in 1962, while the residual nitrogen from the 80- and 160-lb applications resulted in four times more heads and seeds than on nonfertilized western wheatgrass (Table 4). The results are averaged for all phosphorus levels and times of fertilizer application. The weight of individual heads decreased as the number produced per unit area increased. Seed heads on nonfertilized grass were larger and heavier than those produced by fertilized grass. Standard seed germination tests showed a range of 80 to 91% viable seed, with perhaps a possible trend favoring seed from fertilized grass.

Protein Content of Forage

Nitrogen fertilizer significantly increased the total protein yield at both sites (Tables 3 and 5). The relation between crude protein yields and rate of nitrogen application was linear up to the highest rate used, 160 lb/acre of nitrogen. The effect of nitrogen and the crude protein percentage was significant only in the first and second year.

Fall and spring fertilizer applications significantly increased crude protein yields above those obtained with a summer application. However, the percent of crude protein was generally higher in summer-fertilized forage. The mean crude protein content of forage at site A was 9.94, 10.26, and 10.65% for fall-, spring-, and summer-applied fertilizer, respectively.

The four-year average crude protein content of other species and grass species on site A was 9.50 and 8.75%, respectively. No differences were found between the protein percentages of grasses and other plant species at site B. The mean crude protein content of the forage was 9.50%.

Crude protein content of all grasses at both sites was below the minimum requirement for beef cattle except in the year 160 lb of nitrogen fertilizer was applied. An 800-lb beef animal requires 0.90 to 1.00 lb/day of digestible protein along with 17.1 lb of dry matter (Morrison, 1962). Nonfertilized grass at site A in 1958 supplied about 0.56 lb of digestible protein in the required amount of dry matter. The protein digestibility coefficient was estimated at 45% (Morrison, 1962). Grass species fertilized at the 160-lb nitrogen rate supplied 0.93 lb of digestible protein. The minimum protein requirement could be attained by increasing dry matter intake to 30.7, 24.8, and 21.4 lb/day for grass fertilized with 0, 40, and 80 lb of nitrogen, respectively.

Phosphorus Content of Forage

Phosphorus content of the forage was dependent on the application rate of nitrogen and phosphorus fertilizers and on the time of application. Phosphorus fertilizer significantly increased the phosphorus content of the forage at both sites (Tables 3 and 5). Forage at site A fertilized in the summer had a higher phosphorus content than fall- or spring-fertilized forage. However, the time of application had no effect on the phosphorus content at site B.

Botanical composition also influenced the overall phophorus content of the forage. Grass species at site B fertilized with 40, 80, and 160 lb of nitrogen contained 0.133, 0.139, and 0.135% phosphorus. Similar nitrogen addition to other species resulted in phosphorus concentrations of 0.174, 0.169, and 0.191%, respectively. Residual effects from the 160-lb phosphorus application at site A were measured in the third year.

The minimum dry matter requirement (17.1 lb/day) at site B would supply 0.019, 0.024, and 0.026 lb/day of phosphorus, respectively, from grass fertilized with 0, 80, and 160 lb of phosphorus. The daily phosphorus requirement for an 800-lb beef animal is 0.033 lb/day (Morrison, 1962). At the same phosphorus addition on site A, the minimum dry matter requirement would furnish 0.027, 0.029, and 0.032 lb of phosphorus, respectively, on a grass diet in 1958. Inclusion of other species would greatly increase the daily phosphorus intake.

Summary

The effects of nitrogen and phosphorus fertilization on botanical composition, forage yields, and chemical composition of forage from two native ranges in eastern Wyoming were investigated.

A single soil application of nitrogen fertilizer to a deteriorated range site changed the botanical composition from predominantly forbs and shortgrass species to a western wheatgrass and shortgrass composition. Nitrogen fertilizer applied to a similar soil on which shortgrass species represented 80% of the total vegetation did not alter botanical composition.

Nitrogen fertilization increased both forage production and crude protein yields at each location. The changes in forage yields were associated with botanical composition as well as the amount of nitrogen applied.

The crude protein percentage of the forage was significantly increased by the application of nitrogen fertilizer.

Phosphorus content in the forage increased with the addition of phosphorus fertilizer.

The relation between the protein and phosphorus content of the forage and the minimum requirements of these elements by range cattle are discussed briefly.

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Thickening and Spread of Crested Wheatgrass Stands on Southern Idaho Ranges[1]

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Highlight

Crested and fairway wheatgrass stands thickened and plants spread to adjacent areas from 1954 to 1966 on six experimental areas in southern Idaho. Drilling produced 10 times more seedlings than broadcasting, and stands reached full production much sooner. Plant survival and final numbers were greatest on the plowed, burned, and untreated seedbeds, in that order.

In the early days of range seeding, many land administrators and some research workers asserted that crested wheatgrass (*Agropyron desertorum* (Fisch. ex Link) Schult.)[2] in the Western States would not spread to adjacent areas, or thicken up between rows. They stated that it would be confined to the original plants even after a considerable lapse of time.[3]

In more recent years, the ability of crested wheatgrass to thicken and spread in areas to which it is adapted is being acknowledged. For example, Weintraub (1953) in summarizing seeding results on western ranges concluded that crested wheatgrass reseeds itself well. Hull and Klomp (1966) found that 20 to 30-year-old seedings of crested wheatgrass in southern Idaho were growing well and that plants had spread far beyond the original seeded areas.

Periodic examinations and recorded data from 1954 seedings on six areas in the sagebrush-grass type in southern Idaho revealed the thickening and spread of crested and fairway wheatgrass stands over a 12-year period. These seedings were designed mainly to compare airplane and hand-broadcasting of pelleted and unpelleted seed with drilling. The results, together with a description of the sites, were reported by Hull (1959).

This study was undertaken to determine the thickening and spread of crested wheatgrass on seeded plots and to determine factors which were associated with this spread. As this paper is concerned only with the thickening and spread of wheatgrass, it does not include those phases of the original study which compared pelleted with unpelleted seed, and airplane broadcasting with other seeding methods.

Experimental Areas and Methods

Elevation and precipitation of the six areas in the present study are given in Table 1. Symbols used in tables, together with site descriptions follow.

S1—*Summit 1* is 20 miles north of Shoshone. Vegetation is mainly big sagebrush (*Artemisia tridentata* Nutt.) with a bluebunch wheatgrass *Agropyron spicatum* (Pursh) Scribn. & Smith) and a bluegrass (*Poa* spp.) understory and frequent plants of Great Basin wildrye (*Elymus cinereus* Scribn. & Merr.).

S2—*Summit 2* is 21 miles north of Shoshone. Vegetation is mixed big and low sagebrush (*Artemisia arbuscula* Pursh.) with an understory of bluebunch wheatgrass, Idaho fescue (*Festuca idahoensis* Elmer), bluegrasses and frequent plants of Great Basin wildrye, especially on the hummocks.

D—*Dubois* is 13 miles north of Dubois. Vegetation is mainly big and three-tip sagebrush (*Artemisia tripartita* Rybd.) with an understory of bluebunch, thick-

Table 1. Elevation, precipitation, and soil texture at the 0-2 inch depth for the six experimental areas in southern Idaho.

Location	Elevation (ft.)	Annual Precipitation (inches)	Mechanical composition (%) Sand	(%) Silt	(%) Clay	Texture
S1	5000	14	30	48	22	loam
S2	5000	14	35	42	23	loam
D	6000	16	46	30	24	loam
S	4450	10	83	7	10	loamy sand
B1	4700	11	57	31	12	sandy loam
B2	4700	11	83	7	10	loamy sand

[1] *Cooperative research investigations of Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture; Bureau of Land Management and Bureau of Indian Affairs, U.S. Department of the Interior; University of Idaho Forest, Wildlife and Range Experiment Station; and Utah Agricultural Experiment Station, Utah Agr. Exp. Sta. Journal Paper 606. Thanks go to personnel of the cooperating agencies who assisted with the field work, and to those who made helpful comments on this paper.*

[2] *Early seeded stands often contained fairway wheatgrass (A. cristatum (L.) Gaertn.). In this discussion, except where specifically mentioned, both species will be referred to as crested wheatgrass.*

[3] *Unpublished reports and personal communications.*

spike (*Agropyron dasystachyum* (Hook.) Scribn.) and streambank (*Agropyron riparium* Scribn. & Smith) wheatgrasses, forbs, and frequent plants of Great Basin wildrye.

S—*Sand* is 3 miles north of the Fort Hall Indian Agency. This area supports scattered plants of big sagebrush and rabbitbrush (*Chrysothamnus* spp.) with considerable skeletonweed (*Lygodesmia spinosa* Nutt.), needleandthread (*Stipa comata* Trin. & Rupr.), sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray), and cheatgrass (*Bromus tectorum* L.). The soil is an alluvial loamy sand which blows readily.

B1—*Buckskin 1* is 7 miles east-northeast of the Fort Hall Agency. Tall plants of big sagebrush form dense to open stands. Where sagebrush stands are open there is a dense understory of needleandthread and cheatgrass.

B2—*Buckskin 2* is 8 miles northeast of the Fort Hall Agency. Douglas rabbitbrush (*Chrysothamnus viscidiflorus* (Hook.) Nutt.) is fairly abundant, with some big sagebrush and a fair understory of needleandthread, sand dropseed, bluegrasses and cheatgrass. The soil is a deep loamy sand which blows readily.

Soils on the experimental areas were analyzed for bulk density, moisture holding capacity, organic matter, pH, soluble salts, and texture. The characteristics which seemed to affect the thickening and spread of seeded plants were the texture and the surface roughness. The texture of the 0-2 inch depth is listed in Table 1.

The seeding procedures were as follows:

3 methods of seedbed preparation; plow, burn, no treatment.

2 methods of seeding; drill (symbol-Dr), hand broadcast (symbol-Br).

3 rates of seeding; 1, 6, 12 lb/A (1 and 12 lb on 3 areas only).

Table 2. Success ratings for crested wheatgrass drilled and hand broadcasted at three rates per acre on a plowed seedbed in 1954.

Method[1], rate, and location			1955	1956	1958	1960	1962	1964	1966
Dr	1	S	6*	5	6	6	7	8	10
		B1	7	7	7	9	9	10	10
		B2	8	5	6	8	9	10	10
	Ave		7.0	5.7	6.3	7.7	8.3	9.3	10.0
Dr	6	S1	8	8	9	9	10	10	10
		S2	9	10	10	10	10	10	10
		D	10	8	9	10	10	10	10
		S	8	7	8	10	10	10	10
		B1	9	9	9	10	10	10	10
		B2	3**	1**	1*	3	5	8	9
	Ave		7.8	7.2	7.7	8.7	9.2	9.7	9.8
Dr	12	S	10	9	10	10	10	10	10
		B1	10	10	10	10	10	10	10
		B2	10	10	10	10	10	10	10
	Ave		10.0	9.7	10.0	10.0	10.0	10.0	10.0
Dr	Ave		8.2	7.5	7.9	8.8	9.2	9.7	9.9
Br	6	S1	2	2	8	10	10	10	10
		S2	2	4	8	8	9	9	10
		D	2	3	7	9	10	10	10
		S	2	1	3	5	7	8	10
		B1	3	2	6	8	8	10	10
		B2	1**	1**	2	4	6	9	10
	Ave		2.0	2.2	5.7	7.3	8.3	9.3	10.0
Br	12	S1	8	5	8	8	9	10	10
		S2	7	3	6	8	9	10	10
		D	5	6	9	10	10	10	10
		S	3	4	7	8	10	10	10
		B1	4	3	5	8	9	10	10
		B2	1**	1*	4	7	9	10	10
	Ave		4.7	3.7	6.5	8.2	9.3	10.0	10.0
Br	Ave		3.4	2.9	6.1	7.7	8.8	9.6	10.0
Plow	Ave		5.8	5.2	6.8	8.2	9.0	9.7	10.0

* Moderate soil blowing ** Severe soil blowing

[1] Dr = Drill; Br = Broadcast.

Check; seedbed preparation treatments made, but not seeded.

Experimental areas were 300 by 520 ft. Each was divided lengthwise into three strips 100 ft wide on which the three methods of seedbed preparation were applied. Most seeding treatments were applied. Most seeding treatments were 40 ft wide and crossed the area at right angles to the three seedbed preparation strips. Thus, each seeding treatment in each preparation strip was 40 x 100 ft.

Areas were fenced and livestock excluded for the 12 years. Rabbits, gophers, or mice were not controlled. Rodents damaged some plants, but we thought their impact on seeded plants was low.

In addition to the experimental plots, 14,000 acres of large-scale seeding was done on 5 areas, either surrounding or adjacent to the experimental plots.

Experimental and large-scale treatments were carried out in 1954. Burning was done in August at Summit 1 and 2 and Dubois, and late October at Sand and Buckskin 1 and 2. Plowing was done during late October and early November. All areas were seeded between November 2 and 17.

We counted plants on all treatments in 1955-56, and obtained herbage yields in 1956. Although Tables 2 and 3 show only even years, we rated success from 1955 to 1966. Most figures are the average of two plots. The rating

Table 3. Success rating for crested wheatgrass drilled and hand broadcasted at three rates per acre on an untreated seedbed in 1954.

Method, rate, and location		1955	1956	1958	1960	1962	1964	1966
Dr 1	S	4	1	1	1	1	1	2
	B1	2	1	1	1	1	1	2
	B2	5	1	1	1	3	3	5
Ave		3.7	1.0	1.0	1.0	1.7	1.7	3.0
Dr 6	S1	8	1	1	1	2	2	4
	S2	6	1	1	1	1	2	2
	D	5	1	3	4	5	8	9
	S	7	2	1	1	1	2	3
	B1	3	1	1	1	1	2	3
	B2	6*	2*	1	1	2	4	5
Ave		5.8	1.3	1.3	1.5	2.0	3.3	4.3
Dr 12	S	9	1	1	1	2	3	5
	B1	7	2	1	1	2	2	3
	B2	9	2	1	2	5	7	9
Ave		8.3	1.7	1.0	1.3	3.0	4.0	5.7
Dr Ave		5.9	1.3	1.1	1.3	2.2	3.1	4.4
Br 6	S1	1	1	.1	.1	1	1	2
	S2	1	.1	.1	1	1	1	2
	D	1	.1	.1	1	1	4	5
	S	1	.1	.1	.1	1	1	2
	B1	1	.1	.1	.1	1	1	2
	B2	1	.1	.1	.1	1	4	5
Ave		1.0	.2	.1	.4	1.0	2.0	3.0
Br 12	S1	1	1	.1	.1	1	4	5
	S2	1	1	.1	1	1	3	3
	D	1	.1	.1	1	1	3	6
	S	1	.1	.1	.1	1	1	2
	B1	1	.1	.1	1	1	1	2
	B2	1	.1	.1	.1	2	5	6
Ave		1.0	.4	.1	.5	1.2	2.8	4.0
Br Ave		1.0	.3	.1	.4	1.1	2.4	3.5
Untreated Ave		3.5	.8	.6	.9	1.6	2.7	4.0

*Moderate soil blowing

Table 4. Plants per ft² in 1955, 1956, and 1965 for crested wheatgrass drilled and handbroadcasted at three seeding rates on plowed and untreated seedbeds at 3 or 6 locations in 1954.

Seeding method and rate	Plowed seedbed 1955	Plowed seedbed 1956	Plowed seedbed 1965	Untreated seedbed 1955	Untreated seedbed 1956	Untreated seedbed 1965
Dr 1*	1.1	.8	1.1	1.9	0	.2
Dr 6	3.1	1.2	1.3	4.3	.06	.4
Dr 12*	6.7	2.0	1.5	10.6	.07	.5
Dr Ave.	3.5	1.3	1.4	5.3	.04	.4
Br 6	.9	.4	1.2	1.0	.01	.3
Br 12	1.2	.5	1.1	.2	.02	.4
Br Ave.	1.1	.5	1.2	.6	.02	.4
Dr and B Ave.	2.3	.9	1.3	3.0	.03	.4

*Average of 3 locations, others average of 6 locations.

system was described by Hull (1954) and indicates the success of an established stand or the potential of a seedling stand as follows: 9-10, excellent; 7-8, good; 5-6, fair; 3-4, poor; 1-2, very poor; zero, failure. A rating of 0.1 indicates a stand far below 1 but not a complete failure. Success ratings were associated with plant numbers and were little influenced by plant size. Counts are in plants per ft² (Table 4). Herbage yields in air-dry lb/acre were determined by clipping, drying, and weighing.

Each year the seeded stands became noticeably thicker. Therefore, in 1965, ratings, plant counts, and plant yields were taken again. The earlier results and the 1965 and 1966 data form the basis for this paper.

Results

Success ratings were high the 1st year, and usually declined the 2nd or 3rd year, after which the stands improved and the ratings increased to the 12th year. Plant numbers were generally highest the 1st year. Subsequently many seedlings died, then natural seeding took place and numbers increased (Fig. 1).

During 1955, the seedlings which survived grew well. Many produced seed, which in turn produced seedlings. These new plants either thickened the original stand or spread to surrounding areas, or both. Thickening and spreading continued on all treatments over the 12-year period. On all areas, seeded grass has spread into unseeded areas such as the 40 x 100 ft check plots. Factors which influenced initial plant establishment and subsequent natural seeding are discussed below.

Seedbed Preparation and Plant Competition

Planting methods which covered the seed gave the best seedling emergence. Seedlings survived best where seedbed treatments eliminated the competing plants. Averaging all seeding rates, methods, and locations, the plowed seedbed commenced with a success rating of 5.8 and ended with 10. The burned seedbed started with 4.1 and ended with 6.5. The untreated seedbed commenced with 3.5, dropped to 0.6, and 12 years later had improved to 4.0. Averaging all treatments and locations, grass yields during 1965 were as follows:

Treatments	*lb/acre*
Plowed	1,085
Burned	564
No treatment	267

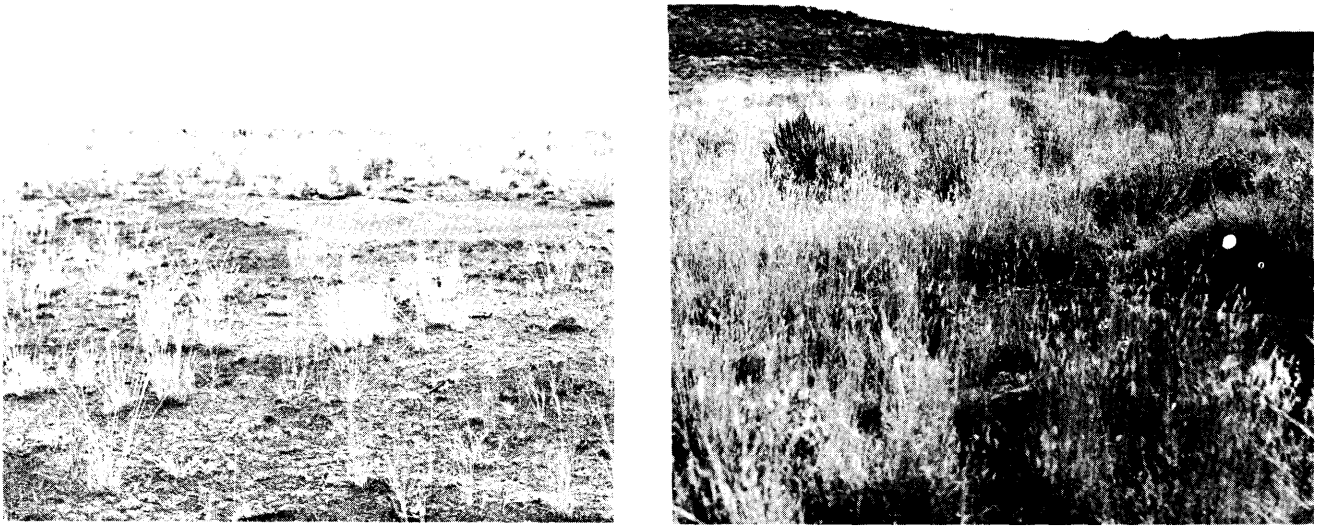

FIG. 1. Seeded crested wheatgrass at Summit 2 increased from very few plants in 1956 to a good stand in 1965. Left—Burned and broadcast at 6 lb/A, there were only 0.05 plants per ft^2 in 1956 and the stand had a success rating of 1. Practically all grass in this photo is native. Right—In 1965 there was one seeded plant per ft^2 with a success rating of 7.

Where all woody plants were burned, the burned plots produced as much grass as did the plowed plots. The moderate ratings (Table 3) and the low yield listed above for the untreated seedbed indicate that enough plants were present for a fair stand, but that vigor and yields were low. Low yields are common where seeded species grew among competing plants.

Plowing.—A 6-inch plow depth killed most of the sagebrush and the shallow rooted plants, but was not effective on rhizomatous grasses and root-sprouting shrubs and forbs. Plowing provided a weed-free but loose seedbed. As the plowed surface was rough, even after the first year, natural seeding was more rapid, and full stands were reached quicker than on the other seedbeds. The poor stands on some plowed seedbeds at Buckskin 2 were the result of severe soil blowing. Where cheatgrass and perennial plants competed with seeded grass, full stands of grass developed slowly.

Burning. — Where burning killed competing vegetation it equaled plowing for seedbed preparation. Since burning killed competing plants on only three of the six areas, seeding results on burned seedbeds on the experimental areas are not included. On both experimental and large-scale seedings, seedling numbers and success ratings decreased for the first two or three years. Plants then increased on the burned and broadcast areas where initial establishment was poor. Plant numbers continued to decrease on some burned and drilled areas where the initial seedling establishment was high. Some of this decrease could have been merging of individual plants.

Following is the average number of crested wheatgrass plants per ft^2 for burning and drilling and burning and broadcasting on four large-scale seedings at Summit 1, Dubois, Sand, and Buckskin 2:

Treatment	*1955*	*1956*	*1961*	*1966*
Burned and drilled	7.2	3.0	1.6	2.2
Burned and broadcast	.08	.04	0.06	.28

Untreated seedbeds. — Drilling untreated seedbeds averaged 5.3 seedlings ft^2 as compared to 3.7 seedlings on plowed and drilled seedbeds. On the untreated seedbed, however, only 0.8% of the seedlings lived one year as compared to 37% survival on the plowed seedbed.

On the untreated seedbed, plant numbers and ratings dropped for 2 to 4 years but were still increasing in 1966. Greatest increases were at Dubois and Buckskin 2. Dubois is a south-facing slope and Buckskin 2 is near watering troughs. Both areas had been depleted by heavy use and there were unoccupied soil areas where seeded plants could obtain a foothold.

Soil Texture and Movement

A slight roughness of the soil surface, followed by soil sloughing or a slight movement of soil by wind or water helps cover seeds. Three areas had these conditions. The soil at Dubois was a loam with considerable surface roughness. This roughness provided depressions and lodging places where seed fell and was subsequently covered by soil sloughing. This helped seeded species thicken and spread on experimental and large-scale seedings in this area. Buckskin 2 had a fine loamy sand which blew readily. Where blowing was severe, it reduced plant numbers and yields during the early years (Tables 2 to 4). As the soil became partially stabilized, the blowing helped cover seed and caused a rapid increase in seedling numbers. As crested wheatgrass thickened, the soil movement decreased.

Soil movement for seed coverage resulted in increased plant numbers on experimental and large-scale seedings at Sand. Soil surface roughness, combined with light trampling by cattle, provided seed covering which resulted in an increase in plant numbers on the large-scale burned and broadcast seeding at Summit 1.

Method of Seeding

Drilling was better than broadcasting, mainly because it covered the seed. Averaging all seedbeds, drilling produced 4.7 seedlings ft^2 and broadcasting produced 0.7. Thus 21% of the seeds from drilling produced seedlings as compared to only 2% from broadcasting. After 11 years of protection, drilling and broadcasting had similar numbers of plants, but drilled plots averaged 745 lb/acre as compared to 530 lb for broadcasting. Stands from drilling reached full production much sooner and kept out weedy competing plants better than broadcasting stands.

Rate of Seeding

Seedling emergence on the plowed and burned seedbeds was roughly proportional to the amount of seed sown. At the end of 11 to 12 years, plant numbers, success ratings, and grass yields from all rates were nearly equal, though still slightly higher at the heavier rates. Low rates eventually produced a satisfactory stand but the higher rates controlled weeds and gave a satisfactory stand much sooner. Also the reinvasion of sagebrush was greatest where good stands of grass established slowly.

Species

At Summit 1 and 2 and Dubois, seed for the experimental plots was fairway wheatgrass, except one plot at each location seeded to crested wheatgrass. Buckskin 1 and 2 and Sand plots were seeded with crested wheatgrass with one plot at each location seeded to fairway. These single plots of crested wheatgrass at the first three locations, and the fairway at the last three are omitted from Tables 2 to 4, thus each location is represented by one species only. Comparing similar treatments, the fairway wheatgrass thickened faster and spread further than the crested wheatgrass. This agrees with Weintraub (1953) and with previous work in Idaho (Hull & Klomp, 1966).

Discussion

This and other studies indicate that crested wheatgrass is well adapted to the sagebrush type in southern Idaho, and that when some plants are established that it will thicken and will also spread to adjacent areas. Studies also indicate a high seedling mortality during the first one or two growing seasons.

On new seedings, high seedling numbers and high mortality are common. Seeding 6 lb/acre of crested wheatgrass with normal seed viability and purity provides 23 good seeds/ft^2. On the average, 25 to 75% of these seeds germinate and plants emerge, but then most of the seedlings die. Loss of seedlings is not serious because they are usually more than needed for the final stand.

In this study, the best seeding emergence resulted from methods which covered seed to the proper depth. Competition with existing plants was the major cause of seedling mortality. Factors which favored plants to increase in numbers on seeded plot and to spread to new areas were: lack of competing vegetation, a rough soil surface, soil movement, and fairway wheatgrass as compared to crested wheatgrass.

This study indicates that a thin seeded stand might become a good stand if favorable conditions exist, and if enough years elapse. However, considering time and uncertainties, the most profitable seeded stands will undoubtedly be obtained by good methods of seedbed preparation and seeding.

Summary

We studied six experimental areas from a 1954 seeding to determine factors which affected thickening and spread of fairway and crested wheatgrasses.

Success ratings and plant numbers were high for seedling stands. Ratings and plant numbers decreased as plants died, and then increased as natural seeding took place.

Plant survival and final numbers were greatest on the plowed seedbed, mainly because plant competition was lacking. Also a slight roughness in the plowed soil surface, followed by soil sloughing or a slight movement of the soil by wind or water helped cover seeds and caused thickening of stands and spread to adjacent areas.

The plowed seedbed started with a success rating of 5.8 and ended with 10. The burned seedbed had 4.1 and ended with 6.5, and the untreated seedbed commenced with 3.5, dropped to 0.6 and 12 years later had improved to 4.0. Where burning was effective, it was comparable to plowing.

Averaging both seedbeds, drilling produced 7 times more seedlings than did broadcasting, mainly because it covered the seed. At the end of 11 years of protection, plant numbers and success ratings were similar, but drilled stands reached full production much sooner.

Comparing the 1, 6, and 12 lb seeding rates, seedling emergence was roughly proportioned to the amount of seed sown. Heavier rates controlled weedy plants and invading brush, and gave a satisfactory stand sooner than lower rates.

Fairway wheatgrass stands thickened sooner and spread more than crested wheatgrass.

Though crested wheatgrass plants in thin stands eventually will thicken and will also spread to adjacent areas, the most profitable seeded stands will undoubtedly be full initial stands obtained by good methods of seedbed preparation and seeding.

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Mechanical Control and Fertilization as Brush Management Practices Affect Forage Production in South Texas[1]

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Highlight

Brush control methods involving a minimum of soil disturbance were the most reliable methods of improving successional stage and increasing forage production. Soil disturbance retarded plant succession and caused a large fluctuation in yearly forage production. Nitrogen fertilizer increased forage production, but adversely affected species composition unless applied in conjunction with mowing. Mowing, as a follow-up maintenance practice, improved range condition, increased forage production on all brush control plots, and greatly increased the beneficial effects of all fertilizer treatments.

Prevention of shrub reinvasion after brush control by grazing management alone is difficult. Follow-up practices should be designed to take advantage of any gain by forage plants after the initial treatment. This study reports the use of fertilizer application and mowing as maintenance treatments in retarding brush reinvasion after mechanical brush removal.

Brush composition in South Texas is complex. Often as many as eight to ten species make up the plant composition referred to as "chaparral" (Box, 1964). These brush species, although growing together in the same habitat, have different growth forms and different physiological responses to brush control treatments. Because many species differ in their physiological response to herbicides, chemical treatment is seldom completely successful (Allison and Rechenthin, 1956). Control of one species often releases another more noxious one. Therefore, this project was designed to study effects of mechanical brush control practices commonly used in South Texas and to develop methods of maintaining the desired effects after treatment.

The study was conducted on the Rob and Bessie Welder Wildlife Foundation Refuge, San Patricio County, Texas. The Refuge lies in the western Gulf Prairies and Marshes (Gould, Hoffman, and Rechenthin, 1960) and has been described in detail by Box and Chamrad (1966).

The climate is characterized by warm temperature and high humidity throughout most of the year. The annual rainfall pattern normally has two peaks, one in the late spring and early summer and one in early fall. Plant production is relatively high and corresponds rather closely to the rainfall pattern, with seasonal peaks in the spring and fall (Box, 1960).

The study area is located on Victoria clay in the chaparral-bristlegrass community. Victoria clay is a heavy, self-mulching grumusol with Gilgai relief, low bulk density, high moisture holding capacity, low permeability, and high fertility (Box, 1961).

Methods and Materials

Five mechanical brush control treatments were applied as 20-acre, randomized blocks at each of three locations in late June, 1963 (Fig. 1). Treatments and costs were shredding (1.50/acre), roller chopping ($5.00/acre), scalping with a KG blade ($10.00/acre), root plowing ($10.00/acre), and root plowing with raking ($16.00/acre) (Box and Powell, 1965). All locations were within a pasture grazed yearlong at the rate of one mature steer to 15 acres and one white-tailed deer to 7 acres.

Brush composition and canopy cover were measured at each location before treatment, immediately after treatment in 1963, one year later in 1964, and two years later in 1965 by a modification of the line intercept method (Canfield, 1942). Fifteen, 100-ft intercepts were located randomly on each treatment.

In June, 1964, five fertilizer treatments were applied in a split-plot design on each brush control plot. Treatments included 100 lb N/acre,

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300 lb N/acre, 100 lb N plus 100 lb P_2O_5/acre, 100 lb P_2O_5/acre, and no fertilizer on a check plot. Nitrogen was applied as ammonium sulfate. Phosphorus was applied as treble superphosphate. Fertilizer treatments were selected on the basis of soil chemical analysis (Box, 1961; Kovar, 1963). Fertilizer was broadcast with a drill-type fertilizer spreader on plots parallel to each other.

A rectangular area across the fertilizer plots on each brush control block was mowed to a three-inch stubble with a rotary blade mower in late June, 1964, at a cost of $1.50/acre. This split split-plot design gave each brush control plot all combinations of fertilized, mowed plots and fertilized, unmowed plots. A cattle exclosure protected each treatment after mowing. Each exclosure contained an unmowed, fertilized area and a mowed, fertilized area of equal size.

Herbage production was sampled by a modification of the ranked set method described by McIntyre (1952). Instead of clipping and weighing a sample from every set, herbage from one in every four sets of ranked samples was weighed. Herbage in the other three sets was estimated. Production was determined in late August, 1964 and 1965 by species on each subplot.

Species composition of herbaceous vegetation on each treatment subplot was used to calculate the percentage of climax grasses as an indication of range condition. Only herbaceous vegetation was used in the calculation since the weight sample of woody plants was not adequate. Herbaceous vegetation from each treatment was sampled to within 10% of the mean.

A composite grass sample, approximating the species composition of the grasses, was collected from each fertilizer plot in late August, 1964, and analyzed for percent crude protein (Assoc. Offic. Agr. Chemists, 1960). On April 1, 1965, samples of Texas wintergrass (*Stipa leucotrica* Trin. and Rupr.) were collected from each fertilizer plot at each of the three locations. These samples were analyzed for percent crude protein and phosphorus (A.O.A.C., 1960).

Differences between brush control treatments were determined by simple analysis of variance. Differences between subplot treatments and interaction between treatments were determined by a split split-plot analysis of variance (Snedecor, 1956). Differences within treatments were determined by Duncan's new multiple range test (Li, 1957).

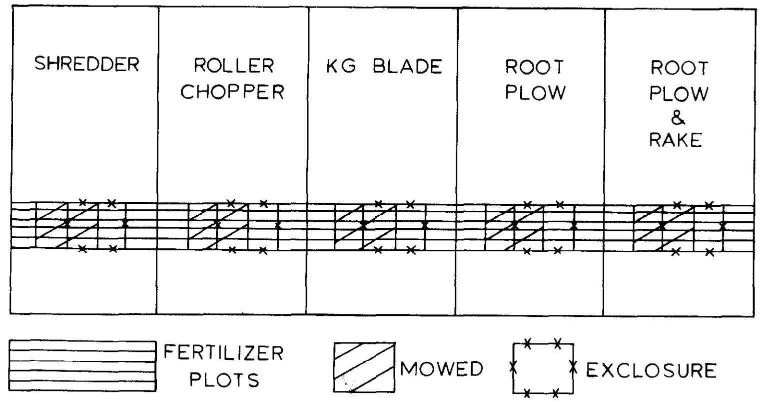

Fig. 1. Plot design of mechanical brush control, mowing, and fertilizer treatments.

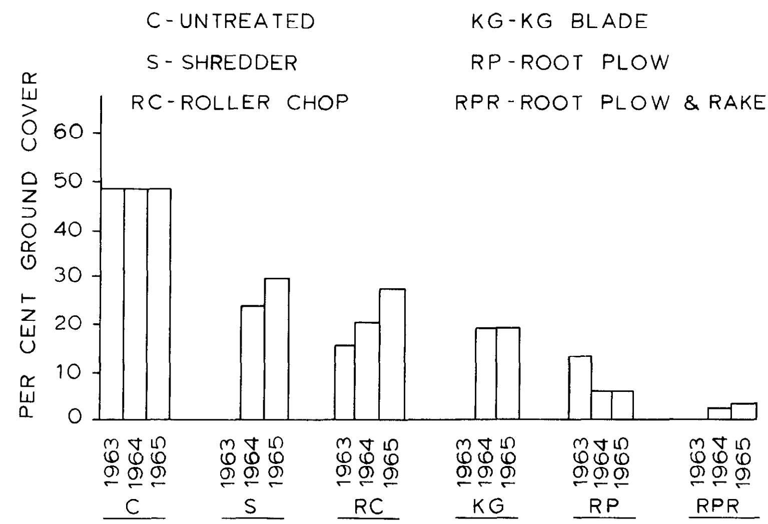

Fig. 2. Average per cent ground cover of woody species on brush control plots on the Welder Wildlife Refuge 1963, 1964, 1965.

Results and Discussion

Brush Control Treatments

Woody Vegetation.—Brush in the untreated, chaparral-bristlegrass community had a total ground cover of 48.6%. Many species of brush, such as blackbrush acacia (*Acacia rigidula* Benth.), agarito (*Berberis trifoliolata* Moric.), granjeno (*Celtis pallida* Torr.), lime prickly ash (*Zanthoxylum fagara* (L.) Sarg.), and *Condalia* spp., were found mixed together in brush "mottes." Huisache acacia (*Acacia farnesiana* (L.) Willd.) and honey mesquite (*Prosopis glandulosa* Torr.) were found more often as solitary plants.

Brush cover was reduced more than 50% by all brush control treatments (Fig. 2). Shredding, scalping with a KG blade, and root plowing with raking removed all brush cover in 1963. Immediately after treatment in 1963, brush cover was 15.9% on roller-chopped areas and 13.7% on root-plowed areas. Many plants on root-plowed areas which appeared to be alive immediately after treatment died later causing a decrease in brush cover between 1963 and 1964.

Between 1963 and 1964, many of the brush plants on top-removal treatments sprouted pro-

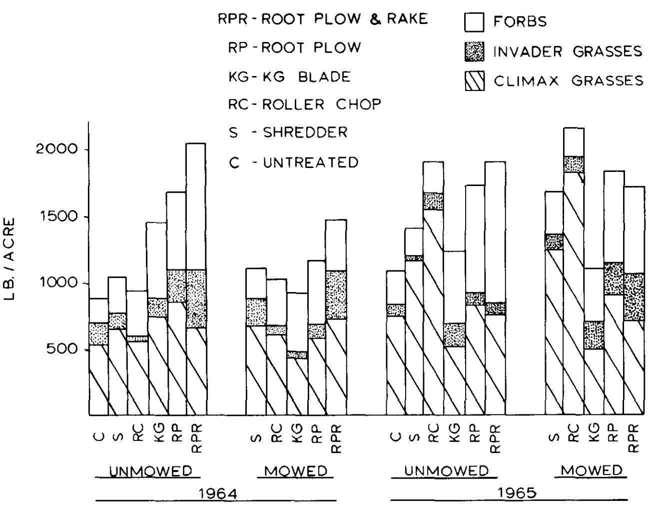

Fig. 3. Oven dry weight of herbage on brush control plots on the Welder Wildlife Refuge 1964, 1965.

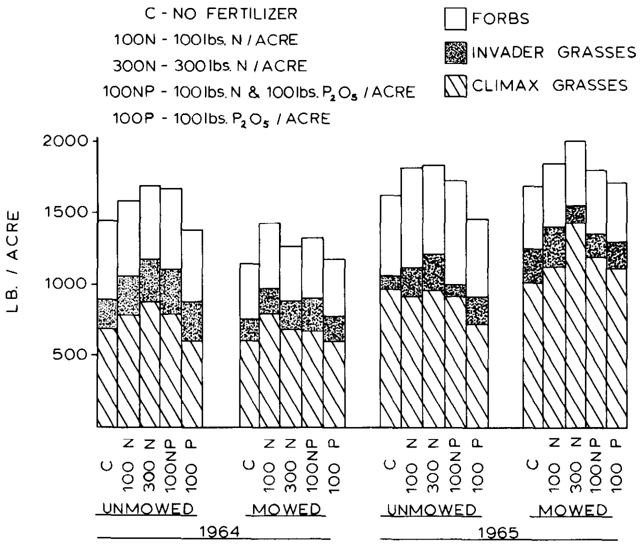

Fig. 4. Oven dry weight of herbage produced on fertilized and mowed plots on the Welder Wildlife Refuge 1964, 1965.

fusely, forming a low, dense brush canopy of succulent regrowth. Brush plants on roller-chopped areas were slightly taller than those on shredded or scalped areas. Brush on scalped areas resembled that on shredded areas except for a lower total brush cover on scalped areas.

Top-removal treatments, such as shredding, scalping, and roller chopping, caused resprouting of many of the same brush species that were cut or chopped. Only honey mesquite, tasajillo (*Opuntia leptocaulis* DC.), and pricklypear (*O. lindheimeri* Engelm.) decreased in percentage composition on those plots subjected to top-removal treatments. Huisache acacia, blackbrush acacia, agarito, granjeno, lime prickly ash, and *Condalia* spp. each had less canopy cover, but all increased in percentage composition as compared to untreated areas.

Root-plowed areas had a brush cover of 6.2% in 1964. Although the soil was root plowed to a depth of 10 to 14 inches, some of the brush plants reestablished root systems while others remained as standing litter. Reestablishment of root systems was especially true for cacti. Ground cover of pricklypear increased 365%, and tasajillo 20% on root-plowed areas. Ground cover of all other woody species decreased on root-plowed areas. Root-plowed and raked areas had a brush cover of 2.0% in 1964, most of which was due to seedlings. Ground cover of all woody species decreased on root plowed and raked areas.

Total brush cover increased to 30.2% on shredded areas and 28.2% on roller-chopped areas as compared to brush covers of 24.5% and 20.7% on these areas in 1964. There was little change in brush cover between 1964 and 1965 on areas which were scalped, root plowed, or root plowed and raked.

Herbage Production.—In 1964 total grass production was significantly ($P<0.05$) greater on root-plowed and root-plowed and raked areas than on the other four brush-treated areas (Fig. 3). However, there was no significant difference in climax grass production between any of the six brush-treated areas. In 1965 both total and climax grass production were significantly ($P<0.05$) greater on shredded and roller-chopped areas than on the other four brush-treated areas. Forb production was significantly ($P<0.05$) greater on scalped, root-plowed, and root-plowed and raked areas than on the other three areas in 1964 and 1965.

Brush cover was negatively correlated with grass production ($P<0.10$) and forb production ($P<0.05$) in 1964. Correlation coefficients between percent brush cover and grass and forb production were -0.796 and -0.843, respectively. Reduction of brush cover allowed more sunlight on areas previously shaded by brush mottes. In 1965 forb production was negatively correlated ($P<0.05$) with percent brush cover, but grass production was not affected by ground cover. Correlation coefficients between percent brush cover and forb and grass production were -0.877 and -0.276, respectively.

Between 1964 and 1965, total herbage increased on untreated, shredded, roller-chopped and root-plowed areas and decreased on scalped and root-plowed and raked areas. Grass increased on untreated, shredded, and roller-chopped areas and decreased on other areas. Forbs increased on untreated, root-plowed, and root-plowed and raked areas and decreased on other areas.

The amount of grass produced

increased most on treatments with least soil disturbance. The percentage of herbage produced by grass increased on shredded and roller-chopped areas and decreased on all other areas. Roller-chopped areas had the greatest increase in grass production (172.0%) and the greatest increase in percentage of herbage produced by grass (26.3%). Root-plowed areas had the greatest increase in forbs, 38.0%, and the greatest decrease in percentage of herbage produced by grass (10.7%).

Species Composition.—Most of the herbaceous vegetation in the untreated, chaparral-bristlegrass community was found in open areas between brush mottes. Grass grew well around edges of brush mottes and in rather open mottes, but few herbaceous species grew under mottes which had 100% canopy cover. In 1964 grass made up 79.2% of the herbage on untreated areas (Table 1).

As on untreated areas, a large percentage of the herbage on shredded areas was produced by grass. Spike bristlegrass (*Setaria leucopila* (Scribn. and Merr.) K. Schum.) was the most abundant grass and produced more than three times as much herbage as any other grass or forb on shredded areas. Grass composition on shredded areas was much like that on untreated areas except for an increase in spike bristlegrass. Most of the increased spike bristlegrass production occurred on those areas formerly covered by dense brush mottes. Of all grasses, spike bristlegrass responded the most vigorously after brush mottes were opened to sunlight. The herbage on shredded areas contained a relatively low percentage of forbs and a high percentage of desirable grasses.

Buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.) was the most abundant grass on roller-chopped areas in 1964 and was more abundant on roller-chopped areas than on any other area. Relative abundance of stoloniferous grasses was increased by roller chopping. Sod-formers were not harmed as much as bunchgrasses but the cutting action of the chopper blades.

The release of spike bristlegrass on shredded mottes was not observed on roller chopped mottes. Shading by the taller brush plants on roller-chopped mottes was enough to maintain suppression of spike bristlegrass plants under the brush. Also, brush cover was present at all times on roller-chopped mottes, whereas there was no brush cover on shredded mottes immediately after treatment.

Nearly all of the grasses on scalped, root-plowed, and root-plowed and raked areas were invaders or "weedy" increasers or those grasses which grow best on disturbed soil and under moist conditions. Because most of the climax grasses on these areas

Table 1. Percentage composition of herbaceous vegetation on brush control plots on Welder Wildlife Refuge.

	1964						1965					
Species	C	S	RC	KG	RP	RPR	C	S	RG	KG	RP	RPR
FORBS	20.8	21.3	39.0	36.7	35.8	45.8	29.1	15.7	12.7	42.5	46.5	56.1
GRASSES												
Andropogon saccharoides	5.3	4.5	5.5	1.0	—	—	3.9	9.9	3.6	T	1.2	—
Aristida roemeriana	5.9	4.0	1.0	1.6	—	—	T	2.0	3.9	—	T	—
Bouteloua rigidiseta	1.0	—	—	—	—	—	—	—	—	—	—	—
Buchloe dactyloides	9.8	8.0	15.0	1.6	T	T	19.8	25.4	21.9	8.5	8.8	1.6
Chloris spp.	1.2	3.0	1.0	7.0	3.1	1.4	—	—	2.0	—	2.3	T
Cynodon dactylon	—	—	T	T	—	1.4	—	—	—	—	—	6.8
Digitaria insularis	—	—	—	—	—	—	—	—	T	—	—	1.3
Eragrostis lugens	T	—	—	—	4.0	T	5.3	2.3	6.6	6.1	3.2	2.1
Eriochloa contracta	4.9	3.0	—	—	4.3	14.7	—	—	—	—	T	T
Eriochloa sericea	—	1.5	—	T	—	—	2.3	5.3	—	—	—	—
Hilaria belangeri	1.8	3.0	1.0	—	—	—	1.4	—	4.2	—	—	—
Leersia monandra	—	4.5	T	—	—	—	T	1.6	1.1	—	—	—
Leptochloa nealleyi	—	2.5	—	3.6	—	1.3	1.5	—	—	15.6	—	3.1
Panicum filipes	8.3	5.6	7.5	11.7	T	9.0	3.2	4.9	5.7	7.4	—	3.1
Panicum obtusum	—	3.0	6.0	T	T	4.7	2.8	T	5.7	—	1.2	3.4
Paspalum pubiflorum	11.2	—	2.5	—	—	—	5.0	2.3	4.4	2.0	—	3.4
Setaria geniculata	3.5	—	2.5	13.5	5.5	14.5	2.7	—	2.0	7.4	2.7	2.7
Setaria leucopila	11.8	28.7	9.0	20.7	39.0	2.6	13.1	22.4	19.1	8.2	25.7	10.4
Sporobolus pyramidatus	4.7	3.5	—	—	5.9	—	T	—	—	—	2.1	—
Sporobolus asper	—	—	—	—	—	—	3.5	T	T	—	1.7	—
Stipa leucotricha	7.1	2.9	8.0	2.6	1.2	T	4.5	6.3	4.8	3.2	1.7	3.8
Tridens albescens	—	—	—	—	1.2	T	1.9	T	T	—	2.1	T
Tridens congestus	2.3	1.0	1.0	T	—	—	—	—	—	—	—	—

C, Untreated; S, Shredded; RC, Roller Chopper; T, Less than 1.0%; KG, KG Blade; RP, Root Plow; RPR, Root Plow and Rake; —, Not present.

were increasers, range condition calculated from percent of climax grasses indicated a lower condition than on plots with less soil disturbance.

Spike bristlegrass was the most abundant grass on scalped and root-plowed areas and produced 62.0% of the total grass production on root-plowed areas. Robust spike bristlegrass plants occurred on scalped microhighs where brush mottes had been sheared clean of vegetation by the KG blade. On root-plowed areas spike bristlegrass grew most vigorously on microhighs around prickleypear and woody plants.

Root plowing with raking destroyed most of the desirable grasses and caused the greatest increase in forbs and invader grasses. Forbs produced nearly half of the herbage, and invader grasses produced almost one-fourth. The percentage of climax grasses on root-plowed and raked areas was lowest for all treated or untreated areas.

Raking after root plowing reduced spike bristlegrass considerably. Root plowing alone did not remove the uprooted brush plants, and the plowing resulted in a rough, uneven surface with microhighs. However, raking removed brush litter, leveled microhighs, and destroyed favorable microsites for spike bristlegrass plants. Good drainage on the microhighs appears to be a significant factor in the distribution of spike bristlegrass and other bunchgrasses.

Most of the surface on scalped, root-plowed, and root-plowed and raked areas remained as bare ground immediately after the brush control treatments in 1963. In 1964 these areas had more, but less desirable, forage than the other brush control plots. The percentage of annual and weedy perennial grasses and invader forbs was greatest on those plots which had the greatest soil disturbance. In general, annual and weedy perennial species were closely associated with soil disturbance.

In 1965 the most abundant grasses on untreated, shredded, and roller-chopped areas were buffalograss and spike bristlegrass. Buffalograss increased considerably on all brush control plots between 1964 and 1965. The percentage of climax grasses remained greater for shredded areas than for any other area.

The greatest increase in climax grasses occurred on roller chopped areas. This large increase was mainly due to a 62.0% decrease in forbs with a subsequent increase in perennial grasses. The percentage of climax grasses on roller-chopped areas in 1965 was only slightly less than for shredded areas.

Both the number of grass species and the percentage of desirable grasses decreased on scalped areas between 1964 and 1965. Both weedy and desirable grasses decreased on scalped areas, and forbs increased. Nealley sprangletop (*Leptochloa nealleyi* Vasey) was the only annual grass which produced much herbage on any brush-control plot in 1965, and most of it occurred on scalped areas.

Forbs produced about half of the herbage on root-plowed and root-plowed and raked plots in 1965. Invader grasses decreased greatly on those plots, while desirable grasses decreased on root-plowed plots and increased only slightly on root-plowed and raked plots. Percentage of climax grasses remained lower for root-plowed and raked areas than for any other area.

Much of the change in species composition and herbage production on brush control plots between 1964 and 1965 was due to a difference in rainfall distribution for the two years (Table 2). During 1963 and the first half of 1964, rainfall on the study area was 40.5% below average. On July 19, 1964, the study area received 6.75 inches of rain. Annuals and weedy perennials responded vigorously to the moisture and produced much of the herbage on plots which had undergone a soil disturbance due to plowing or scalping. During the winter quarter in 1964, rainfall was 21.0% below average. Spring rainfall in 1965 was about average, but the 1965 summer rainfall was considerably less than average.

Near average spring rainfall in 1965 helped to increase production of a high percentage of perennial grasses on shredded, roller-chopped, and untreated areas. Perennial grasses continued to produce green forage throughout the relatively dry 1965 summer, whereas many of the annual and weedy grasses died. The lack of response from annuals and weedy increasers in 1965 resulted in an increase in invader forbs and a sharp decrease in forage production on many of the disturbed areas.

Most of the high forb production on scalped, root-plowed, and root-plowed and raked plots in

Table 2. Average quarterly rainfall on the study area between 1956 and 1963 and between January, 1963, and September, 1965.

Year	Quarter	Rainfall (Inches)
1956-1963	Jan.-March	5.19
	April-June	9.27
	July-Sept.	7.78
	Oct.-Dec.	8.34
	Total	30.58
1963	Jan.-March	1.92
	April-June	3.82
	July-Sept.	5.68
	Oct.-Dec.	6.18
	Total	17.60
1964	Jan.-March	4.30
	April-June	4.91
	July-Sept.	12.63
	Oct.-Dec.	6.46
	Total	28.30
1965	Jan.-March	3.91
	April-June	8.34
	July-Sept.	5.19

1965 was due to the increased production of western ragweed (*Ambrosia psilostachya* DC.) and Texas broomweed (*Xanthocephalum texanum* (DC.) Shinners). Pure stands of these forbs were observed in 1965 on many disturbed areas which were formerly occupied by annual and weedy perennial grasses in 1964.

Forage production fluctuated more widely on disturbed areas than on relatively undisturbed areas in relation to the amount and distribution of the annual rainfall. Methods requiring the least soil disturbance give a more stable yearly yield in areas subect to fluctuating climatic conditions.

Fertilizer Treatments

Herbage Production and Species Composition.—Nitrogen fertilizer significantly ($P<0.01$) increased grass production in 1964 (Fig. 4). There was no significant difference between the three nitrogen treatments. In both 1964 and 1965 grass production was greatest on plots which received the heaviest rate of nitrogen. In 1964 grass production on 300 lb N/acre plots was 32.0% greater than that on check plots. In 1965 grass production on 300 lb N/acre plots was 14.0% greater than that on check plots, but the difference was not significant ($P<0.05$). Grass production, in 1965, was significantly ($P<0.05$) greater on 300 lb N/acre plots than on 100 lb N plus 100 lb P_2O_5/acre and 100 lb P_2O_5/acre plots.

Forb production on fertilizer plots was not significantly different in either 1964 or 1965, and no single forb species appeared to be affected by any fertilizer treatment.

Annual and weedy, perennial, invader grasses responded more vigorously to all fertilizer treatments in 1964 than did climax grasses (Table 3). Invader grasses increased considerably on both nitrogen and phosphorus plots, while climax grasses increased slightly on nitrogen plots and decreased on phosphorus plots.

The relative abundance of forbs decreased on check plots and increased on all fertilized plots between 1964 and 1965. The greatest increase of forbs occurred on the plots which had the greatest decrease of invader grasses. The change in relative abundance of invader grasses, climax grasses, and forbs on each fertilizer plot indicates that forbs, in 1965, were more aggressive than climax grasses on fertilized plots and less aggressive than climax grasses on unfertilized plots.

In general, grasses which responded most vigorously to fertilizer treatments were the annuals and weedy perennials which increased most under conditions of soil disturbance and excess moisture. Rapid growth during the period of readily available soil moisture allowed weedy grasses to utilize more of the fertilizer nutrients than were utilized by the later maturing, climax grasses.

Percent Crude Protein.—Percent crude protein was significantly ($P<0.01$) greater in grass samples from all fertilized plots than in samples from check plots (Table 4). Percent crude protein was greater in grass samples

Table 3. Percentage composition of herbaceous vegetation on fertilizer plots on Welder Wildlife Refuge.

	1964					1965				
Species	C	100N	300N	100NP	100P	C	100N	300N	100NP	100P
FORBS	37.7	32.5	30.5	33.7	36.7	35.2	39.0	34.0	42.0	37.5
GRASSES										
Andropogon saccharoides	1.6	T	T	T	T	2.8	4.1	4.6	4.0	2.9
Aristida roemeriana	1.0	T	T	T	T	1.3	1.8	1.4	T	2.5
Buchloe dactyloides	3.8	7.4	5.3	4.2	4.1	11.1	8.8	8.1	9.3	7.2
Chloris spp.	3.2	1.0	2.3	2.3	2.6	1.1	1.2	2.2	1.5	1.6
Cynodon dactylon	T	T	T	3.6	1.8	1.6	1.7	T	1.1	T
Eragrostis lugens	1.0	T	T	T	1.4	3.6	3.6	1.8	3.4	6.6
Eriochloa contracta	5.7	3.2	5.4	13.2	8.2	T	T	T	T	T
Hilaria belangeri	T	1.0	1.0	T	T	T	1.8	T	T	2.2
Leptochloa nealleyi	1.4	7.8	5.0	1.5	1.4	3.1	5.7	6.5	2.2	2.2
Panicum filipes	7.1	5.9	7.2	6.7	7.1	4.1	4.9	3.3	6.6	5.1
Panicum obtusum	3.0	2.4	2.0	2.5	1.0	3.4	2.9	3.0	2.8	4.2
Panicum reptans	T	T	T	1.4	1.6	—	—	—	—	—
Paspalum pubiflorum	T	1.2	1.6	1.0	2.1	2.5	1.7	1.4	1.1	T
Setaria geniculata	8.6	11.0	10.6	8.1	8.8	2.6	1.3	2.3	2.1	2.9
Setaria leucopila	19.1	16.1	16.5	16.6	14.0	17.3	15.6	19.2	13.3	15.0
Sporobolus asper	—	—	—	—	—	T	1.3	3.3	1.2	1.3
Sporobolus pyramidatus	1.8	2.0	4.0	3.1	3.3	T	1.1	T	T	T
Stipa leucotricha	2.5	2.2	2.7	2.0	2.5	3.6	5.3	3.6	4.9	4.1
Tridens albescens	T	T	1.6	T	T	T	T	2.3	T	1.0
Tridens congestus	T	1.3	T	—	T	T	T	—	T	—

C—No fertilizer; 100N—100 lb nitrogen/acre; 300N—300 lb nitrogen/acre; 100NP—100 lb nitrogen plus 100 lb P_2O_5/acre; 100P—100 lb P_2O_5/acre; — Not present; T—Less than 1.0%.

from plots fertilized with nitrogen than in samples from plots fertilized with phosphorus or with nitrogen and phosphorus together.

Percent crude protein in grass from roller chopped and scalped plots was lower than in grass from shredded, root-plowed, and root-plowed and raked plots (Table 4). Most of the difference in protein in grass from brush-control plots may be attributed to a difference in species composition on different plots. Per cent crude protein in each species was not determined, but it may be assumed that percent protein was not equal in all grasses on the study area. Apparently, the species which made up the bulk of the grass on roller-chopped and scalped areas were not as high in crude protein as the species on shredded, root-plowed, and root-plowed and raked areas.

That all grasses did not respond to different fertilizer treatments in the same manner or to the same degree is also shown by a significant ($P<0.01$) interaction between brush control and fertilizer treatments. Percent crude protein was generally highest in grass samples from 300 lb N/acre plots and lowest in grass samples from check plots. However, this was not consistent on each brush-control plot, and protein in grass samples from any one brush-control plot did not rank consistently high or low for all fertilizer treatments.

Percent crude protein in Texas wintergrass was significantly ($P<0.01$) lower on phosphorus plots and higher on 300 lb N/acre plots than on other fertilizer plots (Table 5). Protein in grass from 100 lb N/acre and 100 lb N plus 100 lb P_2O_5/acre plots was only slightly higher than that in grass from check plots. The higher protein in Texas wintergrass on 300 lb N/acre plots indicates a nitrogen carry-over from 1964 to 1965.

Table 4. Average percent crude protein in composite grass samples from fertilizer and brush control plots in August, 1964.

Brush Control Treatments	Fertilizer Treatments C	100N	300N	100NP	100P	Avg.[1]
Shredder	9.10	11.09	11.36	10.27	10.20	10.41[a]
Roller Chop	7.29	9.33	9.20	8.00	7.87	8.33[b]
KG Blade	9.22	9.67	9.92	9.94	8.55	9.46[b]
Root Plow	8.99	10.55	11.74	10.03	9.39	10.13[a]
Root Plow & Rake	9.83	10.54	10.34	9.09	10.56	10.07[a]
Average	8.88[a]	10.24[b]	10.51[b]	9.46[c]	9.31[c]	

[1] Those averages followed by the same letter are not significantly different; those followed by a different letter are significantly different.

Table 5. Average percent crude protein and percent phosphorus in Texas wintergrass from fertilizer plots in April, 1965.[1]

Percent	C	100N	300N	100NP	100P
Crude Protein	10.88[a]	10.91[a]	14.12[b]	11.25[a]	9.69[c]
Phosphorus	0.20[a]	0.20[a]	0.20[a]	0.34[b]	0.36[c]

[1] Those averages followed by the same letter are not significantly different; those followed by a different letter are significantly different.

A significantly higher percent phosphorus in Texas wintergrass from phosphorus plots indicates a phosphorus carry-over also. Phosphorus was 70.0% and 80.0% higher in grass from 100 lb N plus 100 lb P_2O_5/acre and 100 lb P_2O_5/acre plots, respectively, than in grass from plots not fertilized with phosphorus (Table 5).

Mowing Treatments

Mowing-Brush Control Treatments. — The 1964 data reflect first-year response to mowing treatments. All 1965 data pertaining to mowing treatments were collected 14 months after plots were mowed, and reflect the conditions the second year after mowing.

Mowing significantly decreased grass production ($P<0.01$), forb production ($P<0.05$), and brush production ($P<0.01$) in 1964. Averaged over all unfertilized, brush-control treatments, mowing decreased grass production 11.8%, forb production 21.5%, and brush production 64.7%.

Mowing did not decrease production by the same percentage on all brush control plots ($P<0.01$ interaction). In 1964 mowing significantly ($P<0.05$) increased grass production on plots with high percentages of desirable perennials and decreased grass production on disturbed plots with high percentages of undesirable forbs and weedy grasses. Perennial grasses, particularly buffalograss, appeared to withstand mowing better than annual and weedy, perennial grasses did. However, any comparison which might be made about the relative resistance of climax and weedy grasses to mowing was somewhat obscured by abnormally high summer rainfall after mowing. Many weedy grass plants, not present at the time of mowing, germinated and grew rapidly after the heavy rainfall of July 19, 1964.

In August, 1965, grass production averaged 16.8% greater on mowed plots than on unmowed plots, while forb and brush production averaged 22.0% and 53.8% lower, respectively, on mowed plots. The fact that grass production was greater on mowed plots one year after mowing indicates that grass production might have been greater on mowed plots in 1964 if there had been a longer growing period between mowing and sampling dates.

Between 1964 and 1965, grass increased on all mowed plots, but decreased on the unmowed, disturbed plots. The decrease in grass on the unmowed, disturbed plots was due to the sharp reduction in the production of drought-intolerant annual and weedy grasses during the dry 1965 summer. Mowing increased the percentage of perennial grasses, and grass production increased on mowed, disturbed plots between 1964 and 1965.

Mowing reduced brush cover on all plots from a low of 55.6% on scalped plots to a high of 90.0% on root plowed plots. Huisache was relatively abundant on scalped areas and resprouted rapidly after mowing. Cacti were abundant on root-plowed areas and were severely reduced by mowing. Cacti made up 94.0% of the brush on root-plowed areas and 64.0% on root-plowed and raked areas. Mowing decreased cacti 86.0% on root-plowed areas and almost 100% on root-plowed and raked areas.

Mower blades shredded cactus plants, and very few of the shredded pads formed new plants. Cactus pads, whether shredded or not, formed fewer new plants on grass-covered ground than on bare ground. Mowing appears to be an efficient and relatively inexpensive method of reducing cacti.

Mowing-Fertilizer Treatments. In 1964, grass and total herbage production were lower on all mowed, fertilizer plots than on unmowed, fertilizer plots. This may not be meaningful because of the short growing period between mowing and sampling dates. In 1965, after an equal growing period for both mowed and unmowed areas, grass production was greater on all mowed, fertilizer plots than on unmowed, fertilizer plots.

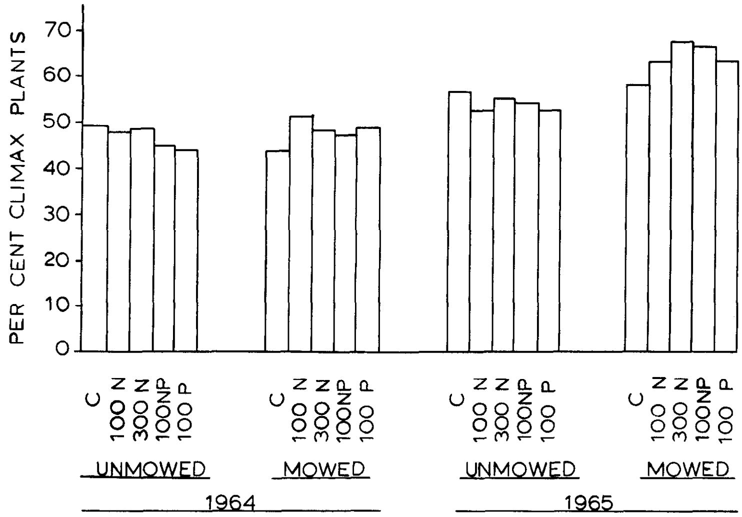

FIG. 5. Per cent of climax grasses on fertilized and mowed plots on the Welder Wildlife Refuge 1964, 1965.

Grass generally responded to fertilizer treatments in the same manner on mowed plots as on unmowed plots. Grass production was greater on mowed and unmowed, nitrogen plots than on mowed and unmowed, phosphorus and check plots. Mowing reduced differences in grass response to fertilizer treatments and masked differences in fertilizer uptake by different grass species. In general, weedy grasses responded readily to phosphorus and heavy rates of nitrogen on unmowed plots, but not on mowed plots.

In 1964 mowing and fertilizer treatments caused a greater reduction in grass on mowed, 300 lb N/acre plots than on other mowed, fertilizer plots ($P<0.05$ interaction). The difference in percent reduction was largely due to a differential response of invader and climax grasses to fertilizer and mowing treatments. The relatively large increase of invader grasses due to the 300 lb N/acre treatment was nullified because mowing reduced invader grasses more than climax grasses. The relative abundance of invader grasses was lower on unmowed check plots than on unmowed fertilized plots and generally greater on mowed check plots than on mowed fertilized plots.

All treatments with fertilizer on unmowed areas decreased the percentage of climax grasses (Fig. 5). In 1964 and 1965 there were more climax grasses on unmowed unfertilizer plots than on unmowed fertilized plots. By increasing the relative abundance of invaders and weedy increasers, fertilizer caused the fertilized areas to be in a lower successional stage than were the unfertilized areas. However, mowing and fertilizer treatments together caused greater climax grass production on all mowed fertilized plots than on mowed unfertilized plots. Mowing reduced invader competition on both fertilized and unfertilized plots. Reduced invader competition allowed more of the fertilizer nutrients to be utilized by climax grasses, and both percentage of climax grasses and grass production increased appreciably on mowed fertilized plots by 1965.

Mowing reduced forb and brush production about the same amount on all fertilizer plots. Neither forb nor brush production was significantly affected by fertilizer treatments on either mowed or unmowed plots in 1964 or 1965.

The probability of improving range condition by mowing, without fertilizer, appears more likely than by using fertilizer, without mowing. Mowing and fertilizer together improved range condition much faster than either mowing or fertilizer alone. The combination of mowing and fertilizer is an excellent means of speeding up succession while increasing forage production.

Summary and Conclusions

Between June, 1963, and August, 1965, the effects of different brush control, fertilizer, and mowing treatments were studied on the Welder Wildlife Refuge in South Texas. Five mechanical brush-control treatments including shredding, roller chopping, scalping with a KG blade, root plowing, and root plowing with raking were applied in June, 1963. Five fertilizer treatments and two mowing treatments were applied one year later on the brush-control plots in a split-split-plot design. Fertilizer treatments included no fertilizer, 100 lb N/acre, 300 lb N/acre, 100 lb N/acre plus 100 lb P_2O_5/acre and 100 lb P_2O_5/acre. Mowing treatments included mowing and no mowing.

Brush cover was reduced more than 50% by all brush-control treatments. Root plowing and raking caused the greatest brush cover reduction. Top-removal treatments caused vigorous regrowth of brush sprouts. Root plowing more than doubled cacti ground cover.

Production of total herbage was higher on all brush-treated areas except mowed scalped areas than on untreated areas. Grass and forb production were greater on disturbed areas than on relatively undisturbed areas in 1964. High summer rainfall and soil disturbance caused an increase in forbs and weedy grasses and a decrease in climax grasses. Because of the abundance of weedy grasses and forbs, areas disturbed by scalping and plowing were in lower successional stages than the relatively undisturbed shredded, roller-chopped, and untreated areas.

Low summer rainfall in 1965 attributed to a large reduction in annual and weedy grasses. Total grass production decreased on all disturbed plots between 1964 and 1965 because of the high percentage of drought-intolerant weedy grasses on these plots in 1964. Forbs, particularly invaders, replaced much of the weedy grass production on disturbed areas. Grass increased on undisturbed areas where climax grasses were relatively abundant.

Grass production was increased by nitrogen fertilizer and decreased by phosphorus fertilizer. Forb and brush production were not significantly affected by fertilizer treatments. All fertilizer treatments increased the relative abundance of invader and weedy grasses. Fertilizer was more readily utilized by weedy grasses than by climax grasses on unmowed areas.

All fertilizer treatments increased per cent crude protein in composite grass samples. The greatest increase occurred in grass fertilized with the heaviest rate of nitrogen. Percent crude protein in grass from different brush control plots was also significantly different. Much of the difference in protein in grass was due to differences in species composition on different brush control and fertilizer plots as well as the effect of different fertilizer treatments on a particular species.

Percent crude protein in Texas wintergrass was increased by heavy rates of nitrogen and decreased by phosphorus. Percent phosphorus was increased by phosphate fertilizer whether applied as straight phosphate or together with nitrogen fertilizer.

Mowing increased grass production and decreased forb and brush production. Mowing decreased invader grasses and improved range condition on all mowed brush-control plots. Cactus density and ground cover were effectively reduced by mowing. Fertilizer and mowing together improved range condition and increased grass production faster than either mowing or fertilizer alone.

Complete eradication of brush on South Texas rangeland appears to be impossible. Brush control may best be thought of as a maintenance problem similar to fence repair. A systematic, brush maintenance or "brush management" program appears more likely to succeed in continually improving forage quality and increasing forage production than many of the "eradication" methods.

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Bud Activity in the Stem, Crown, and Rhizome Tissue of Switchgrass[1]

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Highlight

Bud activity appears to be cyclic in nature in the switchgrass plant. Certain vegetative buds are dormant while others are active during the growing season. This study suggests that switchgrass should be grazed prior to floral initiation so that maximum forage production can be obtained from activated stem buds.

Switchgrass, *Panicum virgatum* (L.), is a perennial, native, warm-season grass of North America. The warm-season growth habit of switchgrass is advantageous for use in pasture rotation systems. It can be grazed during the hot summer months when most cool-season grasses are dormant or semi-dormant. However, early and medium maturing switchgrass decreases rapidly in nutritive value and palatability with maturation. On the other hand, when switchgrass is grazed so that the growing point is removed before emergence from the boot, regrowth may be initiated from the uppermost 2 or 3 axillary buds. Vegetative regrowth in mid-summer provides palatable forage for cattle, and they continue to gain satisfactorily. Heavy grazing too early in the summer may severely weaken the switchgrass plant and induce the invasion of weedy species.

Axillary buds located on the rhizomes, crown, and stem portions of the plant are important meristematic areas for vegetative reproduction in switchgrass. The initiation and development of these buds determine not only thickness of stand, but also the revegetative potential of the grass under grazing conditions. Preliminary investigations at Lincoln, Nebraska have shown that these buds display a seasonal variation in activity. Although several other perennial grasses also display dormancy during the growing season, little work has been done to characterize the nature of this dormancy.

The purpose of this study was to determine the seasonal activity of buds located on the rhizome, crown, and stem portions of the switchgrass plant.

Literature Review

In a review by Samish (1954) the term "dormancy" is defined as the temporary suspension of visible growth; which he further breaks down into two main types, "quiescence" and "rest." Quiescence is the type of dormancy exhibited by the plant when unfavorable external conditions such as high temperature or low water supply prevent growth. Rest is the type of dormancy referred to when external conditions are favorable, but growth is limited by unfavorable internal conditions.

Dormancy has been demonstrated primarily in buds and seeds of horticultural crops. Coville (1920) found that dormancy commonly occurred among trees and shrubs of cold climatic regions.

Evans and Ely (1935) studied the rhizomes of several species of grasses and found that both below and above-ground shoots develop, to a limited extent, at all times when weather conditions were favorable for growth. Laude (1953) reported that a number of perennial grasses in California become dormant during the summer even though supplied with adequate water. He associated summer dormancy with high temperature and a long photoperiod.

In a study of quackgrass rhizomes (*Agropyron repens* (L.) Beauv.), Johnson (1962) found a rest period in April and May which he described as "late-spring dormancy" rather than the more common "summer dormancy." This conclusion was reached because prevailing weather conditions before and during the period were relatively cool and moist and favorable for quackgrass growth.

The apical bud of nutgrass (*Cyperus rotundus* (L.)) has been reported to prevent growth of other buds on the same tubers (Loustalot et al., 1954). This phenomenon is commonly referred to as apical dominance. Another

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example of apical dominance is that found in the potato tuber. When the intact potato tuber becomes active after a rest period, one or more apical buds elongate, but the lateral buds usually fail to grow. If, however, lateral buds and apical buds are cut out and grown separately, both start growing at the same time (Michener, 1942).

It is believed that the dormancy of buds in woody plants, tubers, and herbaceous perennials have similar fundamental processes (Samish, 1954). Therefore, since there are few basic differences between the buds of an underground stem and the buds of its above-ground counterpart, findings of any of these various forms may well be related to the others.

Materials and Methods

The experimental area (3200 ft^2) was located on the Agronomy farm at Lincoln, Nebraska. Nebraska-28 switchgrass was seeded in April, 1959. A uniform stand was ready for sampling in the spring of 1962. The soil was a well-drained Sharpsburg silty clay loam which was fertilized annually with 55 lb/acre of elemental N as NH_4NO_3. The pH of the soil was 6.0. Seventy-one lb/acre of elemental P were applied as 42% concentrated superphosphate on February 20, 1962.

Axillary bud activity of rhizome, crown, and stem was determined by using an *in vitro* method similar to that described by Johnson (1961). Plant tissue was obtained bi-weekly by digging up 2 to 3 ft^2 of sod to a depth of three to four inches (Tables 1 and 2). Plants obtained from the field were washed free of soil with cold tap water. The plants were kept moist during the trip to the laboratory by first wrapping them in a moistened burlap sack, and then placing the entire bundle in a plastic bag. In the laboratory, the plant material was placed in a refrigerator at 5 C and removed as needed during processing. Plant material was again washed with tap water, and adventitious roots and scale leaves on the rhizomes were removed. The rhizomes were cut into 20 mm sections, each having several nodes with at least one noticeable bud and a root. The root was cut free of the rhizome during the sectioning process. A preliminary experiment indicated that rhizome bud activity was variable, but that sections with an attached root(s) consistently had the highest bud activity.

Lower stem buds and basal crown

Table 1. Elongation and dry weight of rhizome, crown, and stem buds of switchgrass grown in the dark at 28 C for 14 days during 1962.[1]

Sampling dates 1962	Rhizome Length[2] cm	Rhizome Dry Weight mg	Crown buds Length[2] cm	Crown buds Dry Weight mg	Stem buds Length[2] cm	Stem buds Dry Weight mg
3-10	5.32	—	9.94	—	0.55	—
3-22	3.66	—	11.14	—	0.13	—
4-5	5.25	98	11.69	325	0.74	31
4-19	5.39	95	12.26	310	0.42	5
5-3	4.39	64	7.34	115	0.60	13
5-17	2.65	28	0	0	2.32	100
5-31	3.30	45	1.07	6	2.18	35
6-14	0.61	7	3.78	32	2.16	21
6-28	2.07	32	5.30	75	2.93	31
7-12	2.68	48	6.72	101	2.90	44
7-26	4.13	66	7.69	157	4.29	95
8-9	1.72	34	10.60	304	1.84	40
8-23	0.32	6	9.87	240	1.63	38
9-6	1.99	34	9.34	342	0.50	12
9-20	1.81	38	6.85	244	0.23	5
10-4	3.30	64	7.16	243	0.75	23
10-18	3.87	70	6.46	170	0.76	16
11-15	1.98	37	5.17	214	0.28	9

1 Implanted in agar and each bud value based on 25 sections for each sampling date.

2 An average of the longest elongated bud of several which occurred on each rhizome or stem-crown section.

Table 2. Elongation and dry weight of rhizome, crown, and stem buds of switchgrass grown in the dark at 28 C for 14 days during 1963.[1]

Sampling dates 1963	Rhizome buds Length[2] cm	Rhizome buds Dry Weight mg	Crown buds Length[2] cm	Crown buds Dry Weight mg	Stem buds Length[2] cm	Stem buds Dry Weight mg
3-12	4.67	96	10.72	312	1.62	24
3-26	5.42	87	10.17	214	1.96	28
4-9	4.82	93	8.53	190	1.63	30
4-23	4.26	63	0	0	1.78	37
5-7	2.42	34	0	0	1.19	30
5-21	1.61	16	0	0	2.47	57
6-4	2.09	27	1.84	15	0.30	10
6-18	1.48	24	7.96	122	0.42	3
7-2	1.56	31	6.39	99	3.53	48
7-16	1.30	20	9.41	220	5.76	152
7-30	1.85	29	10.54	247	2.58	57
8-13	0.89	20	9.45	258	3.82	83
8-27	0.82	13	8.65	273	4.00	84
9-10	0.83	16	11.18	449	2.06	65
9-24	2.49	51	5.04	241	0	0

1 Implanted in agar and each bud value based on 25 sections for each sampling date.

2 An average of the longest elongated bud which occurred on each rhizome or stem-crown section.

buds are commonly located within 1.5 inches of each other on the average switchgrass plant (Fig. 1). Therefore, sections 1.5 inches in length were also sectioned for studying bud activity of the lower stem bases and basal crown buds. Stem and crown bud material consists of the lower 1.5 inches of the culm. Stem buds are referred to as the aerial section and crown buds as the basal portion of the 1.5 inch sections. Bud activity of the lower stem bases and basal crown buds were studied separately on the same section.

The rhizome and stem-crown sections were kept moist before implanting in agar by placing them on moistened blotters in plastic trays. Twenty-five sections of both the rhizome and stem-crown sections were selected at random each sampling date for determining bud activity. Erlenmeyer flasks with a 125 ml capacity served as culture vessels. Each flask contained 50 ml of a solidified 0.8% agar medium. Five sections were implanted per flask resulting in five replications for each type of plant material. The agar had been previously adjusted to a pH of 5.0 with 0.1 NH_2SO_4. Prior to implanting, the plugged flasks (Fig. 2 and 3) containing the medium were autoclaved for 30 min. at 15 psi. The rhizome and stem-crown sections were rinsed several times with distilled water, but no further attempts were made to sterilize them. Flaming of each flask at the time of implanting aided in reducing mold contamination. The flasks containing the plant material were then transferred to a 28 C dark room for 14 days.

Upon completion of the 14 day growth period, the implanted rhizome and stem-crown sections were removed from the flasks. Rhizome or stem-crown sections having noticeable new growth were counted as having active buds. Bud activity was expressed as a percentage based on the number of active sections from the 25 sections originally implanted. The longest elongated bud on each section was measured and was expressed as growth in centimeters. The total weight of all elongated buds was obtained after the excised buds had been dried in an oven at 70 C for 72 hours.

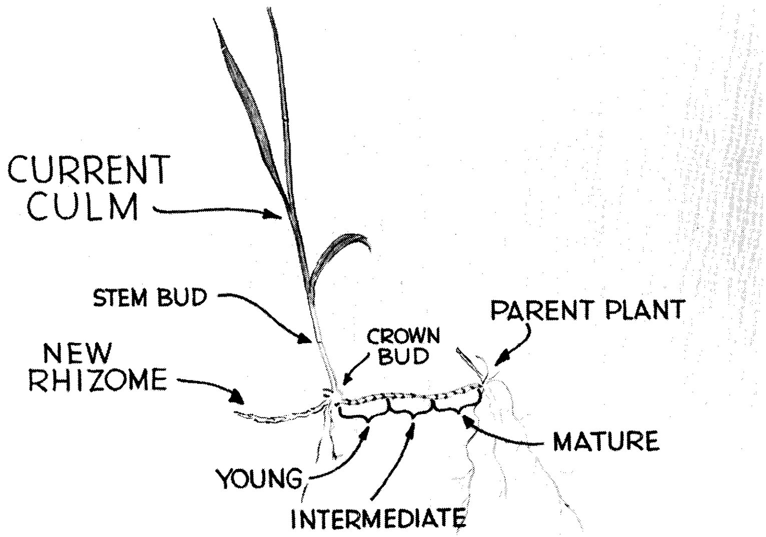

FIG. 1. A typical switchgrass plant showing the parent plant, its subsequent rhizome growth, the current culm, new rhizome growth, and crown and stem buds.

Results

The percentage bud activity, elongation, and dry weights of switchgrass rhizome, crown, and stem buds were studied by using tissue culture techniques during two years, 1962 and 1963.

The average percentage rhizome bud activity (2-year average) was highest in the spring and in the fall (Fig. 4). Rhizome bud activity generally decreased from mid-April to mid-June when the plants were in the early boot stage of growth. A general increase was noted in July as new rhizome growth was

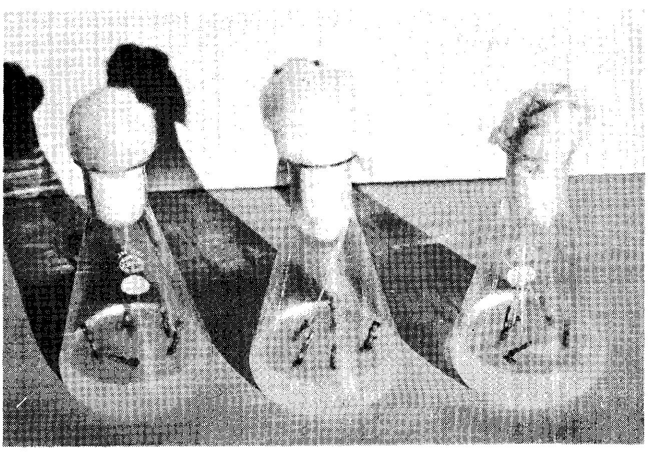

FIG. 2. Tissue cultures of 20 mm rhizome sections after 14 days of growth in the dark at 28 C.

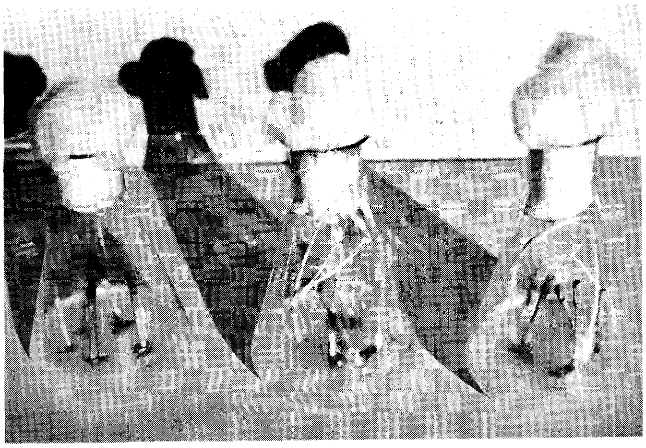

FIG. 3. Tissue cultures of stem-crown sections after 14 days of growth in the dark at 28 C.

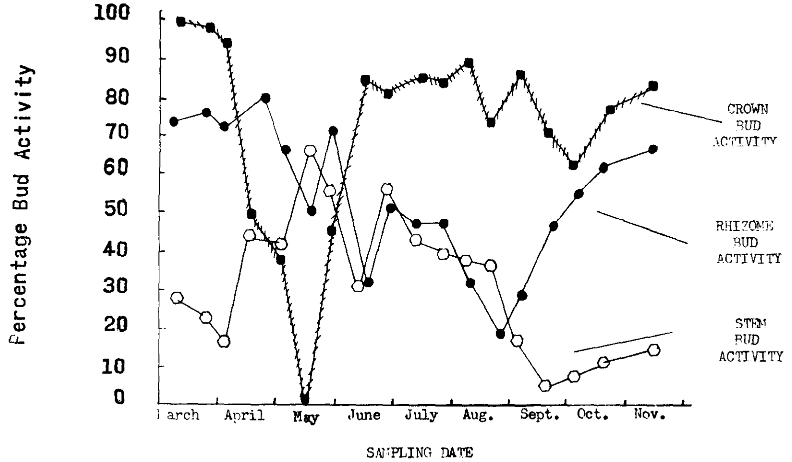

FIG. 4. The two-year average trend of axillary bud activity of rhizome, crown and stem buds of switchgrass.

also observed in the field. During August and early September a definite dormancy period was noted.

Crown and stem bud activity were inversely related to each other (Fig. 4). During March, crown bud activity was above 90% while stem bud activity was below 30%. However, in mid-May, crown bud activity was nonexistent whereas 66% of the stem buds were active. Crown bud activity averaged from 64% to 90% throughout the remainder of the sampling period while stem bud activity generally decreased from 58% during late June to 6% in mid-September.

Rhizome bud elongation measurements taken during 1962 (Table 1), indicated that maximum growth (3.66 to 5.39 cm) generally occurred during March, April, and early May. Minimum elongation (0.61 and 0.32 cm) was noted on June 14 and August 23, respectively. Maximum elongation (9.94 to 12.26 cm) of crown bud shoots was noted from March 10 to April 19. Minimal elongation (0 to 3.78 cm) occurred from May 17 to June 14. Medium elongation was generally noted the rest of the season. Stem bud elongation was greatest (1.63 to 4.29 cm) between May 17 and August 23. A minimum amount of stem bud elongation (<0.76 cm) occurred during the early spring and fall.

Dry matter determinations of elongated rhizome buds during 1962 (Table 1) indicated the most dry matter production (64 to 98 mg) occurred from April 5 to May 3, and on July 26, and during October. Minimum dry matter production (6 to 7 mg) was noted June 14 and August 23. Crown bud weight was the greatest (170 to 342 mg) during April and after August 9. Lower weights (0 to 157 mg) were noted during May, June and July. Dry weight from stem buds was high (35 to 100 mg) on May 17 and 31, and from July 12 to August 23. Lower weights were recorded during the spring and fall and in June.

Measurement of rhizome bud elongation during 1963 (Table 2) indicated maximum elongation (4.26 to 5.42 cm) occurred from March 12 to April 23, and that minimum elongation (0.82 to 0.89 cm) occurred from August 13 to September 10. Minimum elongation of crown buds (0 to 1.84 cm) occurred from April 23 to June 4 while longer measurements (5.04 to 11.18 cm) were recorded throughout the remainder of the sampling period. Maximum stem bud elongation (1.19 to 5.76 cm) occurred from March to late May and from July 2 to September 10. Minimum stem bud elongation (0 to 0.42 cm) was noted during June and on September 24.

Dry matter production from elongated rhizome, crown, and stem buds during 1963 is also presented in Table 2. Maximum weights from rhizome buds (51 to 96 mg) occurred from March 12 to April 23 and on September 24. Minimum weights (13 to 34 mg) were recorded the rest of the season. Minimum weights from crown buds (0 to 99 mg) were recorded from April 23 to June 4 and on July 2. Heavier weights (122 to 449 mg) were recorded throughout the remainder of the sampling period. Maximum dry weights from stem buds (48 to 152 mg) were recorded on May 21 and from July 2 to September 10. Minimum weights (0 to 10 mg) were recorded during June and on September 24.

In general, field observations on each sampling date during both years indicated that terminal rhizome buds were actively producing aerial shoots during late April and early May, and that elongation of new rhizomes occurred during midsummer from July to mid-August. Crown buds appeared to be active only during two periods. The first was in late April when a majority of the crown buds produced tillers, and the second period was in late June when crown buds initiated new rhizome growth. Stem buds appeared inactive throughout the entire sampling period.

Discussion

Bud activity appears to be cyclic in nature in the switchgrass plant. In general, activity appears to move upward (late April and early May) from the rhizome and basal crown areas into the stem until floral initiation in late June, then from the stem back down into the basal crown area, and finally into the rhizome late in the growing season.

Rhizome and crown buds possessed the highest potential for new shoot initiation during early spring in *in vitro* studies. And in field observations, in late April and early May, apical buds of rhizomes and basal crown buds became active and initiated aerial shoots. High activity (*in vitro*) was found in the axillary stem buds of these aerial shoots until seed heads began emerging from the boot in late June. At the same time, (*in vitro*) crown buds were largely absent and rhizome buds were semi-dormant. As the seed heads emerged in late June in the field, newly developed crown buds became active, and initiated new rhizome growth. The new rhizomes elongated and stem bud activity (*in vitro*) decreased until mid-August when rhizomes became dormant. During late September, high bud activity (*in vitro*) was once again evident primarily in the rhizome and crown buds with little activity found in stem buds.

Results of the field observations and the *in vitro* bud activity study failed to coincide during several periods of the growing season. For instance, new rhizome growth in the field was initiated largely from crown buds, and these rhizomes grew actively throughout July and early August. Rhizome elongation was not noted at other times during the growing season. However, *in vitro* studies indicated that rhizome buds were most active during early spring and fall. *In vitro* studies did substantiate field observations in that the least activity was noted during late August and early September.

Stem base and crown tissue cultures indicated that crown buds possessed high activity throughout the sampling period, except during the late spring period after the aerial shoots had emerged. However, field observations indicated that crown buds were largely inactive during the sampling period, except for two instances. The first was in late spring when a majority of the crown buds elongated and formed new tillers. The second period of activity in the field was noted when new rhizome growth was initiated from crown buds during late June.

The lack of continuity between field observations and tissue culture studies of bud activity serves to point out differences in types of dormancy. It is obvious that tissue cultures may have removed apical dominance thus promoting aerial shoots (Michener, 1942). The vertical implantation of normally horizontal rhizome material *in vitro* may have also resulted in promotion of aerial shoots (Palmer, 1954). However, high rhizome and crown bud activity noted in tissue cultures during the spring and fall from buds which were previously inactive in the fields suggested that "quiescence" may have resulted from an unfavorable external condition such as low temperature. When soil temperatures were favorable for growth during late spring and midsummer, apical dominance may have been present, causing buds to remain inactive in the field. Induced crown and stem bud activity may also be attributed to apical dominance. Since little rhizome bud activity was noted in both the field and in tissue cultures during late August and early September an internal factor alone may be suggested as the reason for dormancy during this time. This type of bud dormancy could be the true "rest" referred to by Samish (1954).

Dry matter determinations from shoots produced by rhizome buds prior to forage initiation in late April supports the supposition of Weaver (1963) that high carbohydrate reserves are available for new shoot growth in early spring. However, during late summer when carbohydrate reserves seemingly should be high, they appear to be unavailable in that dry matter production was reduced as well as bud activity. This suggests that respiratory enzymes may be inhibited by certain mechanisms and causes food reserves to become unavailable and consequently dormancy occurs.

Theoretically it appears that the grazing of switchgrass should begin in late May and early June prior to floral initiation in late June. Since maximum stem bud activity exists at this time, production of new palatable lateral shoots from the axillary buds on the stems should produce more forage over a longer period of time. Additional fertilizer coupled with adequate rainfall or supplemental irrigation during this period of regrowth should prevent the switchgrass plants from becoming severely weakened. Further management studies should be designed to test the findings from this study.

Summary

The percentage bud activity, shoot elongation, and dry shoot weights of switchgrass rhizome, crown, and stem buds were studied using tissue culture techniques during 1962 and 1963.

Bud activity appears to be cyclic in nature in the switchgrass plant. During early spring, rhizome and crown buds are active while axillary stem buds are inactive. During late spring, stem buds become active and the rhizome and crown buds are less active. Subsequent to flowering, rhizome and crown buds are reactivated and the stem buds once more become inactive.

Several types of dormancy were apparent in switchgrass rhizomes during the growing season. During early spring and late fall "quiescence" (due to external environmental conditions i.e., low temperatures) was apparent. During late spring, mid-summer, and early fall api-

cal dominance appeared to cause dormancy because buds which were inactive in the field initiated shoots under laboratory conditions when apical dominance was removed. A period of "rest" was observed in late summer in that buds were dormant both under laboratory conditions and in the field.

This study suggests that switchgrass should be grazed prior (late May and early June) to floral initiation (late June) so that maximum forage production from activated stem buds may be attained.

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Influences of Grazing and Fire on Vegetation and Soil of Longleaf Pine-Bluestem Range

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Highlight

Herbage yield and density of cover were greater on moderately or heavily grazed than on ungrazed range. Botanical composition remained relatively constant under moderate use but changed markedly on ungrazed and heavily grazed ranges. Grazing compacted soils, but insufficiently to impair herbage growth or accelerate erosion. Fire had little long-range effect.

A fire in late winter or early spring has been reported to improve accessibility, stimulate growth, and increase nutrient content of new herbage on longleaf pine-bluestem range (Campbell et al., 1954). Grasses are generally utilized heavily the first year after burning, but less intensely during the second.

Effects of grazing pressures and burning on forage vegetation and soils were assessed in a 12-year study on Louisiana range. Influences of experimental treatments on herbage yield and litter accumulation during the first 8 years were published in an earlier issue of the Journal (Duvall, 1962). This paper presents final results and reports changes in ground cover, botanical composition, and physical properties of soil as induced by grazing.

Procedure

The area of study, on the Palustris Experimental Forest in central Louisiana, slopes 2 to 5% and has deep, medium-textured soils chiefly of Bowie silt loam but with some Beauregard silt loam. Internal drainage is moderate to slow. Annual rainfall averages 58 inches; all months except October exceed 4 inches.

The longleaf pine (*Pinus palustris*) forest was cut more than 20 years before the study described here began in 1952, leaving relatively open grassland. Slender bluestem (*Andropogon tener*) and pinehill bluestem (*A. divergens*) were dominant grasses. Panicums (*Panicum* spp.), paspalums (*Paspalum* spp.), and miscellaneous bluestems were also prominent. Carpetgrass (*Axonopus affinis*) inhabited small, heavily grazed areas.

Before 1951, the range was open to unregulated grazing, and wildfires were frequent. Effects of prior burning and grazing were indeterminable.

For this study, eighteen ⅓-acre paddocks were constructed on a site that had been burned by wildfire a year previously. Intermittent grazing by cows and calves began in April 1952, and averaged 140 days a year. Through 1960, six paddocks were grazed heavily, six were grazed moderately, and six were ungrazed. Moderate grazing aimed at utilizing 40 to 50% of current herbage averaged 15 animal-unit days per paddock per year, while heavy grazing averaged 30 animal-unit days.

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[1] *We are indebted to Chung-Yun Hse, formerly Research Assistant, School of Forestry and Wildlife Management, Louisiana State University, for soil property determinations and statistical analyses of a portion of the study data.*

During 1955, six paddocks were burned by controlled backfire in January, six were burned by controlled headfire in March, and six remained unburned. The grazing-burning combinations were replicated twice in a split-plot factorial, making a total of nine combinations. In 1960 backfire was eliminated and only the headfire was repeated, since no important differences had been detected between the two burning methods following initial application. After 1960, grazing was discontinued on blocks that had originally been backfired. Herbage measurements were omitted on these blocks after 1959. Thus, during the final 4 years of study, burning-grazing combinations totaled six.

Herbage production and litter were measured at the end of each growing season by procedures described by Duvall (1962). Ground cover and species composition were determined in the fall in 1952, 1957, and 1963 by use of a modification of the line-loop frequency procedure described by Parker and Harris (1959). Four 66-ft transects were permanently located in each paddock. Cover components were recorded for each of 100 ¾-inch circular plots per transect.

In 1962 rate of water infiltration into soil was measured (Leithead, 1950), and soil samples were taken from 0- to 4-inch, 6- to 10-inch, and 12- to 16-inch depths on all paddocks. Laboratory determinations were made of specific gravity (Jenkins, 1947); texture (Patrick, 1958); bulk density; percolation rate (U.S. Salinity Laboratory Staff, 1954); and distribution of pore sizes (Hoover et al., 1954).

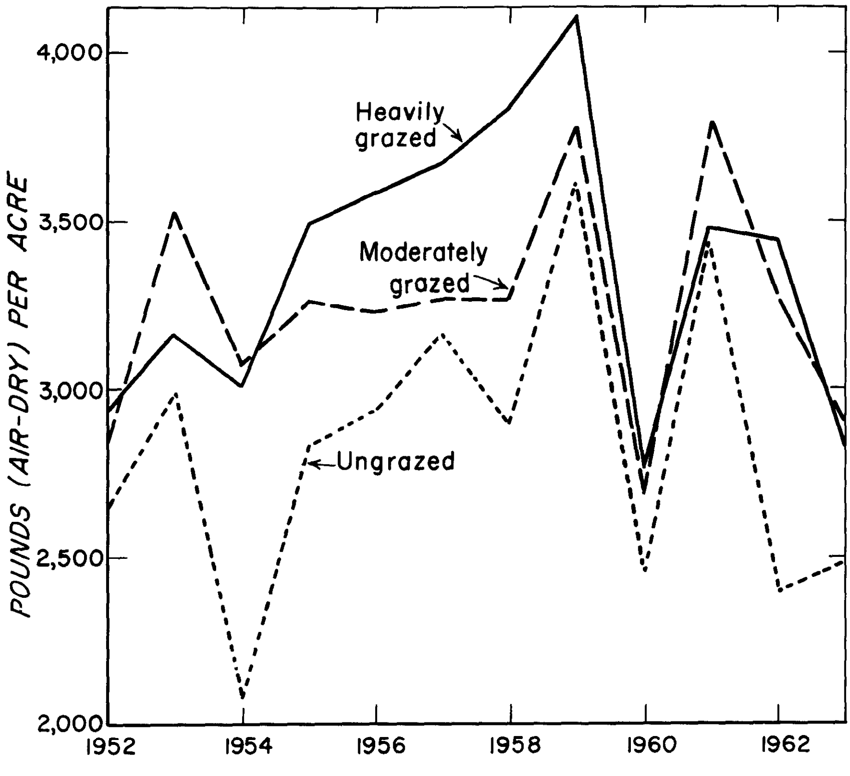

FIG. 1. Grass production, by grazing intensities.

Results and Discussion

Herbage Utilization. — In the 12-year test, herbage utilization averaged 67% on heavily grazed range and 46% on moderately grazed range. Thus, herbage removal under heavy grazing was only about 1.5 times greater than under moderate grazing, although twice as many animals grazed.

Herbage disappearance averaged 34 lb (air-dry) per animal-unit day under moderate, and 26 lb under heavy grazing. Undoubtedly, trampling and wastage was greater under heavy use, but the cattle in moderately grazed paddocks apparently consumed substantially more herbage than those in heavily grazed paddocks. In the heavily grazed paddocks, animals were evidently forced to utilize less palatable herbage and therefore ate less. Also, palatability loss by excreta was greatest on heavily grazed range.

Grass Production.—Grass comprised 97% or more of the herbage under all grazing intensities. The remainder consisted of forbs, except for a few grasslike plants and shrubs.

In the fall of 1952, grass yields were about the same on lands that had been grazed heavily, moderately, or not at all. Within 2 years, however, production on grazed range exceeded that on the ungrazed range by almost 1,000 lb/acre (Fig. 1). After the burn in 1955, the difference between grazed range diminished. For the 12-year period, grass averaged 3,239 lb/acre in moderately grazed paddocks and 3,351 lb in those heavily grazed. These values did not differ statistically, but they exceeded, at the 0.05 level, the 2,828-lb average on ungrazed range. Low yields for all grazing levels in 1954, 1960, and 1963 were attributable to less than average rainfall.

While yields on moderately and heavily grazed paddocks did not differ significantly during the entire study, they differed during the period 1955-59 (Duvall, 1962). Thus, intense grazing benefited production between the third and eighth years, but not thereafter.

Over the 12-year period, fire did not greatly influence grass production. Burning in 1955 significantly increased yields in ungrazed paddocks during the next three growing seasons, but grazed range was unaffected. The difference is attributed to reduction of litter: in an earlier study (Wahlenberg et al., 1939), both slender bluestem and pine-

Table 1. Indices of main cover classes (in percent), by grazing intensities.

Ground cover classes,	Ungrazed				Moderately grazed				Heavily grazed			
	1952	1957	1959	1963	1952	1957	1959	1963	1952	1957	1959	1963
Vegetation												
Grasses	44.1	34.5	20.7	27.1	43.7	44.2	33.2	36.5	49.2	48.7	47.1	48.0
Grasslike plants	1.6	2.1	.8	.6	1.8	1.9	1.0	1.0	1.6	2.7	1.1	1.0
Forbs	3.2	3.9	2.4	1.4	2.5	4.9	3.3	2.0	2.2	4.2	4.1	1.5
Woody plants	.2	.2	.1	.1	.1	.1	0	0	0	0	0	.1
Total	49.1	40.7	24.0	29.2	48.1	51.1	37.5	39.5	53.0	55.6	52.3	50.6
Nonliving												
Herb litter	19.7	56.5	48.2	54.1	21.8	42.9	24.3	26.6	19.8	38.3	12.7	8.4
Woody-plant litter	3.7	2.1	4.7	3.6	2.2	2.1	4.1	1.4	2.6	1.8	1.3	.8
Fecal matter	.5	0	0	0	.9	1.4	1.3	1.2	1.5	1.9	2.3	2.7
Total	23.9	58.6	52.9	57.7	24.9	46.4	29.7	29.2	23.9	42.0	16.3	11.9
Bare soil	27.0	.7	23.1	13.1	27.0	2.5	32.8	31.3	23.1	2.4	31.4	37.5

hill bluestem were smothered by heavy accumulation of plant debris. But in 1960, burning a large volume of litter did not aid grass production even though litter materially exceeded the 1955 level. During the growing season following fire, yield was more than 800 lb/acre greater in ungrazed paddocks that were not burned than in the burned, ungrazed paddocks. This contrary result is attributed in part to sparse rainfall during the ensuing spring—less than half the long-term average—and possibly in part to the high volume of fuel, which generated enough heat to impair the regrowth of the vegetation.

Litter.—After the 1955 fire, litter averaged about 4,400 lb/acre annually on ungrazed paddocks, 2,100 lb on the moderately grazed, and 1,200 lb on the heavily grazed. These differences were significant at the 0.05 level.

Although each fire destroyed about 1,500 lb/acre on heavily grazed range, 2,500 lb on the moderately grazed range, and 5,000 lb on the ungrazed range, accumulations were near preburning levels within 2 or 3 years. For the 12-year period, therefore, burning did not significantly alter quantity of litter. Ungrazed paddocks: unburned averaged 4,748 lb/acre annually and burned, 4,070 lb. Grazed paddocks: litter from unburned paddocks averaged only about 150 lb/acre greater than from burned paddocks.

Although yearly additions on unburned, ungrazed range averaged nearly 2,800 lb/acre, maximum accumulation — measured in 1956—was only about 5,650 lb/acre. The 12-year buildup totaled slightly more than 3,000 lb/acre, with all but 600 lb consisting of new litter. From this it can be seen that dead herbage deteriorated rapidly; after litter accumulations reached 5,000 to 6,000 lb/acre, decomposition equaled or exceeded additions.

Ground Cover.—After the first grazing season, ground cover indices of live vegetation were similar for all use levels (Table 1). They varied only from 48% on moderately grazed range to 53% on heavily grazed range.

During the ensuing 11 years, plant cover declined to 29% on ungrazed paddocks and 40% on the moderately grazed paddocks. Reduction in grass density largely accounted for these changes. Under heavy use, total plant cover and cover by grasses alone remained relatively constant throughout the trial.

Greater density of grasses on grazed paddocks probably accounted for the greater yield of these paddocks. Without grazing, litter and standing herbage apparently impaired establishment and growth of grass seedlings, thereby largely restricting production to older, widely spaced bunchgrasses.

Nonliving cover was mainly herb litter. Ground cover indices of both old herbage and woody plant litter were greatest on ungrazed paddocks, lowest on those heavily grazed. Cattle feces covered slightly more ground on heavily grazed than on moderately grazed range.

Vegetational cover was affected little by burning. Although each fire eliminated most of the nonliving material, these reductions were undetectable in the transect data because measurements preceded burning.

Botanical Composition.—Proportions of the major herb classes remained relatively constant, irrespective of grazing intensity (Table 2). Throughout the study, approximately 85 to 95% of the total vegetation consisted of grasses.

Although total grasses were little affected by grazing, several

Table 2. Botanical composition (in percent), by grazing intensities.

Herb classes	Ungrazed				Moderately grazed				Heavily grazed			
	1952	1957	1959	1963	1952	1957	1959	1963	1952	1957	1959	1963
Grasses												
Slender bluestem	38.9	29.0	16.8	14.7	44.5	32.5	30.2	23.5	41.1	35.8	23.3	28.2
Pinehill bluestem	22.4	29.7	38.3	54.1	23.5	17.6	17.6	31.1	22.8	12.4	8.6	10.0
Carpetgrass	.2	0	0	0	.4	.8	2.9	6.3	.6	4.5	14.5	38.5
Threeawns	1.2	4.7	7.1	1.0	2.1	18.3	19.7	1.5	1.7	17.8	15.5	2.4
Panicums	10.2	10.3	13.0	6.5	6.7	8.0	6.1	3.0	6.2	7.0	5.4	2.2
Cutover muhly	.6	1.0	2.1	5.1	0	.2	0	.2	0	0	0	0
Misc. bluestems	7.2	4.2	3.6	4.2	4.6	3.1	5.8	18.8	8.3	4.6	15.7	9.3
Other grasses	9.1	5.8	5.4	7.2	9.1	6.0	6.2	7.8	12.1	5.6	7.1	4.2
Total grasses	89.8	84.7	86.3	92.8	90.9	86.5	88.5	92.2	92.8	87.7	90.1	94.8
Grasslike plants	3.3	5.2	3.3	2.1	3.7	3.7	2.7	2.5	3.0	4.8	2.1	2.0
Forbs	6.5	9.6	10.0	4.8	5.2	9.6	8.8	5.0	4.2	7.5	7.8	3.0
Woody plants	.4	.5	.4	.3	.2	.2	0	.3	0	0	0	.2

important species showed marked responses. Slender bluestem, which comprised more of the vegetation than any other species in 1952, decreased under all grazing intensities. Reduction was greatest, however, on ungrazed paddocks. Reasons for these changes are uncertain, but vegetation present when the experiment began had been influenced by unrestricted, yearlong use and frequent burning.

Pinehill bluestem, which ranked second to slender bluestem when the study began, increased steadily on ungrazed paddocks, changed little under moderate use, and declined appreciably on heavily grazed range.

The only other species to show important reactions to grazing intensity was carpetgrass, which comprised only a trace of the vegetation in 1952. Although this species subsequently disappeared from ungrazed range, it increased on grazed range, particularly on that used heavily. Thus, after 11 years of utilization averaging 67%, the proportion of this stoloniferous sod-former equaled that of the two principal bunchgrasses combined. Production was greatest in paddocks having the highest proportion of carpetgrass, and consequently the greatest vegetation density.

Generally, threeawn grasses were more common in grazed than in ungrazed paddocks. Since proportions fluctuated widely from one transect inventory to the next, response of these grasses to grazing intensity was difficult to assess. Slimspike threeawn *(Aristida longespica)*, an annual, accounted for much of this variation. Proportions of arrowfeather threeawn *(A. purpurascens)*, the only perennial threeawn encountered, were little affected by grazing.

Frequency of miscellaneous panicums — mainly spreading panicum *(Panicum rhizomatum)* roundseed panicum *(P. sphaerocarpon)*, narrowleaf panicum *(P. angustifolium)*, and woolly panicum *(P. lanuginosum)*—was greater on ungrazed than on the moderately or heavily grazed range. However, differences owing to grazing intensity appeared small and relatively unimportant.

Except for cutover muhly *(Muhlenbergia expansa)*—a low-value perennial that increased on ungrazed range—no other grass comprised as much as 5% at either the beginning or end of the study. The principal tall grasses, big bluestem *(Andropogon gerardii)*, indiangrass *(Sorghastrum nutans)*, and switchgrass *(Panicum virgatum)* showed little response to protection from grazing. These species are often among the first to decrease under heavy use, and are therefore generally expected to increase after grazing ceases. On paddocks ungrazed for 12 years, however, they collectively comprised less than 2% of the vegetation.

Grasslike plants, largely pinehill beakrush *(Rhynchospora globularis* var. *recognita)*, were affected little, if any, by grazing.

The forb population remained reasonably stable throughout the experiment. The failure of forbs to increase under heavy grazing was somewhat surprising, because weedy species usually infest areas of concentrated use. Bitter sneezeweed *(Helenium amarum)*, woolly croton *(Croton capitatus)*, and dogfennel *(Eupatorium capillifolium)* are especially common on overgrazed areas. Since none of these was encountered on transects in heavily grazed paddocks, utilization exceeding 65 to 70% is apparently necessary for their establishment.

With the exception previously noted, changes in botanical composition generally proceeded in orderly fashion. Under moderate use, however, miscellaneous bluestems increased sharply between 1959 and 1963, owing mainly to a 20-fold upsurge in paintbrush bluestem *(Andropogon ternarius)*. In 1959, the proportion of fineleaf bluestem *(Andropogon subtenuis)* on heavily grazed range was about three times as great as in either 1957 or 1963, causing a substantial increase in miscellaneous bluestems. This discrepancy probably reflects errors on identification, as distinguishing between slender and fineleaf bluestems is extremely difficult when plants are closely cropped. Thus, in 1959, the true index for slender bluestem undoubtedly exceeded 23.3% while that for miscellaneous bluestem was probably considerably less than 15.7%.

Transect data collected in 1963 on paddocks that were released from grazing after 1960 revealed notable changes in botanical composition. In paddocks that had been grazed moderately, the proportion of pinehill bluestem was about twice the 1959 level. On range that had been grazed heavily, this species increased sixfold. In general, the changes paralleled those during nonuse beginning in 1952, but the rate of increase was much faster between 1959 and 1963.

On range grazed heavily for 9 years, carpetgrass diminished rapidly after use ceased. It comprised more than 15% of the vegetation in 1959, but only about 3% in 1963, suggesting that this low, spreading type cannot persist where it is overtopped by taller herbs. Proportions of other grasses changed little after grazing was discontinued.

Botanical composition was affected little by burning. When the study ended, the proportion of pinehill bluestem was greater in burned than in unburned paddocks, while unburned paddocks contained more carpetgrass than those burned. Similar relationships existed, however, when the plots were established.

Physical Properties of Soil.—None of the soil properties evaluated was significantly altered by burning. This section summarizes changes in soil as a result of grazing. Complete data may be seen in the Journal of Forestry (Linnartz et al., 1966).

Grazing increased soil bulk density significantly, at the 0.05 level, in all layers. Moderate use for 10 years increased bulk density 5% in the surface layer, 2% at the 6- to 10-inch depth, and 1% at the 12- to 16-inch depth. On heavily grazed range, bulk densities increased 7, 4, and 2%. Compaction consistently reached the 16-inch depth, but deeper sampling might have detected even greater penetration, for Rhoades et al. (1964) reported that grazing increased bulk density 3 ft below the surface in sandy soil.

On ungrazed range, total pore space was greater at all depths than on grazed range, but differences were significant in only the two upper layers. Grazing heavily decreased total pore space from 47.0 to 43.4% in surface soil and from 42.5 to 40.4% in the 6- to 10-inch layer. Under moderate use, pore volume decreased 2.4 percentage points in surface soil, but only 0.1 percentage point at the 6- to 10-inch depth.

Large pore volume differed significantly at all depths among areas grazed at different intensities. In the 0- to 4-inch and 12- to 16-inch layers, volumes were greatest in ungrazed and least in heavily grazed paddocks. At the 6- to 10-inch depth, however, large pore space was greatest under moderate use. Greater porosity could not result from grazing, leaving only the explanation that a chance variation in soil structure was the cause of it.

Surface soil had the greatest volume of small pores in heavily grazed and the least in moderately grazed paddocks; deeper layers were unaffected by grazing. The increase in small pores and the reduction in large pores under heavy use suggests that large pores were transformed into small ones. Trampling attending moderate use did not produce this effect.

Percolation through the surface layer was not significantly impaired by trampling, despite a substantial reduction in large pores under heavy use. Aggregation of surface soils, as evidenced by low bulk densities, was probably responsible. In the 6- to 10-inch layer, percolation was slower in heavily grazed than in ungrazed and moderately grazed paddocks. Thus, percolation rate and large pore volume were similarly related to grazing intensity.

On grazed range, compaction of the 12- to 16-inch layer materially restricted the movement of water through the profile. On ungrazed range, water percolated through this layer at 0.242 in/hr whereas percolation under moderate and heavy use averaged only 0.145 and 0.133 in/hr. From this it is clear that grazing could materially accelerate runoff during prolonged rains; with the surface foot saturated, runoff could be 40 to 45% greater in grazed than in the ungrazed paddocks.

Infiltration rates were lowest on heavily grazed and highest on the ungrazed range. During the first 30 min, for example, infiltration averaged 2.26 in/hr in ungrazed paddocks, and 1.39 in/hr under moderate and 1.03 in/hr under heavy grazing.

In the study area, storms yielding 1.4 to 1.6 inches of rain in 30 min average once annually (Hershfield, 1961). Ungrazed range can absorb most of the rainfall from such storms, unless pre-storm level of moisture in surface soil is high. On heavily grazed range, however, a substantial portion would be lost as runoff.

Although grazing slowed the movement of water into and through the soil profile, thereby increasing runoff, it did not appreciably accelerate loss of topsoil. No evidence of gullying or sheet erosion was observed in measuring transects. Moreover, soil texture did not vary significantly among the areas under different grazing pressures. If grazing had accelerated erosion, the proportion of sand in the surface layer should have been greater on grazed than on ungrazed range.

Conclusions

Grazed range consistently yielded more herbage than ungrazed range. During a substantial portion of the study period, production was greater under heavy than under moderate use. These findings are generally contrary to those reported from bluestem range areas receiving less rainfall (Ehrenreich, 1959; Riegel et al., 1963; Tomanek and Albertson, 1953).

Under heavy use, bunchgrasses diminished and carpetgrass increased sharply. This change, since it was accompanied by an increase in grass production, improved grazing capacity during the growing season. A high proportion of carpetgrass would be undesirable on range grazed during the entire year, however, because the high utilization needed to maintain it would leave little herbage for winter use.

Pinehill bluestem, considered the key management species on most sites, increased slowly on ungrazed range, and increases by big bluestem, indiangrass, and switchgrass were negligible. Therefore, protection from grazing would have little practical value for improving species composition on cutover longleaf pine-bluestem range, except possibly where overuse has been severe.

During the 12-year test grass production, litter, vegetational cover, and botanical composition were little affected by burning.

Grazing was generally detrimental to water infiltration and percolation. Both were reduced sufficiently to limit water intake during intense storms and curtail water movement through the profile during prolonged rains. Water losses were not serious enough to reduce herbage yields, even on heavily grazed range. Where soil is highly erodible or inherently low in rate of water movement, however, moderate grazing during the grazing season could seriously accelerate runoff and soil losses.

On forested ranges, utilization averaging 45 to 50% appears best. For the 12-year period of this study, it stimulated grass production as much as heavy use, and without great changes in composition of forage vegetation. Since soils in most longleaf pine-bluestem ranges are fairly permeable and stable, moderate grazing should be reasonably compatible with other land-use objectives. It not only impairs soil conditions less than heavier use, but leaves more herbage to protect the soil and provide a forage reserve for drought periods. Other factors also favor moderate use. Campbell (1957) reported that trampling and browsing damage to pine regeneration was light under moderate grazing but serious under heavy grazing. Soil compaction induced by heavy grazing, even though not detrimental to herbage production, might reduce survival and growth of pine seedlings.

On cutover forest lands utilized solely as range, beef production may be greater with heavy than with moderate grazing. For use averaging 65 to 70%, cattle per unit of area could number twice those for 45 to 50% use. But increased beef production would be at least partially offset by lower weight gain per animal, since forage consumption is less with heavy than with moderate use. Also, grazing the entire range heavily would probably prove impractical because reserve forage might be inadequate during drought. To minimize runoff and erosion hazards, intense grazing should be confined to gently sloping sites having highly stable soils.

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The Relationship of Tree Overstory and Herbaceous Understory Vegetation

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Highlight

For study of the effect of trees on understory vegetation a good mathematical equation is very helpful. This article presents an equation which fits overstory-understory data better than previously used equations.

Trees adversely affect the growth of herbaceous plants around them; clearings in a forest produce much more herbaceous material than do similar areas with a dense tree cover. Because of competition for light, water, and nutrients, and possible antagonistic chemical effects, this inverse relationship is entirely reasonable and has often been reported in the literature. A few examples are the ponderosa pine *(Pinus ponderosa)*[2] ranges of South Dakota (Pase, 1958), Oregon (McConnell and Smith, 1965), and Arizona (Reynolds, 1962; Pearson, 1964); southern pine ranges (Gaines et al., 1954; Halls and Schuster, 1965); hardwood areas in Missouri (Ehrenreich and Crosby, 1960); and chaparral and woodland ranges of Arizona (Pond, 1961; Arnold et al., 1964). Mathematical expressions of the relationship between trees and the herbaceous understory do not point out the basic causes of the relationship; nevertheless, they have many useful applications.

Several investigators have fitted regression lines to their data. The measurement of trees is taken as the independent variable (x) and the measurement of herbage as the dependent variable (y). The relationship between these variables is clearly curvilinear, and mathematical models published include $\log y = a + bx$, $y = a + b \log (x + 1)$, and $y = a + bx + cx^2$. The model $y = a + b \log (Kx + 1)$ has also been suggested (Batschelet, 1966). Other models could also be fitted; for example, $y = a + bx + cx^2 + dx^3$ gives a good fit in some cases.

All of these models were tried with three sets of Arizona data, and none were satisfactory. The simpler models generally gave a poor fit with the data, especially as x approached zero. The polynomial models were illogical, a fact which became very apparent as the computed lines were extended beyond the limits of the data.

Recently, Grosenbaugh (1965) included as one of several generalized growth functions a 5-parameter transition sigmoid growth curve given by

$$Y=H+A\left(1-e^{-B(X-G)}\right)^{M+1}$$

where X is the independent variable, Y is the estimated value of the dependent variable, and H and A are the upper and lower asymptotes, respectively. B provides the necessary curvature, M adjusts the inflection point, and G adjusts the value of X so that $X - G = O$ when $Y = H$.

For overstory-understory relationships, the X origin may be taken as zero so that $G = O$. Also the sigmoid shape $(M > O)$ may not be necessary, so that values of $M > -1$ were allowed, that is, $(M + 1) > 0$. For $0 < (M + 1) < 1$ the inflection point has a negative abscissa value, and the curves are concave upward in the first quadrant.

Three sets of data were used for computation. The collection of two of the sets was described by Pearson (1964). These data were collected in a ponderosa pine forest in northern Arizona. Basal area of trees was measured with a 10-factor prism using the plotless "Bitterlich" method (Grosenbaugh, 1952). Basal area ranged from 10 ft^2 through 200 ft^2/acre. Tree canopy cover was also measured at each point with a canopy mirror (Lemmon, 1956). In addition, 30 points were taken at random in a cleared area. At each point all herbaceous vegetation from a 9.6-ft^2 circular plot was clipped to ground level, ovendried at 104 C for 48

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[1] *Research reported here was conducted at the Station's project headquarters at Flagstaff, in cooperation with Northern Arizona University; central headquarters are maintained at Fort Collins in cooperation with Colorado State University.*

[2] *Nomenclature follows Kearney and Peebles (1960).*

hr, and weighed. About 36% of the weight of the herbaceous material was made up of Arizona fescue *(Festuca arizonica)* and 49% of mountain muhly *(Muhlenbergia montana)*. The remaining 15% included 4 species of grass, 1 sedge, and some 40 forbs.

The results of these clippings were first averaged for each basal area class, and expressed as total pounds of herbage per acre. The data were then regrouped by canopy classes, and the average herbage weights for each class were determined for the second set of data.

The third set of data was from Arnold et al. (1964). These data were collected at 14 locations in the pinyon-juniper (*Pinus edulis, Juniperus* spp.) type in northern and central Arizona. A total of 220 50-ft transects were measured. Tree cover was measured with the line intercept technique of Canfield (1941). Herbage samples were obtained by clipping a 4-inch strip along each transect. Important herbaceous species included blue grama (*Bouteloua gracilis*) and herbaceous portions of snakeweed (*Gutierrezia sarothrae.*) The results of these clippings were grouped by cover classes, and means of each canopy class were calculated.

A computer program[3] was designed to approximate values of B and M + 1 in the equation by iteration, and solve for H and A in the usual least squares procedure for regression equations. For the three sets of data, the best fit, with the equations, is shown in Fig. 1. The curve for pine basal area (Fig. 1A) was the only one that was sigmoid.

When X = O the maximum departure of Y from the actual plot values was 9 lb/acre, and the curve fit the data well along the rest of the lines. Since the curves do fit the data well, this model is suggested as a general model for overstory-understory relationships.

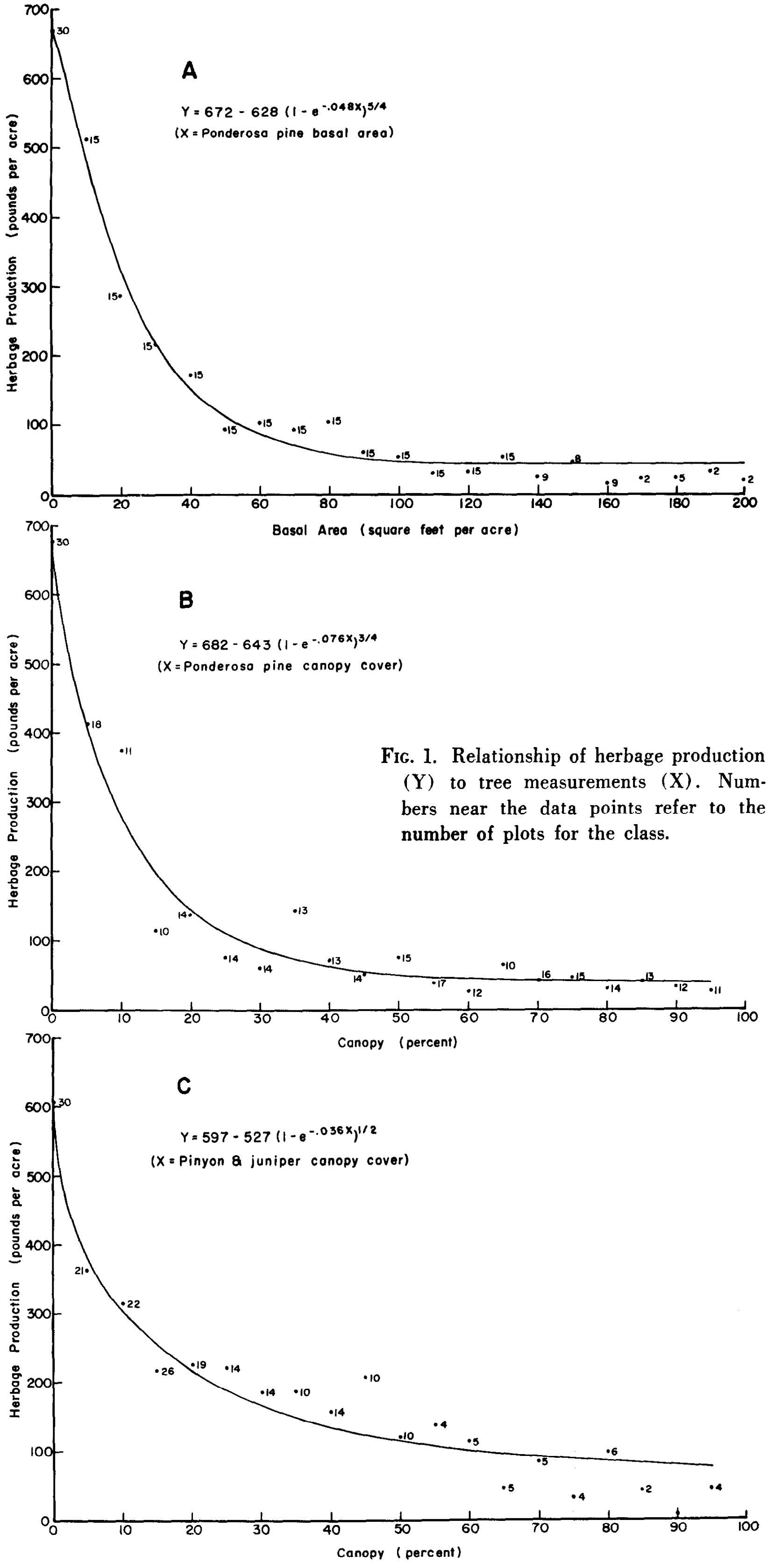

FIG. 1. Relationship of herbage production (Y) to tree measurements (X). Numbers near the data points refer to the number of plots for the class.

[3] *The computer program was written in FORTRAN II-D for the IBM 1620, 20 K storage. Copies of the program can be obtained from the author, although other available programs can also be used.*

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Effect of Grazing Intensity on Plant Composition, Vigor, and Production[1]

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Highlight

Two loamy prairie pastures were studied to determine the effect of different grazing intensities on botanical composition, herbage production, and plant vigor. Indications are that heavy grazing causes a decrease in range condition, an increase in undesirable grasses and forbs, and a decrease in vigor. Heavy grazing did not affect basal density.

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[1] *This study is based in part on a dissertation submitted to Oklahoma State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Financial assistance for this project was provided by Phillips Petroleum Company, Bartlesville, Oklahoma.*

The Osage rangeland of Oklahoma, an area of gently rolling hills, is world renowned for its grass-fattened cattle. The region lies at the southern end of one of the last large segments of true prairie in the United States. The northern portion of this segment is known as the Kansas Flint Hills (Anderson, 1953). The general regional climate is one of hot summers with wet springs and falls. The mean annual precipitation is 32.81 inches with about three-fourths during the growing season.

The principle range site, loamy prairie, is characterized by fertile, deep, upland clay loam soils (Gray and Galloway, 1959). These soils are nearly black, highly granular, and permit good root penetration. Low permeability and rolling topography with many steep, winding ravines make cultivation difficult, therefore, native grass is the most practical vegetation. Many acres of claypan soils of the Parsons silt loam type also occur throughout the area in patchwork fashion, and were described in an earlier publication (Hazell, 1965).

Four important grass species (hereafter referred to as the big four), big bluestem (*Andropogon gerardi* Vitman), little bluestem (*A. scoparius* Michx.), indiangrass (*Sorghastrum nutans* (L.) (Nash), and switchgrass (*Panicum virgatum* L.) are the principle dominants on the loamy prairie site.

Overstocking is a major problem of the region. The purpose of this study was to compare the effect of two different grazing intensities on botanical composition, forage production, and plant vigor.

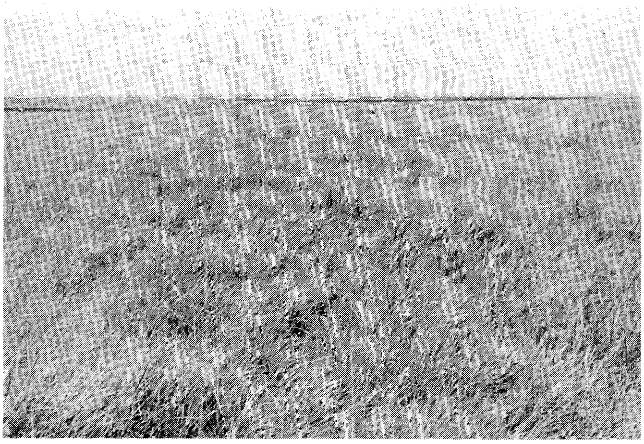

FIG. 1. General view of the moderately grazed pasture in excellent range condition June 1, 1962. Note vigorous growth of grasses and general absence of forbs.

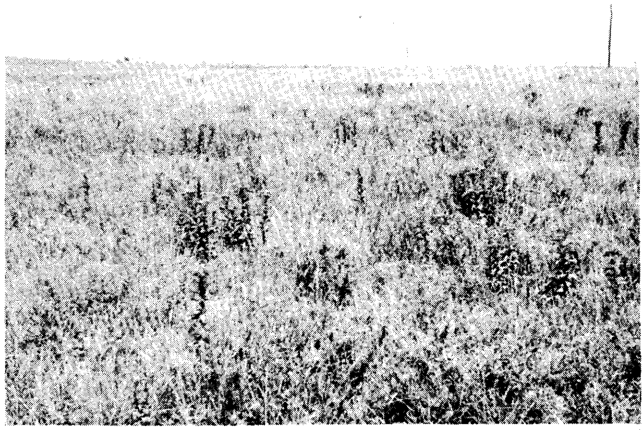

FIG. 2. General view of the heavily grazed pasture in poor range condition June 1, 1962. Forbs were abundant and density of desirable grasses was low.

Study Areas and Methods

Area 1 (Fig. 1), a loamy prairie pasture in excellent condition, was grazed only during calving periods (October 15 to December 1, and February 15 to May 1). Area 2, a loamy prairie pasture in poor range condition, was grazed heavily year round (Fig. 2). It affords an excellent comparison to Area 1 in that heavy grazing has caused marked differences in botanical composition, plant vigor, and herbage production.

The point intercept method (Levy and Madden, 1933) was used to determine basal cover and species composition of the grasses of each study area. Two hundred samples, 2,000 points, were taken along pace transects in each pasture. The abundance and species of forbs were determined by the square-foot method. One hundred square-foot samples were taken in each study area at regular intervals.

Herbaceous forage production was determined by clippings from twenty 11.5 x 24-inch quadrats. Each sample was then oven-dried and the weight recorded in grams. Pounds per acre were calculated by multiplying the average weights in grams by the factor 50.

Vigor of the important grass species was determined by measuring maximum height, average height, leaf length, leaf width, and number of leaves. To obtain length and width, the third leaf from the base of the culm was measured at the widest point on ten random plants. On forbs, ten randomly located leaves from ten plants were measured from petiole to tip.

Results

Sixteen grass species were recorded in the study areas (Table 1). The big four were predominant in Area 1, with little bluestem the most abundant. These four alone comprised an average of 92.5% of the total vegetation.

The big four were sparse in Area 2 (Table 1). Indiangrass, in particular, was widely scat-

Table 1. Percent grass composition on the two study areas for the summers of 1961 and 1962.

	Area 1		Area 2	
Species	1961	1962	1961	1962
Little bluesteam	69.1	74.1	4.7	6.1
Big bluestem	12.5	13.5	4.7	6.1
Indiangrass	7.3	4.8	—	—
Switchgrass	2.0	1.6	1.1	—
Buffalograss	3.0	1.6	25.0	21.6
Tall dropseed	1.1	0.4	21.0	23.4
Silver bluestem	0.4	—	11.5	12.9
Sideoats grama	2.0	1.6	3.9	4.0
Sand dropseed	—	0.4	14.1	8.3
Bouteloua curtipendula				
Scribner panicum	1.4	0.4	3.4	2.6
Panicum scribnerianum				
Blue grama	—	0.4	1.5	2.9
Bouteloua gracilis				
Purple Lovegrass	—	0.4	—	—
Eragrostis spectabilis				
Sand paspalum	0.4	0.4	—	2.0
Paspalum ciliatifolium				
Windmillgrass	0.8	—	5.8	6.1
Chloris verticillata				
Tumblegrass	—	—	3.5	0.9
Schedonnardus paniculatus				
Sedges	—	0.4	—	3.0
Carex spp.				

tered, and though it was present, it did not occur either year in the point quadrat samples. Sims and Dwyer (1965) in a study concerning retrogression on the loamy prairie site near Stillwater, Oklahoma, found that these decreasers declined from 93% in excellent condition pastures to zero in extremely poor condition pastures. The main grasses in Area 2 were buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.), tall dropseed (*Sporobolus asper* (Michx.) Kunth), sand dropseed (*S. cryptandrus* (Torr.) Gray), and silver bluestem (*Andropogen saccharoides* Sw.). These four species alone made up 69.0% of the total vegetation in Area 2.

There was no significant difference in basal density between the two areas. Area 1 had a density of 11.4% while Area 2 had a density of 10.4%. It seems that due to the abundance of the sod-forming short grasses that density would be higher in Area 2. According to Tomanek and Albertson (1953), basal cover increases as overgrazing occurs, when the increasing species are sod-formers. The plants in Area 2 were grazed to such an extreme that they were very low in vigor and this was not the case. The results indicate that grazing intensity affects range condition, but not necessarily basal density.

Although the same forbs occurred in both study areas, the composition and abundance were strikingly different (Table 2). Area 1 produced an average of 56,319 forbs/acre and Area 2 had 229,775. It appears in this study that grazing intensity affects both composition and production of forbs (Fig. 1 and 2).

Forage production in the two areas was somewhat comparable, with Area 1 producing an average of 3,767 lb/acre of dry forage and Area 2 an average of 3,172 lb. The big four contributed 1,730 lb/acre in Area 1 but only 439 lb in Area 2. This is shown in Table 3, with all differences being significant at the .01 level (Steel and Torrie 1960).

Buffalograss, tall dropseed, sand dropseed, silver bluestem, and forbs were the main forage producers in Area 2. These four grasses produced 989 lb and the forbs 1,973 lb; together they contributed 2,062 lb of the total of 3,172 lb. Forb production in Area 1 was only 46 lb/acre.

Forage production decreased from 1961 to 1962, possibly because rainfall in May, 1961, was 5.66 inches and in May, 1962, only 1.86 inches.

The grass species in Area 1 had a significantly greater maximum height, average height, and leaf length than the same species in Area 2 (Table 4). Leaf height seemed to be the most consistent indicator of plant vigor. These

Table 2. Average numbers per acre of the five principal forbs on the two areas for summers of 1961 and 1962.

Species	Area 1 (Moderate Grazing) 1961	Area 1 (Moderate Grazing) 1962	Area 2 (Heavy Grazing) 1961	Area 2 (Heavy Grazing) 1962
Western ragweed *Ambrosia psilostachya*	16,988	17,860	192,040	118,919
Heath aster *Aster ericoides*	13,504	15,682	43,068	61,150
False prairie boneset *Kuhnia eupatorioides*	11,246	9,614	28,019	38,352
Blue salvia *Salvia azurea*	5,227	4,356	17,424	12,632
Baldwin ironweed *Vernonia baldwinii*	4,712	2,614	24,848	22,197
Others	6,916	3,920	17,505	23,396
Total	58,593	54,046	322,904	276,646

Table 3. Differences in production of grasses on study areas 1 and 2. Figures represent production of Area 2 subtracted from Area 1 (lb/acre).

Species	1961	1962
Little bluestem	1759**	1666**
Big bluestem	1213**	479**
Indiangrass	304**	256**
Switchgrass	296**	111**

**Significant at .01 level

Table 4. Average differences in cm for vigor of grasses[1] found on study area 1 and study area 2. Figures represent measurements of area 2 subtracted from area 1.

Species	Maximum Ht. June/61	Maximum Ht. June/62	Average Ht. June/61	Average Ht. June/62	Leaf Length June/61	Leaf Length June/62
Asc	-2.0	16.1**	-12.0**	11.2**	-2.5	1.0
Age	-5.8	17.0**	-7.0**	16.1**	-0.6	8.8**
Snu	4.9	7.7**	9.5**	14.4**	7.7**	9.0**
Pvi	4.3	28.4**	-10.5**	30.7**	9.2**	15.8**
	July/61	July/62	July/61	July/62	July/61	July/62
Asc	15.0**	9.9**	13.8**	6.7**	1.7	8.3+
Age	11.0**	3.7	12.7**	9.8**	3.0	4.7
Snu	11.0**	14.0**	7.0**	7.5**	7.4	8.9**
Pvi	14.5**	41.3**	13.3**	30.6**	3.0	5.0**
	Aug./61	Aug./62	Aug./61	Aug./62	Aug./61	Aug./62
Asc	-2.4	-17.0**	9.0*	5.2+	10.0**	21.6**
Age	-16.0**	-9.5**	-7.8+	10.6**	-1.8	15.4**
Snu	1.0	13.7**	6.0	2.4	1.5	6.9*
Pvi	0.7	29.6**	-2.8	30.6**	2.4	5.9**

[1] Asc=*Andropogon scoparius*, Age=*Andropogon gerardi*, Snu=*Sorghastrum nutans*, Pvi=*Panicum virgatum*.

* Significant at .05 level; ** Significant at .01 level; + Significant at .1 level.

results are in agreement with those of Johnson (1956), but in contrast with those of Blaisdell and Pechanec (1949). Differences in leaf width and number of leaves were not statistically significant even at the .1 level.

Even though the desirable grasses exhibited very low vigor in Area 2, they would probably recover rapidly if given a chance. According to Humphrey (1949), grasses in low vigor usually will show good to excellent vigor within a period of only one or two years, if the cause (overgrazing) is corrected.

Summary and Conclusions

Two loamy prairie pastures were studied during the summer months of 1961 and 1962 in northern Osage County, Oklahoma. One was grazed heavily year round; the other was grazed moderately for only about four months per year. An attempt was made to determine the effect of different grazing intensities on botanical composition, forage production, and plant vigor.

Sixteen grass species were recorded in the study areas. Little bluestem was by far the most abundant in the moderately grazed pasture while buffalograss and tall dropseed were the most abundant in the heavily grazed pasture. Silver bluestem was also abundant in this pasture, indicating that these invader plants increase under heavy stocking. The big four in the moderately grazed pasture were sparse in the heavily grazed pasture. Indications are that indiangrass was one of the least resistant to top removal, as it was not sampled either year by the point quadrat. According to Harlan (1960) part of the differential response of these grasses to top removal is due to differences in the position of shoot apices and dormant buds. With indiangrass, the severity of top removal probably depended greatly on the timing of the treatment with respect to the position of the shoot apices.

No correlation was noted between grazing intensity and basal cover. Grazing intensity did affect forb production. Western ragweed, heath aster, and false prairie boneset, respectively, were the most abundant forbs in each area, but their number in the heavily grazed pasture was tremendous.

Forage yields of around 3,400 lb/acre of dry matter per season were produced on each area. However, the species making up this production were entirely different in the two areas. Big bluestem, little bluestem, switchgrass, and indiangrass were the major forage producers in the moderately grazed pasture; while buffalograss, tall dropseed, sand dropseed, and silver bluestem were the main producers in the heavily grazed pasture.

Leaf height was one of the most consistent indicators of plant vigor. The grasses in the moderately grazed pasture produced a greater maximum height, average height, and leaf length than the same species in the heavily grazed pasture. Leaf width and number of leaves, however, were not correlated with vigor.

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ABOUT THAT LATE MAY ISSUE

You may have wondered why your May issue of the Journal was so late in reaching you—in mid June. Our mss and corrected proofs were ready on schedule, but our printer was reorganizing into two companies and transfer of mailing lists and copy was held up. We hope you receive this July issue on time.

TECHNICAL NOTES

Eurotia lanata Establishment Trials[1]

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Highlight

***Eurotia lanata* has been diminishing from the vast acreages once found throughout the west. Fattening and nutritious qualities, coupled with rapid growth even in an arid habitat, make it a valuable semishrub worthy of cultivation. Seeding trials during spring and fall 1964 near Laramie showed best results from the May 17 seeding date and 0.25-inch depth of seeding.**

Eurotia lanata, known as winterfat or whitesage, is important as livestock feed. It is of high nutritive value, good palatability, and grows rapidly in an arid habitat.

Most authors agree that in recent years winterfat has been retreating from its distribution over the western ranges. The reduction in numbers of this plant has caused a decrease in grazing capacity in many areas. Its high palatability has resulted in severe overgrazing to the point of its extinction in many areas. It is grazed to the roots wherever found (Hilton, 1941; Kinsinger and Strickler, 1961; May, 1963).

Reestablishment of this nutritive and palatable shrub would increase grazing capacities of many areas.

A seeding trial with *E. lanata* was conducted west of Laramie, Wyoming, to determine the most desirable time of planting and depth of seeding for establishment of this plant.

Methods

This study was conducted on a dryland portion of the Agronomy Farm of the University of Wyoming at Laramie, in 1964. The land had been summer fallowed for seven years. Precipitation for the year was 7.77 inches. Precipitation for the growing season from the first planting date to October 15 was only 3.74 inches.

The field was first disked, then leveled by a hand hoe and rake.

The *E. lanata* seed was collected from a golf course south of Pine Bluffs, Wyoming in November, 1963. It was cleaned at the Plant Materials Center in Bridger, Montana. Germination was tested in the Wyoming State Seed Laboratory shortly before each planting.

Seed was planted in two 10-foot rows, 30 inches apart and 15 inches from either edge in half of the plots. Fifty seeds were planted in each row, two inches apart and 0.25 inch deep. One hundred seeds were broadcast in the center 30-inch strip of the other 5x10-foot plots. The seeds were hand broadcast and raked into the soil. Three row and three broadcast plots were planted on each date: May 6, May 17, June 1, June 17, September 13, September 27, and October 15.

Plots were seeded June 1 and June 17 in rows to a depth of 0.5 and 0.75 inch, replicated three times. The plots were hand weeded and kept clean throughout the summer.

The number and height of plants that emerged were recorded. The growing plants were counted at the end of the first, second, third, and fourth month after each planting and again on October 15, in all plots.

Results

The germination of *E. lanata* seed at room temperature was 91%.

The first *E. lanata* plants appeared in the field 10 days after planting. A total of 306 plants emerged from 2400 seeds planted in all plots; 12.7% of those planted. A total of 203 plants emerged in the plots seeded in rows and 103 in the broadcast plots. There were 156 seedlings established in all plots on October 15, or 6.5% of the total seeds planted. There were 94 plants in the plots seeded in rows and 62 in the broadcast plots.

Thirty-nine plants were established in the plots planted May 6; 21 were in the rows and 18 in the broadcast plots. Sixty-nine plants were established on October 15, in all plots seeded May 17, 1964; 37 in the plots in which seed was planted at 0.25-inch depth and 32 in the broadcast plots. Twenty-nine plants were established in the plots planted June 1; 22 in the row plots and 7 in the broadcast plots. Nineteen plants were established in the plots planted June 17; 14 in the row plots and 5 in the broadcast plots (Table 1).

There were 36 plants in the six plots in which the seed was planted 0.25 inch deep, 25 in those planted at 0.5 inch, 17 at 0.75 inch and only 13 plants in the six broadcast plots (Fig. 1).

Total number of seedlings that emerged in the plots of the May 17 planting was significantly greater than for the other planting times.

Also the number of seedlings established in the May 17 plantings was significantly greater than in the other plantings.

The number of seedlings established in the rows planted 0.25 inch deep was significantly greater than in the broadcast trials.

There was no significant difference in height of the plants of the row or broadcast-planted plots on August 17 or October 15, 1964. Average plant height of the June 17 planting date was about 2 inches less

Table 1. Mean[1] number of *E. lanata* plants established on October 15, 1964.

Type of Planting	Date: May 6	May 17	June 1	June 17
Row[2]	7	11	7	5
Broadcast	6	16	2	2

[1]Mean determined from plants found in three 5 by 10 plots.
[2]Rows—seeds were planted one-fourth inch deep.

[1] *Published with approval of the Director, Wyoming Agricultural Experiment Station, as Journal Article 322.*

than the heights of the plants seeded at the other dates.

No emergence was noted in the three fall plantings until the spring of 1965.

Discussion and Conclusions

Seeds used in the trial had 91% germination. 12.7% of the seeds planted in the field emerged and half of these plants were well established on October 15, 1964. The extremely low precipitation during the growing season was undoubtedly responsible for the small number of plants that emerged and became established in the field. Precipitation for 1964 averaged about normal for the first four months. Precipitation for May was .58 inch lower than normal. June was .12 inch higher than normal. Precipitation in July was only .25 inch as compared to the normal 1.73 (Becker and Alyea, 1964). Precipitation for the growing season May 6 to October 15, was 3.74 inches. Total precipitation for the year was 3.42 inches below normal.

Hail and wind killed 63 of the 170 plants growing on June 21, 1964. Some of these plants would have become established had this not occurred.

Hilton (1941) and Eckert (1954) stated that germination and seedling establishment were both hampered by very high or low temperatures. This was true in this study as low temperatures were recorded during the early part of the planting period. The minimum temperature average for May was 36.4 F. The temperature dropped below freezing eight times during May. These low temperatures may have retarded the germination and seedling establishment.

The greatest number of plants emerged and became established in the May 17 planting. There was sufficient moisture and the soil was warm enough for germination and growth at this time.

The greater number of plants emerged and became established in the row plantings, with the greatest number at the 0.25-inch depth. Fewer plants were established in the rows planted 0.5 inch deep and the smallest number at 0.75 inch deep. Riedl (1958) and Telwar (1961) obtained good results from shallow plantings.

Seed was planted deep enough for moisture to be available at 0.25 inch.

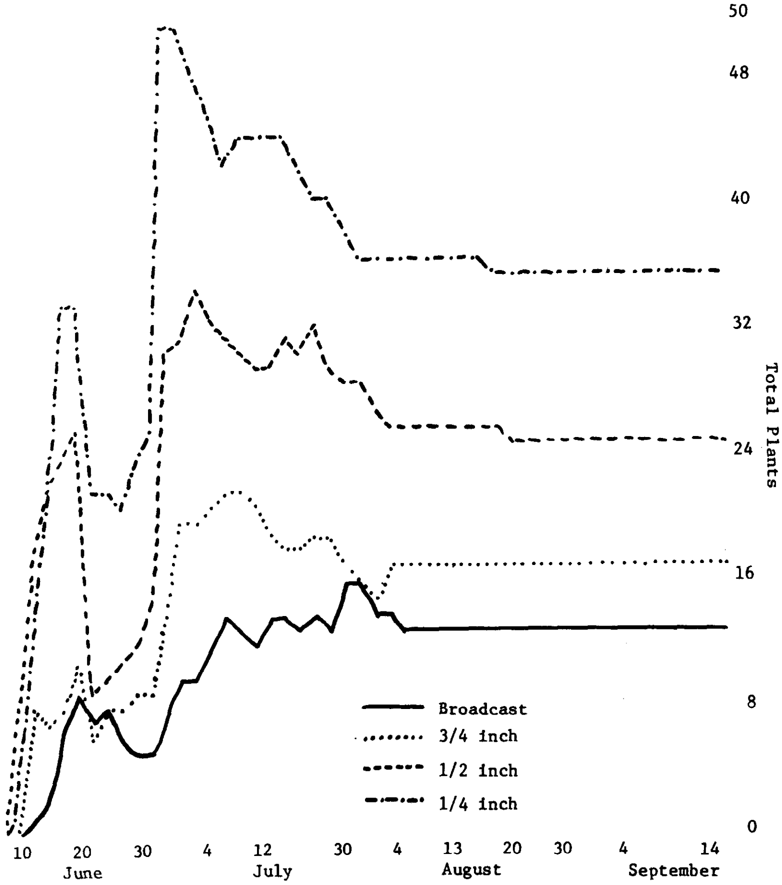

Fig. 1. Plant survival at various depths of seeding after emergence. Total plants from two planting dates; June 1 and June 17.

The broadcast seed was not planted this deep. It probably germinated and dried out or blew away. The 0.5-inch and 0.75-inch depths were too deep for satisfactory emergence. Many seedlings were not vigorous enough to penetrate this much soil.

Fall planting in the high plains is only occasionally feasible due to lack of available moisture at this time of year. Seeds did not germinate in the fall due to lack of moisture. High winds may have blown the seeds away during the dry winter. Germination of the seeds the following spring was considerably less than the year before. This was due to the considerable reduction in germination of *E. lanata* seed a year and two months after harvest date, as found by Hilton (1941) and the germination tests conducted with this study.

Very few plants grew the following spring in the trials planted in the fall of 1964. More seedlings appeared in the row plots than in the broadcast plots.

There was no significant difference in plant heights for the four dates of planting either in rows or broadcast. The average height of all [illegible] 17 plantings was one inch as [illegible]pared to the other spring plantings which were about three inches.

The year 1964 was poor for attempting this type of study. The year was plagued by extremely low precipitation and temperatures and a hailstorm in June did considerable damage to the plants. Even under these conditions, results were encouraging for establishment of *E. lanata* in large areas. The low percentage of *E. lanata* plants which became established would have increased the population of these plants more than 10,000/acre. This would greatly increase grazing capacity of many areas in the arid west in a few years.

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Herbage Production on High Sierra Nevada Meadows

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Highlight

A preliminary sample of five High Sierra Nevada meadows in California ranged from 835 to 1,436 lb/acre of herbaceous material, with sedges contributing more than grasses.

In 1963, I made a study of herbage production in the meadows of the High Sierra in central California. The study was designed to obtain preliminary sampling information for an intensive study that was to follow. The study was discontinued after completion of the preliminary sample. Because there is little published information on the Sierra Nevada Meadows, this preliminary survey data should be of interest to range managers.

I selected five meadows of 24 to 45 acres at an elevation of 6,500 to 7,000 ft in the vicinity of Jackass Meadow, Sierra National Forest, California. Three of the meadows are called John Brown, Strawberry, and Marshall. They are used heavily by cattle during the entire grazing season (mid-June to mid-September). The wet sites are trampled, and some parts are eroded. The other two meadows—both parts of Jackass Meadow—are referred to as North and South Jackass. They are lightly grazed during summer, with most of the use in fall. A favorable time of the year for a short period of heavy use is fall, when the meadows are relatively dry and the grasses and sedges have headed out.

Among the common grasses present on the dry sites are Idaho fescue (*Festuca idahoensis*), California danthonia (*Danthonia californica*) and pullup muhly (*Muhlenbergia filiformis*). Sedges (*Carex* spp.), present on both wet and dry sites, are more plentiful than the grasses.

The five meadows were sampled in September. Sampling intensity ranged from 1 plot/acre to 1 plot/2.3 acres, or 14 to 26 plots/meadow. All plots were protected from grazing during the previous summer by a wire-mesh cage of the type described by Westfall and Duncan (1961). A total of 108 square-foot plots were clipped 0.5 inch from ground level to estimate production and to obtain information on probable sampling requirements for future studies. The clipped vegetation was air-dried and weighed to the nearest tenth gram. Jeffery shootingstar (*Dodecatheon jeffreyi*), the only abundant plant observed to be unpalatable, was excluded from the sample.

Production on the five meadows ranged from 835 to 1,436 lb/acre (Table 1). Estimates of carrying capacity were based on 40% of the available herbage being used and were determined by methods recommended by Wood et al (1960). From this preliminary sample, about 100 plots/meadow probably would be necessary to estimate herbage production with a standard error of about 10%. But this requirement may change, depending on weather patterns. Although wet and dry sites were studied, I did not have enough data to make any recommendations on sampling requirements for these sites. Furthermore, it might be difficult to recognize the vegetation sites in spring during exceptionally high moisture conditions. When I selected our potential sample plots, virtually all sites were wet due to heavy winter snowfall and late runoff.

Table 1. Production and estimated carrying capacity for the 1963 growing season, selected meadows, Sierra National Forest, California.

Meadow	Acres	Prod. (lb/acre)	CC[1]
North Jackass	31	1436	24
South Jackass	45	888	22
Marshall	42	835	19
Strawberry	37	909	18
Brown	24	1178	15

[1] CC = Estimated carrying capacity, 1000 lb AUM.

Table 2. Percent weight composition (Comp.) and production in lb/acre (Prod.) of the major species groups on North Jackass and Marshall Meadows, Sierra National Forest, California.

Species	Comp.	Prod.
Carex nebraskensis	11	123
Unknown carex	12	130
Other grass-like spp.	40	452
Muhlenbergia filiformis	21	239
Danthonia californica	2	24
Agrostis idahoensis	1	6
Other grasses	([1])	([1])
All legumes	3	30
Other	10	115
	100	1,119

[1] Trace.

The plots on North Jackass and Marshall Meadows were also sampled with a point frame for foliar composition. The clipped material was sorted by hand for plant group composition by weight. *Carex* plants, the most abundant plants present, and other grass-like plants accounted for 63% of the composition, by weight, and produced 705 lb/acre. Grasses were second, with 25% of the composition and 269 lb/acre. Clover and forbs accounted for the remainder (Table 2).

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From this sample it appeared that any additional ecological or management studies made should emphasize the "grass-like" plants. A partial list of plants is included to give some indication of the species encountered in High Sierra Nevada meadows (Table 3).

The assistance of C. A. Graham, M. J. Reed, C. E. Conrad, W. H. Kruse, and S. E. Westfall is gratefully acknowledged.

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Table 3. Partial list of plants found on high Sierra Nevada in the vicinity of Jackass Meadow, Sierra National Forest, California.[1]

CYPERACEAE	GRAMINEAE
Carex abrupta Mack.	*Poa palustris* L.
C. integra Mack.	*Puccinellia erecta* (Hitchc.) Munz
C. nebraskensis Dewey	*Danthonia californica* var. *americana* (Scribn.) Hitchc.
C. ormantha (Fern.) Mack.	*Deschampsia elongata* (Hook.) Munro ex Benth.
C. simulata Mack.	*Agrostis idahoensis* Nash
C. teneraeformis Mack.	*A. scabra* Willd.
Eleocharis acicularis (L.) R. & S.	*Muhlenbergia filiformis* (Thurb.) Rydb.
E. acicularis var. *bella* Piper	MISCELLANEOUS FLOWERING PLANTS
Scirpus congdoni Britt.	*Viola macloskeyi* Lloyd
JUNCACEAE	*Polygonum bistortoides* Pursh
Juncus bufonius L.	*Dodecatheon jeffryi* Van Houtte
LEGUMINOSAE	*Mimulus primuloides* Benth.
Lupinus nevadensis Heller	*Penstemon oreocharis* Greene
Lotus purshianus (Benth.) Clem. & Clem.	*Potentilla gracilis* ssp. *nuttallii* (Lehm.) Keck
Trifolium bolanderi Gray	*Epilobium glaberrimum* Barb.
T. longipes Nutt.	*Perideridia parishii* (C. & R.) Nels. & Macbr.
T. microcephalum Pursh	*Aster foliaceus* Lindl.
T. monanthum var. *parvum* (Kell.) McDerm.	*Phalacroseris bolanderi* var. *coronata* Hall
	Brodiaea lutea (Lindl.) var. *analina* (Greene) Munz

[1] Taxonomic determinations were made by the U.S. Forest Service Herbarium staff.

Forage Analysis as Influenced by Sampling Position and Processing[1]

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Highlight

Collecting a representative sample of conserved forage is necessary if such practices as forage testing are to be meaningful. When uniform samples of Coastal bermudagrass and alfalfa were systematically sampled in nine different ways, the coefficient of variation for crude fiber and protein averaged approximately 5%. Sampling procedures satisfactory for one species may well be unsatisfactory for another.

Chemical analysis has been the time-honored method of evaluating feedstuffs and forage evaluation has attracted much research attention in recent years attesting to the popular interest and economic importance of forage-based enterprises. A large number (Anonymous, 1963) of state forage-testing programs are based primarily on crude protein and crude fiber analyses. These activities have as an objective, establishing the nutritive value of a forage so that supplemental feeding may be designed to complement the forage fed.

Attempts to establish forage "quality" have often ended in frustration or in technical procedures that met with less than complete acceptance (Sullivan, 1962; Van Soest, 1965). Problems associated with forage quality measurements are diverse and include: (a) errors in sampling due to lack of homogeneity in the sampled forage, (b) significant interactions for species x sampling meth-

[1] *Journal Paper No. 531 of the College Experiment Station of the University of Georgia, College of Agriculture Experiment Stations.*

od making standards for one species inappropriate for another species, (c) analytical variation due to the variable nature of carbohydrates and particularly the fiber fraction, (d) changes due to processing, and (e) within and among laboratory analytical variations. Several experiments have shown that grinding and pelleting a forage results in an apparent reduction in crude fiber (Brooks et al., 1962; Haught et al., 1960; King et al., 1963).

The research reported here was conducted to establish the effects of sampling location within bales and sampling at various points in the grinding and pelleting operation on the fiber, protein, ash, and ether extract (crude fat) content of Coastal bermudagrass (*Cynodon dactylon*, Poir) and alfalfa (*Medicago sativa*, L.). A part of this objective was to determine the size of the sampling error which is obtained under forage testing conditions for the different components at a given sampling location for each of the species. Another objective was to determine whether grinding or grinding and pelleting affected the chemical compositions of the forages.

Table 1. Treatment means as % of dry matter for sampling coastal bermudagrass.

Sampling position	Crude fiber	Crude protein	Ash	Ether extract
Bale End				
1. Center	33.7	8.1	5.1	1.6
2. Edge between ties	34.1	7.9	5.1	1.9
3. Sheared Corner	32.6	8.1	5.0	1.5
4. Pressed Corner	32.7	8.7	5.1	1.9
Bale Sides				
5. Flat-side between ties	32.9	8.0	5.1	1.5
6. Sheared Edge	32.3	8.0	5.0	1.6
Processed				
7. Ground	32.3	7.5	4.9	1.5
8. Mixed	32.2	8.1	5.0	1.6
9. Pelleted	31.2	7.9	4.9	1.3
Average	32.7[b]	8.0	5.0	1.6[a]
C.V. (%)	2.8	4.7	2.0	9.7
Standard Deviation[c]	0.7	0.3	0.1	0.1

[a] Significant at 0.05 probability level.
[b] Significant at 0.10 probability level.
[c] Within treatment standard deviation.

Procedure

Thirty bales of Coastal bermudagrass from the Southeast Georgia Branch Station, Midville and 30 bales of alfalfa from the College Station, Athens, were used as test material. The bermudagrass was from a lot of hay that had been fertilized with 500 lb/acre of 0-10-20 in April and 75 lb of N on May 10. It was mowed on June 16, baled on June 17, and stored until December 5. The alfalfa had been fertilized with 1000 lb/acre of 0-10-20 in March, mowed and conditioned on May 5, baled May 7, and stored.

The bermudagrass and alfalfa were allotted to three replications of 10 bales each. The ten bales were sampled individually at six points with a Pennsylvania State forage sampler having a new cutting head. Four sample locations were from the end of a bale and 16 inches deep: (1) in the center, (2) on the side of the bale and between the ties, (3) on the sheared edge outside the tie, and (4) on the pressed edge outside the tie. They were also sampled (5) from the flat side of the bale between the ties near the center and approximately 30° from the perpendicular and (6) from the sheared edge of the bale toward the pressed edge and 30° from the perpendicular.

The bales were then run through a hammer mill with 5/16-inch screen and further sampled as follows: (7) from base of the collector, (8) between the conditioning chamber and pellet mill, and (9) after pelleting.

Positions 7, 8, and 9 were sampled by "grabbing" 20 to 25 samples per replication. Samples from all sampling locations were composited by species and sample location within replications. The composited samples were ground through a Wiley mill and analyzed for crude fiber, crude protein, ether extract and ash[2]. To make the results comparable with those from forage testing programs, a single chemical analysis was made of each sample.

Results and Discussion

Coastal bermudagrass sampling positions 1 and 2 had the highest fiber content (33.7% and 34.1%) and the pelleted forage had the lowest (31.2%). The spread between the highest and lowest fiber was 2.9%, or approximately 10% of the mean. Other positions showed less than 1% variation from the mean and ranged between 32.2% and 32.9%. There was a difference in replications which was found in randomly selected 10 bale samples from an apparently uniform lot of grass. This effect may have been due to chance or to some biological effect for which an explanation is not readily apparent. Combining replication and error sums of squares produced a coefficient of variation (C.V.) of 5.3%. The C.V. for fiber due to sampling positions and with replication effects removed was 2.8%. Under field conditions, an average variation of 5% of the mean in fiber would appear to be the expected range of error on single samples from specified locations within a bale. With random samplings errors might be either smaller or larger but probably would average about 5% of the mean or about 1.5% of crude fiber in samples containing 30% fiber. Differences in fiber between sampling positions was significant at approximately the 8% level of probability (Table 1).

Protein content for different locations for Coastal bermudagrass was not significantly different and the 4.7% C.V. indicates that protein was not uniformly distributed and/or consistently stratified throughout the bale. The variation by sampling position ranged from 7.5% on position 7 to 8.7% on position 4. The C.V. within sampling position for protein was 4.6% and shows that for a specific element such as N, sampling errors

[2] *Appreciation is extended to the Georgia Department of Agriculture, Phil Campbell, Commissioner, and Mr. Harry Johnson, Chemist, for chemically analyzing the forage samples reported in this manuscript.*

Table 2. Treatment means as % of dry matter for sampling alfalfa.

Sampling position	Crude fiber	Crude protein	Ash	Ether extract
Bale End				
1. Center	28.7	16.4	7.6	2.0
2. Edge between ties	31.5	16.4	7.7	2.1
3. Sheared Corner	29.9	16.1	7.4	2.0
4. Pressed Corner	31.9	16.3	7.9	2.0
Bale Sides				
5. Flat-side between ties	31.6	16.2	7.5	2.0
6. Sheared Edge	30.4	17.4	7.8	2.0
Processed				
7. Ground	35.2	15.4	7.0	2.0
8. Mixed	33.5	16.0	7.7	2.1
9. Pelleted	32.4	16.1	7.6	2.1
Average	31.7[b]	16.2	7.6	2.0[a]
C.V. (%)	6.0	3.0	3.6	2.3
Standard deviation[c]	1.9	0.5	0.3	0.05

[a] Significant at 0.05 probability level.
[b] Significant at 0.10 probability level.
[c] Within treatment standard deviation.

as large as 5% of the mean can be expected and that the sampling treatments studied were not effective in reducing the variation.

In Coastal bermudagrass, ether extract showed a C.V. of 9.7% and a significant difference between sampling positions. However, ether extract is a very minor component of the grass and thus the variation is quite small as a percentage of the dry matter. Positions 2 and 4 were highest in ether extract and suggests that plant parts high in this component were stratified in the bale. Position 2 was also highest in protein. The high C.V. suggests that no sampling position was especially efficient in measuring ether extract. Nutritionally, ether extract content in forages is of little importance and in forage evaluation can be largely ignored.

Differences in Coastal bermudagrass ash due to sampling were not significant and the C.V. was 2.0%. Apparently ash is the factor most uniformly distributed throughout Coastal bermudagrass and ether extract is the most variable. However, both are generally of minor significance in forage evaluation. Variations in fiber appeared to be more consistent by positions within the bale and protein variability was much more random. The data suggest that when a given lot of Coastal is systematically sampled and analyzed for fiber and protein, errors are likely to average approximately 5% of the mean. However, when random hay samples are collected and single determinations made, errors should be higher.

Variation within alfalfa samples for fiber was approximately three times as high as for Coastal bermudagrass. Fiber varied from 28.7% at position 1 to 35.3% for position 7. This is a difference of 6.60 percentage points or 20% of the mean. It is obvious from the results that "grabbing" (position 7) samples of ground alfalfa collects more stems than leaves. This did not appear to be as serious a problem with the Coastal bermudagrass. Why position 1 should be 1.2% lower in crude fiber than the next value (position 3) and 3.0% lower than the average is not understood (Table 2).

The pelleted alfalfa had 32.4% fiber and ranked 3rd from the highest. It appears that pelleting alfalfa had no influence on fiber content. This is in contrast to previous work and may be associated with pelleting conditions such as temperature, etc. It is interesting that Haenlein and Holden (1965) concluded that variations within sample position was due to sampling error.

The C.V. for alfalfa fiber was 6.5% and when combined with the widely divergent position effect raises a question as to the reliability of normal sampling techniques. When sampling errors are combined with analytical and random errors which may be expected under field conditions, considerable variation should be expected.

Crude fiber is a variety of compounds and varies both qualitatively and quantitatively with forage age (Miller et al., 1963) and between species (Sullivan, 1964). More analytical variation is normally obtained in the empirical crude fiber determinations than is experienced when a definite material such as N (crude protein) is being measured.

Protein content of alfalfa as influenced by position of sampling varied a total of 2.0 percentage points. The low value of 15.4% was on position 7 and was probably low due to stems staying in the container while leaves were lighter and flowed around. The same sampling position also had the lowest level of crude protein in the Coastal bermudagrass.

Sampling alfalfa from the cut edge of the bale (position 6) increased the protein 1.2% above the average. The C.V. for protein was 3.0% and it appears that positions 1, 2, 3, 4, 5, and 9 would be closest to the average.

Ash followed a trend similar to protein and no differences were evident. The C.V. for ash was 3.6% and shows the variation that can be expected in a single lot of similarly treated alfalfa.

The position by species interaction for fiber was highly significant indicating that a sampling procedure satisfactory for one species may not be valid for another. The species difference obtained here is not surprising as Sullivan (1962) has noted that for a number of chemical measurements species differences were very wide.

Summary

Uniform lots of Coastal bermudagrass and alfalfa were divided into three replications of 10 bales each and systematically sampled by bales in six different locations. Three additional samples were collected at various stages of grinding and pelleting. Samples were composited within replications and analyzed for ash, crude protein, ether extract and fiber. Data collected show that differences in ether extract and fiber can be expected within the same lot of Coastal bermudagrass depending upon where the sample is collected. In addition, variations of 5% of the mean in fiber content should be expected when single composite sam-

ples from 10 bales of Coastal are analyzed. Ether extract showed considerable error between samples and a C.V. of 9.7%. Since the amount of ether extract is quite small this large percentage error is not of great importance. Protein was not uniformly or consistently distributed through a bale of Coastal and the within treatment coefficient of variation was 4.7%.

Fiber in alfalfa was more variable both within and among treatments than in Coastal bermudagrass and ranged from 28.6 to 35.2%, a difference of 20% of the mean, at different positions sampled. The within treatment C.V.'s of alfalfa and Coastal were 6.0 and 2.8%. Differences due to sampling positions in alfalfa for protein and ether extract were significant. The "grab samples" of ground alfalfa contained the highest level of fiber and may be the least desirable sampling method.

Pelleted Coastal bermudagrass had the lowest average fiber content of any position sampled. The fiber level of the pelleted alfalfa was above the mean of all samples. The sampling position by species interaction for fiber was highly significant indicating that a sampling procedure valid for one species may not be as reliable for another.

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Cheatgrass Coloration—A Key to Flammability?

ROBERT W. MUTCH

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Highlight

The drying rate of cheatgrass was studied on four plots in western Montana and northern Idaho. The characteristic color changes in cheatgrass while it is curing (from green to purple to straw color) are proposed as an indicator of impending flammability because these colors are generally correlated with progressive drying of plants.

Range management objectives are both benefited and hampered by cheatgrass *(Bromus tectorum* L.). The plant is currently important in terms of soil stabilization and forage production (Stewart and Hull, 1949). Conversely, its presence in any significant quantity constitutes a serious fire hazard.

Cheatgrass was introduced into eastern North America from Europe about 1850. It invaded the West just before the turn of the century. A recent survey indicates that the plant now occurs on at least 60 million acres in the 11 Western States; it is most abundant in the sagebrush-grass type in the Columbia and Great Basins (Hull, 1965). In Nevada alone, wildfires burn thousands of acres of cheatgrass range each year, destroying or damaging perennial grasses, sagebrush, and other plants (Fleming et al., 1942). Other observations indicate that a cheatgrass fire can reduce early forage the following spring and that repeated fires injure the soil and inhibit forage production over an extended period of years (Pechanec and Hull, 1945).

Habitat and growth characteristics of cheatgrass make this plant a fire hazard that has a high potential for accelerating the spread of fire. These characteristics can be delineated as follows because the plant:

1. Produces large quantities of highly viable seed that usually develop dense stands.
2. Provides a flammable link between open grasslands and forests.
3. Grows primarily in the 6- to 22-inch precipitation zones characterized by severe fire weather.
4. Cures early in the fire season.
5. Ignites readily during dry periods because of its finely divided stems and pedicels.
6. Responds readily to changes in atmospheric moisture because of this fine structure.

An understanding of the relative flammability of cheatgrass at varying stages in its life cycle is necessary to the management and protection of ranges on which it occurs. The objective of this study was to determine whether the characteristic color changes that take place while cheatgrass is curing are indicative of flammability. Because moisture content is the most important single factor influencing cheatgrass flammability, the investigation centered on an analysis of the drying rate of the plant as related to coloration.

Materials and Methods

Four stands of cheatgrass were used as study areas. The areas were sampled as follows:

Area No.	
	1964
1	West. Mont. (north exposure)
2	West. Mont. (south exposure)
3	West. Mont. (south exposure)
	1965
2	West. Mont. (south exposure)
3	West. Mont. (south exposure)
4	N. Idaho (level bench)

Area No. 1 was not sampled in 1965 because the density of the cheatgrass was very light. Area No. 4, consequently, was added to the sampling schedule in 1965.

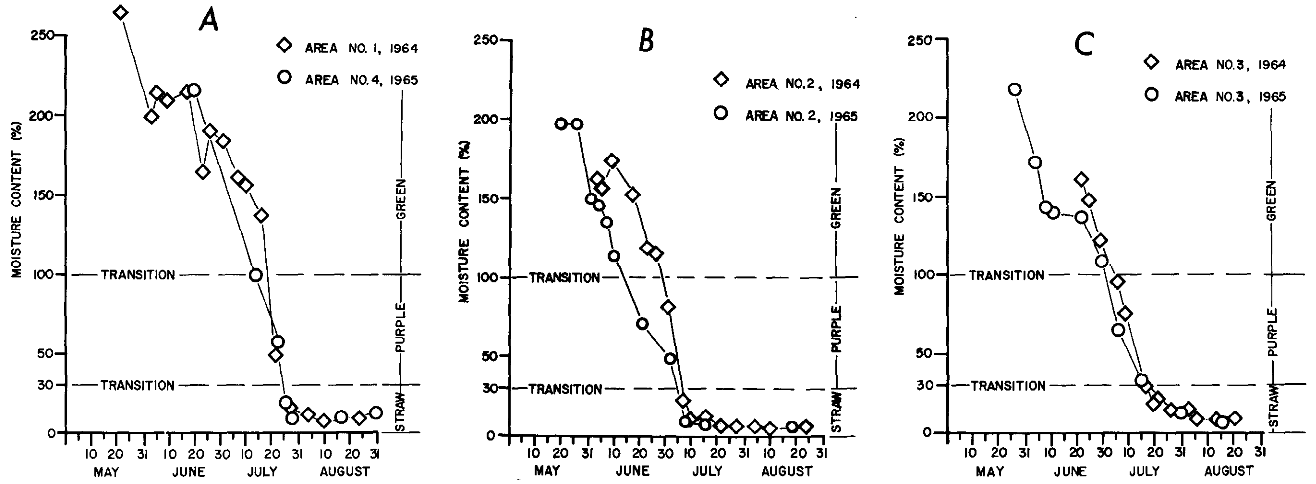

FIG. 1. Moisture content and plant coloration of cheatgrass by month and day at different locations: *A*. Area No. 1, western Montana, north exposure, 1964, and Area No. 4, northern Idaho, level bench, 1965; *B*. Area No. 2, western Montana, south exposure, 1964-65; and *C*. Area No. 3, western Montana, south exposure, 1964-65.

On each sampling day, two or three replications were collected from each area during the early afternoon hours. Cheatgrass samples were clipped at ground level for moisture content determinations to establish drying-rate curves. To avoid the problems associated with free water on the plants, no samples were collected during periods of precipitation.

To minimize moisture loss, samples were placed directly into tared distillation flasks in the field. Moisture content was measured by the xylene distillation method (Buck and Hughes, 1939), and all results were expressed on a dry weight basis. The coloration stage of the samples (green, purple, or straw) was noted and subsequently correlated with the drying rate curves. Plant coloration was described in terms of overall stand appearance and individual plant parts. Flammability was tested on each sampling day by igniting a few clipped plants with a match and determining whether combustion was sustained upon removal of the heat source.

Results and Discussion

The study areas, although located on diversified sites, exhibited similar drying curves (Fig. 1). The calendar dates of curing were different, but the slopes of the curves from spring growth to a cured condition in July were almost identical.

The relation between plant color and moisture content on all areas was as follows:

Plant color	Moisture content (%)
Green	> 100
Purple	30-100
Straw	< 30

The above classification represents the predominant coloration of individual plants. As the transition points of 100% and 30% moisture content were approached, there was a greater degree of color variation within plants. Plant coloration was consistent enough, however, to use as an indicator of moisture content and thereby as an indicator of the flammability of the grass.

Use of coloration as an indicator of flammability requires close-up inspections. A cheatgrass stand may appear purple from a distance, but close-up inspections frequently reveal considerable traces of green remaining in stems, upper leaves, and seed heads. The true onset of the purple stage is indicated by the vivid purpling of all plant parts.

The match test showed that the cheatgrass was not readily ignitible until it reached the straw-colored stage. Even when only a trace of purple remained in individual plants, flaming was marked by the popping sounds associated with the burning of moist material.

The time required for the moisture content to drop from 100% to 30% (and for the plant coloration to change from purple to straw) ranged from 8 days at Area 1 in 1964 to 23 days at Area 2 in 1965; the average was 14 days for all areas.

Exposure of the plots influenced the calendar date on which moisture content of the plants had dropped to 30%. In both 1964 and 1965, cheatgrass on Area 2 (severe south exposure) showed 30% moisture content on July 5; on Area 3 (south exposure receiving some afternoon shade), 30% moisture content was recorded on July 15; on Area 1 and Area 4 (more moist sites) it was recorded on July 25.

Summary and Conclusions

The visual characteristic of cheatgrass most indicative of flammability is coloration. The plant is not readily ignitible when it is in either the green or purple stages. It is only highly combustible when it is straw-colored. The onset of vivid purpling forewarns of hazardous fire conditions within approximately 2 weeks.

Because cheatgrass is an important plant on western rangelands, management must cope with the extreme susceptibility of this grass to large-scale fires. Noting changes in plant coloration may be an efficient means of predicting the rate at which cheatgrass becomes flammable.

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Viability of Grass Seed After Long Periods of Uncontrolled Storage[1]

ARTHUR R. TIEDEMANN AND FLOYD W. POND

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Highlight

In 1961, germination tests were made on seeds of 12 southwestern grass species collected between 1933 and 1939. Some seeds of vine-mesquite, silver beardgrass, curlymesquite, and Arizona cottontop remained viable, even though stored with no control of humidity or temperature.

In 1960, several small cardboard boxes filled with grass seeds were found in a storage locker at the Sierra Ancha Experimental Forest, elevation 5,100 ft, near Globe, Arizona. These seeds, collected on or near the Experimental Forest by various people between 1933 and 1939, presented an opportunity to study long-term viability of native grass seed.

Several studies (Soil Conservation Service, 1951; Wheeler and Hill, 1957; Little, 1937; Hafenrichter et al., 1965) have shown that grass seed may remain viable for several years if stored in a cool, dry place. The locker at Sierra Ancha provided no special protection from humidity or temperature, nor did the unsealed, though relatively tight, cardboard boxes. Temperatures at the Experimental Forest vary from 100 F. during the summer to almost 0 F. during some winters. Humidity rarely exceeds 50% for more than 1 or 2 days at a time in this semi-arid locality, which receives about 21 inches of rainfall each year.

In July of 1961, the seeds were subjected to standard germination tests by the Colorado State Seed Laboratory at Fort Collins, Colorado. Results are based on the number of pure seeds that developed into normal seedlings after 24 to 36 days in a petri dish with blotter substrate.

Table 1. Percent germination of 12 species of native southwestern grass seed after 20 years' storage without control of humidity or temperature.

Species and collection date	Percent germination Initial	July 1961
Vine mesquite		
(*Panicum obtusum* H.B.K.)		
1933	?	22
1934	?	27
1934	?	34
1936	?	8
1936	98	11
1936	98	3
1938	?	9
Silver beardgrass		
(*Andropogon saccharoides* Swartz)		
1933	?	17
1934	?	0
Curlymesquite		
(*Hilaria belangeri* (Steud.) Nash)		
1936	?	6
Arizona cottontop		
(*Trichacne californica* (Beuth.) Chase)		
1936	?	25
Green sprangletop		
(*Leptochloa dubia* (H.B.K.) Nees.)		
1939	26	0
Side-oats grama		
(*Bouteloua curtipendula* (Michx.) Torr.)		
1933	91	0
1939	?	0
Hairy grama		
(*B. hirsuta* Lag.)		
1934	?	0
Bullgrass		
(*Muhlenbergia emersleyi* Vasey)		
1933	?	0
1934	?	0
1937	?	0
Purple three-awn		
(*Aristida purpurea* Nutt.)		
1933	?	0
Fringed brome		
(*Bromus ciliatus* L.)		
1936	?	0
Plains lovegrass		
(*Eragrostis intermedia* Hitchc.)		
1936	?	0
Texas timothy		
(*Lycurus phleoides* H.B.K.)		
1936	?	0

Results and Discussion

Of the 12 species tested, 8 showed no sign of viability (Table 1). Initial germination of most species was not checked, but of those which showed no viability in 1961, green sprangletop and the 1933 collection of side-oats grama germinated 26 and 91% respectively, at time of collection.

[1] *Assistance of the Colorado State Seed Laboratory, Colorado State University, Fort Collins, and the Arizona Agricultural Experiment Station, University of Arizona, Tucson, is gratefully acknowledged.*

[2] *Forest Service, U.S. Department of Agriculture, with headquarters at Fort Collins, in cooperation with Colorado State University. Mr. Pond is located at the Station's project headquarters at Flagstaff, in cooperation with Northern Arizona University.*

Four species—vine-mesquite, silver beardgrass, curlymesquite, and Arizona cottontop did germinate in 1961. These results (Table 1) indicate that seed of some species can maintain viability under uncontrolled conditions of storage for long periods of time.

Long-term viability differences between species were probably due to physiological as well as morphological differences in the seeds (Asgrow Seed Co., 1954; Quick, 1961). Although data are insufficient to allow comment on physiological differences, some morphological differences between the seeds are obvious. Arizona cottontop and silver beardgrass, for example, both have hairs on the outside of the seed that may provide insulation from heat and excessive humidity when the seeds are closely packed. In addition, both have fairly hard seed coats, particularly Arizona cottontop. Vine-mesquite has a hard coat and a large amount of endosperm, which may account for its longevity. Curlymesquite grass, on the other hand, has a small seed with a thin seed coat, and its continued viability is apparently due to factors other than morphological characteristics.

The initial germination of two vine-mesquite samples collected in 1936 was high, 98%, but the viability of these two samples in 1961 was considerably lower than the samples collected in 1933 and 1934. The initial germination of the earlier collections could have been little better than that of the 1936 samples; yet the viability of the earlier samples held up better during storage. Several factors could have been responsible, but the most logical are impermeable seed coat and moisture content at time of collection. The effect of these factors is also shown by the continued viability of the 1933 sample of silver beardgrass, while the 1934 collection failed to survive.

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We would like the membership to remember the library when disposing of personal libraries. Gifts or bequests are tax deductible at fair market values. Prepaid freight labels and estimates of value may be obtained from the librarian. Address all correspondence to:

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DU WAYNE GOODWIN, of the Pakistan Forest Institute at Peshawar reports that a Pakistan Society of Range Management is being organized there.

DIRECTOR PECHANEC RECEIVES SUPERIOR SERVICE AWARD

Joseph F. Pechanec, director of Intermountain Forest and Range Experiment Station, has received a Superior Service Award from the Secretary of the U.S. Department of Agriculture according to announcement today by Edward P. Cliff, chief of the Forest Service. Mr. Pechanec has worked with the Forest Service since 1933 in a variety of research and administrative posts.

The citation accompanying Mr. Pechanec's award read: "For outstanding contributions to wildland conservation through distinguished administration of a comprehensive forestry and wildland research program, eminent personal research, and inspiring professional leadership."

Mr. Pechanec has been director of the Intermountain Station, with headquarters in Ogden, Utah, since June 1962. From 1953 to 1956 he was director of the Division of Range Management Research of the Forest Service in Washington, D.C. For part of this time he was staff assistant to the deputy chief in charge of Forest Service research.

Mr. Pechanec was one of the founders of the American Society of Range Management when it was organized in Salt Lake City in 1948. He was the society's first president and was editor of its Journal of Range Management for one year in 1953. In 1951 he was a member of a United Nations team, with headquarters in Rome, assigned to evaluate range resources in several underdeveloped nations. In 1954 he received a second assignment for foreign service as advisor in range resources for the Foreign Operations Administration.

Virgle L. Cunningham Jr. former Area Conservationist, Soil Conservation Service, Amarillo, Texas was recently named Assistant Chief Management Records Branch, Budget & Finance Division of the Soil Conservation Service and transferred to the Washington, D.C. office.

MANAGEMENT NOTES

My Range Use Affects Salmon and Steelhead Production[1]

W. C. GOVER

Rancher and member, California ASC State Committee, Anderson, California.

Highlight

The Gover Ranch carries out a program of streambank manipulation and shore protection that maintains suitable spawning grounds for king salmon and steelhead. Estimated values are very high.

Although our Society is dedicated to promote advancement in the science and art of grazing land management, I want to discuss a topic that is becoming important to those of us who own and operate range land — The Preservation of Wildlife. To be more specific, I want to describe how we on the Gover Ranch stimulate salmon and steelhead production through the performance of sound range management practices.

We operate 14,000 acres of rangeland adjoining Battle Creek and the Sacramento River in Shasta County, California. This land is 100 air miles from the ocean; however, it is 200 miles as a fish swims.

What we do on our range lands affects a multitude of wildlife because it is the residence of hundreds of deer, birds of many kinds, and fronts on seven miles of trout and salmon streams.

I could spend a considerable amount of time telling you of the many popular and accepted practices we do to provide improved cover that benefit wildlife.

These include leaving 300 to 400-ft wide strips of brush along streams, piling brush to protect bird life, manipulating brush to provide browse for deer and similar practices. These, however, are accepted and well known to all of us. We have what we believe to be a unique situation because what we do for our ranch to provide streambank or shore protection on our streams has a direct effect on the salmon and steelhead production in the Sacramento River and its tributaries.

FIG. 1. Bulldozed gravel bed for salmon spawning on Battle Creek, Gover Ranch, Shasta County, California.

Battle Creek, a major tributary of the Sacramento River, runs through our ranch. It is an all-year cold running stream averaging in width from 50 to 75 ft with a minimum flow of approximately 400 sec/ft. It provides an excellent salmon and steelhead spawning area. However, in winter months it is subject to flash floods which erode the land and leave narrow channels running between mounds of compacted gravel in the stream. It builds up banks of gravel on the inside of "S" and "U" curves and washes away the banks on the outside. Because of this annual erosive action it is necessary for us to protect our lands adjoining Battle Creek to prevent the topsoil from being washed into the Pacific Ocean 200 miles away.

The problem we face is to protect our land and yet protect and improve the salmon and steelhead spawning grounds. Since the mounds of gravel and the compacted gravel in the stream are useless for spawning fish as well as useless in providing protection to our adjoining lands, it is necessary for us to take measures that will protect both the lands and the spawning grounds.

Now, you may ask, why are we so concerned about protecting the king salmon and steelhead when the actual business we are in is raising range livestock. Let me give you a description of these valuable fish, their habits and the benefits we derive through their protection.

The average weight at spawning time of the king salmon is 20 lb although some individuals exceed 50 lb and the record is over 100 lb. King salmon taken in the ocean are usually immature and average smaller than those in rivers.

King salmon spawn in cool or cold streams where there are gravel bottoms, preferably loose gravel. They prefer gravel in which most of the larger rocks are about 6 inches in diameter or a little smaller. The preferred spawning area is the lower end of a pool where the water is beginning to pick up speed, just above or within the edge of a riffle.

At spawning time a female selects a spot and digs a nest. She rolls on her side on the bottom and with a swimming or pumping motion moves the gravel downstream, and leaves a pit in which she deposits some eggs which are immediately fertilized by a waiting male. The female then moves upstream a short distance and resumes her digging, thus covering her previously deposited eggs and extending the nest farther upstream. More eggs are deposited and the process repeated until she is spawned out. After spawning, all Pacific salmon die, whether they are large or small, male or female. A few may last a week, or even two, but none lives to spawn again.

Eggs hatch in 50 or 60 days at California temperatures, and in the next three or four weeks the young wriggle up through the gravel to the water above. When newly hatched, the young have a large pink yolk which gives them a tadpole-like shape. They live off this yolk until it is absorbed and then start feeding on minute forms of life in the stream.

In California most young king

[1] *Paper presented at Nineteenth Annual Meeting, American Society of Range Management, New Orleans, Louisiana, February 1 to 4, 1966.*

salmon migrate to the ocean in the first few months. A small percentage wait in the stream until they are over a year old before this migration. These yearlings are seven to ten inches long and are often taken by trout fishermen.

In the ocean many king salmon stay relatively close to the mouth of the river in which they are spawned, but many others migrate long distances. Salmon from the Sacramento River move down California's coast in quantity to Monterey Bay and also as far north as the northern part of the State of Washington. A relatively smaller number go as far north as Vancouver Island, Canada. Of the salmon taken in the vicinity of the Golden Gate, over 90% are from the Sacramento-San Joaquin River System. Farther north the percentage drops off, but even in northern California, more than half of the king salmon taken in the commercial catch are Sacramento River fish.

When a salmon approaches maturity, it returns to the stream from which it migrated to the ocean. Relatively few salmon will ascend any other river system. "Straying" into the wrong tributary is somewhat more common and it has been demonstrated in the Central Valley of California that salmon which were bound for a certain tributary would ascend another if their home stream was not accessible to them.

The greater part of California king salmon mature when four years old; but many mature at three. Five-year olds are less common, sixes are rare, and sevens are almost unknown. Large numbers of precocious males mature at two years of age; these fish weigh about three pounds. Relatively few females mature at this size and age however.

Although somewhat similar in appearance, steelhead trout are considerably different from king salmon. Steelhead trout are known as the sea-going rainbow trout. In general most steelhead enter streams in the winter and spring, but in the Sacramento River the principal migration is during early fall and winter. Steelhead spawning resembles that of salmon, but the young fish spend a much longer time in the creek. Young steelhead usually remain in fresh water one or two seasons before migrating to the ocean; some remain three seasons, and a few for even longer.

After reaching salt water steelhead grow rapidly and usually return to spawn in their home streams after one or two seasons in salt water. Unlike salmon, steelhead do not necessarily die after spawning. The rigors of migration and spawning do cause a high mortality, but fish that have spawned two or three times are not at all uncommon. Because juvenile steelhead remain in the stream a long time, their habitat requirements differ from salmon. Spawning areas are usually the limiting factor in the fresh water requirement of king salmon, while nursery or rearing areas are generally limiting in steelhead protection.

Values

The average fall-run of king salmon in Battle Creek is estimated to be about 12,000. In the lower six miles of Battle Creek there are about 4.5 mi of stream that have excellent spawning habitat.

Let's examine the life cycle of 100 adult salmon that reach the spawning bed in Battle Creek. The California Department of Fish and Game, based on records over a period of years, estimate that 400 of the progeny of the 100 adult salmon live to reach maturity. Of this number 240 would be caught commercially, 60 by sport fishermen, and 100 would return to perpetuate the spawning cycle. It is interesting to see what happens when one puts a commercial benefit value on each of these fish. The net commercial benefit value is $4.08/fish, which is determined by taking the average weight of 12 lb. times 34¢/lb. Sport salmon fish-value of a day's salmon fishing is $1.80. It takes three days of ocean sports fishing to catch a salmon (3 x $1.80 = $5.40) and seven days for a river-caught fish (7 x $1.80 = $12.60). The composite sports value weighted on the basis of 69% being ocean caught and 31% being river caught is $7.65.

Therefore, the value of the fisheries in Battle Creek for the average run of 12,000 spawners is estimated to be as follows:

Net Commercial: 28,800 @ $4.08	$117,504
Sport (both ocean and fresh water) 7,200 x $7.65	55,080
Total annual value	$172,584

Each spawner thus has an estimated value of $14.28, and each acre of spawning habitat has a value of $17,258/acre/year.

In the 4.5 mi of stream there are about 10 acres of salmon spawning habitat. At a reasonable interest rate of 5%, one acre has a capital value of $345,160.

The value of one acre of gravel in Battle Creek may be estimated in another way; that is by figuring the cost of replacing one acre of natural spawning gravel by an artificial spawning channel. The 2.8-acre Comanch spawning channel in the Mokelumne River costs about $750,000 or $270,000/acre. Spawning channels in Canada, Oregon, and Washington have been estimated to cost from $120,000 to $470,000/acre. Streams such as the Fraser River with the spawning stream bed of 305 acres have produced a Sockeye salmon pack valued at as much as 50 million dollars at the cannery; this is about $160,000/acre annually. At 5% interest this represents a capital value of $3,200,000/acre.

Clearly, gravel made unsuitable for spawning or extracted from salmon rivers for other uses produces only a small fraction of the value produced when used for salmon production.

Management Practices

Battle Creek in the winter months is subject to flash floods which erode the land and leave mounds for compacted gravel in the stream. In the summer months we go in with bulldozers and push the gravel from the inside of the curves to the outside to increase the width of the channel by 100 to 150 ft. The gravel is left loose in a wide channel bottom. It is this area which creates ideal spawning beds for salmon and steelhead. In moving this gravel we exercise every reasonable precaution to prevent muddying or silting the creek.

Whenever possible, prior to the removal of materials from the channel bottom of the live stream a gravel barrier separating the stream channel from the removal area is constructed in such a location that it will prevent silt or mud from entering the stream. This barrier is kept intact as much as possible throughout the period of operation. Every precaution is taken to avoid siltation. Siltation caused by the rolling effect of a dragline or bulldozer operation can suffocate downstream eggs and fry and also destroy organisms in the water necessary for fish survival.

We conduct our operation in such a manner that the fish will have free passage at all times. Only when absolutely necessary or when we are making the final crosscuts with the bulldozer, do we operate directly in the live-stream channel. We keep the removal of living vegetation to the minimum; however, when it cannot be avoided, exposed banks are revegetated by seeding grass or other good binding vegetative cover to reduce bank erosion and stream turbidity.

We also encourage the growth of overhanging trees and other vegetation along the banks, which supply the fish with considerable food from insects falling into the water. We schedule the necessary work in the stream beds to those periods of time when spawning fish are not present and when eggs are not incubating in the gravel. In general this is February through May for steelhead and October through February for king salmon. We have found that an irregular bottom is much better for fish production than a smooth bottom. Therefore, in excavating new channels no back-blading is done by the bulldozer in the final cuts across the channel. By not back-blading the bulldozer will leave ridges or berms a blade width apart. These berms create the riffles necessary for a good spawning bed.

In this work we have the close cooperation of the Department of Fish and Game of the State of California. Also the work we are doing is right along the lines of the U. S. Department of Agriculture's endeavor to encourage conservation measures which also have recreational and wildlife benefits. The California ASC State Committee encourages this very type of multiple land use practice through the Federal Agricultural Conservation Program.

I hope I have given you a little insight to the possibilities of preserving and improving, in one operation, our beef and fish supply of food for our tables while at the same time our fish supply for the sportsmen.

Does Your Range Have Wheatgrass Bugs?

J. W. BOHNING AND
W. F. CURRIER
Range Staff, Santa Fe National Forest, Santa Fe, and Branch Chief, Range Improvement, Albuquerque, both of Forest Service, U.S.D.A., in New Mexico.

Highlight

Introduced wheatgrasses furnish a considerable amount of forage on western rangelands. An insect, *Labops hesperius* Uhler, commonly called the wheatgrass bug, is attacking wheatgrasses in epidemic numbers in several western states. Early development of satisfactory control measures is essential to assure preservation of wheatgrass stands.

Plantings of various species of wheatgrasses (*Agropyron* spp.) have long enjoyed a unique position in range rehabilitation work. They are well adapted to many different local situations and have aided immeasurably in supplementing native forage species, lengthening the grazing season, or providing supplemental management units. Now, in some areas, this position is being challenged by a wheatgrass bug, *Labops hesperius* Uhler. In epidemic numbers, the bug drastically reduces the herbage production of wheatgrasses, and after repeated attacks it has been known to kill the grass plants.

The most obvious evidence of large numbers of the bug is the appearance of patches up to 20 ft in diameter, usually circular, of yellowish to whitish foliage within an otherwise healthy stand (Fig. 1). These patches are easily recognizable. The insect apparently has been present in the western states for many years, but population upsurges sufficient to cause concern have been reported only recently (Denning, 1948).

Distribution

The seriousness of the problem is amply shown by the roster of states from which it has been reported: Arizona, Colorado, Idaho, Montana, Nebraska, New Mexico, Oregon, South Dakota, Utah, Washington and

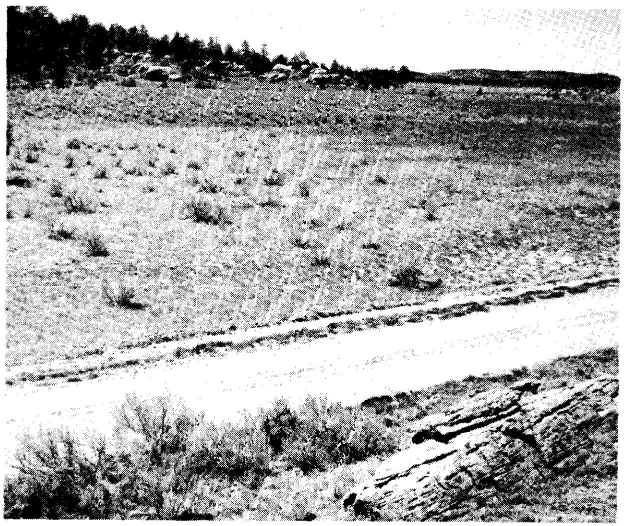

FIG. 1. Crested wheatgrass damaged by wheatgrass bugs.

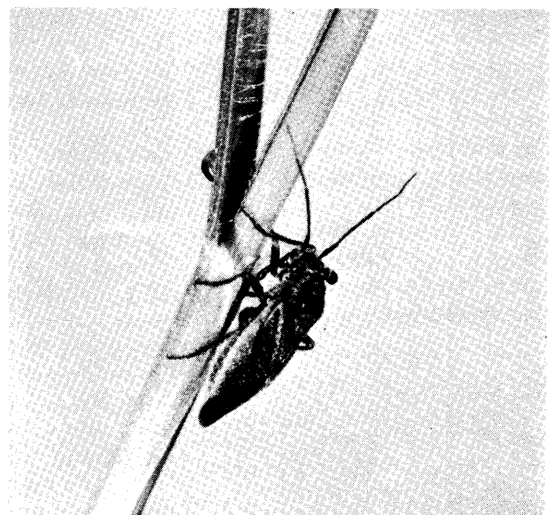

FIG. 2. Adult *Labops hesperius*.

Wyoming. These states include almost all states in which wheatgrass plantings are an important part of the range revegetation program. Canada is also plagued by this pest, with damage reported from Alberta, the Yukon, and British Columbia (U.S.D.A., A.R.S.).

The bug epidemic has been of serious proportions for at least five consecutive years in Utah. In two counties alone, 58,000 acres of crested wheatgrass plantings have been severely damaged (U.S.D.A., A.R.S.). In New Mexico, on the Santa Fe National Forest, 10,000 acres were reportedly attacked by the bug in 1966.[1] The bug was found to infest Montana wheatfields and did much damage in 1938, and again in 1951 and 1952, when it moved into wheat from adjacent crested wheatgrass plantings. Bug damage in Montana was described by Mills (1939, 1941) on grassland on the Crow Indian Reservation in 1938, and on wheat near Bozeman in 1939.

Since reports of damage have appeared only recently, a question might be asked regarding the origin of this insect. Has it been here all along, or was it imported from an outside source? According to Wilford,[2] the wheatgrass bug is probably native. He refers to an 1871 survey in which the bug was described. It was also identified in Colorado and Montana in 1900 (Knight, 1922).

Damage

Why, then, has the wheatgrass bug assumed importance as a dangerous range pest only in the last few years? Probably because in recent years, we have greatly expanded our acreage of seeded range land. These seedings apparently provided an optimum habitat for a native bug, and populations of the insect increased to epidemic proportions in a short time.

The bug increases very rapidly under favorable conditions. On a ranch near Doylesville, Colorado, a 0.25-acre infestation in 1962 expanded to approximately 400 acres in 1963.[2] On the Santa Fe National Forest, a 0.25-acre bug colony first detected in 1962 spread to over 10,000 acres by 1966.[1] Both of these eruptions occurred primarily on crested wheatgrass plantings.

The yellow or whitish patches of vegetation caused by the bug reflect severely depleted vigor and production of the affected grasses. In Utah, losses in production up to 50% have been reported (U.S.D.A., A.R.S.). On the Santa Fe National Forest, a decline in production of 10 to 60% was observed. Hay yields in Wyoming were halved by insect attack. In Colorado, bug-infested plants attained only one-third the height growth of uninfested grass.

Repeated infestation can eventually kill the host plants, and does so even more quickly where other factors, such as drouth or heavy grazing, have exerted depreciating pressures on plant vigor. Plant mortality attributable to the bug has been observed on the Santa Fe National Forest in New Mexico.

Although often called the crested wheatgrass bug, it is known to attack other grass species as well. It has been found feeding on pubescent wheatgrass (*Agropyron trichophorum*), intermediate wheatgrass (*Agropyron intermedium*), and other wheatgrasses, plus various native species. Slater (1954) cites records of the bug feeding on prairie Junegrass (*Koeleria cristata*), Sandberg bluegrass (*Poa scunda*), needleandthread (*Stipa comata*) and others.

Life History

What does *Labops hesperius* look like? The adult grass bug is described by Agricultural Research Service entomologists as being about 0.25 inch long, dull black in color (except for the wing covers, which have a pale yellow streak along the edge). It has pale yellow spots on the head and large black eyes which project to the sides on narrow stalks (Fig. 2). Nymphs are overall pale green in color, shading to darker green and then black as they mature to adulthood. Young nymphs measure about 1/32 inch in length. *Labops hesperius* is a true bug, a member of the order *Hemiptera* and the *Miridae* family. It is a sucking insect, and damages the plant by sucking the plant juices (Fig. 2). Removal of the chlorophyll creates the distinctively discolored grass patches. Whether or not the bug feeds actively throughout its life cycle has not been established.

In all stages, the bug is extremely active and hard to catch. They are easily disturbed while feeding, and when disturbed fall to the ground and disappear into earth crevices or plant debris. This hyperactivity probably should be considered in devising possible control measures.

Very little formal work has been done to describe the life history of the wheatgrass bug. During the spring and early summer of 1966, Charles Brandt of the Santa Fe National Forest conducted a study to collect information on the insect's life cycle. He began field observations on March 16 and made frequent observations until all insects had disappeared, about June 1. Further north, an insect had been collected in Colorado in mid-July, but it was a sole observed survivor of bugs reported to be abundant in early June. In Wyoming, the bug was found to be most plentiful during May and June.

In the 1966 study on the Santa Fe, nymphs were first seen on March 29. As the season progressed, nymphs were repeatedly observed, even after mature adults were reported to be mating on May 6. By May 24, a decline in numbers was noticeable, and by May 31, they had disappeared, except for a few scattered individuals. Attempts to find the location of egg deposition were fruitless. Entomologists state that the grass bug probably over-winters in the egg stage, and that there is only a single generation per year. Both points need further study.

Control

The wheatgrass bug's taste for native grass species certainly must be considered in designing control measures. The earliest report of experimental control efforts in 1948, involved DDT compounds (Denning, 1948). A pilot spraying project was carried out on seeded stands on the Cuba Ranger District of the Santa Fe National Forest in May 1964. A helicopter was used to apply malathion at a rate of 0.5 lb/acre, in a diesel oil carrier, on 900 acres. Spraying was limited to areas where populations were greatest within the

[1] *Brandt, Charles J., 1966. Crested Wheatgrass Bug Study. Forest Service report. 10 p mimeo.*

[2] *Wilford, B. H., 1963. Crested Wheatgrass Damage, Gunnison National Forest, 1963. Forest Service report. 10 p. mimeo.*

infested area. However, wheatgrass bugs were again found in the treated area the next year.

Increased reporting of wheatgrass bug damage shows not only an expanding problem, but also a wider recognition of the problem. This increased recognition is resulting in an accumulation of knowledge cataloging the strengths and weaknesses of the bug. As an example, the first specific effort to observe and record the bug's life history was made in 1966.[1] It is hoped that dissemination of the limited information obtained in that study will stimulate additional work. This could lead to the development of effective control methods. The wheatgrass bug does, in fact, pose a very serious threat to an important segment of the western range resource. The need for early development of adequate control measures presents a challenge which must be met.

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BOOK REVIEWS

The XIT Ranch of Texas and the Early Days of the Llano Estacado. By J. Evetts Haley. *The University of Oklahoma Press, Norman. 259 p. 1967. (Western Frontier Library Edition.) $2.00.*

Would you contract to erect a state capitol building for Texas in exchange for three million acres of "the great American desert?" Such a trade actually was made in the early 1880's between the state of Texas and Taylor, Babcock and Company of Chicago. The development of the land grant as an operating ranch was compiled from interviews with cowboys and other persons connected with the ranch, from newspapers and other popular writings of the time and from files supplied by the Capitol Freehold Land and Investment Company, the successor to Taylor, Babcock and Company.

Mr. Haley operates his own cattle ranch at Canyon, Texas, not far from old XIT country. In one biography he is listed as a cowpuncher at the age of nine years. He is an accomplished historian, and his writings are as comfortable as a good saddle. In this book he has blended together 15 distinct stories into a single volume of interesting history, which by his own admission, "makes no pretense of telling the whole story."

The stage is set with a brief review of the early history of the region, beginning with the Spanish explorations. The story really begins with land-poor country legislators "down in the skillet" seeking to pawn off three million acres of desert Panhandle land on an unsuspecting city Yankee in exchange for a state capitol building second only to the Capitol at Washington. This was countered by the vision, resources, and determination of John V. and C. B. Farwell and their colleagues who had helped transform Chicago from an overgrown frontier town into a business metropolis. When the Farwell dream of colonizing the grant with farmers proved impractical at the moment, they turned to the alternative of ranching in an orderly and systematic way. Their first act was to order a careful inspection of the land they had contracted. The surveying and fencing were organized in minute detail. By the late 1890's the XIT had more than 1500 miles of 4-wire fence, the top wire of which served also as a telephone line. Windmills were set up over wells and tanks were constructed hardly in time for the first cattle which arrived in 1885.

The real strength of the book for range men is found in the organization and operation of the ranching units. There are a number of practical lessons. Good management is illustrated as a firm hand, definite work rules, and delegated authority. For business operation the ranch was divided into management units, each of which was independent and concerned with only one breed of cattle or class of animal. Detailed and systematic reports were required of all supervisors. Financing involved the solicitation of foreign capital and the merging of the original company into the organization of the newly-formed enterprise. The XIT brand is considered by many to mean "ten (counties) in Texas." Its real utility was that it was easy to make, and was rather difficult to alter. The foundation herd of the XIT Ranch was Longhorn, but the ranch compared the performances of Angus, Hereford, and Shorthorn cattle under range conditions. In the transition from the original Longhorn stock, the XIT built in 24 years the largest herd of Polled Angus cattle in Texas. By 1900, XIT cattle were sought by feeders from throughout the Middle West.

The first colonizing began in 1890, when some 80,000 acres were cut into farming tracts. The real land rush began shortly after 1900. Large blocks of land were sold wholesale, to be further divided and sold retail as farms and ranches. When the Capitol Reservations Lands were liquidated December 31, 1950, the original three million acres had been reduced to a mere 20,000 acres. Some of the family descendants still hold mineral rights under some of the original lands as the Capitol Mineral Rights Company of Chicago. Other memorials such as the Panhandle town of Farwell also persist.

The complete records of the ranch were given to the Panhandle-Plains Historical Society of Canyon, Texas. The original edition of this chronicle was commissioned by the Farwell family as a memorial to their people, their associates, and their cowboys. It has long been out of print, and is sought as a collector's item. This new edition has been selected by the University of Oklahoma Press as Volume 34 in their Western Frontier Library series. The new ediiton did not seem to suffer any condensing in the re-printing. In fact, the new edition has an added index and bibliography. — *Wayne G. McCully,* Texas A&M University, College Station.

History of North Dakota. By Elwyn B. Robinson. *University of Nebraska Press Lincoln. 599 p. 1966. $7.95.*

North Dakota is not primarily a range region, as Robinson points out in this one-volume history, although the original vegetation of the state was almost entirely grassland. The typical ways of the open range came only to the Little Missouri Valley, about 50 to 60 miles from the western border of the state. Farther east, the small ranchers followed a middle course between the methods of handling cattle in the humid East and those on the open range of the semiarid West.

Probably because of this fact Robinson treats the grazing industry in North Dakota and the background of its development barely adequately, and without much detail. Range men will probably be somewhat disappointed in the conventional, although perceptive, treatment of the historical areas in which they would be particularly interested.

As a history of North Dakota, however, the book is excellent. It is an intensely interesting and analytical account of the political, economic, and cultural life of the people of the northernmost Plains state. Robinson's history of the state is woven around the six themes which he finds to dominate the North Dakota story: remoteness, dependence, economic disadvantage, agrarian radicalism, the "too-much-mistake" (trying to do too much too fast with too little), and adaptation to environment. He feels that every event in the history of the state is related in some way to one or more of these themes.

The chapters on "The Progressive Movement," "The Great Socialist Experiment," and "A Socialistic State in the First World War" examine impartially the background and development of the remarkable political and economic actions which culminated in the rise and then the ultimate decline of the Nonpartisan League. If one is familiar with the background of these events, he essentially has the key to understanding the North Dakota of today. The over-all dominating influence of the wheat crop, and the resulting close dependence of the economic welfare of the state on the milling and wheat marketing interests of the Twin Cities, is a theme which still has pertinence in the events of the present day.

Dr. Robinson is a professional historian, a fact which is made manifest by the precise organization of the book and the clarity of his writing. He is Professor of history at the University of North Dakota and has been on the faculty there since 1936. Probably the principal achievement of the book is to bring into relevant focus the events and forces which have shaped the history of the state and its people since 1900. Persons concerned with the details of pioneer history will still want to consult the Lounsberry and Crawford sources as well as the specific articles in *North Dakota History.* Without doubt the Robinson book stands as the clearest and most meaningful interpretation of the brief but colorful history of the 39th state.

The book is attractively bound, and the typography is excellent. The typographical excellence of the book is marred, however, by the concentration of the illustrations in a 32-page section near the center of the book. As is always the case with this procedure, the essential value of the illustrations as an enhancement of the text material is completely lost. —*Warren C. Whitman,* North Dakota State University, Fargo.

Public Land Classification. The Bureau of Land Management expects this year to classify 40 to 50 million acres of public land for retention and 500,000 acres for disposal, under the Classification and Multiple Use Act of 1964. Numerous public field hearings on the classification proposals are in prospect during the next few months. In hearings to date, public sentiment has strongly favored retention of public lands for multiple-use management. Most of the areas considered in hearings so far have involved lands proposed by BLM for retention.

CURRENT LITERATURE

Edited by Meredith Morris, Charles Terwilliger, Jr., and Graduate Student-Faculty Seminar members, Range Management Department, Colorado State University, Fort Collins, Colorado.

Continued from May, 1967 issue of the Journal

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NEWS AND NOTES

Material from many sources; not necessarily the opinion or position of the EDITOR or OFFICERS of THE AMERICAN SOCIETY OF RANGE MANAGEMENT

RANGE AND WILDLIFE CHIEF

John S. Forsman, who has been in the Forest Service Chief's office since 1963, succeeds Avon Denham as assistant regional forester in charge of range and wildlife management for the Pacific Northwest Region of the U.S. Forest Service. A graduate of the University of Montana, Forsman was supervisor of the Custer National Forest before his transfer to Washington.

Water Protection High on Legislative Agendas

More than 700 measures touching on water supplies and pollution control are now being considered by legislatures of the 44 states now in session, says Commerce Clearing House in their recent News Bulletin.

These measures deal with flood control zones, pollution control schedules, water pollution taxes, water authorities, sanitary and sewer facility financing, state water control compacts, soil erosion and siltation and refuse in waters.

Connecticut presently tops the list of water-related proposals with no less than 76, while New York is considering 62 measures and Oregon and California are studying 46 and 45 bills, respectively.

The legislatures of Illinois, Indiana, Maryland, Minnesota, Texas, Washington and West Virginia each have at least twenty separate measures touching on some aspect of water that are under study, said CCH, publishers of WATER CONTROL NEWS.

While the total includes some duplicate measures introduced in both houses in some of the legislatures and similar or almost identical bills offered by two or more members, it also suggests water law proposals are high on 1967 state legislative agendas, CCH said.

With Florida slated to convene in April, and Alabama and Louisiana in May, the volume of state water control proposals in 1967 could possibly be the heaviest ever.

KLING L. ANDERSON: It is with regret that the Journal publishes the news that Kling Anderson of Kansas State University is forced by Multiple Sclerosis to retire from his classroom and the bluestem prairies where he became a world authority in range management.

Kling, a charter member of the Society has devoted his knowledge, ability and enthusiasm without stint to the Society, having been active on several committees, chairman of the Program committee for the Society convention in 1964 and an officer in his Section.

A scholarship in his name will be established at the University. Anyone wishing to contribute or to write a letter to Kling may address Agronomy Department, Waters Hall, Kansas State University, Manhattan, Kansas 66502.

REPRESENTS WILDLIFE SOCIETY

James D. "Jim" Yoakum of the B.L.M. in Reno, Nevada was recently installed as representative from Region 8 of The Wildlife Society.

PESTICIDES AND PUBLIC POLICY

Senate Report #1379 prepared by the Subcommittee on Reorganization and International Organizations (Chairman, Senator Abraham Ribicoff), is a result of 15 months of hearings and study examining the role of the Federal Government in dealing with one of the great problems of our time: *Man's contamination of his environment.* The main thrust of the study is directed to use of pesticides, and endeavors to answer the question, "What is the total effect on a man-induced change in the environment on the quality and quantity of our civilization?" The report concluded that:

. . . Predictions of impending disaster arouse great anxieties because the public is not well informed.

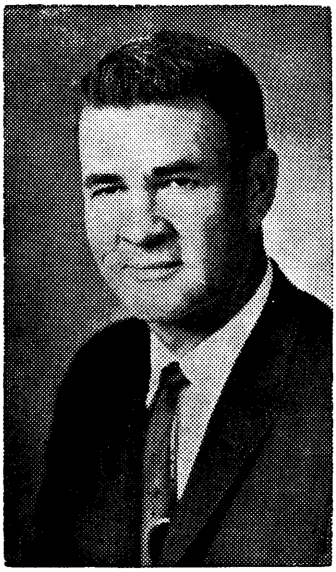
. . . The magnitude of the future benefit-risk equation is uncertain in many important areas.

. . . Much more information is needed to guarantee future balance of the benefit-risk equation and to assure public confidence.

Recognizing that the development and use of chemical pesticides has produced immeasurable benefits for mankind, that continued and expanded pest control will be necessary and will require integration of all the methods which scientists can devise, the Ribicoff Report is intended to assist Members of Congress to identify issues where further study or legislation may be considered appropriate.

John R. McGuire, a Society member formerly with the California Section, has been appointed Deputy Chief of the Forest Service in charge of Programs and Legislation. Mr. McGuire served as Director of the Pacific Southwest Forest and Range Experimentation Station at Berkeley, California from 1963 to the present.

Dr. Waldrip Named Supervisor of Spade Ranches



Wm. J. (Dub) Waldrip, project leader of the Texas Experimental Ranch since 1958, has been named General Supervisor of the Renderbrook-Spade Ranch, south of Colorado City and the Chappell-Spade Ranch, northwest of Tucumcari, New Mexico, it was announced by Frank H. Chappell, Jr., Partner and Owner of these two ranches.

Dr. Waldrip has an earned Ph.D. from Texas A & M University in August, 1962. He had received his B.S. and M.S. degrees from Texas A & M in 1949 and 1950.

Dr. Waldrip has served as advisor in research, teaching, and extension at the state college of agriculture at Saltillo, Coahuila, Mexico. In 1958 he became project leader of the Texas Experimental Ranch at Throckmorton, and is serving as a member of the Board of Directors of the Swenson Land and Cattle Company.

He is a director of the American Society of Range Management, Texas Section. He is recognized as one of the outstanding authorities on the subjects of range management and brush control and has contributed many articles on these subjects to government and ranch publications.

Tropical Grasslands

This new Journal, the official publication of the Tropical Grassland Society of Australia, contains the proceedings of the Societies' quarterly meetings and contributed articles reporting the results of applied regional research in species testing, pasture evaluation, animal performance studies and soil fertility studies, critical field observations, documented case studies of successful primary enterprises, letters to the Editor and reviews.

Issued twice yearly, May and October, $A5 per year.

Information concerning subscriptions from:

The Business Manager,
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QUEENSLAND. AUSTRALIA.

Dr. Henry A. Wright has joined the Range Management staff at Texas Tech as Assistant Professor of Range Management. Dr. Wright received his B.S. degree in 1957 from the University of California at Davis, and completed his M.S. and Ph.D. degrees in 1962 and 1964 at Utah State University.

At Tech Dr. Wright will teach range management and range ecology courses and conduct range research with primary emphasis on brush control.

Range Management in West Pakistan was initiated in 1954 when the Muslakh Range Management Project became operational. The Project was a joint effort of the West Pakistan Government and US AID. Hoy Connelley was the guiding spirit during these early days.

Since that time Range Management in West Pakistan has grown in importance, interest generated and area involved. By 1964, Range Management project areas were located throughout the Province. To administer these projects a Range Improvement Cell had been established. US AID was active in this through the presence of Norman H. French.

By 1965 Range Management was so conspicuous a part of the wildland management activities of the Province that it was considered feasible and advisable to hold a conference of all persons working in Range Management. Several attempts to convene the conference were made but success was not achieved until July 1966, when it was finally agreed that a suitable time would be October, 1966.

So it was that on 5 October, 1966, the first Range Management Conference for West Pakistan was inaugurated. Approximately forty people attended the conference. Included were personnel from all forest regions in the Province and from other governmental departments. Twenty-three of the twenty-seven papers read were prepared and delivered by Pakistan personnel. Most aspects of range management were covered by at least one paper.

The Conference was organized by Mr. M. I. R. Khan, Director, Pakistan Forest Institute; D. L. Goodwin, FAO Expert in Range Management and Mr. M. Nazir, Range Management Officer. Participants from outside Pakistan included C. Kenneth Pearse, FAO; Robert S. Rummell, Jon J. Norris from the U.S.A.; and Mr. Hugh Martin from Turkey.

It appeared that considerable enthusiasm was generated by the conference. Those who attended suddenly realized that they belonged to a sizable active group engaged in a necessary and valuable activity. For these reasons in addition to the benefit gained through exchange of ideas and problems, the Range Conference was judged to have been successful.

Subsequent to the Conference there has developed a desire for a Range Management Society of Pakistan. An ad hoc Chairman has been appointed and a constitution is being written.

LETTERS TO THE EDITOR

Letters may be accepted for publication which contribute to the objectives of the American Society of Range Management. The Society however, assumes no responsibility for statements and opinions by contributors.

(Editor's Note — So many letters of interest to Journal readers were received during the first four months of 1967 that we can publish only portions of each. —*R. S. Campbell)*

Dear Bob:

Congratulations on the November issue of the Journal — naturally my interest was on the space allotted to foreign activities. When I was with FAO in Rome in 1959-60, the interest in range management wasn't much. As opportunities came, I was busy telling the men that a major portion of this globe would never be cultivated and that to get the most out of these areas in food and fiber, wildlife, and water, it is necessary to manage native vegetation — Range Management. A lot of other folks in recent years have pounded the same drum. It is very gratifying to me to view the progress; today many of our Range Society members are on the ground showing people how they can get more out of their renewable resources.

Down under, the folks I have been working with are capable and dedicated to the improvement of their countries' natural resources. They have many hurdles to cross, social and political as well as technical, but I am sure they are on the way. . . . There is progress.

Regards,
Orval E. Winkler
Villa Elisa, FCNGR, Argentina

Dear Sir:

As an interested member of the ASRM and a working range manager I would like to offer some suggestions. I believe the ASRM should publish only one magazine. It should include abstracts of pertinent research publications similar to the papers in the technical notes section and the sources where the full publication could be obtained. The Journal should include a national and international "outlook", including bills before Congress, action on these bills, and analysis of proposed legislation. The articles should be concerned primarily with practical application of research and know how on-the-ground. I would also favor one or two articles in each issue written by nationally recognized authorities, politicians, policy makers, etc. on the interrelationships of their endeavors with range management and the professional stature of range managers. I believe a classified ad section on job positions wanted and available would add interest.

Regardless, the Journal is the most readable and interesting publication of its kind available.

Respectfully,
Joe L. Frazier
Circleville, Utah

Dear Bob:

I have some concern over the new Journal scheme, which puts a charge on all pages over four per article. It may be injurious to the Journal as a scientific profession. I realize the need for page charges, and agree that they are part of the cost of doing and reporting research, but I believe a different charge procedure may be more effective.

Many journals set a flat page rate and thus do not necessarily discriminate on length of the articles. Some journals which do set limits on length of articles use various devices to get more information on a single page than the Journal of Range Management. I feel the new scheme of charging eventually will result in more applied articles, fewer comprehensive scientific research articles, fewer comprehensive review articles, and a loss of professional stature and image for the field of range management.

I think the following procedures would be more effective. First, assign a flat per-page charge. Impose additional charges for setting up complex formulae and for an excessive amount of tabular or illustrative material. Provide a means, subject to the editor's discretion, to allow unsponsored research or notes to be published with partial or no charge.

It appears to me that you are depending upon people who write scientific articles to carry the weight of publishing in the Journal. Perhaps this is necessary. However, if we are to improve the science phase of the art and sicence of range management we are going to have to attract more scientific articles to the Journal. Many of these articles have already been sent to other journals because they did not easily fit within the six-page limit. Now, with a four-page limit I'm afraid we may lose even more scientific articles. Perhaps this can be overcome if it is made clear to the authors and to the reviewers that an article is to be considered on its total merit, not whether or not it will fit within a four-page limit even if the author can get the additional costs sponsored.

Sincerely yours,
George M. Van Dyne
Fort Collins, Colorado

(Editor's Note: Van Dyne's last point is well taken — It should be made clear that papers longer than four printed pages are welcome. The Journal operates on a very tight budget and some way must be found to accommodate the increasing number of good scientific and applied mss submitted. As stated in the May, 1967 Journal (20:192), we do hope to encourage all authors to write more clearly and concisely. But the main purpose of the page charge is "to let the authors' agencies bear part of the cost of longer papers." There is legal difficulty with the various U. S. departments and some State agencies in the proposal to charge some papers and not others.— *R. S. C.)*

Dear Prof. Poulton:

I have read with great interest your editorial, "What Are We Going to Do About It?" in the March, 1967 Journal (20:63). I will tell you what I have done about it, in the hope that perhaps the Society may wish to help.

Last summer our son took about 1500 color photos of the American native grass lands. Dozens of these will be appearing during the next two or three years in several national magazines, along with articles which my wife and I have written. These pictures are truly breath-taking.

We have just signed a contract for the publication of a beautiful 36-page, 11 x 11-inch art book, including 43 of these photos, telling the story of grass, conservation, and range management in simple but highly poetic language which we believe will appeal to all Americans. Publication date is July 1. It will be on sale at the National Grassland Field Day and Conference in Lincoln, and subsequently in bookstores, museums, art galleries, etc., over the country. The first printing is for 50,000 copies.

We hope to reach millions of people with this message, in one way and another. There should be quite a bit of "spin-off" from the book and the magazine articles. For example, an art exhibit of the photos is in prospect, for showing at art museums over the country. An eastern textile designer is considering a series of prints based on native-grass designs. With a little help, it might turn into quite a tidal wave.

There are several ways in which the Society could help, if it so desired, especially in encouraging acceptance of the book in educational institutions, public schools, etc. We plan to get out a series of teaching aids for use with it.

Sincerely yours,
Jim Wilson
Polk, Nebraska

Dear Mr. Wilson:

I certainly appreciate your response to my editorial, "What Are We Going to Do About It?" One of the things an editorial of this nature can do is to bring to the fore things that are being done and which more of us need to know about. I wish we had 500 or 1,000 doers like you in ASRM.

I am sending a copy of your letter to Don Huss, chairman of our public relations committee. While I do not feel that the Society should officially promote the work of others where the purpose is financial gain from sale of writing, I certainly think there are some things we can do together to tell the story of range management. Some of these possibilities may fall within the purview of our public relations committee. When your book is ready we should have a review of it in the Journal.

I would also suggest that you contact the Executive Secretary, Science Teachers Association, Washington, D.C. They may be interested in the book for its possible use in high school science teaching.

Another thing your son might consider is the possibility of making some of his pictures available to teachers of ecology and of high school biology. Their salability for this purpose would depend largely on how well they are annotated in terms of the location and kinds of vegetation or species represented.

I hope these comments will help you to continue your fine work in the promotion of range management, range resources, and grass. You will do the Society, and those of us professionally engaged in it, a great service if you can help bring about a more widespread appreciation of the importance of range resource areas throughout the world.

Sincerely yours,
Charles E. Poulton
Corvallis, Oregon

Dear Sir:

I have a few comments on Mueller and Harris article "Economics of Selected Alternative Calving Dates" (JRM 20:67-69, March, 1967).

1. Late spring calving means breeding the cows during the heat of summer, which tends to reduce conception and lengthens the calving period. Also bulls are less inclined to travel.
2. Late spring calving usually occurs when there is other spring work to do, such as farming and fencing. As a result more labor must be hired or some jobs will be neglected. This same thinking could also be applied to fall calving when there is harvesting to do and grain to plant.
3. Early spring calving makes better use of available labor. Also the cows are confined where they can be easily watched, especially the first-calf heifers. The calf crop is based on good management and should be just as high as other calving periods as long as the cow herd receives the rancher's undivided attention.

Sincerely,
Charles M. Jareki
Polson, Montana

Dear Mr. Jareki:

You have made some very pertinent observations regarding factors which influence the economics of cattle operation. Your point on breeding during the heat of the summer (July and August) for late spring calving (April 15 to June 15) is well taken. However, summer temperatures interfere less when the cattle are on high mountain summer ranges, as was the case for the ranch operations surveyed in our study. Evening and morning temperatures are relatively low, even in July and August. These are the times when the cattle are gathered together on the bed grounds, or moving toward a gathering at water. And these are the natural times when the bulls contact the cows. During the heat of day, both cows and bulls apparently have other things on their mind. And, there are some hot days in May and June (breeding time for early spring calving) at the lower elevations where cattle spend these months.

Admittedly, the cow man has fewer important things going on to distract his attention from calving in early spring than late spring. And it is a natural job to watch for calving difficulties while feeding. But on the other hand, a cow that is dropping her calf onto a snowbank, or into the half-frozen mud of the feed yard requires a lot more attention than one out on spring range. And furthermore, the rancher has many more hours of daylight to get his jobs completed.

From your letter it is evident that you are a good manager. But the average operator in Washington loses many early spring calves to exposure and disease (especially to infectious scours) which might be saved at the same level of care in a late spring calving situation. Our article was meant to stimulate thought. Your comments point out that there is room for differences in practice as well as opinion.

Sincerely,
Grant A. Harris
Pullman, Washington

Dear Sir:

Re: Economics of Alternative Calving Dates, by Mueller and Harris.

I have been a rancher all my life and have yet to meet one fellow rancher that doesn't want fair pay per hour of work and interest on his investment. Any industry that doesn't earn interest on investment soon becomes a declining industry — for example there is absolutely no ranch enlargement going on around here on ranch-earned money. Very few young people are going into ranch business. The article left out some words. It's a * * * hard way of life — most of us average in a year more than twice the hours of work that union members and most of the rest of the nation's workers put in.

Now, if anyone is wondering why we stay in business, we have a big investment to look after, and a lifetime of ranch knowledge . . . Anyway, who wants a soft job?

Sincerely,
West Donohoe
Luther, Montana

(Editor's Note: Mr. Donohoe's letterhead carries the pointed slogan: "ENJOY YOUR MEAL. . . . never before in history has one-hour's labor purchased the quality and quantity of red meat as grace America's tables today".—*R. S. C.)*

Dear Mr. Donohoe:

I was very pleased by your comment "who wants a soft job"? Surely you don't, any more than the other thousands of ranchers who would rather starve on a cattle ranch than increase their income by selling their land and putting the money out on interest. I am sure that ranchers get their money's worth out of doing what they like best. But as you say, there is "no ranch enlargement on ranch-earned money, (and) very few young people are going into the ranch business." You just about have to inherit it because you can't borrow the money and pay the interest from ranch-earned income.

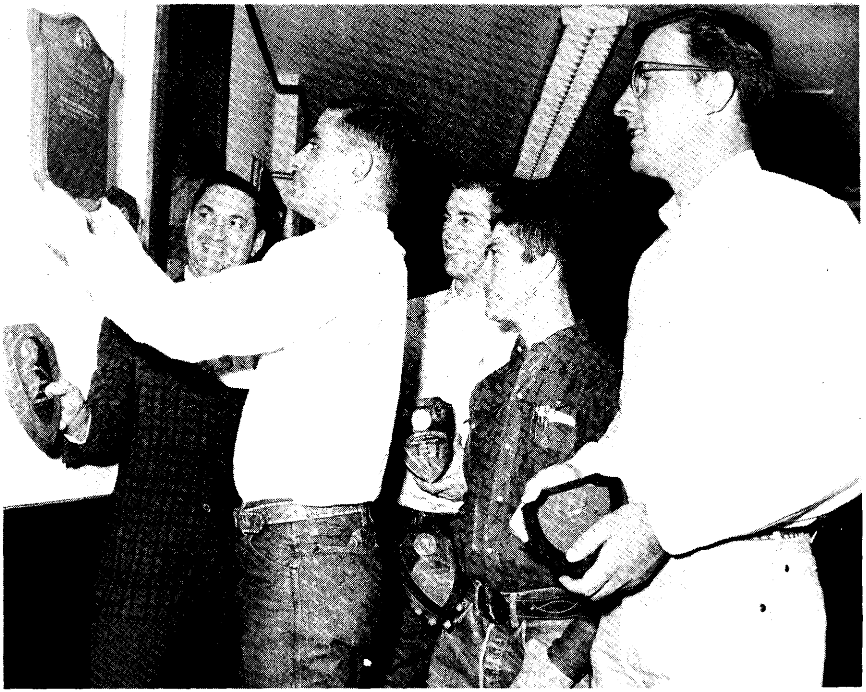
Sincerely,
Grant A. Harris
Pullman, Washington

(Excerpts from letter of March 20, 1967 from F. J. Hermann (Forest Service, Washington, D. C.) to M. M. Mathews, University of Chicago, concerning derivation of the term FORB.)

I've been under the impression that the term was coined by the ecologist F. E. Clements, and E. L. Little, of our Division of Timber Management Research, has the same conviction. The etymology given in Webster seems plausible. . . . The earliest mention of forb I've come across is in Dayton's "Glossary of Botanical Terms Commonly Used in Range Research" (USDA Misc. Pub. 110, 1931). In his "Notes on Western Range Forbs" (USDA Agric. Handbook 161, 1960), Dayton states that neither term is entirely satisfactory. The western stockman's term "weed" covers nongrasslike herbs whether palatable or nonpalatable, injurious or harmless, desirable or undesirable. And "forb" is objectionable. The Greek from which it is anglicized means food — especially forage or fodder, and applies primarily to grasses. . . .

(Editor's Note: My first edition of Weaver and Clements "Plant Ecology", copyrighted in 1929, refers to tall forbs on page 421, with a footnote that "The term forb is used to denote herbs other than grasses". In addition, I recall a visit by Clements to the Jornada Range in southern New Mexico about 1929, in which he expounded at some length on the superiority of the term "forb" over "weed" for broad-leaved herbs. Does anyone have references or recollection of use of the term forb prior to 1929? — *R. S. C.)*

WITH THE SECTIONS



Texas Tech's Range Plant Identification team won first place in the national range plant identification contest at this year's Annual Meeting of the American Society of Range Management in Seattle on February 15, 1967.

The Tech team scored 2,982 points out of a possible 3000 in winning. Jimmy Brown of Wellington and George Mitchell of Breckenridge tied for first place for individual honors with 996 points out of a possible 1000. Mike Smith of Florence was third high individual with 990 points. Alternate Roger Banner of Lubbock racked up 982 points.

Colorado State was second and the University of Wyoming third. Tech gained permanent possession of the championship trophy by sweeping the contest for three consecutive years.

Dr. J. L. Schuster is Texas Tech's coach. Tech's trip to Seattle was sponsored by the M. G. and Johnnye D. Perry Foundation, Robstown, Texas.

The Texas Section has busted the barrier! The Section Scholarship Committee has succeeded in obtaining a grant of $10,000 for ten $500 scholarships for each of the school years of 1967-68 and 1968-69. The donor is the Moody Foundation of Galveston, Texas. The scholarship will be used at any of five Texas schools teaching Range Management. None of the money may be used for administration, that being the responsibility of the Section. It is believed that this is the largest sum of money ever to be granted in a lump to the Society or one of its Sections.

Left to right:
Bayard Toussaint, Vice-President & Manager, Babcock, Fla. Ranch
K. A. Coleman, Ghana
G. M. Barangi, Uganda
Y. G. T. Aleni, Uganda
Stuart Bell, AID Technical Leader
W. S. Kpinidng, Ghana
L. L. Yarlett, Range Conservationist, SCS, Florida
F. K. Kiiza, Uganda
J. B. Hilmon, U.S. Forest Service, Ft. Myers, Florida
F. K. Mutubero, Uganda

SOUTHERN SECTION

Section members Bayard Toussaint, L. L. Yarlett, and J. B. Hilmon recently accompanied a group of agricultural technicians and students from Ghana and Uganda on a tour of south Florida range operations and research installations. Toussaint, chairman of the Charlotte Soil Conservation District and vice-president and manager of the Babcock Florida Ranch was host to the group. During the visit to the ranch near Punta Gorda, the group was shown many aspects of herd management including cross breeding and culling. Farming operations were reviewed and the group learned that after one or two years of farming, the land was planted to improved pastures. Yarlett, Range Conservationist, Soil Conservation Service, discussed the use and management of native forages and the application of range conservation practices in conjunction with improved pastures and animal husbandry. On a tour of the Caloosa Experimental Range near Ft. Myers, the group was shown experimental procedures and some of the results obtained by range and wildlife research. Hilmon, Project Leader, U.S. Forest Service, discussed rates of stocking, results of fire and effect of rock phosphate on tree and grass growth.

PACIFIC NORTHWEST

Plans are in full swing for the 1967 Inland Empire Natural Resources Youth Camp at Camp Heyburn near Plummer, Idaho, for which our society is a co-sponsor. The camp's central committee is diligently working on a new brochure and making refinements in the notebook, which was a new innovation started last year.

This year we are striving to increase enrollment from 60-75 to 100-130 boys. Surprisingly, one of the difficulties of the camp is finding boys to attend. In this regard, we are urging *all* central and eastern Washington members to publicize the camp through their local schools, service clubs, boy scouts, 4-H, etc. The brochures and applications will be available through the county agents. Any member wishing to participate in the camp as an instructor may contact Phil Hess, P.O. Box 51, Yakima, Wash. 98901. Camp dates are June 11-18, with range management being instructed on June 14.

The Pacific Northwest Section held its annual winter meeting in Spokane, Washington, November 27 to 29, 1966. Papers were divided into three general groups: Range Environment, Range and Recreation Values, and Practical Aspects of Range Management. Contributors included ranchers, public land employees, representatives from non-range organizations and university staff members.

The Range Environment was discussed in relation to synecological philosophy, fire and game habitat, soil-vegetation relationships, and woodland grazing values. Practical Aspects of Range Management included water development, range improvement, National Forest management, operation of a wheat-range organization, and problems of mixed land ownership.

Great divergence of viewpoint was expressed in the recreation section. Here ranchers, public land managers, and representatives of sportsman's organizations discussed rancher problems, compatability of recreation and range management, the recreationist's viewpoint, influences of range improvement, and recreational needs in research. No conclusions were drawn but the section members were stimulated to seriously consider many new ideas and problems.

One chapter submitted a booklet on formation and operation for chapters. Since our section is interested in forming additional chapters, the booklet seems to be a welcome addition.

The PNW Section will hold the 1967 winter meeting at Penticton, B.C. on Nov. 27-28, 1967. Brian Radford, Kamloops, B.C., is the Local Arrangements Chairman and Claude Dillon, Spokane, Wash., is Program Chairman. We will report preliminary plans following the Summer Tour at Ft. Spokane.

WYOMING

The Wyoming Section will conduct a two day summer field meeting in the Big Horn Mountains of north central Wyoming, July 21 and 22. The grazing management on selected national forest grazing allotments will be discussed. Of special interest will be discussions by ranchers and administrators on the rest-rotation grazing systems. The meeting will begin July 21 at the Deer Haven Lodge above Tensleep at 8 a.m. On July 22, the tour will begin at the research pastures near Burgess Junction. Anyone in the area at that time is welcome to attend the meetings.

Selections have been made for the annual awards to be given to outstanding range management students at the University of Wyoming. The graduate scholarship went to F. Robert Gartner. The under-graduate scholarship and the Plant Science Division honor book both went to Kenneth W. Macy, a junior from Pine Bluffs, Wyoming.

ARIZONA SECTION SUMMER 1967 MEETING
August 10 and 11

The summer meeting of the Arizona Section will be held at Chinle, Arizona, and will be hosted by the Branch of Land Operations of the Bureau of Indian Affairs. Chinle is one of the five agencies comprising the Navajo Reservation and is located in the northeast corner of the State, approximately 130 miles northeast of Holbrook. Canyon de Chelly National Monument, operated by the National Park Service is located at Chinle. This meeting will present an opportune time for many members to see a part of Arizona not well known to many Arizonans.

CALIFORNIA

John R. McGuire of Berkeley, California, a member of American Society of Range Management since 1963, has been appointed Deputy Chief of the Forest Service in charge of Programs and Legislation.

In his new position, with headquarters in Washington, D.C., Mr. McGuire will be responsible for developing and analyzing longrange forestry and conservation programs of the USDA's Forest Service.

Since August 1963, Mr. McGuire has served as Director of the Pacific Southwest Forest and Range Experiment Station, with headquarters at Berkeley.

Eighteenth Annual Meeting of A.I.B.S.

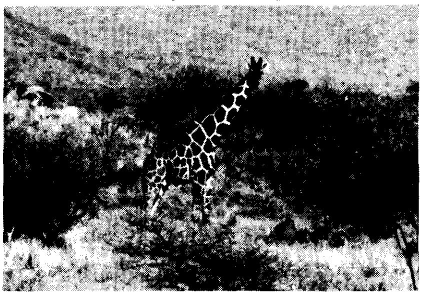
At Texas A & M, as a part of the AIBS meeting there will be held two symposia in which some members of the American Society of Range Management will be interested.

The first of these to be held on Monday, August 28, will be on the topic, "Accreditation Pro and Con", and is co-sponsored by the American Society for Horticultural Science and the Commission on Education in Agriculture and Natural Resources of the National Academy of Sciences-National Research Council.

The second, entitled "Conflicts in Conservation", will be on August 30, co-sponsored by the Commission on Education in Agriculture and Natural Resources and the National Association of Biology Teachers.

Membership in AIBS is not essential for attendance.

EAST AFRICA



Reticulated Giraffe, Samburu District, Kenya

The New East Africa Section reports the election of the following officers:

President ....Mr. S. E. Bastard
President-Elect ....Mr. W. Miles Fletcher
Council Members:
Three-year term ..Mr. Luke Isavwa
Two-year term ....Mr. V. C. Gilbert, Jr.
One-year term ....Mr. V. L. Bunderson

John T. Cassady was appointed Secretary-Treasurer.

An Executive meeting was held on May 2, 1967, in Nairobi to plan our first Section Meeting.

In a letter to Editor Campbell, Mr. Cassady says, "There are 42 members in the East Africa Section as of 15 May 1967: one or two of these may not have paid 1967 dues yet. We are getting new members steadily, and I hope we can double the membership this first year. Nearly half of our members are Africans and we hope to maintain a large proportion of Africans in the Section. Unfortunately the ASRM dues are quite high for some of these members, when their relatively low salaries are taken into consideration. The scheduled increase in dues will not help. I suspect that the Section will have to develop and authorize some kind of associate membership, whereby the associate could participate in Section activities, have access to copies of the Journal of Range Management but pay lower dues. After all, one of our main objectives is to bring together for professional communication and advancement progressive African and European ranchers, Range Management specialists from other countries, the staff of the Range Management Divisions of Kenya, Tanzania and Uganda and any others that can contribute to Range Management in East Africa.

PACIFIC NORTHWEST

John P. Nagle will retire as chairman of WSU's department of forestry and range management June 30, and will be succeeded by Dr. Grant A. Harris.

A WSU staff member since 1934 and department chairman since 1954, Nagle has broadened the department's academic base, stepped up its research program and service to the state's forestry industry, added an academic degree and improved its professional rating.

Dr. Grant A. Harris, member of the Department of Forestry and Range Management at Washington State University since 1956, has been named chairman of the department effective July 1.

During his professional career, Harris worked with the U.S. Forest Service in supervising range management research, conducted joint research with the state fish and game commission, and was Extension forester and forest scientist. Much of his work has been concerned with research on development and wise use of Washington's range area. He has been a member of the Governor's technical committee of the North Cascades recreation study team, and has also been chairman of a technical advisory committee of the Department of Natural Resources. He is a member of several professional societies inculding Society of American Foresters and American Society of Range Management of which he has been northwest sectional president.

IDAHO

Mark your calendar right now, August 4 and 5, 1967, are the days for our 1967 summer tour. Ralph Roberts and Roy Daniels have been working hard on this event. The 4th will be spent in the Preston, Idaho, area on a horseback tour of improved cattle range. The 5th will be a pickup or car tour north of Soda Springs, Idaho, on Federal, State, and private range. Many beneficial range and land management practices will be shown.

SOCIETY BUSINESS

THE PRESIDENT SPEAKS OUT

It is rather obvious from correspondence that the members of the Society want to hear of problems that confront our organization. Furthermore, many members have voiced a desire to share their ideas for possible solutions. You can be assured that your views will receive consideration if you care to submit them. The more important issues to be dealt with are:

1. What approach should the Society of Range Management take to receive recognition by scientific groups in America that have mutual interests? Many feel that our interests are mission oriented and our academic training and research efforts are entirely "practical" in nature. The term *"range management"* has a non-academic connotation to some government granting agencies and many reviewing panels.

2. How can we make the term *"range management"* more meaningful to John Q. Public? If you ask people on the street what range management means to them, you hear "range stoves," "a gun firing range" or "a missile firing range." Most of you have heard similar remarks when you enter a downtown cafe in a convention city with your *range management* registration badge pinned on your coat lapel.

3. How do we solve our journal problem? The issue of 2 journals has been proposed. The range scientists tend to believe that our present journal is too general and the livestock producer members feel that the journal does not carry a sufficient number of practical articles that deal with their problems. Certainly both of these criticisms are justified and so far the only solution appears to be a 2 journal effort sometime in the future. A second journal might be called "Range Science." It would carry scientific articles that are aimed at a contribution to science while the present journal would carry applied and general interest articles. The second journal would be self-supporting by page cost charges for accepted manuscripts. The question is, "Would the second journal give us greater scientific appeal to other scientific associations without dividing our membership?"

4. How can we get a standing committee in range management recognized by the National Academy of Sciences? Such a committee would need a good program with well founded objectives. An action program in the NAS would be a worthwhile program for our Society if we are truly concerned with fostering the advancement of science in range management.

5. What steps should our Society take to have range management per se recognized in its proper perspective in the programs of the International Grassland Congress? To date this group has been largely agronomically and ecologically oriented but have encompassed the science of managing range lands by recognizing the synonymy of range lands and grasslands.

The term "Range Management" is not well known in countries other than our own and has no connotation in terms of a science or a profession by most foreigners unless they have been closely associated with American range technicians or livestock producers. The question naturally arises, are we going to convert foreign countries to our way of thinking or will range management be absorbed by the many Grassland Societies now being organized throughout the world. At the moment the American Forage and Grassland Council is suggesting the formation of sections throughout the United States. Since this group includes both agronomic forage crops and rangelands, what sort of a marriage or competition does this present? Some believe that the American Society of Range Management must grow and become influential or be lost in the shuffle of modern scientific advances in other disciplines.

At the present, range management in its true interpretation is not in any manner considered in the International Biological Program presently being planned. Our Society needs formal activity in IBP. Certainly the development and use of the biological resources of the world are our concern. The American Society of Range Management has never been recognized by the American Association for Advancement of Science in any of its annual meetings or in the many symposia that it holds. Affiliation with AAAS can be obtained only by application and justification that we are scientifically oriented in teaching, research and practice.

This prompts the question, Is *Range Management* truly a science? If so, why has the term been so neglected in scientific programs both at home and abroad.

Many feel that if the American Society of Range Management becomes more sophisticated and affiliates with other scientific organizations, that the livestock producer groups will be neglected. A preponderance of Society members certainly want nothing changed that would cause dissension among our technician and rancher members. At no other time in history has the development and use of our biological resources needed a coordinated effort between ranchers and scientifically trained range managers more than it does today.

6. How can range management and ranching become a more respected occupation? A profession dealing with the wise use of such a great and important resource should receive the gratitude of the entire population of America who share in the wealth of a country because of its abundant supply of natural resources. These resources represent national and local wealth only when they are managed and used.

The Society and its members have a responsibility to enlighten the general public on the importance of the range forage resource and the role it plays in the welfare of mankind in an enterprising world of tomorrow where people need to be fed and employed. This important resource is going to be called upon to help supply food for the overcrowded countries. Furthermore, the use and management of the renewable resources of the lands are going to furnish occupation of people in a self-satisfying manner of contributing something for humanity. Managing ranges for the sole purpose of appearance does not meet all of the requisites of good range management. Management implies accrued benefits to mankind from efforts and energies expended.

Far too many believe that range livestock production is not compatible with the wise use of land, but rather, is contrary to the true meaning of conservation. Conservation should mean wise use of a resource and not non-use as some groups infer. Preservation is one term and conservation is another.

Our code and creed pledges the members of our Society to foster the advancement of the science and art of range management. The question is have we as individuals or as a Society lived up to this pledge.

7. How can we obtain acceptance of a standard curriculum of training for professionally trained range conservationist by the Civil Service Commission?

A high standard of formal college training should appeal to livestock producers as well as professional resource managers. It seems reasonable that livestock producers and administrators of wildland resources would need highly trained scientists to advise them on the many complicated decisions that must be made if the all important rangeland resource is to receive its rightful consideration. Far too many decisions concerning the use and management of the renewable rangeland resources of the world are being made by disciplines other than range science.

If this is true, then it would seem that ranchers and land management administrators would support a standard of college training and a discipline that is claimed only by range scientist, a range technician or a range professional.

Range managers, whether they are livestock producers, wildlife managers, watershed managers, soil conservationists or range conservationists should all work together with truly dedicated efforts to see that the science and art of range management attains stature, understanding and respect among all people. Dedicate a little of yourself to this great cause. The Society needs your efforts in their behalf and you need the Society.

8. What steps should be taken to allow your Society to indulge in more activities to give it stature and meaning? The first requisite to the solution appears to be more finances. The Society cannot continue to operate on a deficit budget. We need a full time Executive Secretary to give our committees and programs continuity from year to year. We need representation in many high level meetings particularly in America, but also throughout the world. A full accounting of our 1967 budget will be made in the next issue of the Journal of Range Management.

9. A perennial problem since the organization of the American Society of Range Management has been how to increase stable membership. This may be astounding news to you but presently we have dropped from this year's membership rolls 650 individuals who did not pay their 1967 dues. We hope our plan for this year will contribute substantially to the solution of this problem but why not ask your section membership chairmen if you can help. Each member should ask any of his acquaintances who have an interest in range management if they are members. If they are not, take the time to explain the Society to them and invite them to accompany you to the section activities and to become a member. In addition, help your section carry on a program of activities that will satisfy all membership interests.

Your current officers and committees are trying to solve all of these problems and others not mentioned herein. Each of you may know of problems not listed that you would like considered. If so, give your officers, both national and section, your ideas. In addition, we invite you, personally, to send us your views concerning the solution to any of the many problems currently facing the Society.

C. Wayne Cook

A CASE FOR THE SMALLER CITY?

The twentieth annual meeting of the American Society of Range Management in Seattle, Washington, left some of the members with a rather cool attitude toward future annual meetings. While the arrangements for speakers and room facilities for the sessions were quite adequate, many other arrangements were open to question.

One of the loudest complaints heard in Seattle, and still being echoed in correspondence, was over the $14.00 registration fee ($8.00 registration and $6.00 banquet). Many members felt that the $8.00 fee was much too high. The question raised was: "What did we get for $8.00?" Some members are aware that the cost of printing the abstracts and the programs are partly paid from registration fees. In the Seattle area, where paper and lumbering are key industries, one might suppose that with a minimum of effort the host section might have found one or more industries to cover printing and paper costs.

Following the banquet, another question was raised: "Was part of the registration fee used to purchase the services of a local dance band?" If so, who was to enjoy the four hours of dancing *other than* local members? Since the majority of Society members were not able to take their wives to Seattle, it would appear a rather selfish interest to hire a dance orchestra for post-banquet entertainment. For considerably less money excellent entertainment could doubtless have been secured through the Universities of Washington and Seattle.

A final question concerning registration was that students were also relieved of $8.00. In a few cases, students were refunded the registration fee. However, not *all* the students who registered were so fortunate. Fourteen students from the University of Wyoming (not all of whom registered at Seattle) paid all or part of their expenses in order to travel to the annual meeting as interested Society members or participants. For these future Society members (hopefully), the registration fee was too costly.

Another questionable arrangement for students, and other members as well, was that of rooms. Students enjoying the "special" rate at the convention hotel ($5.00/night) found themselves stacked four or five in a room with one bathroom, broken-down roll-away beds and, perhaps, one chair. Some enterprising individuals were quick to cancel their reservations (after viewing the situation), and move to a nearby hotel with better rooms for one-half the cost. One might suppose that many other Society members would have done likewise had time permitted.

The matter of listing available hotels, rates, and distances from the convention headquarters should be the responsibility of the local arrangements committee. How many hotels were listed (in addition to the convention hotel) in the November 1966 issue of the Journal? Four—count them! The number of hotels within a four block radius of convention headquarters was estimated at ten. Certainly, one of those with clean, adequate facilities could have been contacted for special rates for students by a local member of the host section.

The cost of "convention living" in Seattle, Las Vegas, and New Orleans is unquestionably higher than in Boise, Rapid City, and, perhaps, even Albuquerque. Many state and federal agencies, universities, and colleges are restricting their travel budgets at a time when travel costs are increasing. In addition, ranchers and other interested members travel at their own expense. Therefore, it would appear that it is time that Society officers and board members take a closer look at future sites for annual meetings. They might also review the procedures and policies for local arrangements, especially those concerning printing of programs, abstracts, and banquet entertainment costs. Finally, they should insist that hotels and motels within walking distance of the convention center are listed in the Journal, together with the distance and direction from the convention center.

In conclusion, the author wishes to acknowledge his awareness of increasing convention costs, especially in larger cities. Most state and federal employees, and ranchers, comprising the bulk of our Society membership, are on limited travel budgets. Thus, the case for the smaller city having adequate facilities for our annual meeting might well be reviewed by the Society officers. University and college facilities should not be overlooked.

F. Robert Gartner
University of Wyoming

Mr. Gartner's letter raises some legitimate questions about our conventions that deserve recognition and reply. The accompanying financial report makes some answer as it shows where the money came from and where it went. In explanation of the budget, Mr. Waldron, chairman of the budget and finance committee says, "The preliminary budget for the convention was made following the Pacific Northwest Section meeting at Spokane in November, 1966. The estimated registration fee was $7.00 per person based on an estimated 400 registrations. In addition, the estimate of additional income from donations and from advertising for abstract covers was somewhat less than we actually received. The committee met again Sunday, February 12 and at that time advance registrations at the Olympic Hotel as well as other information available to the committee indicated that very likely the attendance could be about the same or less than the 300 in attendance at the New Orleans meeting in 1966. After consideration of fixed expenses in light of expected registration, it was determined to establish registration fee at $8.00. This was not done lightly; considerable discussion and debate centered around this particular point. We were pleasantly surprised to find the registration started out heavily and continued so the first two and a half days of registration."

It is always a question up until the last moment, what registration fee to charge. In my experience with eleven Society local arrangements committees, I have yet to find one that wanted to make money but rather would take a chance on losing some. The objective is to break even. Uncertainty about attendance is the bug-a-boo that worries the committee most and there is a natural inclination to estimate small in order to end in the clear.

There are several factors which go to make up a successful convention and they can be listed thus:

1. The program.
2. The work of the local arrangements committee.
3. The facilities; rooms, lights,

speaker system, seating, ventilation, projection equipment, heating.

4. The efficiency of the hotel staff in meeting the planned needs.

Of these items the last is by no means the least important. Having meeting rooms ready, clean and equipped with platform, lectern, seats, tables and chairs, water and glasses or whatever else is needed at the proper time, is the job of the staff. Unobtrusively cleaning and rearranging is also its work. If all goes well the visitors are unaware of the work behind the scenes. If some minor item is neglected the delegates begin to be uncomfortable and to complain.

Hotels equipped to handle conventions offer meeting rooms for the program — perhaps several at one time—for committees, contests displays and business meetings free of charge to the organization. Also a suite or two are complimentary to the President or other officers. The only way the hotel has of recovering the cost of these rooms and their preparation is through rental of guest rooms, meals served and banquet charges. If organization members room elsewhere, eat elsewhere and boycott the banquet, the hotel is the loser. If this happens too often, convention goers will be paying higher fees yet for meeting rooms. At Seattle, of the 403 paying registrants there were only 197 rooms rented in the Olympic. It is submitted that we have not had anywhere any better facilities, any better services than there.

In the smaller cities such as Boise and Rapid City — and Albuquerque the last time we were there—programs for groups our size would have to be held in buildings away from any hotel. This situation has been strenuously objected to whenever we have encountered it in the past. In addition these remote facilities are generally had only at a price.

Hotel and motel rates, meal costs and parking costs are escalating, it seems, faster than the general level of inflation. What I paid five dollars for in 1940 is now fourteen to eighteen dollars. The question of where to go is one that greatly concerns the directors. Shall we continue to patronize a first class convention hotel or shall we scatter ourselves around some small city with little outside attraction? A large city offers much to the convention delegates other than the program and the business of the organization. It would be interesting to know through the Advisory Council what the membership thinks.

John G. Clouston

ASRM CONVENTION 1967 FINANCIAL STATEMENT SUMMARY

INCOME:		
Registrations: 403 @ $8.00		$3,224.00
Banquet tickets: 391 @ $6.00		2,346.00
Contributions		390.00
Advertising on Abstract covers		120.00
Sale Extra Abstracts		12.00
TOTAL		$6,092.00
EXPENSE:		
Printing and Publicity	$ 173.25	
Photo and Plant Contests	364.10	
Ladies Program net loss	16.52	
Local Arrangements Misc.	174.18	
Program	816.17	
Banquet (includes orchestra & gratuities)	3,202.59	
Discount Canadian checks & currency	7.75	
TOTAL	$4,754.56	
SURPLUS:		$1,337.44
PAID BY EXECUTIVE SECRETARY'S OFFICE:		
Abstract Covers	$ 146.05	
Donation to Contestant expense @ $10.00 per student	450.00	
Plaques & Certificates to Contest Winners	189.05	
*Expenses Youth Facts Forum delegates	437.89	
	$1,222.99	
SURPLUS:		$ 114.45

* It may be considered that this item is properly chargeable to the Society's youth program. However, had there been no convention there would have been no expense.

FINANCIAL REPORT AMERICAN SOCIETY OF RANGE MANAGEMENT

According to the recommendations of the Advisory Council, the Board of Directors and officers are publishing a financial report. The budget approved for 1967 is $51,971.89 and the anticipated income is $48,000.00. This represents a deficit of approximately $4,000.00. The budgeted funds for 1967 over 1966 amounted to approximately $6,644.00. The items where increases were approved are starred in the 1967 budget.

The tentative budget is formulated by the coordinated efforts of the Planning Committee and the Finance Committee. After being reviewed by the President and the Executive Secretary, it is submitted to the Board of Directors for their consideration and approval.

The major differences in budget requests are under categories (B) the Executive Secretary's Office and (F) Public Relations. In the first case the salary expense covers the wages of six people; three of whom work a scheduled five day, 30 hour week. One of these, an editorial clerk, was added last September. She will work her first full year in 1967. She is responsible for make-up of the entire Journal as well as complete work on News and Notes, Society Business and With the Sections. One other employee was added on a part time basis to assist in the keeping of records, filing and typing. The employment of four people in the Executive office brought us under the compulsory unemployment and workmen's compensation law both Federal and State and raised the amount payable for Social Security taxes. In addition the last item was raised by two tenths of one percent. The increase in the amount for salaries and the taxes determined by salary expense, account for $4,526.00 of the budget increase over 1966. The rest is nearly all in the public relations field. A few items have been reduced a total of $1,255.00.

The Board of Directors would like to give our Public Relations Program a real send-off during 1967. Item 1 includes travel of Society representatives for public relation purposes with other societies and organizations with mutual interests. Item 5 was believed desirable in order to see that range management, particularly range livestock production, receives its rightful place in multiple use planning and in all international biological resource programs. Both national livestock associations and the federal agencies have pledged their support toward building a more favorable concept of range management and livestock production and the resource contribution to the people of the world. Range management and livestock production are honorable professions and we shouldn't have to wear white hats to prove it.

Under expense category E., item 1 includes purchase of a new typewriter, desk and chair and item 2 covers cost of plaques and certificates and $10.00 cash to each of the Plant Contest entrants.

In category G the cost of bringing two Range Facts Forum boys to Seattle Convention is presented.

During the last part of 1967 or early in 1968, the Society hopes to initiate more of its re-organization plan by adding a full time Executive Secretary. This will allow the Society to have representation where and when it needs it. This will allow programs to be followed through to completion with knowledgeable personnel.

It can be seen from the budget allocations for 1967 that the Board of Directors wants the Society to move ahead and gain stature among other professional and scientific organizations of the world. The only source of increased funds to accomplish this appears to be through increased dues and increased membership.

As a result of this consideration, the Board approved a $15 assessment for annual dues with a $1 refund to the sections. However, the Society will collect any additional assessment a section desires to charge its membership. Sections proposing to charge $2 section dues would have their members pay $16 to the national and receive a $2 refund.

The dues of other professional societies for membership comparable to our own follows:

Society of American Foresters	$20.00*
Soil Conservation Society	10.00
Soil Science Society	16.00
American Society of Agronomy	16.00
Crop Science Society	16.00
Wildlife Society	15.00**
American Fisheries Society	15.00
Ecological Society	12.00
American Society of Animal Science	9.00
Institute of Mathematical Statistics	20.00
American Society of Agricultural Engineering	25.00
American Dairy Science Society	12.50
Entomological Society of America	15.00
AVERAGE	$15.50

* Senior member—after 3 years as a Junior at $10.00

** For 1967-68. Will be $20.00 in 1969

For those who have student members, the average dues are $7.00 including subscription to one publication. Some other societies have complicated dues structures according to classes of membership such as fellow, retired, junior, senior, sustaining, affiliate, etc. Also some offer more than one publication at an increased price. Several charge institutions a higher price for a subscription than charged for individual members. The amounts indicated are for what might be called regular members.

We hope this report will help you understand the necessity of increasing the membership dues for 1968.

Approved Budget for 1967

A.	President			
	1. Postage and Supplies	$ 150.00		
	2. Clerical	....		
	3. Travel (including Directors)	1,150.00		$ 1,300.00
B.	Executive Secretary's Office			
	1. Salary Expense (including Editor and Editor's clerk)	17,670.00		
	2. Rent and Janitorial	2,400.00		
	3. Stationery and Supplies	1,500.00		
	3.1 Equipment Maintenance	200.00		
	4. Telephone and Telegraph	200.00		
	5. Postage	1,500.00		
	6. Freight, Drayage, Express	75.00		
	7. Annual Audit	25.00		
	8. Travel	1,200.00		
	9. Miscellaneous	150.00		
	10. Employers Contribution to FICA	780.00	4.4% of salary	
	10.1 Employers Unemployment Tax	689.00	3.9% of salary	
	10.2 Workmen's Compensation Tax	20.00	.15% of Oregon Salary	
				26,409.00
C.	Editorial			
	1. Postage and Supplies	375.00		
	2. Travel	650.00		1,025.00
D.	Journal Publishing			
	1. Print Volume 20	16,640.00		
	2. Postage and copyright	450.00		
	3. Mailing services	500.00		
	4. Spanish Summaries	400.00		18,000.00
E.	Other Projects			
	1. Furniture, Fixtures, Equipment	500.00		
	2. Prizes and Awards	750.00		
	3. General Committee Expense	250.00		1,500.00
F.	Public Relations			
	1. Travel	1,500.00		
	2. Advertising	200.00		
	3. Postage	100.00		
	4. Displays	300.00		
	5. Cooperation with Livestock Assocs.	1,000.00		
	6. Press Room	200.00		3,300.00
G.	Range Facts Forum	437.89		437.89
	TOTAL			$51,971.89

Expected Income in 1967 $48,000.00

PHOTO CONTEST RULES

21st Annual Meeting
Albuquerque, New Mexico
February 13-16, 1968

All members of the American Society of Range Management are invited to participate in the photographic contest at the 1968 annual meeting to be held in the Western Skies Motor Hotel at Albuquerque, New Mexico. Both black and white photographs and color slides may be entered.

A. Eligibility

1. Contestant must be a member of the American Society of Range Management and represented at the annual meeting.
2. Members may enter a maximum of sixteen (16) exhibits; only one photo per category except in the picture story and range condition and trend.
3. Contestant has the responsibility of delivering and reclaiming photos to the photo contest committee. Contestant's name, address, and category must be on the back of each photo.
4. All photos with the exception of the picture story must have been taken by the contestant. At least one photo in the picture story sequence must have been taken by the contestant.
5. Winners will be required to furnish a copy upon request.
6. Previous grand champion and first place pictures (photos not people) are not eligible for subsequent contest.

B. Size of Photos

1. Black and white photos will be no larger than 11 inches by 14 inches with a glossy to matte finish. No hand colored photos will be accepted. Prints will have a stiff back, preferably of 15 inches by 18 inches size; not in frame.
2. Eligible colored slides will be of a size suitable for a standard projector.

C. Deadline

Deadline for receiving photographs will be noon of the first day of the formal meeting (Tuesday, February 13, 1968 at the ASRM registration desk in the Western Skies Motor Hotel, Albuquerque, New Mexico).

D. Scoring

Persons registering for the meeting will receive a ballot to vote on black and white photos and color slides. This must be turned in by noon of the second day (Wednesday, February 14, 1968).

E. Awards

1. Ribbons will be awarded to first, second and third place winners in each category and to the grand champion black and white photo and grand champion colored slide.
2. Suitable awards will also be given the first and second place winners in each category and grand champion black and white photo and grand champion colored slide.
3. Grand champion winners must place first in their respective category. Grand champions will be selected by vote shown on the ballots.

F. Journal Cover Photos

Winning entries will be eligible for selection as cover pictures for forthcoming issues of the *Journal of Range Management*.

G. Categories

Categories for black and white photos and color slides are:

1. Range Plant (s)
2. Range Animal (s)
3. Range Condition and Trend (may include a sequence of two or more photos, maximum of four, to show changes in native vegetation, results of cultural treatment, or a range site in different conditions).
4. Range Improvement
5. Range and Ranch Scene
6. Range Recreation
7. Associated Range Use
8. Picture Story (only black and white photos)
   a. Tell a story concerning range management
   b. Use sufficient captions to explain the story
   c. Maximum number of six photos per entry; minimum of three photos
   d. Prints to be no larger than 11 inches by 14 inches

Contestant will specify the category in which pictures or slides are to be judged

H. Lost Photos

The committee will not be responsible for lost or stolen photos.

RANGE REFERENCE STUDY AREAS

At their Seattle meeting, the Society's Board of Directors unanimously approved the following two recommendations of the Advisory council.

1. Change the name of the Natural Areas committee to Range Reference Study Areas committee.
2. Policy statement on range reference study areas:
   The grazing resources of North America are highly significant from the standpoint of domestic livestock and game production, recreation, watersheds, and other uses within the general economy. Our present-day knowledge is not likely to be adequate to meet the increased demands on these resources and the land use problems of the future.
   Representative areas of important plant communities from a range resource standpoint are essential as outdoor laboratories for research and teaching. The identification and location of such reference areas needs to be given special attention if adequate outdoor research and teaching facilities are to be provided. There is a danger that some of these may be lost as land comes under more intensive use.
   Therefore, it is the policy of the American Society of Range Management to provide the leadership necessary to identify and locate reference areas in important rangeplant communities through its Sections and other interested organizations.