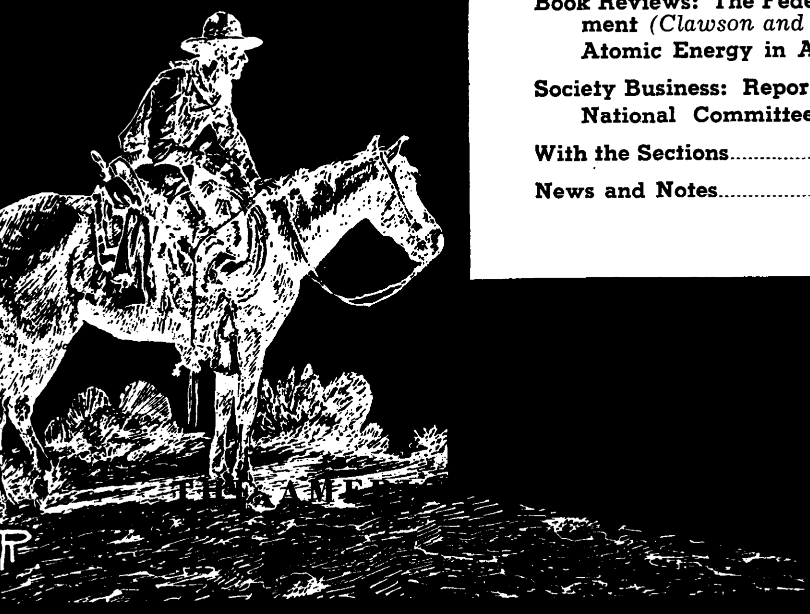
Journal of

In This Issue



American Society of Range Management

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

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.

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Letters to the Editor

This section is open to comments by any member of the Society. Opinions expressed do not necessarily represent those of the Journal and the Society.

I'm Not Satisfied with the Journal . . . !

Our librarian, one day, asked me, "What has happened to the Range Journal? Not a single article is worth indexing. It's almost like the *Farm Journal.*" Apologetically, I explained that this was true only of the November issue, that in the next five issues there would be at least some articles worth indexing. (The January issue bears this out.) Of course, I shouldn't have been embarrassed as I didn't have anything to do with the policy which begat the "November issue." Up to now, passiveness has been my only mistake.

Criticism of the rancher issue is not discrimination against a minority group of contributors. Like the late "student issue", this collection of papers says in effect that these articles cannot stand by themselves when sandwiched between the offerings of researchers and experienced writers. Therefore, they must be grouped in the minor leagues so no reader could make the error of comparing a paper by a rancher or a student with one by a professional range manager. The student session held at the tail end of the past annual meetings reflects the same caste-system thinking. More recent annual meetings have heightened the prestige of the Range Society considerably by holding a "technical session"—also stuck on the tail end of the convention.

Now, if the rancher articles were sprinkled evenly throughout the volume, they would not, in fact, compare favorably with the technical articles. This statement is true only when made by persons interested in nothing but technical articles. I am told that

ARNOLD M. SCHULTZ

there are range technicians who read rancher articles avidly. Some even write them. On the other hand, I know of no reasons why ranchers who read only rancher articles would spend any money on buying the *Journal of Range Management* when the *Western Livestock Journal, National Woolgrower, Sheep and Goat Raiser* and many others present such fare without so much technical dilution. Those who write the articles would find a bigger reading audience in the popular magazines than they find in the Range Journal. Most technical people have access to the popular magazines—through libraries and routing services—whether they are subscribers or not, so the kind of audience is not an issue.

I am not deprecating the quality of the "rancher" articles in the Journal. Most of them are well written, objective, and easily read—more than can be said of many of the technical articles. I assume that the rancher writing the article likes to ranch and also likes to write, while many a range technician likes to do research but hates to write it up. So the argument is not whether such articles should be written but whether they should be published in the Journal of Range Management, since there are already many publications devoted to this type of article while there is only one which could be devoted entirely to professional papers on range management.

It's a matter of space. Technical journals are limited, for financial reasons, to a certain maximum number of pages per volume. This naturally limits the number of articles and pages per article that can be published in a volume. What other pure medium—devoted entirely to range management—do our range scientists have in which to disseminate the results of their research and expound their theories? I have gotten the impression that the chief purpose in forming the American Society of Range Management was to provide this medium. A group—all scientists, I believe—who were not satisfied with the attention given to range by two other societies (Society of American Foresters and American Society of Agronomy) initiated the ASRM. Thereafter came the thirst for big membership. And although the noble objectives are restated on the inside cover of each issue, the Journal's policy is considerably watered down to satisfy the thirst.

I have heard many comments that some of the articles in the Journal are *too technical.* The comment is seldom made by ranchers! Perennial rancher members, as against the one-year-turnovers who were sold "subscriptions" by hucksters in over-zealous section membership drives, enjoy reading and evaluating the technical articles written by the scientists or administrators. The comments about being too technical, when made for themselves, are usually made by people who want everything to come in readily soluble capsules, the uninquisitive, the non-discerning, and the gullible. But more often, the comments are made "altruistically" by semi-technical men turned administrators who feel the need to "talk down" to the rancher and other lay members of the Society. They find the Journal a convenient tract for this purpose.

As to the question whether the Journal is too technical, let us compare it with publications in allied fields: *Ecology, Agronomy Journal, Journal of Animal Science,* and *Journal of Forestry.* The latter carries four or five good technical articles per issue, but the real high-powered ones have recently been siphoned off into *Forest Science.* The other three journals have only technical papers involving original research, and review type articles which are scientific, to be sure. Only a few of the papers in these four pertain to range; the others are, in general, no more or no less profound than those on range, and all are significant contributions to the particular disciplines or professions. The *Journal of the British Grassland Society,* which comes closer to our Range Journal than any other publication in subject matter and purpose, is certainly a scholarly periodical compared to ours.

While I was editor of the Current Literature section of the Range Journal, I had the pleasure of reading all the periodicals which carried articles pertaining to range management published over the period 1954-1957. I was induced to read many interesting papers only remotely connected with range management. The journals which impressed me the most were those which achieved uniformity of quality in their contents. Those that disgusted me most had achieved a mixture of evangelistic preachments about conservation, testimonials on "how I make it pay back home," pep rallies for GRASS, and a few technical papers that probably were rejects from the scientific journals.

For the reader not acquainted with the following, I suggest perusing some recent issues of the *Journal of Wildlife Management, Journal of Farm Economics, Proceedings of the Soil Science Society of America, Forest Science, Canadian Journal of Botany,* and others. All of these have carried papers which would have been not only appropriate but good for the Range Journal. The reasons why excellent research and progressive theories are reported in these professional journals are many; to us the most important thing is, why weren't they offered to the *Journal of Range Management?*

More and more members should enjoy the technical aspects of range management as time goes on. Almost every college in the West teaches a course or has a curriculum in this field. Several offer a Ph. D. degree. This must mean that there is a deep, philosophical side to range management. The courses required for such a degree are in science. None are art courses.

In conclusion, I am firing some bullets as suggestions to improve the Journal. The last one can remain in the chamber unless the first five don't hit their mark.

1. Journal policy should recognize the objectives of the society and realize that the "art" of range management is based only on science. The Journal should reflect this no matter what groups comprise the membership of the Society.

2. All the technical articles should be upgraded. The good papers coming out in other periodicals are being sent there because the Range Journal is thought to be too "popular."

3. The rancher issue should be cut out—if the articles are good enough to be in the Journal they are good enough to be in any issue. There's no room for second class articles.

4. Authors should swamp the editor with lots of manuscripts so that he can choose and reject. Remove the stigma of being the *Journal of Skimmed Milk.*

5. Members should ask themselves why they joined the society: to improve the understanding of range management principles, or to revel in how well we have taken care of the range? OR ELSE:

6. A new journal, *The Journal of Range Science.* — *Arnold M. Schultz,* Specialist, School of Forestry, University of California, Berkeley, California.

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Relative Preference and Productivity of Species on Summer Cattle Ranges, Big Horn Mountains, Wyoming

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Cattle ranges in the Big Horn Mountains of north central Wyoming contain many herbaceous species. Grasses, sedges, and forbs are all well represented. In general, the non-timbered areas of the cattle ranges are well covered by the herbaceous vegetation. The abundant ground cover suggests that an ample supply of palatable feed is present.

Palatability of a forage has been attributed to a number of things. In some instances, soil fertility, mineral content, sugar content, vitamin A, protein, moisture content, succulence, and fineness or coarseness of plant material, have been associated with palatability. While some workers have found palatability to be directly related to such things as phosphorus and crude protein content, others found no such relationship. Instinct of the grazing animal to choose species of the greatest value has been advanced and rejected. Ivins (1952) states that "Until such times as the theory of nutritional wisdom is conclusively confirmed or disapproved for such an animal as the dairy cow, then the selection of herbage by the animal is a factor which must be respected by both grassland and livestock authorities alike." Undoubtedly beef cattle and sheep, grazing on range vegetation, could also be included in this statement.

Research on livestock ranges has shown that some species are grazed readily while others are not grazed or only lightly grazed. In an attempt to so classify species on Big Horn Mountain cattle ranges, both utilization and herbage production were studied from 1951 to 1954. This permitted the species to be ranked for preference (palatability), herbage production, and forage production.

As used here, preference is the same as palatability defined by Ivins (1952) and the Society of American Foresters (1950), in that the term includes the sum of all factors that operate to determine whether and to what degree the forage plants are consumed by domestic livestock or other animals. This differs from the concept that considers palatability to include the degree to which the plant species should be utilized under certain conditions (Inter-Agency Range Survey Committee, 1937).

The Study Area

Summer cattle ranges of the Big Horn Mountains support a variety of plant species, most of

FIGURE 1. Large brush-free openings are characteristic of much of the cattle range.

[1] *Central headquarters maintained in cooperation with Colorado State University at Fort Collins. Research being reported was conducted in cooperation with the University of Wyoming, Laramie, Wyoming.*

which are perennials. These ranges are characterized by large parks or openings rimmed by dense stands of lodgepole pine *(Pinus contorta)*, as seen in Figure 1. Engelmann spruce *(Picea engelmannii)* and alpine fir *(Abies lasiocarpa)* are sometimes associated with the pine or may, in some cases, form the forest canopy. Willows *(Salix* spp.*)* are common along the drainages and in the wet meadows. Shrubby cinquefoil *(Potentilla fruticosa)* is often locally abundant. Big sagebrush *(Artemisia tridentata)* is common on some south and west slopes, particularly on soils derived from limestone. Here, as well as in the brush-free parks, perennial grasses, grasslike plants, and forbs are common. Idaho fescue *(Festuca idahoensis)* is often the dominant grass. Some of its common associates are needleleaf sedge *(Carex obtusata)*, bluegrasses *(Poa* spp.*)*, wheatgrasses *(Agropyron* spp.*)*, needlegrasses *(Stipa* spp.*)*, silky lupine *(Lupinus sericeus)*, avens *(Geum triflorum)*, starry cerastium *(Cerastium arvense)*, yarrow *(Archillea lanulosa)* and herbaceous cinquefoils *(Potentilla* spp.*)* (Beetle, 1956, Hurd and Kissinger, 1952).

Preference studies were confined to non-timbered upland sites, since these were believed to be the principal forage producing areas. Much of the vegetation growing along stream bottoms and wet meadows is readily grazed by cattle, but such sites are relatively small in aggregate area. Timber stands, because of the tree growth and sparseness of herbaceous vegetation, are used primarily for resting, shading, and protection. The grazing season on these cattle ranges is limited to about a four-month season beginning in June and ending in late September.

Areas of investigation ranged from 7,200 to 9,000 feet in elevation. Average annual precipitation varies from 19 to 30 inches, depending upon the elevation, exposure, and local topography. Soil depth is variable, as is apparent fertility and moisture holding capacity. Both granite and sedimentary parent rocks are present, and, in general, soils derived from sedimentary rocks support a greater and more diversified herbaceous vegetative cover. In addition, there are several areas where crystalline and sedimentary rocks are intermixed. In these deposits of Tertiary age (Darton, 1906) the vegetation is similar to that on residual soils formed from granite rocks.

Methods

Utilization estimates were the basis for determining species preference. The assumption was that, since cattle had a free choice of species in the sampled area, they would eat those that they liked. This in turn would be reflected in the utilization estimates. Thus, preference varied directly with utilization, and always the preference of the species could be ranked in a 1, 2, 3, order.

Utilization was determined by estimating the percentage of herbage weight the grazing animals removed from each species growing within the sample plots (Pechanec and Pickford, 1937a). The utilization transects consisted of ten 25-sq. ft. circular plots spaced approximately 50 feet apart. These transects sampled the grass-forb cover type on (1) the residual and colluvial soils from sedimentary rocks (limestones, sandstones, and shales), and (2) the residual soils from granite rocks (including here those soils derived from Tertiary deposits). The big sagebrush cover type was sampled also. It constituted the third plant-soil condition studied.

Utilization studies were made in the grass-forb vegetation in each of the 4 years of the study and in the sagebrush cover type in 1953 and 1954. Every year utilization was estimated at the end of the grazing season on all grasses and grass-like plants. Additional estimates were made at mid-season in 1951 and 1952; at this time utilization of forbs was also estimated. In 1953, utilization was estimated on approximately July 10, August 10, September 10, and October 3. Both grasses and forbs were estimated on the first three dates, but forbs were omitted in October because most had withered.

Ground cover and herbage production were estimated on a species basis in each area sampled by utilization transects. A square frame containing 9.6 sq. ft. was used to outline individual plots, and ten such plots spaced approximately 50 feet apart constituted a transect. Cover and herbage production estimates are made at the time most of the perennial grasses had reached maximum height growth. The percentage of ground cover (vertical crown projection) was estimated for each species providing it amounted to at least 1 percent of the plot area. Lesser amounts were classified as "other grasses" or "other forbs." Herbage production for each species was estimated and recorded in grams; the technique followed was that described by Pechanec and Pickford (1937b). Herbage samples of most species were collected and air dried, so that estimated green weights could be converted to an air dry basis.

A total of 340 utilization transects and 65 cover herbage production transects were used during the 4-year period. These transects sampled 23 areas on 11 cattle allotments that ranged from 4,000 to 30,000 acres in size.

Some species were found so infrequently or in such small amounts on the sample plots that they could not be adequately evaluated. Consequently, they are omitted from the tables.

Specimens of many of the species mentioned are on deposit at

Table 1. Average preference rating of major grasses and sedges at end of grazing season—1951-54.*

Species	Preference rating: Grass-forb cover, Sedimentary soils	Grass-forb cover, Granitic soils	Sagebrush cover, Sedimentary soils
Big bluegrass *(Poa ampla)*	High-1	—	High-1
Idaho fescue *(Festuca idahoensis)*	High-2	High-1	High-2
Pumpelly brome *(Bromus pumpellianus)*	High-3	—	—
Spike fescue *(Hesperochloa kingii)*	High-4	High-3	Int**-7
Wheatgrasses (*Agropyron* spp.)	Int-5	Int-4	Int-5
Sandberg/Canby bluegrass *(Poa secunda/canbyi)*	Int-6	Int-6	Int-9
Inland bluegrass *(Poa interior)*	Int-7	—	Low-13
Timber oatgrass *(Danthonia intermedia)*	Int-8	Int-5	Low-11
Subalpine needlegrass *(Stipa columbiana)*	Low-9	Int-7	High-4
Sedge *(Carex petasata)*	Low-10	Low-8	Int-8
Needleleaf sedge *(Carex obtusata)*	Low-11	Low-10	Low-12
Prairie Junegrass *(Koeleria cristata)*	Low-12	Low-9	Low-10
Needleandthread *(Stipa comata)*	—	High-2	—
Raynolds sedge *(Carex raynoldsi)*	—	—	High-3
Nodding brome *(Bromus anomalus)*	—	—	Int-6

* 1953-54 only for sagebrush.
** Intermediate.

the Rocky Mountain Herbarium, University of Wyoming, Laramie. Appreciation is extended to Dr. C. L. Porter, Curator, for identifying those species.

Results

Preference varied greatly among species. As a group, the grass and grasslike species have a higher preference than forbs. Average utilization for grasses and sedges was 21 percent, compared with 2 percent for forbs. All grasses and sedges were grazed to some extent, but many of the forbs were not. For those forb species that were grazed, the utilization averaged 8 percent.

Grasses and Sedges

Cattle were also selective in their choice of grasses and sedges. For example, throughout the 4-year period big bluegrass *(Poa ampla)* and Idaho fescue ranked high in preference. In contrast needleleaf sedge and prairie Junegrass (*Koeleria cristata*) were consistently low in preference. Wheatgrasses usually occupied an intermediate position. Thickspike wheatgrass *(Agropyron dasystachyum)* was the only wheatgrass encountered on the granitic soils. It, as well as slender wheatgrass *(A. trachycaulum)*, and bearded wheatgrass *(A. subsecundum)*, was found on the other two plant-soil conditions. The preference of the major grasses and sedges are given in Table 1.

Generally, soil and cover types appear to have little effect on preference (Table 1). However, the relationships are not always clear-cut. Idaho fescue and big bluegrass had a high preference wherever they grew. There was a tendency for subalpine needlegrass *(Stipa columbiana)* and the closely allied William's needlegrass (*S. williamsii*) *to have a* higher preference in the sagebrush cover type than in the grass-forb cover. In contrast, timber oatgrass (*Danthonia intermedia*), when growing in the sagebrush cover, had a lower preference ranking than it did on the other two plant-soil conditions. Some species were not found on all three soil-plant conditions.

Preference for a particular species did not change much as the grazing season progressed. The 1953 data, which contain four periodic observations, show that, in general, the preference position at the beginning of the grazing season is maintained. The 1951-52 supplemental information tends to support these results. However, occasional variations did occur. For example, Idaho fescue had an intermediate preference during the first half of the grazing season, but it finished with a high preference rating except on granitic soils, where it had a high preference ranking at all times. In contrast, subalpine needlegrass declined in preference as the grazing season progressed.

Heavy grazing had no material effect on preference. Usually, the preferred species were grazed more intensively, without any switch to the less palatable species. When the estimated utilization of Idaho fescue increased 15 to 60 percent, it and big bluegrass were still the preferred species. Needleleaf sedge and prairie Junegrass still had low preference ratings despite 60 to 70 per cent use of the fescue.

The high preference of Idaho fescue together with its high ranking in pounds per acre of herbage produced make it the leading forage grass (Table 2). Pumpelly brome and needleandthread, although having high preference (Table 1), occurred infrequently and in small amounts. Consequently, they were of little importance as forage producers. In contrast, those grasses having intermediate or low preference ratings but producing substantial amounts of herbage per acre, often assumed more importance as forage plants. This can be illustrated by subalpine needlegrass growing in the grass-forb-sedimentary soil condition (Tables 1 and 2). Here, it ranks low in preference, but because it is a relatively high herbage pro-

Table 2. Herbage and forage production rating for major grasses and sedges.

Species	Production rating: Grass-forb cover, Sedimentary soils, Herbage	Forage	Grass-forb cover, Granitic soils, Herbage	Forage	Sagebrush cover, Sedimentary soils, Herbage	Forage
Idaho fescue	High-1	High-1	High-1	High-1	High-1	High-1
Wheatgrasses	High-2	High-3	Int-5	High-2	High-3	High-2
Subalpine needlegrass	High-3	Int-4	Int-6	Int-6	High-2	High-3
Big bluegrass	High-4	High-2	—	—	*	—
Sandberg/Canby bluegrass	Int-5	Int-5	High-3	High-3	Int-7	Int-6
Needleleaf sedge	Int-6	Int-6	High-2	Int-4	Int-5	Low-9
Inland bluegrass	Int-7	Int-7	—	—	*	—
Timber oatgrass	Int-8	Int-8	Int-7	Low-8	Low-9	Low-10
Sedge (*C. petasata*)	Low-9	Low-9	Low-10	Low-10	Low-10	Int-8
Prairie Junegrass	Low-10	Low-11	Int-4	Int-7	Low-11	Low-11
Pumpelly brome	Low-11	Low-10	—	—	—	—
Spike fescue	Low-12	Low-12	Low-8	Low-9	High-4	Int-5
Needleandthread	—	—	Low-9	Int-5	—	—
Raynolds sedge	—	—	—	—	Int-6	High-4
Nodding brome	—	—	—	—	Int-8	Int-7

* Not present on composition and production sample plots, although occasionally found on the more numerous utilization plots.

ducer, it assumes an intermediate position as a forage plant.

Forbs

Forbs were common in all soil-plant conditions (Fig. 2). As many as 45 species were found on the sample plots. However, only 19 species were estimated to have been utilized 1 percent or more. The average utilization of these grazed forbs ranged from 6 percent in the sagebrush cover type to 11 percent in the grass-forb-granitic soil condition.

Light and spotty grazing of forbs tends to mask clear-cut preference trends among years. However, blueleaf agoseris (*Agoseris glauca*), dandelion (*Taraxacum officinale*), and white loco (*Oxytropis sericea*) had high preference ratings. Silky lupine, one of the two dominating forbs, was grazed sporadically. In some areas all or most of the lupine leaves were removed; in other areas, no evidence of grazing was detected. This was particularly noticeable on granitic soils.

Observations suggest that grazing by mule deer and possibly by elk may contribute to the high preference rating of such species as white loco, hoary balsamroot (*Balsamorhiza incana*), elkweed (*Frasera speciosa*), and ballhead sandwort (*Arenaria congesta*). No attempt was made to separate game use from cattle use. However, the high preference ranking of blueleaf agoseris and dandelion is attributed to cattle because of the consistency with which these species were grazed on the cattle ranges.

Utilization of forbs increased as the grazing season progressed. Based on the 1953 data, the average percentage utilization for the grazed forbs was 1, 5, and 10 percent on July 10, August 10, and September 10, respectively. Frosts made utilization estimates unreliable after September.

The importance of forbs as forage plants increased directly with an increase in the utilization of grasses and sedges. When the utilization of Idaho fescue increased from 20 to 65 percent, the pounds of forb herbage consumed increased as much as 12 times in some areas. In one sampled area where Idaho fescue was utilized 85 percent, the forbs supplied 53 percent of the forage. In another area where Idaho fescue was utilized 20 percent, the forbs supplied 8 percent of the forage.

Silky lupine contributed 67 percent of the total forage provided by forbs. It, together with various combinations of blueleaf agoseris, white loco, and dandelion, produced 86 percent of the forb forage. Average herbage production of silky lupine during 1953 was 186 pounds per acre air dry. Blueleaf agoseris averaged 19 pounds per acre. Dandelion and white loco were abundant only in local situations.

Average forb herbage production was twice that of grasses and sedges (560 and 285 pounds per acre air dry, respectively). Forb production was least on the granitic soils. Of the forbs that were grazed, many produced small amounts of forage because of either low preference (light utilization) or small amounts of herbage produced. Some forbs, although abundant, were grazed little or not at all. Starry cerastium, pussytoes (*Antennaria rosea* and *A. media*) showy phlox (*Phlox multiflora*), paintbrushes (*Castilleja* spp.), fleabanes (*Erigeron* spp.), and avens are examples. Avens, when growing in the grass-forb-sedimentary soil condition, produced more herbage than any other forb and yet was rarely grazed. Forbs accounted for 5, 8, and 13 percent of the forage consumed on the grass-forb-granitic, sagebrush, and grass-forb-sedimentary conditions, respectively.

Discussion

Surprisingly few species carried the major portion of the grazing load. Within the grass-forb-granitic soil condition, Idaho fescue contributed approximately 75 percent of the forage taken by cattle. Consequently, maintaining or improving the productivity of this single species appears to be of paramount importance in managing such ranges. In the sagebrush cover type, Idaho fescue, the wheatgrasses, (largely slender wheatgrass), and subalpine needlegrass provided 65 percent of the total forage. Again, these species ranked high in preference and herbage production. A similar situation existed on the grass-forb-sedimentary soil condition, where Idaho fescue, big bluegrass, and the wheatgrasses ranked in that order as forage producers. These species provided 69 percent of the forage obtained from grasses and sedges, although as many as 17 grasses and sedges were sometimes present. Here, subalpine needlegrass ranked fourth in forage production, third in herbage production, and ninth in preference. The combination of these characteristics suggests that management practices that would cause this needlegrass to decrease and favor the increase of Idaho fescue, big bluegrass, and the wheatgrasses would result in more pounds of desirable herbage.

FIGURE 2. Forbs were common on the cattle ranges, produced twice as much herbage as grasses and sedges combined, and were lightly grazed.

Forbs are a minor portion of the cattle diet even when it is assumed that cattle are responsible for all utilization. Although forbs may supply a relatively small quantity of forage, they may be of some importance nutritionally. Cook and Harris (1950) conclude that preference shown by sheep for certain types of forage was important in the nutritional value of the diet. As has been pointed out, forb utilization increases as the season progresses. Furthermore, as the utilization of the grasses and sedges increased from light to heavy, the pounds of forbs taken increased as much as 12 times in some areas. This suggests that, under these circumstances, the increase in forb utilization was due to a decrease in availability of the more highly preferred herbage rather than any tendency for the cattle to select the forbs.

The utilization of forbs and, to a large measure, grass and sedges appears to hinge largely on the preference of the species itself rather than such factors as herbage production, percentage ground cover, or distribution. Several species illustrate this. Silky lupine ranked high in preference among forbs as well as in herbage production and ground cover; also, it is common on the upland sites. Avens, when in the grass-forb-sedimentary soil condition, produced more herbage than any other forb, had an 80 percent frequency (3.1 x 3.1 ft. plot) and yet was rarely grazed. Blueleaf agoseris also had an 80 percent frequency but was a minor species in the vegetative cover, and yet it ranked high in preference. Idaho fescue was abundant, uniformly distributed (91 percent frequency), provided more ground cover than any other grass or sedge and was a preferred species. In contrast, subalpine needlegrass within the grass-forb-sedimentary soil condition had a low preference, although it ranked high in herbage production and was fairly well distributed—62 percent frequency. Similar examples indicating that utilization is due to preference rather than amount of herbage produced have been reported by Richards and Hawks (1954), Hurd and Pearse (1944), and Cook and Harris (1950).

On the cattle ranges sampled, forbs out-yield grasses and sedges approximately 2 to 1. However, only 6 percent of the total forb herbage produced was taken, and the forbs furnished 9 percent of the forage. The general conclusion, then, is that a shift in the balance toward equal production of forbs and grass-like plants would provide a considerable increase in palatable herbage. If this were achieved there would still be ample amounts of forb herbage available for selective grazing. Investigations on very lightly used areas and protected exclosures indicate that herbage production of forbs is essentially the same as that of grasses and sedges (Hurd and Kissinger, 1952).

Summary and Conclusions

From 1951 to 1954 investigations were made in the Big Horn Mountains of north central Wyoming to determine the species preferred by cattle grazing on upland sites. Utilization estimates formed the basis for giving species a preference rating. In addition, herbage production was estimated for individual species. Utilization estimate multiplied by herbage production for a species indicated the importance of the species as a forage plant. A total of 340 ten-plot transects were used for the preference work, and 65 transects, for herbage production. These transects sampled 23 areas on 11 cattle allotments ranging from 4,000 to 30,000 acres in size.

Grasses and sedges were preferred to forbs. Within the grass-sedge group, some species were consistently high in preference while others were low. Throughout the 4-year period, both Idaho fescue and big bluegrass were preferred grasses wherever they occurred. Wheatgrasses were generally in the intermediate preference category, while needleleaf sedge and prairie Junegrass were least preferred.

Generally, there were no striking changes in preference for grass-sedge species as the grazing season progressed. Similarly, no preference changes were noticeable when the grazing pressure increased; instead, the preferred species were grazed more closely.

Idaho fescue was the number one forage plant. On granitic soils, it alone supplied 75 percent of the forage. On the other two plant-soil conditions, it, together with the wheatgrasses, big bluegrass, and subalpine needlegrass, provided 65 to 70 percent of the forage.

Forbs, although abundant, were generally lightly grazed. Estimated utilization averaged 8 percent for those species grazed 1 percent or more. Many species were not grazed. Blueleaf agoseris, dandelion, silvery lupine, and white loco were the preferred species. Various combinations of these four species account for 86 percent of the forb forage.

Forb herbage production was double that of the grass-sedge group. However, only about 6 percent of it was eaten. As grazing pressure increased on the grass-sedge group, the utilization of forbs rose. Under these conditions, silvery lupine became an important producer of forage.

Utilization of a species did not appear to be influenced by frequency, abundance, or amount of herbage produced. A species was selected or rejected by cattle because of its preference or palatability. Accordingly, those species having a relatively high preference and high herbage production were the important forage producers. Management practices should be aimed at maintaining or improving the production of these important forage species.

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CALL FOR PAPERS FOR THE 1959 ANNUAL MEETING

Members who wish to present papers at the next annual meeting of the Society to be held in Tulsa, Oklahoma, in January 1959, are requested to submit titles and short abstracts to the Program Committee. Final date for titles to reach the Committee is July 15, 1958.—E. H. McIlvain, Chairman Program Committee, U. S. Southern Great Plains Field Station, Woodward, Oklahoma.

Competition Between Forbs and Grasses

DON D. DWYER

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Competition is occurring all the time among plants of the same as well as those of different species. However, little is known about how much the results of competition affect the production of grass. There is very little literature available concerning competition between native forbs and grasses. Weaver (1942) has described competition of western wheatgrass (*Agropyron smithii*) with relict vegetation but there is no discussion of competition between forbs and grasses as such.

Probably one of the most comprehensive accounts pertaining to plant competition was afforded by Clements, Weaver, and Hanson (1929). Hopkins (1951) felt that forbs decrease the production of grass, but that this reduction is compensated for by the yield of forbs, even though they may be lower in palatability.

Weaver and Clements (1938) stated that competition always occurs where two or more plants make demands for light, nutrients, or water in excess of the supply. Competition is essentially a decrease in the amount of water, nutrients, or light available for each individual.

The present study was conducted in an area near Hays, Kansas, that has been free from grazing or other unnatural disturbances for many years. The area, a big bluestem (*Andropogon gerardi*) type, was described by Albertson (1937) as a little bluestem (*Andropogon scoparius*) type. However due to the drought of the 1930's, big bluestem has largely replaced little bluestem. Big bluestem alone comprised over 60 percent of the vegetation (Tomanek and Albertson, 1953). The chief associates with this dominant were side-oats grama (*Bouteloua curtipendula*), 9.4 percent, and little bluestem, 26.6 percent.

The study began at the close of the growing season in order to obtain the results of a full season's growth. Big bluestem alone was used for the yield determinations.

Plan and Method

The object of the study was to determine the amount various forb species reduced the yield of big bluestem. The assumption was made that competition between the forb and grass was the only factor involved in the reduction. The square-foot method was employed to measure how forbs growing in close contact with big bluestem affected the production of the grass.

It was intended that the competition be limited strictly between the grass and a single forb species; therefore, the areas were selected. Selecting a sample involved finding an area where big bluestem was growing with the forb under study. This square foot had no other forb species present. In addition to this quadrat, another comparable area was selected near-by as a control and was represented by a pure stand of big bluestem. A total of ten such samples and controls were taken for each forb species studied.

These square-foot areas were clipped to within one inch of the ground and the forbs and grasses separated. Air-dry weight of clippings from both quadrats was compared in an effort to measure the degree of competition.

Scientific names of the plants cited in this study are in agreement with those found in Gleason (1952). Common names are taken from *Standardized Plant Names* (1942).

Results

Rhizomatous Forbs

Of the 5 rhizomatous forbs studied, heath aster (*Aster ericoides*) caused the greatest reduction in grass yield. An average of 19 asters was present in each square foot sampled. The weight of the asters averaged 13.3 grams per square foot (Table 1). The big bluestem produced an average of 28.5 grams of foliage per square-foot plot in pure stands, but only 9.1 grams in competition with heath aster. The reduction in grass yield averaged 68.1 percent.

This great reduction is easily explained when the underground structure is observed. The rhizomes are tough and woody, and are intricately interlaced among the rhizomes of big bluestem. In the upper 4 inches of soil, competition is very severe since the rhizomes of the two opposing plants are in direct contact with each other.

Stiff goldenrod (*Solidago rigida*) is a robust plant which has very short rhizomes. These rhizomes bunch together forming a large heavy crown that often produces as many as 12 plants. An average of 6 plants occurred in each sample. The average decrease in grass due to competition was 53.2 percent. Competition for space, in this case, was a factor in decreased grass production since the goldenrod often exclusively occupied as much as 16 square inches of the square-foot plot.

Western ragweed (*Ambrosia psilostachya*) is one of the most common forbs of the prairie. Its dense societies were very effective in reducing the yield of big bluestem an average of 55.7 percent. The rhizomes of ragweed

Table 1. Species of rhizomatous forbs studied, forb and grass weights, and percent reduction in yields of grass with forb competition.*

Species	Weight of Forb	Wt. of Grass in Quadrat With Forb	Wt. of Grass in Quadrat Without Forb	Average Percent Decrease Due to Competition
	gm.	gm.	gm.	%
Heath aster	13.3	9.1	28.5	68.1
Stiff goldenrod	38.8	10.2	21.8	53.2
Western ragweed	16.2	11.3	25.5	55.7
Aromatic aster	6.2	10.0	20.4	51.0
Velvety goldenrod	17.6	13.2	24.6	46.4

* All differences were significant at the 5 percent level.

were strongly intermingled with those of big bluestem and frequently, even grew through the heavy root crowns of the grass. There was an average of 6 plants per quadrat.

Although aromatic aster *(Aster oblongifolius)* is rather small in above-ground stature, its underground structure seemed to be very effective, since the yield of big bluestem was reduced 51.0 percent in plots where the aster was present. There were usually 16 plants represented in each quadrat. The rhizome growth characteristics of the aromatic aster greatly resemble those of heath aster. However, the former's rhizomes are a lighter tan in color and not as woody.

Velvety goldenrod (*Solidago mollis*), one of the less common goldenrods of the area, was rather robust in growth, usually around 15 inches in height, and an average of 11 plants were found in each sample. The rhizomes were dichotomous in nature, the older branches giving rise to many young shoots. There was an average decrease in the weight of the grass of 46.4 percent in the ten samples clipped. Unlike the short rhizomes of stiff goldenrod, the rhizomes of this forb were quite long, often with 4 or 5 plants attached to a single underground stem. These plants then sent out other rhizomes from the base of the shoot. Thus, with such a network of underground stems functioning to serve the numerous above-ground shoots, it is easy to understand the great reduction in grass yield.

Taprooted Forbs

Five taprooted forbs were chosen for study as a contrast to the rhizomatous plants.

Slimflower scurfpea (*Psoralea tenuiflora*) is a common inhabitant of the mixed prairie. The taproot is quite heavy on a mature plant—usually 2 or 3 inches in diameter immediately below the soil surface. It often extends to a depth exceeding 16 feet in a soil with a deep profile. This is far below the reach of prairie grasses and reduces competition between the plants. The weight of big bluestem clipped from the quadrat with the scurfpea averaged 20.4 grams while the plot with a pure stand of bluestem produced 23.2 grass. This represents a loss of only 12.8 percent (Table 2).

Blacksampson (*Echinacea angustifolia*) was widely scattered over the study area and there was seldom more than one plant in each sample. The quadrats containing this species produced only 18.9 percent less grass yield than those with pure big bluestem.

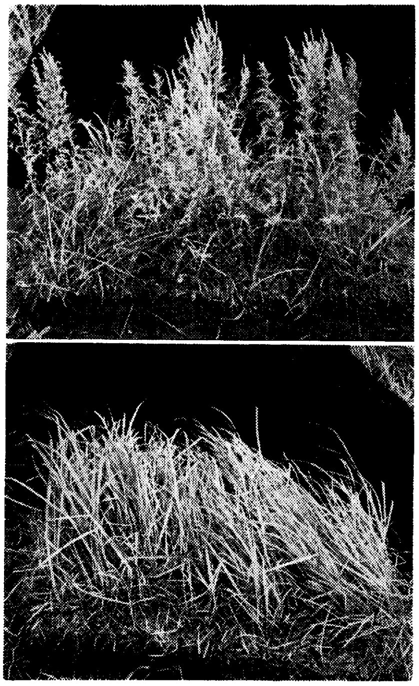

FIGURE 1. One-half meter sods 4 inches deep of western ragweed in competition with big bluestem *(above)* compared with one-half square meter of pure big bluestem *(below)*.

Broom snakeweed *(Gutierrezia sarothrae)*, a semi-woody plant with a heavy taproot, had an average weight of 12.5 grams per quadrat. It caused an average decrease in grass production of 12.4 percent.

Catclaw sensitivebriar (*Schrankia uncinata*), is a spine-covered plant whose decumbent growth characteristics had little

Table 2. Species of taprooted forbs studied, forb and grass weights, and percent reduction in yields of grass with forb competition.*

Species	Weight of Forb	Wt. of Grass in Quadrat With Forb	Wt. of Grass in Quadrat Without Forb	Average Percent Decrease Due to Competition
	gm.	gm.	gm.	%
Blacksampson	2.9	18.9	23.3	18.9
Scurfpea	5.2	20.4	23.2	12.8
Broom snakeweed	12.5	14.9	17.0	12.4
Sensitivebriar	4.2	19.4	21.8	11.1
Prairieclover	5.3	12.7	14.1	9.9

* No significant difference at the 5 percent level.

effect on the surrounding vegetation. Usually 2 or 3 plants were present in each sample.

No distinction was made between purple or white prairie-clover (*Petalostemon purpurea* or *P. candidum*) due to their similarity in form and growth habits. This plant usually consisted of 3 stems about 18 inches tall arising from a root crown. Grass production in quadrats containing these forbs was only 9.9 percent less than in pure grass quadrats.

The differences were tested for the taprooted forbs and found not to be significant at the 5 percent level. However, the decreases found due to the presence of rhizomatous forbs in the quadrats were all highly significant.

Roots and rhizomes

The object of this part of the study was to determine the reduction in roots and rhizomes of big bluestem due to the competition from rhizomatous forbs. Sods, one-half square meter in area by 4 inches deep, were removed. The sod containing rhizomatous forbs in competition with the grass was compared with a sod exhibiting a pure stand of big bluestem (Figure 1). These sods were taken within a few feet of each other. Water spray was used to remove the soil and reveal the underground parts. The roots of the forbs and grass were carefully separated and air-dry weight determinations made of each.

The sod containing heath aster revealed an amazing mass of interlacing rhizomes when the soil was washed away. These rhizomes tend to occur between the root crowns of big bluestem and the soil surface (Figure 2). No area existed in the one-half square meter which was free of aster rhizomes.

There were 167.4 grams of heath aster roots and rhizomes and 237.1 grams of big bluestem (Table 3). The control quadrat produced 600.1 grams of big bluestem roots and rhizomes. The loss incurred by the grass roots due to competition from heath aster was 60.5 percent.

Aromatic and heath asters were growing closely enough together that a single control quadrat of pure bluestem was used as a comparison for both. Roots and rhizomes of aromatic aster weighed 98.6 grams, and the bluestem roots produced in this same quadrat weighed 371.6 grams. In the control, 600.1 grams of roots occurred. The decrease of grass roots and rhizomes was 38.1 percent.

The rhizomes of western ragweed were found to be mostly below the crowns of big bluestem. Although the weight of ragweed was small, 70.2 grams, the reduction in the grass roots was 53.6 percent.

Velvety goldenrod's roots and rhizomes weighed 69.7 grams and the grass roots with it weighed 387.5. The pure stand of bluestem in the control plot with it produced roots weighing 508.8 grams. The percent loss of grass roots and rhizomes due to competition from the forb was 23.8.

Summary

The purpose of this study was to determine the loss in weight suffered by big bluestem (*Andropogon gerardi*) as a result of competition from both rhizomatous and taprooted forbs.

The results obtained readily reveal that in all but one in-

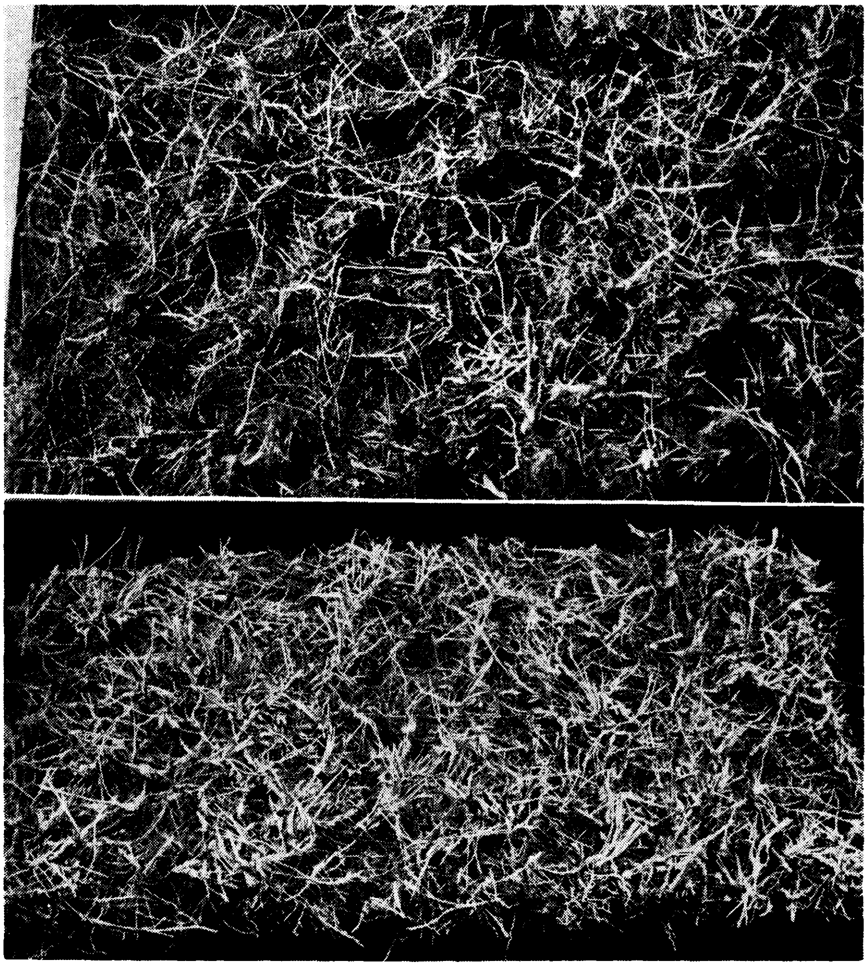

FIGURE 2. One-half square meter of heath aster and big bluestem roots and rhizomes *(above)* compared with one-half square meter of pure big bluestem roots and rhizomes *(below)*. Note lighter colored rhizomes of the aster intermingled in the sparse bluestem rhizomes *(above)*.

Table 3. Weights in grams of roots and rhizomes in one-half square meter sods and percent decrease in big bluestem roots and rhizomes with competition.

Plant	Sods With Forbs			Sods Without Forbs	Percent Decrease of Roots and Rhizomes of Grass
	Forb	Grass	Total	Grass	
Heath aster	167.4	237.1	404.5	600.1	60.5
Western ragweed	70.2	332.1	402.3	717.4	53.6
Aromatic aster	98.6	371.6	470.2	600.1	38.1
Velvety goldenrod	69.7	387.5	457.2	508.8	23.8

stance the plants with rhizomes decreased the production of big bluestem over 50 percent. Heath aster *(Aster ericoides)* caused the greatest decrease in yield, both aboveground and in the roots and rhizomes of the grass belowground. Competition from velvety goldenrod *(Solidago mollis)* was the least effective of plants with rhizomes in reducing grass production.

A possible explanation for the reduction in grass yield might be that the rhizomes of the two competing plants are in direct contact with each other in the surface 4 inches of soil. The roots strive to satisfy mutual needs which, for the most part, are obtained from the surface layer. When demands are made in excess of the supply, reduced production is the only alternative.

None of the taprooted forbs studied caused a significant decrease in grass yield. These plants utilize moisture and nutrients below the roots of the grasses, thus reducing competition below-ground to a minimum.

Competitive effects of rhizomatous forbs on big bluestem roots and rhizomes were great. Even the combined weights of roots and rhizomes of the opposing plants did not equal the weight of the bluestem in pure stands.

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Summer Society Meeting With The Pacific Northwest Section

Kamloops, B. C., July 11-12, 1958

The annual field trip of the Pacific Northwest Section of the Society is to be held in Kamloops, British Columbia on July 11 and 12, 1958. The National Directors will be meeting with us at this time, therefore a cordial invitation is extended to all members of the Society to attend.

This two-day meeting will take the form of a "workshop" in which ranchers and Range Technicians will discuss and analyze range problems as they exist on the areas visited. Everyone present will have an opportunity to participate and thereby learn.

The first day of the tour will be spent on the Range Experimental Farm and its adjacent ranges. Here will be seen and discussed; irrigated forage production, plant introduction, plant poisoning by timber milkvetch, dryland range seeding, sagebrush control by beetles as well as chemicals, game and beef cattle competition for the range, and the use of managed pastures for breeding beef animals.

The second day will take the tour into "Timber Ranges" with discussions of management needed, logging road reseeding, fencing, salting practices, and carrying capacities of the different range types.

Apart from the academic side of this tour we plan to show a little western Canadian hospitality which is guaranteed to relieve any monotony.

You are reminded that this is Centennial year for British Columbia, 1858-1958. We are marking our one hundredth birthday with a tremendous celebration accenting our early history. A visit to our Province this year will prove both enjoyable and interesting.

If you are planning to attend the "summer roundup," and we hope you are, will you let us know by dropping a line to the address below. Everyone loves a roundup so please come and join in ours.

W. L. Pringle, Chairman
Field Trip Committee
Box 340
Kamloops, B. C.

Measurement of Time and Rate of Growth of Range Plants with Applications in Range Management

LORENZ F. BREDEMEIER

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It is generally recognized that rest from grazing is often the most economical way to restore a range to full productivity. However, in order for the rest to be effective it must be related to the seasonal growth habits of the forage species to be benefited. Benefits result from seed production, but primarily from the increased storage of carbohydrates in the roots. McCarty and Price (1942) showed how carbohydrate content in the roots is correlated seasonally with stages in the growth cycles of various grasses.

It is also generally recognized that returns are greatest from grazing grasses in their most active growth period. Sullivan and Garber (1947) in a review of chemical composition of pasture plants as it affects nutrition, concluded that the stage of growth is the most important factor. In early stages of growth, all grasses are succulent with high protein and low fiber content. In later stages of growth, the composition changes in the direction of a lower protein and phosphorus content with higher carbohydrate, fiber, and calcium content. Palatability and therefore intake also varies with the maturity or stages of growth in each species.

The foregoing considerations point to a need for more accurate local data on the time, rate and stages of growth of range plants.

Procedure

Range plants were measured at weekly intervals in 1955 and 1956. The interval was extended to 2 weeks when the growth rate declined. Measurements also were made throughout the winter but at irregular intervals as weather permitted. Included in the study were over 100 plants in 1955 and over 300 in 1956. The height of each leaf tip, the green or live portion of each leaf, and the collar height of each was measured on all grasses in 1956 and on part of the grasses in 1955. The balance of the grasses in 1955 were measured for highest growth and height of the remaining green portion. These measurements were each recorded by individual bunches or individual shoots. The ground surface was the base or zero for all measurements. Approximately 50,000 measurements were recorded for the 1956 season.

Phenological data were also recorded both years. Portions of these data are consolidated for presentation here as three variables in the growth cycles of perennial grasses. They are total elongation, residual length and green length.

Total elongation will mean the total growth in length or height of all leaves and flowering stems to a certain date, whether or not still present on the plant. It is attained for each grass by adding the height measurements of all the leaves and flowering stems on a certain date.

Residual length will mean the remaining length or height of dead and live leaves and stems still attached to the plant at the time of measurement. Rabbits, insects, field mice and possibly other small animals sometimes ate the green leaves. It seemed they preferred the ones being measured. Wind, hail, snow and handling also broke off dry portions.

Green length will mean the observable green length on the leaves and stems at the time of measurement. Green length is of special interest because it largely governs grazing preferences by seasons.

The study was in an ungrazed area 3 miles south of North Platte, Nebraska, which is served by a first order Weather Bureau station with over a half century of meteorological data. Total precipitation in 1955 was .51 inch above normal and in 1956, .64 inch below normal. The soil of the area was mapped as a very fine sandy loam on loess parent material.

Results

Data on three widely known range grasses, which are also important on the study area, are presented in Figure 1. These grasses are: Western wheatgrass *(Agropyron smithi)*, a grass evolved from northern ancestry; sideoats grama *(Bouteloua curtipendula)*, a grass with ancestry believed traceable to the Mexican Plateau and little bluestem *(Andropogon scoparius)*, a grass of tropical ancestry. The data show time and rate of elongation, and are not intended to show forage production (Fig. 1).

The three variables as shown in Figure 1 are averages from representative plants of each species. The months are divided into quarter months.

Visible fall growth on western wheatgrass started on October 3, 1955. Elongation as shown by the solid line was rather rapid until the last quarter of October. From the first quarter of November to the first quarter of March there was a very small amount of elongation. Some plants of western wheatgrass did not elongate during this period but others did. Spring growth was first evident the first quarter of March. Rapid

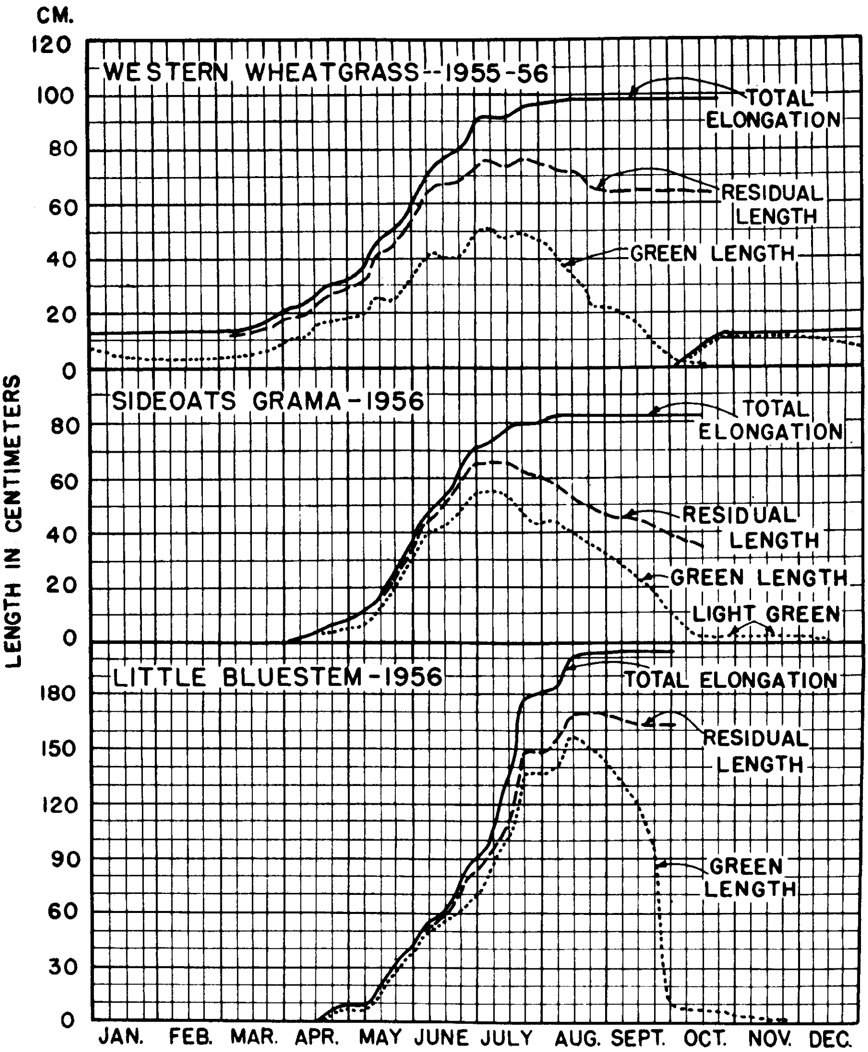

FIGURE 1. Graphs showing total elongation for time and rate of growth of three range grasses at North Platte, Nebraska, in 1956. Residual length and green length are also shown.

growth started the second quarter of May. Rate of growth declined the first quarter of July, and elongation essentially stopped by mid-August. The foliage loss as shown by difference between total elongation (solid line) and residual length (dashed line) in March, April and May was largely that which grew the previous fall. The loss increased the second quarter of June, but growth offset loss so that maximum residual length occurred in July. It declined during August, becoming rather stable by Sept. 1. This stability of residual length in western wheatgrass indicates its effectiveness in maintaining a mulch. Green length, indicated by the dotted line, was evident all winter. It reached the lowest point by the last quarter of January, remaining stable through February. Most plants which started elongation in the fall maintained some green length through the winter. The earliest or oldest leaves were damaged most by freezing weather. The newest or the rolled center leaf was rarely affected except for a gradual slow browning starting at the tip. Green length increased with the start of spring elongation. The maximum was attained the first quarter of July. Some continued into the third quarter of October, thus overlapping the time it started growth the previous fall. From this it could be said that western wheatgrass was green the year around.

Visible growth on sideoats grama started on April 1. The rapid elongation rate started the second quarter of May and subsided the first quarter of July. Maximum elongation was attained by the second quarter of August. The residual length shows very little foliage loss until the last of June. The leaves of sideoats grama are very brittle when brown and dry. Moreover, the majority of the leaves are relatively close to the ground so are subject to the extremes of the microclimate. Low freezing temperatures in the early growth period caused some brown on essentially all of the first spring leaves. Green length correlated closely with total elongation, the maximum occurring the first half of July. It declined at a rather uniform rate until the second quarter of October. A small amount remained into the winter, but by November it was a light green. Some green length may persist through the winter, since some greenness was measured April 1 on leaves which obviously grew the previous year. This possibility is being studied currently.

The first growth of little bluestem, visible out of small lower sheaths, was in the second quarter of April. Rapid elongation started the second quarter of May and declined the second quarter of August. The accelerated rate in mid-July was during jointing and the appearance of the inflorescenses. The tip of the uppermost lemma was measured on each raceme emerging from separate sheaths. Although the racemes and pedicels continued to grow, elongation was slower during the last quarter of July and the first quarter of August. Secondary racemes then appeared beside the first, out of the uppermost sheaths. The measurement of these produced the apparent resumption of elongation in the second quarter of August. Elongation was completed by the last quarter of August. Residual length shows that the foliage loss was gradual until the last quarter of July, when a sizeable loss occurred. Residual length then paralleled elongation until the first quarter of September, when there was a little more loss. It then remained about the same, indicating that little bluestem is effective in maintaining a mulch. Green length shows that there was only a small amount of browning early in the growth period, indicating that little bluestem was affected less by low freezing temperatures than was sideoats grama. The greatest amount of green length occurred in the second quarter of August. It declined rapidly during September. The small amount remaining green on October 1 browned gradually, with a small amount remaining green until November 24. None was visible December 16.

The five species producing the bulk of the forage in the area are western wheatgrass, sideoats grama, prairie sandreed *(Calamovilfa longifolia)*, needleandthread *(Stipa comata)*, and little bluestem. The grand period of growth for a species is the period of most rapid elongation or the time in which the bulk of its foliage is produced. The date of the maximum green length and the grand period of growth for five grasses are shown in Table 1.

In Table 1 the grasses are listed in the order in which they successively attained maximum green length. Western wheatgrass and sideoats grama did this on July 9. These were followed by prairie sandreed July 22, needleandthread July 28, and little bluestem August 14.

Although the phenology of these species is quite different, it is highly significant in range management that the time of beginning of the grand period of growth varied but little. It occurred the second quarter of May for each of the five species. The duration of the grand period of growth varied from 1¾ months for western wheatgrass and sideoats grama to 3 months for little bluestem.

If these five species were arranged in the order in which they began visible growth in the spring, the order would be: western wheatgrass, needleandthread, sideoats grama, little bluestem and prairie sandreed, with very little difference between the last two. All five attained their maximum elongation in August.

Discussion

Measurement of the highest growth only, as was made on many plants in 1955, does not reflect all the growth activity. Plains muhly *(Muhlenbergia cuspidata)* is an unpretentious appearing grass with a much branched stem. Often two stem branches with leaves grew from one node in a single sheath. Its tallest growth was only 22 centimeters, but the maximum elongation averaged 238 centimeters.

Certain species may appear brown and dormant throughout the winter. New growth is not discernible by green color at the base of shoots, as such winter increments are frozen and become brown as they are added. In such cases, measurements of total length revealed an increase, even though the shoot appeared brown at two successive measurements. The term "pseudodormancy" is suggested for this condition.

It is recognized that amount, and to a lesser degree, time of rainfall have an effect on grass growth. However, the weather is never the same, at least in Nebraska, so variations are normal. Total precipitation in 1955 was .51 inch above normal, with May and June 74 percent above normal and July and August 84 percent below normal. The 1956 precipitation, which was .64 inch below normal showed a deficiency of 56 percent in May. In June it exceeded normal by 79 percent, but in September it was 98 percent below normal. Moreover, no precipitation was received in October until the 24th. The amount of precipitation received during the different months varied widely between the two years. Even so, the total elongation each year for prairie sandreed and western wheatgrass showed a marked correlation in time and rate of growth. Elongation was greatest in 1955 for both species.

Conclusions

Western wheatgrass and needleandthread, which start new growth in the fall, are in a state of pseudodormancy through the winter.

The time of beginning the grand period of growth is essentially the same for five phenologically different but major grasses on the site. They are western wheatgrass, needleandthread, sideoats grama, little bluestem and prairie sandreed. Little bluestem had the longest grand period of growth, which was 3 months.

Table 1. Date of maximum green length and the grand period of growth (period of most rapid elongation) for five major range grasses on the silty range site at North Platte, Nebraska.

Species	Maximum Green Length *Date*	Grand Period of Growth (Most rapid elongation) *Month and Quarter*
Western wheatgrass	July 9	May 2nd. Q—July 1st. Q
Sideoats grama	July 9	May 2nd. Q—July 1st. Q
Prairie sandreed	July 22	May 2nd. Q—July 4th. Q
Needleandthread	July 28	May 2nd. Q—July 1st. Q
Little bluestem	Aug. 14	May 2nd. Q—Aug. 2nd. Q

Maximum elongation was attained by all five species at essentially the same time, that is, the fourth quarter of August in 1956.

Differences in the time and amount of precipitation in 1955 and 1956 had little influence on the grand period of growth. The major percentage of forage was produced in essentially the same relatively short period of both years.

Species varied in their effectiveness in maintaining a mulch. These data make possible more accurate timing of periods of rest or grazing to accomplish desired objectives, whether for strengthening or increasing certain species, or for maximum rate of livestock gains.

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Sagebrush Control with 2,4-D

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Sagebrush covers about 95 million acres of rangeland in the western United States. In northeastern California alone, 5 million acres are in this vegetative type, largely dominated by one of three species: big sagebrush (*Artemisia tridentata*), black sagebrush (*A. arbuscula*), or silver sagebrush (*A. cana*). These three kinds of sagebrush have very low palatability for livestock on this rangeland, which is valued for summer grazing. The sagebrush competes strongly with forage plants, thereby reducing forage production and grazing capacity of the range. Field scale experiments conducted from 1946 to 1954 have shown that sagebrush is effectively controlled by use of selective herbicides.

All three species of sagebrush proved highly susceptible to 2,4-D (2,4 dichlorophenoxyacetic acid). The best spray solution was 2 pounds acid equivalent butyl ester of 2,4-D in an oil-water emulsion at 10 gallons per acre. Spraying was most effective when new twigs were 3 to 4 inches in length—between late May and mid-June on the areas selected for the experiments. Airplane, helicopter, and ground-rig spraying gave highly satisfactory kill of sagebrush if care was taken to obtain complete coverage of the foliage at the optimum growth stage with the recommended spray material.

[1] *Maintained at Berkeley, California by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.*

Previous Tests and Chemicals

The earliest spraying of sagebrush with hormone sprays in northeastern California was conducted in 1946 by R. K. Blanchard in fire control research and A. L. Hormay in range-management research, both of the California Forest and Range Experiment Station. Heavy rates of application were employed; the sodium salt of 2,4-D was applied at rates of 12.5, 25.0 and 37.5 pounds acid equivalent in 1,600 gallons of water per acre. The important finding from these early experiments was that sagebrush was susceptible to 2,4-D, and the results pointed to the desirability of developing practical field methods to use in chemical control of sagebrush.

Control of big sagebrush by use of chemicals has been reported by other workers, including Hyder (1954) in eastern Oregon, Hull and Vaughn (1951) and Bohmont (1954) in Wyoming, and Hervey (1951) in Colorado. Their findings are in close accord with the results reported in this paper.

Methods and Results of Field-scale Spraying

To determine the best time to apply hormone sprays, a series of large plots was sprayed at monthly intervals beginning in May 1949. A motor-driven sprayer, which was placed in the bed of a pickup truck, and a 20-foot boom were used. The work was centered on the Lassen National Forest at an elevation of 5,600 feet. In this area most of the precipitation comes as snow in the winter. The soil was well supplied with moisture after snow melted in April and on through May. As the temperature climbed during this period, conditions became favorable for rapid vegetative growth.

The highest percentage kill of sagebrush was obtained from spraying in May and June (Table 1), when the new twig growth was in early stages of development. The optimum stage for spraying came when 3 to 4

Table 1. Control of sagebrush sprayed in 1949 with 1 pound of butyl ester of 2,4-D per acre at monthly intervals and with 2 pounds in June.

Type of sagebrush	Sagebrush kill, when date and rate of spraying were—			
	May 20	June 20		July 20
	1 lb.	1 lb.	2 lbs.	1 lb.
	Percent			
Big sagebrush	77	75	98	60
Black sagebrush	92	89	94	35
Silver sagebrush	70	81	96	38

inches of new twig growth had been produced. During the course of these studies, this stage occurred between May 20 and June 15, varying from year to year.

The three species of sagebrush did not differ significantly in susceptibility to 2,4-D when sprayed at the optimum time and rate—in June with 2 pounds of the butyl ester (Table 1). In another test, solution was applied by airplane at the same growth stage and gave big sagebrush kill of 100 percent; black sagebrush, 98.3 percent; and silver sagebrush, 98.8 percent. Big sagebrush was more susceptible than black or silver sagebrush when sprayed in July (Table 1). Black sagebrush proved more susceptible than big sagebrush in May, and at the 1-pound rate of 2,4-D, in June.

Silver sagebrush was the only species that showed a tendency to sprout from the base after the tops had been killed by spray. This resprouting was not sufficient to present a serious problem of re-invasion.

Several formulations of 2,4-D were tested[2] during the years 1948 to 1954 (Table 2). Butyl ester of 2,4-D proved the most effective and economical of all forms used. The sodium salt, alkanolamine, and isopropyl ester forms did not give such consistently good results as the butyl ester. Two low volatile esters of 2,4-D—butoxy ethanol ester and propylene glycol butyl ether ester—were slightly more effective than the butyl ester but were not as economical, considering cost per pound in relation to percentage kill.

Where no susceptible agricultural crops grow near the sagebrush to be sprayed, the high volatile butyl ester is recommended. Where near-by crops may be injured by volatilization and drift of the selective herbicide, low volatile ester should be used. Comparisons of 2,4-D and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) revealed that the latter gave no higher kill of the sagebrush species than 2,4-D. Since the 2,4,5-T is more costly, it is not recommended.

The kind and rate of the carrier for the selective herbicidal sprays is important. The amount cannot be great or the cost of treatment will be too high; yet the gallonage per acre must be sufficient to give good coverage of all the foliage and to penetrate and permit movement of the selective herbicide in the plant. Adequate coverage for sagebrush control requires several small droplets for each leaf. Spray should cover at least 30 percent of the foliage area as described by Graham (1953). Nine gallons of water and ½ gallon of diesel oil per acre as an oil-water emulsion gave the best results. Addition of the selective herbicide at about ½-gallon

[2] *Selective herbicides were furnished for testing by American Chemical Paint Company, Dow Chemical Company, and Thompson Chemicals Corporation.*

Table 2. Comparison of selective herbicides for control of sagebrush in experiments conducted during 1949, 1951, 1952, and 1953. Lassen National Forest, California.

Formulation	Rate acid equivalent per acre	Control of sagebrush
	Lbs.	*Percent*
	—1949—	
Butyl ester 2,4-D	2	96
Butyl ester 2,4-D	1	82
Butyl ester 2,4-,5-T	1	41
Butyl ester 2,4-D and 2,4,5-T mixed	2	83
	—1951—	
Butyl ester 2,4-D	2	99
Butoxy ethanol ester 2,4-D	2	99
Butyl ester 2,4,5-T	2	96
Butyl ester 2,4-D	1	83
Butoxy ethanol ester 2,4-D	1	97
Isopropyl ester 2,4-D	1	87
	—1952—	
Butyl ester 2,4-D	2	100
Butoxy ethanol ester 2,4-D	2	98
Alkanolamine 2,4-D	2	95
Isopropyl ester 2,4-D	2	82
Butoxy ethanol ester 2,4-D	1	87
	—1953—	
Butyl ester 2,4-D	1	81
Alkanolamine 2,4-D	1	75
Butoxy ethanol ester 2,4-D	1	94
Propylene glycol butyl ether ester 2,4-D	1	96
Propylene glycol butyl ether ester 2,4-D	2	100

Table 3. Helicopter and ground sprayer results in controlling sagebrush: 1950 application, Lassen National Forest.

Method	Treatment				
		Rate per acre			
	Form of 2,4-D ester	Acid equivalent	Oil-water emulsion carrier	Speed of application	Kill of sagebrush
		Lbs.	*Gal.*	*M.p.h.*	*Percent*
Air by helicopter	Butyl	2	10	30	92
	Butyl	1	10	30	76
	Butyl	1	5	30	44
	Butyl	1	5	60	24
	Butyl	1	2½	60	27
Ground by 10-foot boom sprayer	Butyl	1	10	4	96
	Isopropyl	1	10	4	65

makes a total volume of 10 gallons per acre.

Spraying by helicopter was tested in 1950 on 200 acres in the Lassen National Forest. As a part of this operation, the helicopter was used to apply different rates of active herbicide and of carrier per acre. These experimental applications were compared with others made at the same time by ground rig (Table 3). For aircraft application, the 2-pound rate of 2,4-D was superior to the 1-pound rate. Also, 10 gallons of carrier and 2,4-D per acre gave a higher percentage kill than either 5 or 2½ gallons per acre. Applying the same form and rate of 2,4-D by ground sprayer gave a better distribution of spray over the foliage, hence a higher percentage of kill than application by helicopter. Although the 1-pound rate gave high percentage kill when applied by ground sprayer in this test, through the years ground application at the 2-pound rate has proved more consistently effective.

An airplane was used in 1951 to spray more than 3,000 acres of sagebrush on the Lassen and Modoc National Forests. Also, a 200-acre area of sagebrush at 5,800-feet elevation was sprayed on Bureau of Land Management rangeland near Cedarville, California. Two pounds acid equivalent of butyl ester of 2,4-D was applied in 9½ gallons of oil-water emulsion per acre.

The airplane was highly satisfactory for spraying. Excellent coverage of the foliage was obtained on 90 percent of the total area sprayed on the Lassen National Forest at an elevation of 5,600 feet. Where this excellent coverage was obtained, 98.5 percent of the sagebrush was killed. Certain strips were inadequately covered with spray because winds shifted, or swaths were not properly aligned. Also, scattered pine trees occasionally obscured the pilot's view of flagmen, causing a few strips to be missed. The kill on this 10 percent of the area was only 11.8 percent and apparently resulted from spray drifting from adjacent strips. The airplane spraying for the entire area of 1,750 acres on the Lassen National Forest resulted in a sagebrush kill of 88.5 percent. The highest percentage kill, 99 percent, was obtained on the area sprayed in the south Warner Mountains of the Modoc National Forest, at an elevation of about 7,500 feet. Two species, big and silver sagebrush, were equally represented at this location. On the Bureau of Land Management rangeland, sprayed the same season with the same equipment and formulation, the mortality was 92 percent (Fig. 1).

Discussion

Spraying with selective herbicides for sagebrush control has the greatest application on rangeland with enough understory grass present to establish an adequate vegetative cover of palatable forage plants. This treatment provides a method of extending improvement practices into areas that have good soil but are too rocky, sandy, or steep for plowing and reseeding.

Where plowing is required for preparation of a seedbed, or

FIGURE 1. Big sagebrush killed by airplane spraying with 2,4-D, June 7, 1951, on Bureau of Land Management rangeland near Cedarville, Calif. Photographed June 17, 1952.

where burning is feasible, it may not be advisable to spray. If seeding of forage plants is required, greater forage production may be realized when the deteriorated rangeland can be plowed or burned. Burning requires a fairly dense brush and understory material for carrying the fire. Where sparseness or patchiness of growth occurs on sagebrush rangeland, then spraying will be superior to burning.

Any attempt to control sagebrush increases the importance of good grazing management. The more palatable plants must be allowed to increase and provide vegetative cover for control of erosion and improvement of the soil. Poor management and excessive grazing may cause greater deterioration of the soil than if the sagebrush cover were permitted to remain.

Summary

Three species of sagebrush (big, black, and silver sagebrush) occur on 5 million acres of rangeland in northeastern California and were found highly susceptible to 2,4-D. The best control was obtained with 2-pounds acid equivalent of butyl ester of 2,4-D in 9 gallons of water and one-half gallon diesel oil per acre. Sagebrush in active stage of growth with new twigs from 3 to 4 inches in length coming between late May and mid-June was more susceptible to spray than earlier or later stages of seasonal growth. Distribution of spray to all of the foliage was necessary for good kill and was accomplished by airplane, helicopter, and ground-rig sprayers.

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Natural Sources of Nitrogen and Phosphorus for Grass Growth[1]

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Fertility is essential for grass growth. The amount of nitrogen and phosphate available often regulates production within the limits of available moisture. Recent studies of fertilizer applications on ranges have demonstrated that greater production is possible with greater fertility.

Since grass grows year after year without fertilization, it is reasonable to assume that there are some natural sources of fertility.

Nitrogen

The large and continual loss of nitrogen establishes that there is a source of nitrogen. Losses of nitrogen occur both from the soil, and from the vegetation, both growing and dead. Leaching by both surface run-off and percolating waters cause a loss of nitrates. Volatilization is a factor (Lyon, Buckman, Brady; Black, 1952). The carry away of nitrogen by the grazing animal is particularly important.

Information that would establish the source of nitrogen and the amount that is needed, is lacking. Ideas accumulated from various sources indicate that the amount of nitrogen available to the grass plant on the range is greater than is generally realized. Possibly 100 pounds of nitrogen per acre, or more, may be available annually on ranges capable of producing 1 animal unit month of carrying capacity per acre.

What are some possible sources of nitrogen?

Legumes have been known to fix large amounts of nitrogen. A report from New Zealand (Hafenrichter, 1957) cites that as much as 600 pounds of nitrogen per acre can be fixed on pastures with white clover (*Trifolium repens*). Possibly where native legumes make up a considerable portion of the cover they are an important source of nitrogen. Even poisonous legumes such as locos (*Astragalus, Oxytropis*) and lupines (*Lupinus*) may be of value on the range from the standpoint of nitrogen fixation. Many ranges have few or no legumes. Ranges without legumes seem to produce as much as do those with legumes.

Is lightning a source of range nitrogen? Only small amounts of nitrogen have been shown to fall with rain or snow. It is of the magnitude of five pounds or less, where thunderstorms are frequent (Lyon, Buckman and Brady, 1952). The amount of

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nitrogen supplied from lightning seems small compared to the amount needed to grow grass.

A *hidden* source of nitrogen is frequently referred to. The following are examples of such references.

McGinnies and Retzer (1948) have stated: "Vigorous range plants need nitrogen, phosphorus and potassium. When ranges are in good condition, these essential elements are usually available in adequate quantities." McGinnies and Retzer associate fertility with range in *good* condition.

Voight (1951) has stated: "Until organic matter accumulates and fertility is partially restored by *reaction* of *grasses* and *forbs*, there seems little chance of better grasses and forbs becoming established." What kind of a *reaction* of grasses and forbs does Voight have reference to that restores fertility?

Connaughton (1948) states: "The forage was too closely cropped, the plants lost vigor, less and less organic matter was produced to be returned to the soil. Fertility in turn declined." Is there perpetual motion in the nitrogen cycle? With greater production, in terms of carrying capacity, wouldn't the losses of leaching, volatilization and carry away be greater? Wouldn't fertility decline with greater production, instead of increase?

Hormay (1956) has recommended resting the range for a year or two at a time to restore production. Would such a rest be necessary to provide an accumulation of fertility?

Clements (1949) states: "The ecologist looks upon grassland in general and the prairies and plain in particular as almost inexhaustible reservoirs of soil fertility ..." Where did the fertility come from to fill the reservoirs, with sixty million bison and other wild animals grazing on the plains?

There are factors in established range management practices that provide and restore fertility. The factors seem to be associated with ranges in healthy, good condition.

There is a type of nitrogen fixation that may be providing most of the nitrogen for range growth. Lyon, Buckman and Brady (1952) reported that 42 pounds of nitrogen accumulated in the soil on plots kept in grass with all of the residues remaining. The amount of nitrogen that accumulated in the soil would be only a part of the nitrogen fixed. The amount lost from the plant residues through volatilization and leaching is not accounted for.

Conditions on the range are favorable for nonsymbiotic fixation. Millar (1955) reports that nonsymbiotic fixation is favored by lime, phosphate, aeration, a supply of highly carbonaceous organic matter and a lack of available soil nitrates.

The supply of carbonaceous organic matter may be the regulating factor (Thompson, 1952). Just how or where the bacteria carry on their fixation is not well understood. It is conceivable that the bacteria use for energy the carbonaceous organic matter of the replaced grass roots and possibly the litter that accumulates on the soil surface. Healthy range grasses replace an enormous amount of their extensive root system every year (Stoddart and Smith, 1955).

The theory of nonsymbiotic fixation explains many of the established range practices. A supply of carbonaceous organic matter for energy is necessary. Limited utilization provides organic matter in the roots produced and the litter that accumulates on the surface. It has been shown that close utilization practically stops root production (Weaver, 1926). Could the restriction of nitrogen fixation be an important factor in too close a utilization?

Root and top growth are dependent upon adequate fertility. McGinnies and Retzer (1948) state: "Important amounts of fertility are returned to the soil by decaying herbage after grazing." Nonsymbiotic fixation apparently doesn't supply enough nitrogen for each year's growth. Some nitrogen needs to be left in the ungrazed cover to maintain fertility. "When the harvestable portion of the range is gone, however, there is a residue that must be left if the range is to continue normal production." (Stoddart and Smith, 1955).

Factors that favor growth, particularly root growth, would favor nitrogen fixation. Rogler and Lorenz (1957) reported that two years of fertilization with 90 pounds of nitrogen each year did more to improve range condition and increase production than six years of complete isolation from grazing. The applied nitrogen increased the supply of accumulated organic matter by stimulating growth. With increased organic matter, nitrogen fixation increased.

Organic Matter

It has been established for arable soils that the level or amount of nitrogen determines the amount of organic matter that will accumulate (Millar, 1955). Having nitrogen available for organic matter accumulation may explain the upgrading of range from light utilization, and the deterioration in range condition from over utilization. McGinnies and Retzer (1948) state: "A vigorous grass range owes its existence to the soil stability, fertility, and reasonably favorable soil moisture conditions maintained by the grass cover. If the stand of grass has deteriorated, growing conditions are less favorable ..." The soil organic matter becomes depleted as the grass stand deteriorates. The nitrogen is used up in growth and there is not enough fixation for replenishment.

It is conceivable that grasses that produce more roots would enhance greater nitrogen fixation and a faster build up of organic matter.

Manure

Sampson (1928) reported that one third less range was required for sheep where they spend only one or two night on the same bed ground. The manure contains about 80 percent of the fertility value of the grass consumed. Loss of manure-fertility in brush and tree areas, and bedding and camping areas constitutes a direct loss to grass production.

The fertilizing value of the manure is much greater when green grass is being grazed. The fertility value of manure from the grazing of mature grass is low. Phosphates are readily leached out of mature forage (Stoddart and Smith, 1955). This is also true of nitrogen. In the spring and summer the grass is highly nutritious (Morrison, 1956), being well supplied with protein (nitrogen) and phosphorus. The young plants gorge on nitrogen and hold it for later use. (Allison, 1957).

Light applications of fertility from manure are almost impossible to obtain. Woodhouse, Peterson, and Lucas (1957) reported that up to 700 pounds of nitrogen per acre are applied in bovine urine spots. In areas where the stock collect, the rate of application is greater. If manure accumulates until a supply of soil nitrates develops, nitrogen fixation is retarded (Bear, 1948).

With the carry away of fertility by the grazing animal the soil becomes depleted in nitrogen and phosphorus. Without fertility the grasses are not able to produce root-carbonaceons organic matter for nonsymbiotic fixation. The carry-away loss of fertility is particularly acute during the times when the grass is green. Where moisture is available for continual growth (as in snow drift areas), almost all of the fertility is removed with the grazing of the continually green grass.

Phosphates

There are some natural sources of phosphate supply. Soil organic matter has been shown to cause unavailable phosphate to become available (Thompson, 1952). Increasing the soil organic matter increases the amount of available phosphate.

Deep rooted plants are able to obtain nutrients, chiefly calcium and phosphorus from the lower soil horizons and deposit them in the surface horizons as constituents of leaves and stems (Weaver, 1926). Pieters (1927) reported that sweet clover *(Melilotus alba)* is able to secure potash and phophates from ground which corn makes almost no growth whatever. Similar effects have been shown for alfalfa. Alfalfa is able to absorb mineral from rock phosphate and feldspar that is not readily available to wheat or corn. Native legumes undoubtedly have properties of absorption similar to alfalfa and sweet clover.

Some phosphate is carried over in the plant residue.

Measure of Fertility

"The best yardstick we have of soil fertility is relative yield," Davies (1952). Range fertility production can be measured in carrying capacity and animal gains—on a sustained basis.

In this area (southwestern Montana) range production can be increased on favorable sites by plowing out the native cover and sowing to orchard grass *(Dactylis glomerata)* and alfalfa (Miles, 1954). Ground that has a productive capacity of one animal unit month when in good condition native range, will produce three animal unit months of grazing when sown to alfalfa and orchardgrass.

With plowing and reseeding the source of nitrogen changes from nonsymbiotic fixation to symbiotic. Waksman (1952) reports that a much smaller expenditure of energy is required for symbiotic fixation. About three times as much carbohydrate energy is required for nonsymbiotic fixation as is required for symbiotic.

Love and Williams (1956) report that in California, introduced range clovers increased production two to six times and caused a desirable change in the grass composition.

Summary

Sustained production on the range under proper management proves that there is a source of range fertility. The nitrogen lost in different ways, volatilization, leaching, carry-away by grazing animals, is replenished. The amount of nitrogen available annually for grass growth appears to be considerable.

Either lightning or legumes are considered to fix too little nitrogen on most ranges to be of significance. Numerous references to an obscure or hidden source of nitrogen are cited. There appears to be ample nitrogen on ranges that are in good condition.

Nonsymbiotic fixation is considered as a possible source of range nitrogen. The full capacity of nonsymbiotic bacteria to fix nitrogen has not been determined. Conditions on the range are favorable for nonsymbiotic bacteria activity.

Carbonaceous organic matter for energy may be a limiting factor in nonsymbiotic fixation. The replaced fibrous grass roots are suggested as a possible source of organic matter as food for nonsymbiotic fixation. This theory explains present range management practices of keeping the grass plants in vigorous condition, so that they are able to continually replace their root systems. A carry-over of fertility is necessary for adequate root and top growth. Applications of commercial nitrogen are thought to enhance root replacement and nitrogen fixation.

The supply of nitrogen is known to regulate the accumulation of organic matter. Nitrogen and organic matter accumulation may be important factors in range condition.

The loss of fertility or productive value of manure is heavy where the animals collect on bed grounds, or brush and tree areas that produce little feed. Even distribution, particularly of bobine excreta, is impossible to obtain. The fertilizing value of manure is greater where green grass is being consumed. Also, greater removal of fertility is effected where green grass is being consumed. The removal of fertility is considered to have an effect on nonsymbiotic fixation.

An increase in soil organic matter causes more phosphate to become available. Deep-rooted plants bring fertility up from the deeper soil horizons. Legumes are able to absorb phosphate more readily than other plants.

Fertility can be measured in production. A change from native grasses to cultivated legumes and grasses can increase production. When grasses are replaced with legumes, the source of nitrogen changes from nonsymbiotic fixation to symbiotic. Under favorable conditions symbiotic fixation has the capacity to fix considerably more nitrogen than nonsymbiotic. Nonsymbiotic fixation requires more energy than does symbiotic fixation.

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Shrub Invasion of a Southern New Mexico Desert Grassland Range[1]

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The grazing value of a large portion of the desert grassland in southwestern United States has been greatly reduced during the last 100 to 150 years by the invasion of undesirable shrubs. Although much of the present area is now lightly infested, infestation does not have to be heavy before range productivity is seriously damaged. As the economic welfare of the Southwest depends in large measure upon its grazing and soil resources, investigations to determine the extent of shrub invasion, rate of range deterioration, and possible reasons for this retrogression in plant cover are important. In this study, records of vegetational changes, environmental conditions, and forage utilization were compiled and analyzed in an attempt to determine the extent of shrub invasion on a southern New Mexico semidesert grassland range over a thirty-year period.

Study Area

The Jornada Experimental Range, where data analyzed in this study were collected, lies within a basin adjacent to the Rio Grande Valley, Dona Ana County, south-central New Mexico. The area is typical of much of the semidesert grassland of the Southwest. The experimental range contains approximately 145,000 acres of essentially flat mesa land ranging in elevation from 3900 to 4700 feet. The climate is arid; wind movement and evaporation rates are high, measuring approximately 35,000 miles and 100 inches per annum, respectively (Ares, 1952). Rainfall averages 9 inches per annum over the 90-year period of record, and has the winter-summer pattern typical of the Southwest. More than 50 percent of the annual total falls during the summer months of July, August, and September.

Much of the vegetation consists of species occurring largely or exclusively in the desert grassland formation. Black grama (*Bouteloua eriopoda*) communities occur on the upland sites and tobosa grass (*Hilaria mutica*) in the lowlands. Other grasses in association with these two dominant species, but less abundant, are *Aristida* spp., *Bouteloua* spp., *Hilaria* spp., *Muhlenbergia* spp., and *Sporobolus* spp. Shrubby species include: honey mesquite (*Prosopis julifora* var. *glandulosa*), western honey mesquite (*P. juliflora* var. *torreyana*), tarbush (*Flourensia cernua*), creosotebush (*Larrea tridentata*), snakeweed (*Gutierrezia sarothrae*), soapweed (*Yucca elata*), salt bush (*Atriplex canescens*), *Acacia* spp., and *Opuntia spp.* Of these, mesquite, tarbush-creosotebush and snakeweed associations are the most prominent, covering extensive areas and forming distinctive vegetation types.

The mesquite of the area is a shrub growing in many-stemmed clumps 3 to 5 feet in diameter. It has an extensive root system, the taproot often extending to a depth of 20 to 50 feet and the laterals reaching as fas as 40 to 50 feet from the root crown. Mesquite is exceptionally drought-enduring and aggressive. It is resistant to grazing and invades grasslands readily when a seed source and transportation medium are present.

Tarbush, also known as blackbrush, is a resinous, thick-leaved shrub that will invade desert grassland sites when the sod is broken. The shrub is unpalatable to livestock, and may poison sheep when the animals graze the ripe fruits of this plant.

Creosotebush, the most common and widely distributed shrub in the desert, is a much-branched, evergreen species. It forms pure stands over much of its range, particularly on sandy or gravelly mesas. The plant is worthless as forage, and the growth of better forage plants is restricted where it is abundant.

Snakeweed is an aggressive suffrutescent perennial that rapidly invades areas where the grass cover has been depleted. This plant develops a deep taproot during its first season, and establishes abundant lateral roots as it matures. Snakeweed is poisonous to cattle when eaten in quantity, and its presence in dense stands during periods of normal rainfall is believed to indicate overuse of the more palatable forage.

Study Methods

Vegetation maps and field write-up sheets of the experimental range compiled during

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range reconnaissance surveys in 1915 and 1928 were compared. Mosaics made from 1946 aerial photographs of the area were also analyzed. Vegetation types were delineated on the mosaics and these types were evaluated to determine vegetation dominants. The vegetation types, as they appear on the maps and mosaic, were planimetered to determine the acreage of each. From these data the percentage of shrub cover on the experimental range at different periods was calculated and analyzed.

Records of management practices, operating procedures, stocking rates, and 90 years of climatic data were analyzed. An extensive search was made of historical and scientific literature pertaining to the Southwest to determine conditions that have existed throughout the desert grassland region since early Spanish explorations. Factors contributing to possible shrub encroachment were considered in the light of these records.

Table 1. Changes in dominant vegetation, Jornada Experimental Range, 1915 to 1946. Figures are based on a total area of 145,330 acres.

Year	Area occupied by vegetation dominants									
	Grass spp.		All shrubs		Mesquite		Tarbush-Creosote		Snakeweed	
	acres	% of total	acres	% of total	acres	% of total	acres	% of total	acres	% of total
1915	62189	43	83141	57	27545	19	40108	27	15488	11
1928	51818	36	93512	64	47754	33	36730	25	9028	6
1946	44666	31	100664	69	57133	39	36774	25	6757	5
Net	decrease		increase		increase		decrease		decrease	
change	17523	12	17523	12	29588	20	3334	2	8731	6

Results

The grassland vegetation on the experimental range consists of two major associations; black grama on the uplands and tobosa grass in the swales. In 1915, 43 percent or 62,189 acres of the Jornada mesa were classified as grassland dominant (Table 1). By 1946, only 44,666 acres, or 31 percent of the mesa remained as grassland. This is a 30-year shift from grass to brush of 17,523 acres. Although this loss of grassland acreage is equal to only 12 percent of the total mesa area, it represents a 28 percent loss of the acreage originally dominated by grasses.

A total of 27,545 acres, 19 percent of the mesa, was classed as mesquite dominant in 1915. By 1946, mesquite had become dominant over 57,133 acres or 39 percent of the total area. Although the encroachment took place mainly at the expense of other lower-growing shrubs, large areas that were formerly grassland had also been invaded. The area dominated by mesquite in 1946 represented an increase of 107 percent in the acreage dominated by this shrub in 1915.

Approximately 40,100 acres, or 27 percent of the mesa, was classed as tarbush-creosote dominant in 1915. During the 30-year period between 1915 and 1946 this acreage was reduced by 8 percent. The 3,334-acre loss in tarbush-cresote vegetation was accounted for mainly by the encroachment of mesquite-covered sand dunes.

Snakeweed was dominant on 15,488 acres, or 11 percent of the area, in 1915. Inasmuch as the snakeweed-infested areas occur primarily between the grassland and mesquite types, this suffrutescent shrub seems to be a pioneer invader in the grassland. The 8,731-acre reduction in snakeweed between 1915 and 1946 was due mostly to encroaching mesquite; at the same time, however, snakeweed invaded a large area previously classed as grassland. Therefore, it appears that when range condition is deteriorating, snakeweed makes the initial invasion and later gives way to other woody species. On the other hand, when range condition is improving, snakeweed may be replaced by grasses (Campbell, 1934).

Discussion

Rainfall records for southern New Mexico have been kept since 1853. There are, however, only 90 years of actual record as the data are incomplete for 13 years. This 90-year record indicates a cyclic pattern of precipitation. Five cycles are evident in the graphs compiled by the U. S. Forest Service at the Jornada Experimental Range (Ares, 1952). These cycles oscillate between 18 to 20 years of below-average to 18 to 20 years of above-average precipitation. The 40-year record on the Jornada shows no marked deviations from the other, longer-term records. The period of 1915 to 1926, an 11-year span of below average rainfall on the experimental range, falls within the latter part of the third dry cycle of the longer record. For the next 19 years, rainfall on the Jornada averaged 15 percent above the mean. The present dry cycle, which began in 1945, has averaged 26 percent below the long-term mean (Ares, 1952).

During these periods of extended drouth, grasses make little or no growth, and in many instances grasslands are killed, literally "douthed out." There were, however, individual years within these dry periods when rainfall was adequate and grass growth was excellent. Because of their relatively shallow roots, desert grasses depend on surface moisture for their water requirements; the lack of sufficient surface moisture is a major factor in their death. Shrubs, on the other hand, by virtue of their deeper and more extensive root

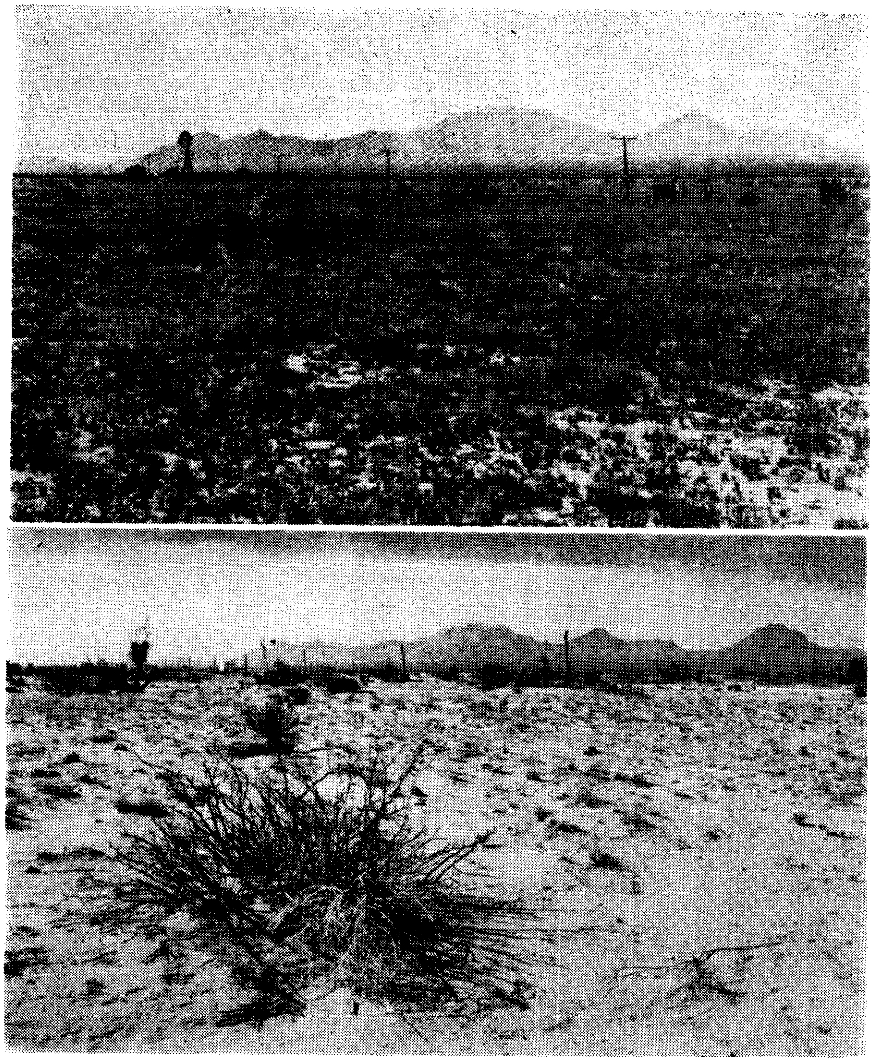

FIGURE 1. *(Above)* South Well, Jornada Experimental Range, as it appeared 35 years ago —typical grassland range with a few scattered invading shrubs. *(Below)* Same area as it is today—wind-blown sand is forming dunes around established mesquite plants.

systems, are able to remain alive by drawing moisture from deeper levels; they may also utilize winter and spring moisture when temperatures are too low for grass growth. These shrubs may continue to grow, therefore, even during drouth years and may invade adjacent grasslands.

When a dry cycle is broken and rainfall is adequate for normal grass growth, the grasses must begin growth from the dormant state or from seed. Those shrubs that have been actively growing are in a position to utilize more of the immediately available moisture than the grasses. Therefore, unless shrub growth is curtailed either during or between drouths, it is reasonable to assume that shrubs will continue to encroach upon and eventually dominate the grasslands under such climatic conditions.

Grazing pressure appears to be a factor in this shrub invasion. According to the vegetation maps shrubs increased more rapidly during the interval 1915 to 1928 than between 1928 and 1946 (Table 2). Grassland acreage decreased by 17 percent in the earlier period and by only 14 percent during the later, longer interval. The average stocking rate from 1915 to 1925, which was also a period of drouth, was twice as heavy as during the next 18-year interval when rainfall was above average. Although shrub invasion did not stop with lighter utilization and above average rainfall, it was slower than the encroachment under the reverse conditions of heavy grazing and drouth. Perhaps the change from drouth to more favorable precipitation was responsible for the retarded invasion and the lighter degree of utilization was merely coincidental; however, the theory that grazing pressure is at least partially responsible for shrub invasion is supported by Brown's (1950) study of this encroachment on an Arizona desert grassland range. He noted a 30 percent increase in shrubby vegetation under total protection, and 55 percent increase under open grazing.

No reference to fires in the Jornada area were found in the review of historical literature connected with this study. This might lead to the conclusion that fire, or the lack of fire, has not been a factor in shrub invasion on the grasslands in the area. On the other hand, it has been established that range fires occurred periodically in the desert grassland during the early years of, and before white settlement (Nunez, 1905; Humphrey, 1953). The Jornada area seems to have been an extensive grassland

Table 2. Percent change in vegetation dominants on Jornada Experimental Range for the periods 1915 to 1928; 1928 to 1946; and 1915 to 1946. Type acreage in 1915 equals 100 percent.

Vegetation Dominants	Percent Change		
	1915-1928	1928-1946	1915-1946
Grassland	-17	-14	-28
Mesquite	74	20	107
Tarbush-Creosote	-8	0	-8
Snakeweed	-42	-25	-56

plain relatively free of the shrubby invaders that dominate vast areas there today. It is impossible, however, to determine the extent of shrubby vegetation on the Jornada as it appeared 100 to 150 years ago, as the reports of early travelers through the area give only generalized descriptions of the vegetation and are somewhat conflicting.

Wislizenus (1848) and Marcy (1852) in their reports of the Jornada del Muerto,—the geographical area of which the experimental range is now a part, both comment that they found the grass "good" or "tolerable" and, ". . . a small growth of scrubby brush, which answered very well to cook with; . . . ." Wislizenus also refers to ". . . an abundance of mesquite and palmillas. . ." Beale (1858), however, describes the Jornada plain as thousands of acres of rich soil covered thickly with the finest grass in the world; he makes no comment on the occurrence of any shrubby growth. Froebel (1859) makes no reference to shrubs on the Jornada and says, ". . . there is excellent grass the whole way, . . ."

With the exception of Wislizenus, there was no mention of an extensive shrub cover on the Jornada found in the historical records, and it would seem that if the shrubby vegetation so common there today had existed 100 years ago, it would have been referred to in these reports of early explorations. Although no early travelers on the Jornada reported the evidence of fire, the fact that fires were prevalent throughout the desert grassland, and the area in question apparently was being somehow maintained as desert grassland dominant, might well lead one to conclude that periodic fires, although not reported, may have occurred in the area and may have been a factor in restricting or preventing the spread of shrubs.

Summary

A study was made of shrub invasion over a thirty-year period on a southern New Mexico semidesert grassland range. Twelve percent of the total area, formerly classed as grassland, is now dominated by shrubs. Twenty-eight percent of the original grassland acreage has been lost to this invasion. Mesquite is the principal invader, having increased its original acreage by 107 percent. Tarbush-creosote type vegetation occupies 8 percent less area than before; the snakeweed dominated acreage has been reduced by one-half.

An analysis of climatic data covering the past 90 years in the area indicates a cyclic climatic pattern that favors the invasion of the grassland by shrubs when other biotic factors have been adversely affecting the grass species, and shrub growth has not been retarded by physiological or mechanical damage.

Grazing pressure by domestic livestock has been important on the area. This utilization appears to be a factor in shrub invasion as it disseminates noxious plant seed, weakens the grass plants, removes the fuel from the ground, and breaks the sod.

A review of scientific and historical literature disclosed that prior to white settlement, the periodic recurrence of wild fires which swept the desert grassland may have been a factor in keeping the grasslands free of shrubby invaders.

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Herbage Production and Grazing Capacity on Annual-Plant Range Pastures Fertilized with Sulfur

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Widespread tests over a period of years have shown a deficiency of sulfur in several soils derived from a variety of parent materials at many locations in California (Conrad, 1950). On foothill range with sulfur-deficient soil, fertilization offers a positive means of improving the natural annual-plant cover (Bentley, 1946; Bentley and Green, 1954). It is a low-cost treatment that, in plot tests, has given economical returns (Green and Bentley, 1954).

To determine how improvements in the vegetation from sulfur fertilization are reflected in range livestock production, a grazing test was started at the San Joaquin Experimental Range in 1949. A major objective was to learn how sulfur fertilization fits into year around management of foothill ranges. The experiment was conducted cooperatively by the California Forest and Range Experiment Station, U. S. Forest Service, and the Department of Animal Husbandry, University of California.

This article presents the herbage production, range stocking, and herbage utilization results obtained during the first 7 years in the experimental pastures. Gains, grazing habits, and diet of the steers will be covered in companion articles.

The Experiment

The experimental area is located at an elevation of about 1,100 feet in the Sierra Nevada foothills (Talbot, et al., 1942). Precipitation, averaging 19.4 inches annually for a 20-year period, ordinarily occurs as rain from October to May, with high-

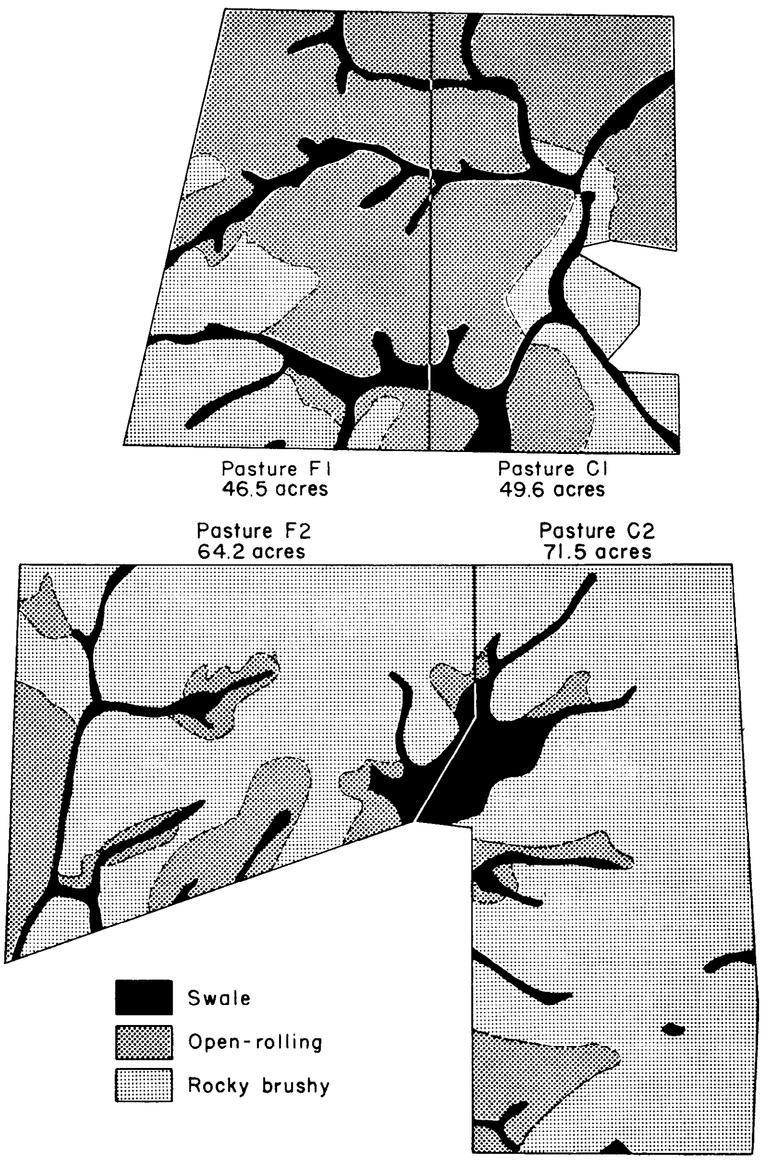

FIGURE 1. Two pairs of experimental pastures showing distribution of site classes; F1 and F2—fertilized, C1 and C2—unfertilized.

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[1] *The California Forest and Range Experiment Station is maintained at Berkeley by the Forest Serivce, U. S. Department of Agriculture, in cooperation with the University of California.*

[2] *With the Agricultural Research Service for one year when this agency cooperated in the grazing trials.*

est amounts during the winter months. Herbaceous vegetation is a typical mixture of annual grasses and forbs including several legumes (Bentley and Talbot, 1951). The soil is predominately Vista sandy loam developed from granite bedrock. Soil depth is variable, mainly less than 2 feet, and rock outcrops are common.

The experiment was conducted in two pairs of pastures: F1 and F2—fertilized, control pastures C1 and C2—unfertilized (Fig. 1). The pastures were located and their approximate boundaries delineated from a range site map (Bentley and Talbot, 1951). Acreages of swale and slope sites and of nongrazable area covered by rock or brush were determined by line sampling, and pasture boundaries were adjusted to make the two pastures in each pair as comparable as possible.

At the time of fencing in 1948, the four pastures were judged approximately equal in grazing capacities, and each adequate for 10 yearling steers for 6 months. The smaller pair, pastures F1 and C1, contained considerable swale and open rolling slopes which were the most productive sites (Fig. 1). The larger pair, pastures F2 and C2, contained a high proportion of rocky, brushy slopes which were variable in productivity but generally poor. Pastures F1 and C1 proved closely paired but comparability of pastures F2 and C2 was somewhat less precise.

The fertilization practice followed had been developed in plot tests at the experimental range. Pasture F1 was first fertilized in January 1949, again in January 1953, and in December 1955. Pasture F2 was fertilized originally in February 1951, again at a low rate in October 1953, and at the regular rate in January 1956, to put its treatment on the same schedule as pasture F1. The rate of each application was 60 pounds elemental sulfur per acre except for 40 pounds per acre in pasture F2 in 1953. Gypsum was used as the carrier of sulfur except in pasture F1 in 1949, when a mixture of superphosphate and soil sulfur was applied. Both pit-run and agricultural gypsum were used.

Herbage yield in each pasture was sampled near plant maturity in May on temporary quadrats that were systematically spaced along permanent grid lines. Ungrazed vegetation was clipped at ½-inch stubble height on 50 to 70 square-foot quadrats per pasture. In pastures grazed during the green-forage season the quadrats were protected by cages made of 2-inch mesh poultry netting. The vegetation from an individual quadrat was placed in a paper bag and air-dried in a glass house. During periods of low humidity the plant material from each quadrat was weighed, and weights of individual species or plant groups were estimated for each.

One pair of pastures was stocked with two groups of weaner steers in July. The steers

Table 1. Herbage production in two pairs of pastures; one pasture in each pair was fertilized and the other pasture was an unfertilized control.

Pastures F1 and C1

Year and treatment	Grass	Legume	Other	Total
		Pounds per grazable acre[1], air dry		
1949:				
Fertilized[2]	826	79	449	1,354
Control	746	151	494	1,391
	80	—72	—45	—37
1950:				
Fertilized	928	1,147	1,247	3,322
Control	895	428	1,519	2,842
	33	719**	—272	480*
1951:				
Fertilized	3,089	612	572	4,273
Control	1,621	221	653	2,495
	1,468**	391**	—81	1,778**
1952:				
Fertilized	2,754	638	703	4,095
Control	1,482	258	822	2,562
	1,272**	380**	—119	1,533**
1953:				
Fertilized[2]	2,471	168	198	2,837
Control	1,580	59	317	1,956
	891**	109**	—119*	881**
1954:				
Fertilized	1,803	1,517	460	3,780
Control	1,490	441	653	2,584
	313*	1,076**	—193**	1,196**
1955:				
Fertilized	2,473	530	827	3,830
Control	1,165	176	840	2,181
	1,308**	354**	—13	1,649**
1956:				
Fertilized[2]	2,326	606	448	3,380
Control	1,058	201	711	1,970
	1,268**	405**	—263**	1,410**

Table 1. (Continued)

Pastures F2 and C2

Year and treatment	Grass	Legume	Other	Total
1949:				
Fertilized	697	136	341	1,174
Control	546	165	421	1,132
	151	—29	—80	42
1950:				
Fertilized	660	474	872	2,006
Control	591	275	922	1,788
	69	199	—50	218
1951:				
Fertilized[2]	2,835	161	428	3,424
Control	2,487	47	243	2,777
	348	114	185	647*
1952:				
Fertilized	1,359	1,126	540	3,025
Control	991	312	541	1,844
	368	814**	—1	1,181**
1953:				
Fertilized[2]	1,868	197	161	2,226
Control	1,173	174	145	1,492
	695**	23*	16	734**
1954:				
Fertilized	1,602	744	716	3,062
Control	1,220	179	783	2,182
	382	565**	—67	880**
1955:				
Fertilized	1,589	716	561	2,866
Control	1,010	229	510	1,749
	579**	487**	51	1,117**
1956:				
Fertilized[2]	1,468	396	327	2,191
Control	623	185	467	1,275
	845**	211**	—140**	916**

[1] Excludes rock outcrop and soil inaccessible to cattle.

[2] Pasture was fertilized during preceding fall or winter.

** Difference is significant at 1 percent level.

* Difference is significant at 5 percent level.

were in these two pastures during the remainder of the dry-forage season, utilizing vegetation that had grown during the preceding winter and spring. In some years the steers remained in these pastures during part or all of the winter season, which started with effective fall rains, utilizing some of the new plant growth. In other years the steers were moved to the second pair of pastures at the start of the winter season. The steers were in the second pair of pastures throughout the green-forage season utilizing current vegetation growth, and were removed in the summer after the vegetation had dried and the pastures had been moderately grazed. From 1949 to 1954 inclusive the steers were put in pastures F1-C1 in July and were moved later to the other pair of pastures. The grazing seasons were reversed in 1955 so that the steers were put in pastures F2 and C2 in July and later moved to pastures F1 and C1.

Notes were made on plant growth and utilization each year. Degree of utilization was recorded when the steers were removed. Photographic utilization standards (Hormay and Fausett, 1942) were used, but adaptations were necessary when final ratings were made in winter after heavy rains had occurred.

Herbage Production

The pattern of vegetation response to sulfur fertilization in the pastures (Table 1) was the same as that reported from plot tests (Bentley and Green, 1954). The first apparent effect was stimulation of legumes, mainly native annual clovers, during the year after fertilization—in 1950 for pasture F1 and in 1952 for pasture F2. In each pasture this initial response did not occur during the first season of fertilization because rainfall was insufficient for good legume growth.

The second effect of fertilization was increased production of grasses resulting from a buildup of soil nitrogen by the legumes. This increased grass yield first occurred in 1951 for pasture F1 and in 1953 for pasture F2. In subsequent years significant increases in production of grasses, legumes, and total herbage were maintained by repeat fertilization (Table 1), except that in 1954 yield of grasses in pasture F2 was not significantly greater than that in its control.

Production of forbs other than legumes generally decreased after fertilization became effective. Most of this decrease usually was in yield of broadleaf filaree, which composed the bulk of the other forbs. Reduction of filaree was plain in pasture F1; in 1949 it made up about the same percentage of the herbage

Table 2. Average herbage yield and response to fertilization by site class.

Site class, pasture, and treatment	Proportion of pasture acreage	Yield per grazable acre[1]	Increased yield
	Percent	*Pounds*	*Pounds*
Swale:			
C1 — Control	10.8	5,242	......
F1 — Fertilized	13.0	5,985	743
C2 — Control	8.9	4,224	......
F2 — Fertilized	12.3	5,689	1,465
Average difference[2]	......	......	1,014
Open, rolling slopes:			
C1 — Control	62.5	2,404	......
F1 — Fertilized	63.5	3,751	1,347
C2 — Control	34.6	1,971	......
F2 — Fertilized	33.5	3,082	1,111
Average difference[2]	......	......	1,259
Rocky or brushy slopes:			
C1 — Control	26.7	1,601	......
F1 — Fertilized	23.5	2,189	588
C2 — Control	56.5	1,312	......
F2 — Fertilized	54.2	1,635	323
Average difference	......	......	489

[1] Yields are averages for the years in which quadrats were classified by site class, after fertilization became effective: Pastures F1 and C1, 5 years, 1950-54; pastures F2 and C2, 3 years, 1952-54.

[2] Weighted average based on all quadrats in the site class.

in both pasture F1 and pasture C1, but in 1951 and later years its percentage in pasture F1 was only half that in pasture C1. Reduction of filaree in pasture F2 was less marked, but records since 1954 indicate it now composes a significantly lower percentage of the herbage in the fertilized pasture than in its control, pasture C2. This reduction in broadleaf filaree and the increases in grasses and legumes are improvements in the herbage composition on annual-plant ranges, particularly on range grazed during the dry-forage season.

Increased production of herbage resulting from sulfur fertilization was most marked in pasture F1, which contained a high proportion of the more productive sites (Fig. 1). For the 6-year period 1951-56, after fertilization was fully effective in pasture F1, its average yield was 1,408 pounds per acre greater than the average yield of the control pasture C1. This increase in grasses and legumes is considered a good measure of the effect of fertilization. In the low-production year of 1949, the clipped yields were the same in pasture C1 and pasture F1 and on a series of unfertilized strips in pasture F1. In 1950, when the first response from fertilization occurred, the yield of pasture F1 was greatly increased over yields of pasture C1 and the unfertilized strips (Fig. 2). The greater yield of pasture F1 over pasture C1 was clearly evident in succeeding years.

Increased production was less apparent in pasture F2. During the period 1952-56, when fertilization was effective in pasture F2, its yield averaged 966 pounds per acre more than the yield of control pasture C2. This greater production was caused primarily by fertilization but may have been influenced by site differences between the pastures. Increased production was evident in 1952 and subsequent years.

Effect of Site

Herbage sampling in the pastures clearly showed that best returns were obtained from fertilizing the most productive land

Table 3. Weight, density, and yield of vegetation in fertilized pasture F1 and control pasture C1 at different dates in 1951.

Date and pasture treatment	Average plant height	Average foliar density	Average dry weight
	Inches	*Percent*	*Lbs./acre*
February 22:			
Fertilized	2.1	63	[1]1,560
Unfertilized	1.6	59	1,100
	0.5	4	460
March 16:			
Fertilized	2.6	70	[2]2,004
Unfertilized	2.2	61	1,514
	0.4	9	490
May 12:			
Fertilized	([3])	([3])	[2]4,273
Unfertilized	([3])	([3])	2,495
	....	....	1,778

[1] Yield based on correlation with density x height developed in previous studies.

[2] Yield based on clipped samples.

[3] Not measured.

(Table 2). For a 5-year period in pastures F1 and C1, when the clipped quadrats were classified by site class, the average yields were greatest from the open, rolling slopes with few outcrops and less than half as great from rocky or brushy slopes with shallower soil.

Considering all quadrats in all pastures for a 3-year period, the yield of herbage in the fertilized pastures was greater than in the control pastures by 1,014 pounds per acre in the swales, by 1,259 pounds per acre on the open, rolling slopes, and by 489 pounds per acre on the rocky, brushy slopes. Yield figures for swales were based on few quadrats, but a large number were used in determining relative yields from the slope sites. Increased production from swales occurred mainly in the years of heaviest precipitation. The open, rolling slopes were consistently higher in all years in the fertilized pastures, but on rocky or brushy slopes the only impressive production from fertilization was in years with above-average rainfall.

Season of Growth

Most of the increased production under sulfur fertilization resulted from more rapid plant growth in April. Growth also was more vigorous during late winter and early spring in pasture F1 than in its control pasture, but the plants were only slightly taller. Production appeared much alike in the fertilized and control pastures in February and March during the years when pasture F1 was not being grazed at that time. Yet in later years, when it was grazed during late winter, the steers made materially better gains at that time than steers in the unfertilized pasture. Slight increases in production of available herbage during late winter months were more important than they appeared to be.

The value of such increases is illustrated by differences in plant growth in pasture F1 and its control during the late winter and spring of 1951 (Table 3). Both pastures had been closely grazed until December 27, 1950, but were not grazed during the remainder of the plant growing season. In February and March increases of only 0.4 to 0.5 inch in average height, along with slightly more foliar density, produced 460 to 490 pounds more available herbage per acre.

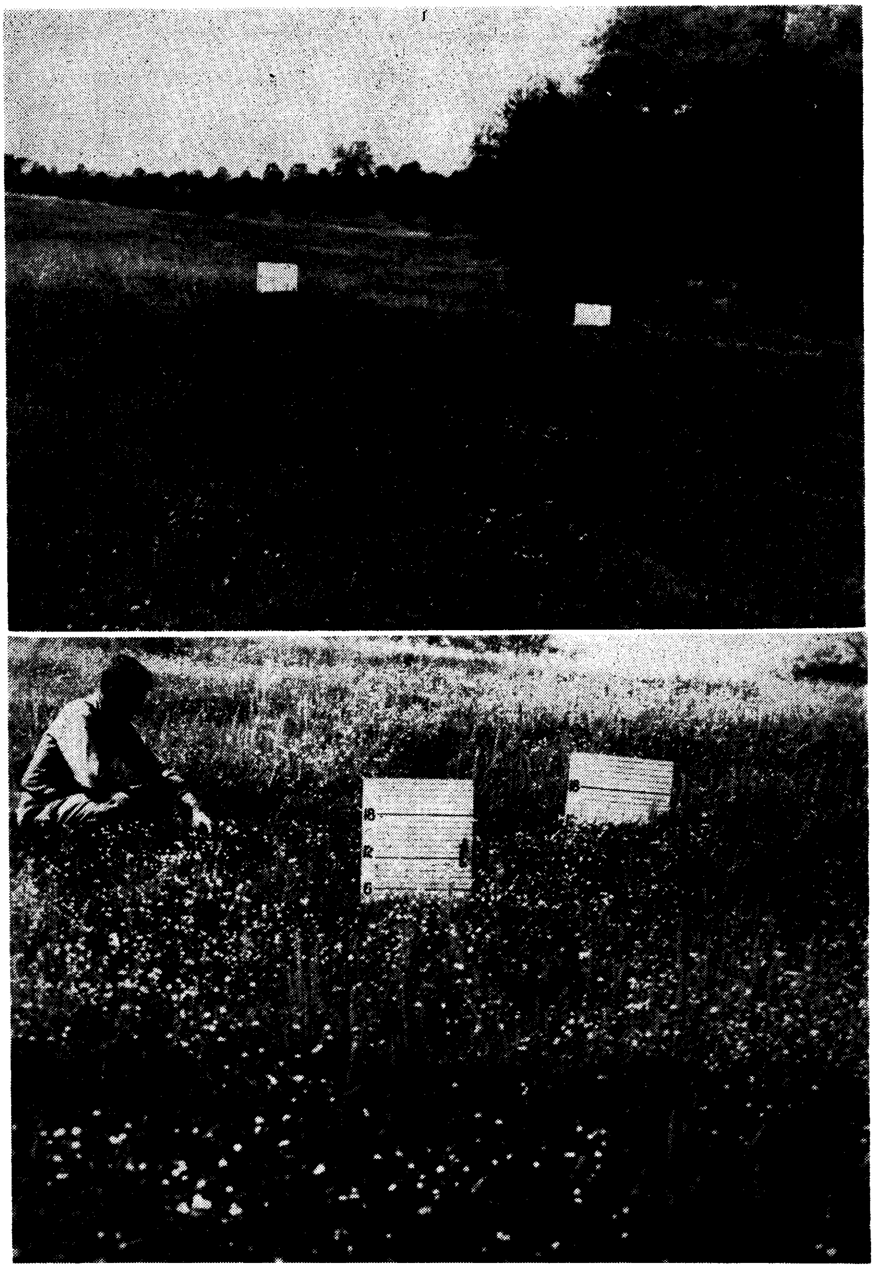

FIGURE 2. *Upper:* Initial heavy clover production on good site in sulfur fertilized pasture F1, April 1950. *Lower:* Good growth of clover after second fertilization compared with low growth on unfertilized strip in center of photo, pasture F1, April 1954.

Earlier plant growth from fertilization was never apparent in pasture F2 and was not indicated by the steer gains. The reasons were not known; stimulation of legume growth seemed adequate to increase available soil nitrogen in some winters.

Yearly Fluctuations

Sulfur fertilization had little effect on yearly fluctuations in total herbage production. After

Table 4. Stocking and utilization of pastures grazed during the dry-forage season and into the winter season in some years, and estimates of increased grazing capacity of fertilized pasture over control pasture.

Year and pasture	Stocking of pastures: Dry-forage season	Stocking of pastures: Winter season	Utilization of pastures	Increase of fertilized pasture over control in—: Total herbage yield[1]	Actual dry-season stocking	Estimated dry-season capacity[2]
	Steer-days	*Steer-days*	*Degree*[3]	*Percent*	*Percent*	*Percent*
1949:						
C1	1,050	0	C to M	—3	0	
F1	1,050	0	C to M			0
1950:						
C1	860	810	M			
F1	1,032	972	M to L	17	20	35
1951:						
C1	1,170	320	M to L			
F1	1,170	384	L to M	71	0	65
1952:						
C1	800	950	M			
F1	960	1,710	M to L	60	20	55
1953:						
C1	1,230	0	C to M			
F1	1,845	0	C to M	45	50	50
1954:						
C1	1,223	1,247	M			
F1	1,921	1,463	M	46	56	55
1955:						
C2	1,368	630	M			
F2	2,052	630	M	64	50	55

[1] Dry weight per grazable acre, from Table 1.

[2] Increase in stocking estimated from observation of actual stocking and utilization of the pastures, as that needed to obtain equal utilization of fertilized and control pastures at end of dry-forage season.

[3] Degree of utilization at time steers were removed from pasture: C, close; M, moderate; L, light; C to M on the moderate side of close; M to L on light side of moderate; etc.

fertilization had become fully effective, yields of the fertilized pastures fluctuated in about the same manner as yields of the control pastures (Table 1). Coefficients of variations were similar for the fertilized pastures and their control pastures. This is in contrast to results from nitrogen fertilization reported by Hoglund and co-workers (1952), who found that annual applications reduced fluctuations. Under periodic application of sulfur, legume stimulation and availability of organic soil nitrogen are greatly influenced by yearly weather conditions as well as by the level of soil sulfur supply.

After the soil nitrogen supply had been built up by growth of legumes, the total herbage production of the fertilized pastures in most years was more than 50 percent greater than in the control pastures. For pasture F1, 1951 to 1956 inclusive, the increase ranged from 45 to 76 percent; for pasture F2, 1953 to 1956 inclusive, from 40 to 72 percent. For the 5-year period 1952-56 when fertilization was fully effective in both pastures, herbage production of pasture F1 averaged 59 percent greater than its control. In pasture F2 it was 57 percent greater. These figures indicate that the base stocking level could be materially raised after fertilization and maintained at a high level without adding to the problem of adjusting to a fluctuating herbage supply.

Grazing Capacity

Grazing capacities of the fertilized pastures during the dry-forage season increased in about the same proportion as the herbage yields. But during the green-forage season in some years capacities were increased less than the herbage yield figures would indicate.

Fertilized pasture F1 was stocked below its capacity during the dry-forage season and was grazed rather lightly in each of the first 3 years after fertilization had become effective (1950-52, Table 4). In each of the next 3 years the fertilized pasture was stocked during the dry season well above stocking in its unfertilized control pasture; nevertheless degree of utilization was the same in both pastures. In some years extra steers were grazed in the fertilized pasture during the winter months to remove excess herbage that remained at the end of the dry season.

Averaged for several years, the increase in herbage resulting from fertilization was a reliable index of increase in grazing capacity during the dry season. Herbage yield increased 57 percent for the period 1951-55; grazing capacity, 56 percent.

During the green-forage season, results differed in the two pairs of experimental areas. Stocking and utilization records did not indicate much increased grazing capacity in the fertilized pasture when the steers were in pastures F2 and C2 (Table 5). Capacity appeared to be about the same in both pastures in 1950 and in 1951 even though herbage yield per acre, sampled under cages, was greater in the fertilized pasture. In 1953 and 1954, after the soil nitrogen level had been built up in the fertilized pastures, its increase in estimated capacity averaged only 25

Table 5. Stocking and utilization of pastures grazed during the green-forage season and during the preceding winter season in some years, and estimates of increased grazing capacity of fertilized pasture over control pasture.

	Stocking of pastures			Increase of fertilized pasture over control in—		
Year and pasture	Green-forage season	Winter season	Utilization of pastures	Total herbage yield[1]	Actual green-season stocking	Estimated green-season capacity[2]
	Steer-days	*Steer-days*	*Degrees*[3]	*Percent*	*Percent*	*Percent*
1950:						
C2	0	1,250	L to M			
F2	0	1,250	L to M	12	0	0
1951:						
C2	0	1,910	M to L			
F2	0	1,910	M to L	23	0	0
1952:						
C2	610	1,912	M			
F2	610	2,004	M	64	5	15
1953:						
C2	385	1,628	M to C			
F2	490	2,072	M to C	49	27	30
1954:						
C2	910	1,727	M to L			
F2	910	2,099	M to L	40	22	20
1955:						
C1	0	1,261	M			
F1	0	1,925	M to L	76	53	60
1956:						
C1	0	1,886	M			
F1	0	2,890	M to C	72	53	50

[1] Dry weight per grazable acre from Table 1.

[2] Increase in stocking estimated from observation of actual stocking and utilization of the pastures, as that needed to obtain equal utilization of fertilized and control pastures at end of dry-forage season.

[3] C, close; M, moderate; L, light; L to M on moderate side of light; M to L, on light side of moderate, etc.

percent while increase in herbage yield averaged 56 percent. In contrast, when pastures F1 and C1 were grazed during the green-forage season the estimated increase in capacity averaged 55 percent, the increase in herbage yield 53 percent. The reasons for the contrast were not apparent; when pasture F2 was grazed during the dry-forage season, the increases in capacity and yield agreed fairly well.

Discussion

Sulfur fertilization can be recommended for open, rolling land if the soil is deficient in this element. Fertilization of rocky or brushy, steeper slopes, which usually have shallower soil, is questionable or at least of lower priority. Returns are lower and fertilizing more difficult on these slopes. The productive swale areas should be fertilized, but plot tests indicated that better returns could be obtained if phosphorus also is applied on these sites. The good returns from fertilization in this experiment would have been even greater and more economical if the pastures had included only the better land.

The results show that after sulfur fertilization has become fully effective, the range can be stocked at a heavier level during both the green-forage and dry-forage season. This makes possible full utilization before the forage value of the herbage has been lowered by leaching. The heavier stocking rate cannot be maintained, however, during the winter season when cattle are grazing mainly on the slow-growing new vegetation. At this time of year the livestock should be on other kinds of range.

Sulfur fertilization changed the pattern of utilization on the range, particularly during the dry season. The herbage on the open slopes was more attractive on fertilized range. Consequently, the steers did not concentrate so heavily on the swales in the fertilized pastures, and grasses in the swales, especially Mediterranean barley, were less closely grazed. Better utilization might be obtained by a different kind of fertilization aimed at stimulating growth of clover on this productive site.

A desirable overall mixture of forbs and grasses was maintained on both the fertilized and unfertilized range under moderate grazing in both the green-forage and dry-forage seasons. The vegetation was better on the fertilized range, particularly if grazed during the dry season, because of the greater proportion of legumes and grasses and the lower amount of broadleaf filarees. With dry-season grazing and light utilization in pasture F1, ripgut brome increased more than is desirable. The increase was more rapid than observed in the past under similar grazing of natural range, apparently because of the higher fertility level in the fertilized pasture.

Dry-season grazing will be necessary each year on sulfur-fertilized range that is held back to round out the yearlong forage supply. To guard against possible undesirable changes in botanical composition of fertilized range, rotation of grazing between range units, so that no one unit is grazed continually during the dry summer and fall, should be a desirable practice even though the benefits to be obtained have not been thoroughly demonstrated.

Summary

On California annual plant range at the San Joaquin Experimental Range periodic sulfur fertilization increased herbage production in two range units above that in unfertilized controls by 59 and 57 percent during a 5-year period. Initial response was stimulation of native clovers. Production of grasses and legumes increased in subsequent years after soil nitrogen had been built up. Greatest returns were on the better range sites. Yearly yields fluctuated because of weather about the same on fertilized as on unfertilized range.

Grazing capacities were increased proportionally with yields, except for one pasture in the years when its was grazed during the green-forage season. Stocking of fertilized range could be raised materially above unfertilized range during the dry-forage and green-forage seasons but not during the winter season. Fertilization produced more grazable herbage during late winter in one pasture but not in the other. Most of the greater growth on fertilized range occurred during the spring months.

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Generalized Curves for Gain per Head and Gain per Acre in Rates of Grazing Studies[1]

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A considerable number of degrees-of-grazing studies has been conducted during the past twenty years or more. The purpose of the study here reported was to see if the type of information obtained from the studies was sufficiently consistent to permit the development of a generalized pattern for animal gain under differential rates of stocking. To this end a hodgepodge of data was assembled from publications, progress reports and other sources rather generally available. The contributing studies ranged from Georgia to California and from Texas to North Dakota and represented a wide assortment of livestock, vegetation, climate, management, stocking rates and other variables. It was felt that if such a collection of data should conform to a theoretical function of some type, then this function in all probability must be rather basic and fundamental to the relationship between animal performance and rate of stocking.

Gain per Head Curve

General Form

Information obtained from degrees of grazing studies takes the form indicated in Table 1, insofar as gain per head is concerned. With a few exceptions to be discussed later, the gain per head decreases with increasing stocking rates, but not in a straight line. Cattle on moderately grazed pastures gain more than the arithmetic mean between gains obtained on lightly and heavily grazed pastures. The relationship, if any, must therefore be represented by a curved line. Several plausible curves e.g. logarithmic, exponential, parabolic, were essayed and rejected as not providing realistic fits to the data. The curve shown in Figure 1, however, appeared to give a remarkably good fit. Considering the variety of sources from which these data came and the wide diversity in vegetation, management, experimental procedure, and the complexity of the interaction be-

[1] *Cooperative investigations between the Crops Research Division and the Oklahoma Agricultural Experiment Station.*

Table 1. Average gain per head in some rate-of-stocking studies.

Location	No. Years	Rate of Stocking Light lbs.	Moderate lbs.	Heavy lbs.	Y* lbs.	Reference
Hays, Kans.	9	207	185	130	7.25	(3)
Spur, Tex.	6	148	—	93	5.15	(5)
Mandan, N. D.	17	—	310	230	11.7	(11)
Woodward, Okla. (1)	10	—	301	262	10.5	(9)
Woodward, Okla. (2)	10	400	384	361	13.5	(9)
Alapaha, Geo.	4	161	114	76	6.0	(4)
Sonora, Tex. (1)	5	266	223	172	9.2	(10)
Sonora, Tex. (2)	5	362	274	212	12.2	(10)
Sonora, Tex (3)	5	211	201	165	7.4	Calc.
San Joaquin, Calif. (1)	4	271	281	247	——	(6)
San Joaquin, Calif (2)	4	229	207	155	8.0	(6)
Manitou, Colo.	7	236	222	181	8.3	(7)
Bighorn, Wyo.	3	196	179	160	6.7	(1)
Manhattan, Kans.	6	242	244	222	8.4	(2)

* Value in pounds for each unit of Y used to fit data to the gain per head curve.

tween the biological variables of vegetation and livestock, the approximation of actual data to the theoretical curve seems to be unusual. It is uncommon for biological materials to provide so good a fit to a mathematical function except in growth curves under controlled conditions. But rates of grazing studies using young, growing animals should yield a growth curve of some nature, even though conditions may not be so well controlled as we would like.

The curve as drawn here is a double exponential of the general form $y = 16 - 2^{\frac{2^x}{4}}$. Data from Table 1 were fitted to the curve by simply selecting an appropriate scale for the y values (see table) to account for the wide variation in magnitude of the gains. Slight adjustments to the left or right along the curve were also made, but once one point was fixed the others were also fixed, since the magnitude of x was held constant for all data (Alapaha only excepted). Most of the points so established cluster over the x axis at the points marked as light, moderate, and heavy. A few, however, fall between, and these are of considerable help in extending the curve to the left and right of the well established points.

Points to the Left

Three sets of data fit the curve to the left of the indicated rates of grazing, Figure 2. The Woodward data for summer grazing were obtained from pastures that were intended to be grazed moderately and heavily. The gains per head, however fit the curve a little on the heavy side of light and moderate respectively. This study was conducted for 10 years during the 1940's when conditions were unusually favorable. Those in charge of the experiment frankly admit that during some of these years the intended degrees of use were not obtained, and the moderately grazed pastures were actually close to lightly grazed and the heavily grazed pastures close to moderately grazed. Nevertheless, it is not likely that this was the situation for the average of the whole ten year period. Another explanation is required.

The explanation appears to be in the ecological nature of the vegetation involved. The association is a mixed grass prairie. The most important increasers under use are blue grama and sand dropseed. Both are excellent grasses for the area and provide a substantial amount of high quality forage even under conditions where the taller grasses are much reduced. In the "heavily" grazed pastures, where blue grama and sand dropseed carry the bulk of the grazing load, the nutritional plane is maintained at a high level shoring up the per head gain. Thus, it is evident that the curve is not a stocking rate curve *per se*, but a nutritional curve indicating the relationship between animal performance and the nutritional plane provided at the rates of stocking concerned.

In a similar way the data from yearling grazing at three intensities at Woodward also fit the curve when displaced significantly to the left. This is consistent considering the ecology of the vegetation and also considering the fact that yearlong grazing must be at a lighter rate of stocking than summer grazing. A residue of grass must be left in the fall to carry the animals through the winter. Consequently, the degrees of utilization must be lower in pastures grazed yearlong than in pastures grazed in the summer only.

The data from the Bighorn mountain trial are for only three years, and it is likely that the cumulative effects of the three degrees of use have not yet had time to be fully expressed in vegetative changes. The data are inserted here only because they help to describe the left end of the curve because it would be of interest to see if in future years the values obtained slip down the curve to their proper places. The Bighorn ranges have one feature in common with the Woodward ranges, however, and that is the high nutritive value of the forage. Both areas give very good per head gains, so that similar places on the curve are not altogether unexpected.

Points to the Right

It is difficult to find data to describe the right end of the curve, primarily because the experimenters are very reluctant to graze pastures at rates heavier than those they consider to be al-

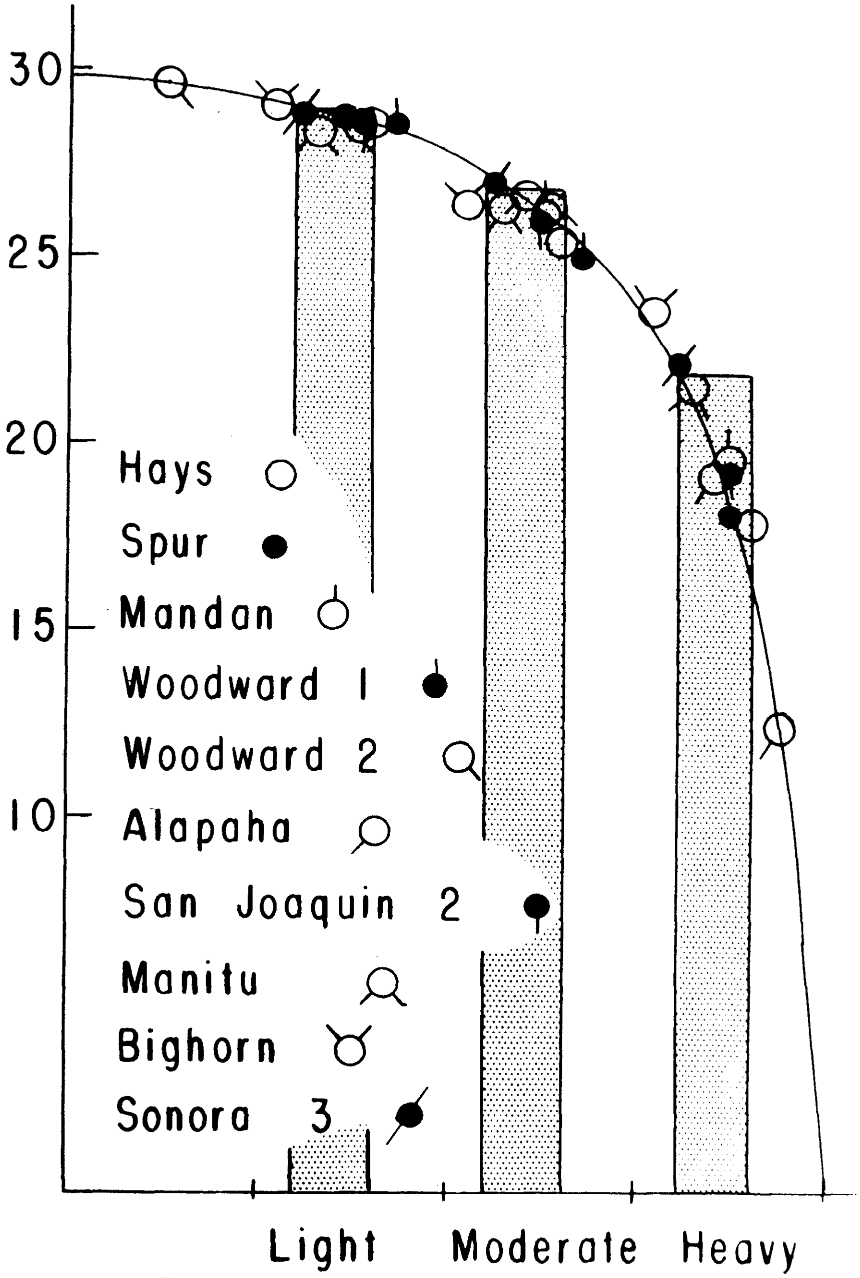

FIGURE 1. Gain per head data fitted to theoretical curve.

ready too heavy. The Georgia data, however, fit the right portion of the curve very closely, Figure 3. It may be that from the vegetational point of view the heavily grazed pastures were not overgrazed, the moderately grazed pastures were properly utilized, etc. But from the nutritional point of view this was obviously not the case. Young, growing animals were on wiregrass pastures from March until October and still gained an average of only 76 pounds per head on the heavily grazed pastures. Nutritionally, the animals were close to starvation whether the vegetation was grazed "heavily" or not. Once again, the curve appears to have validity, but it is a nutritional curve, not a stocking rate curve as such.

The Sonora Data

Most of the data in the center of the curve fit very well, but those obtained from a study near Sonora, Texas seemed to be exceptional. The values for Sonora 2, Table 1, were the only ones in which gain per head of cattle grazed at a moderate rate was lower than the arithmetic mean of the gains from lightly and heavily grazed pastures, Figure 4. In this very interesting study conducted on the Edwards Plateau, the performance of cattle alone was compared to cattle grazed with sheep and with sheep and goats at different stocking rates. The values for Sonora 2 in Table 1 and Figure 4, represent the gains per head of cattle when grazed with sheep and goats. In the same study it was found that the sheep and goats grazed with the cattle at the moderate stocking rate actually gained more per head than at any other rate of stocking. When the gains of the sheep and goats were added to that of the cattle and weighted to give an animal unit gain, the values once again gave a good approximate fit to the curve, Figure 4.

The anomalous data can, therefore, be readily explained on the basis of an interaction between the cattle and the sheep and goats. This still further emphasizes the nutritional basis of the functional relationship graphically represented by the curve.

In Sonora 1, cattle grazed alone gave the poorest fit of any of the data of its kind. Cattle on the moderately grazed pastures did not do as well as they should. Cattle at the same degree of grazing but with sheep and goats in the same pasture gained 50 pounds more per head per season, and nearly 100 pounds per head increase was obtained at the light rate. In this type of vegetation, then, cattle benefit significantly from the presence of sheep and goats. The exact nature of the interaction is probably not known, but presumably the sheep and goats in some way condition the vegetation favorably for the cattle. The advantage was hardly noticeable the first two years of the experiment, so that the benefits were most likely to have been due to changes in botanical composition.

Data that do not Fit

The only data that did not fit the curve at all were those listed as San Joaquin 1, Table 1. These are calf gains, and the calves on lightly grazed pastures gained less than those on moderately grazed pastures. Moreover, when a scale was selected to fit the cattle gains of the moderately grazed pasture to the curve, the gains from the heavily grazed pasture gave a poor fit. This study was conducted for 4 years on a winter annual type range. No explanation is offered at the present time for the poor fit. Data for San Joaquin 2, however, gave an excellent fit. These values were for the same pastures but computing gains of cows and heifers on an animal unit basis.

The Manhattan data presented something of the same problem for gains on lightly stocked ("understocked") pastures. They gave a good fit, however, when moved a full degree of grazing to the left. Again, we do not expect Dr. Anderson to agree that his overstocked pastures were really only moderately grazed, but during the early years of a stocking rate study this may well be the case from a nutritional point of view. In tall grass country, it is quite possible to exploit the considerable reserves of these grasses for a few years. If the overstocked pastures are permitted to reach a buffalograss-little barley sward, we confidently expect the per head gains to drop lower on the curve. It is apparent from the Manhattan and San Joaquin 1 data that understocking can, under certain conditions, decrease per head gains.

Other data are no doubt available that might be used in support of or in contradiction to the

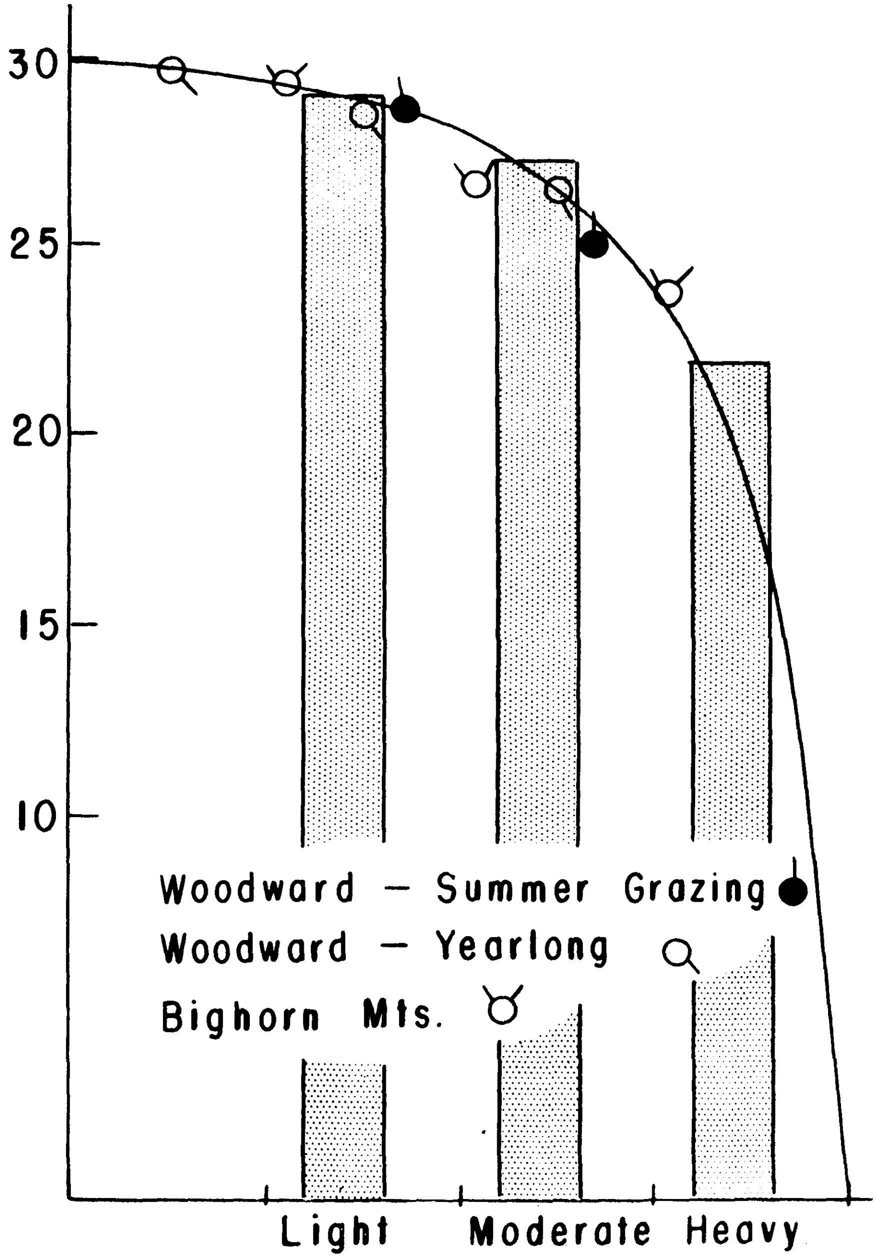

FIGURE 2. Points to the left end of the curve.

validity of the relationship here suggested. For the sake of argument we shall take the position that in normal stocking rate studies, gains per head will decline with increasing stocking rate according to the curve proposed. If we assume the validity of this theorem, then certain corollaries follow.

Corollary 1:

From the proposed curve for gain per head it follows that one full degree of grazing increment beyond the "heavy" rate will invariably result in loss of weight. As indicated above, the experimenters are reluctant to graze at such degrees of stocking intensity so that there are no data with which to explore the extreme right end of the curve. There are some indications, however, that the corollary is probably correct. In the 8th and 9th years of the Hays study, livestock were removed from the

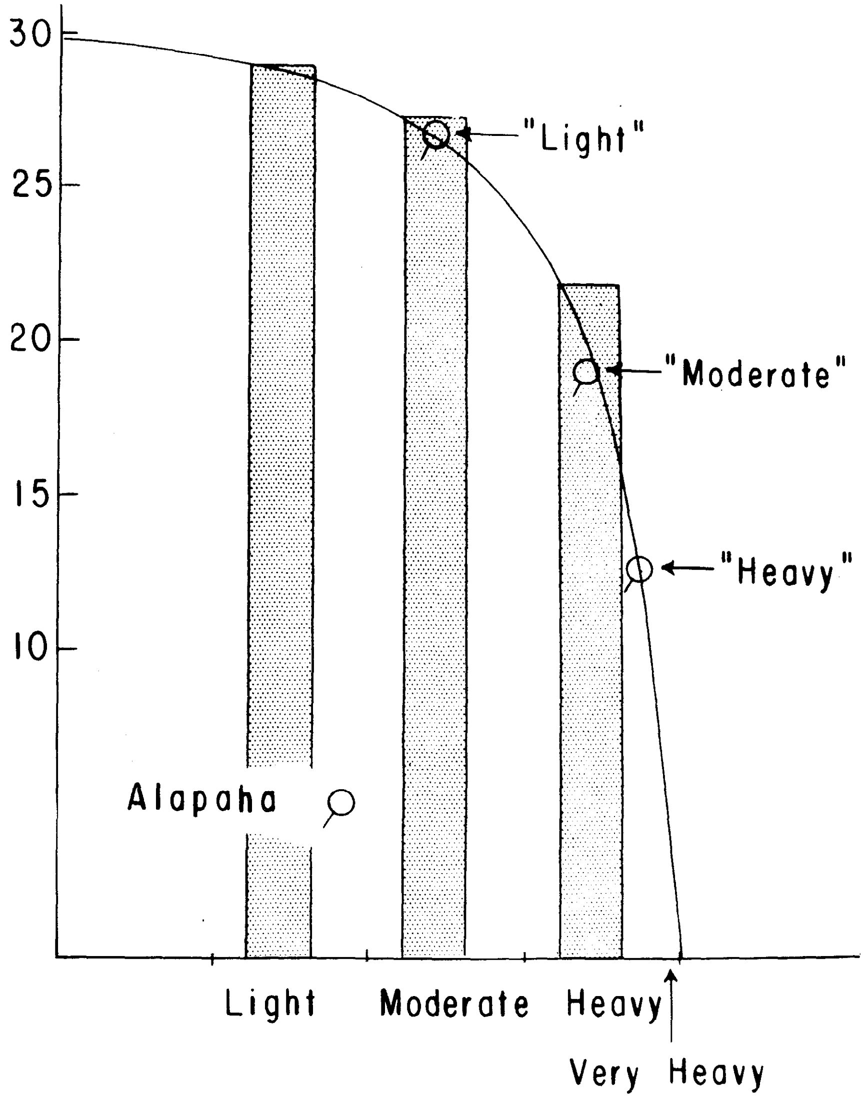

FIGURE 3. Points to the right end of the curve.

heavily stocked pastures for want of forage. In the Woodward study, grazing with steers was discontinued after 10 years, and the degree of grazing study continued with cows. In 1954 and 1955 the cows had to be removed from the heavily grazed pastures or fed hay to prevent undue loss of weight or outright loss by death. Cattle were removed from the heavily grazed pastures in the Manitou study in 1951 due to drouth. It seems evident, then, that a rate of grazing considered "heavy" by those conducting the experiments is indeed close to a peril point. As the curve is actually described, one half of one stocking rate increment beyond "heavy" will bring the livestock to the point of no gain. It is doubtful if this portion of the curve can ever be explored in detail since measurements of both livestock and vegetation to this degree of precision are not possible.

Corollary 2:

From the shape of the curve at the right end, it follows that livestock must either gain weight or lose weight; an equilibrium could not be established by means of rates of stocking, so that an exact balance is maintained without change in weight. The point is perhaps academic but emphasizes the consequences of the extremely rapid decline in per head gains when the stocking rate is on the heavy side of "heavy". In this portion of the curve, the values for y are so much greater than the values of x that an equilibrium would seem to be out of the question. If the grazing intensity was such that the cattle were living from hand to mouth on new growth, a shower might induce gains, a drouth cause loss of weight, but a balance could not be long maintained.

Corollary 3:

The "heavy" rate of grazing will yield a higher gain per unit area than moderate or light. This has generally been found to be the case. Exceptions occur sporadically especially in dry years when "heavily" grazed pastures are in fact very heavily grazed, and the peril point is approached or passed. The higher gain per head at moderate and light stocking rates is not sufficient to offset the smaller area per head at the heavy rate. In fact, grazing rates must be very close to the peril point before per acre gains decrease materially. This is a consequence of the shape of the gain per head curve.

Corollary 4:

Animal gains on heavily grazed pastures should be more variable than those on moderately or lightly grazed pastures. This, again, is due to the shape of the curve in the "heavy" region. The scattering of points in this region in Figure 1 suggests that the corollary is probably correct, but few data so far are suitable for a statistical analysis of this point.

Gain per Acre Curves

Curves for gain per unit area are shown in Figure 5. Gain per acre cannot be expressed as a single curve, but rather by a family of curves with the general

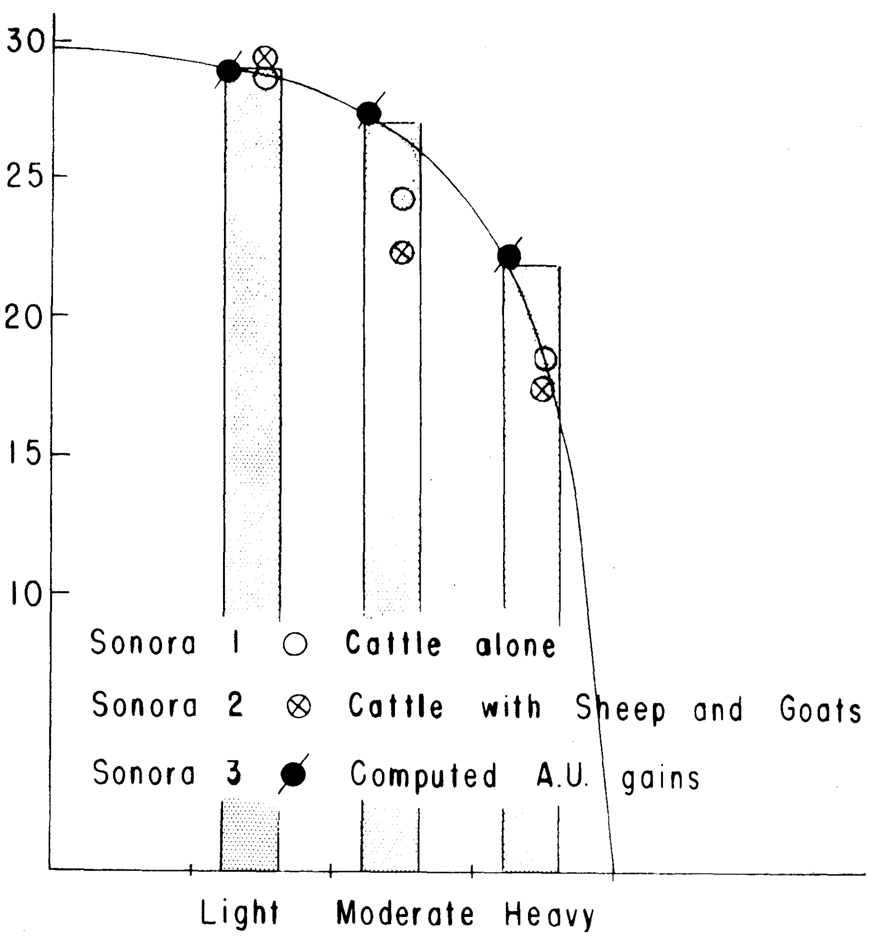

FIGURE 4. Gain per head of cattle and corrected to animal unit gain.

form indicated. There was a considerable variation in experimental design in the several studies. Perhaps the majority of the studies used stocking rate differentials on the order of 1, 1.5, and 2 units of area per head at the heavy, moderate, and light rates, respectively. The Sonora study was on the basis of 1, 2, and 3 units per animal unit at the three rates of grazing. Curves calculated for both types of differential are shown in figure 5. When actual data are used and plotted against a standard differential, the curves take the form indicated in Figure 6. However these values may be plotted, the general form is similar, rising steadily to a peak at the heavy grazing rate and then plunging sharply, crossing the x axis at the same point as the gain per head curve.

Use of the Curves

Interpolation and Estimation

Although considerable care and reservation should be exercised in making interpolations and estimations based on the curves presented, one can visualize situations in which such manipulations could be of very real practical value. Grazing studies of any kind are always expensive. Land, fencing, water, cattle, labor, all add up to a considerable bill. If it were possible to interpolate results for only one degree of grazing, savings of thousands of dollars could often be realized. For example, in the Spur study light and heavy rates of stocking only were used. Both points fell exactly on the line when a suitable scale was used to fit either point. In all probability the results of a moderate degree of grazing trial could be obtained by reading its value (136 lbs.) directly from the curve as accurately as if the trial actually had been conducted for a period of several years. The Mandan figures were for moderate and heavy grazing only. A light degree of use might be projected (336 lbs.) without danger of being very far wrong. Similar interpolations and estimations might be used elsewhere at a substantial saving in research funds.

Such a procedure could hardly be recommended, however, in areas where the ecology of the vegetation was not reasonably well understood, or where no grazing experience was available. On the other hand, if the ecological dynamics of the vegetation is well understood and there is considerable experience with it, and it is possible to state on *a posteriori* grounds that such and such a stocking rate constitutes moderate grazing (or any other degree), then it would seem that degrees of grazing studies are quite unnecessary. Estimated per head and per acre gains based on one degree of use would be adequate.

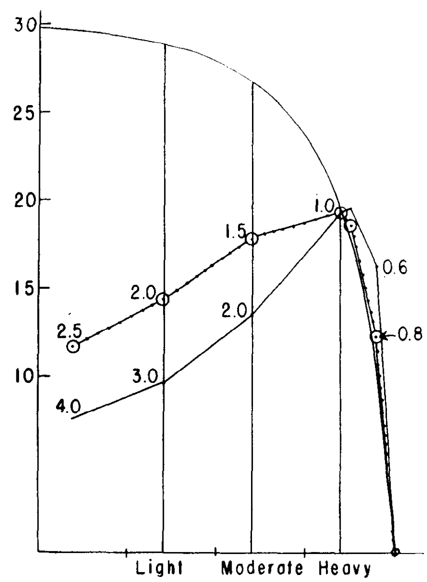

FIGURE 5. Two calculated curves for gain per unit area; pitch depends on stocking rate differentials.

Basic Ecology

A second use of the curves wolud be as an aid to the understanding of the ecological behavior of the vegetation in question under differential usage. As indicated above the per head curve is a functional expression of the nutritional plane provided the livestock. If values are displaced to the left, as in Woodward 1 and Woodward 2, this information is of value in the ecological interpretation of the vegetative changes that took place under the several degrees of utilization. If the values obtained are displaced to the right of expected, as in the Alapaha study, the nutritional value of the forage is clearly reflected. The same is true of the complex of interactions in the Sonora trials, where the values for the moderately grazed pastures were displaced downward from the expected values.

General Interpretation

If the curves are valid, they help to explain in a clear and graphic way some features of rates-of-grazing studies that have not been too clearly understood in the past. They show clearly why it is that the heavy grazing rates persist in giving higher gains per acre even at grazing rates we know to be detrimental. They show that there is very little leeway between maximum gains per acre and no gains at all per acre. Operators who habitually graze heavily may make the most beef per acre and the most profit, but they are also skating on the thinnest ice. With a bad growing season or two, they are the ones who have to take their stock to town and take a whipping at the market place. The operator who habitually grazes his pastures at a moderate rate has considerable leeway in either direction. He is far enough from the peril point that he can weather through most of the bad years in good shape. The operator who habitually grazes lightly (unless he is trying to upgrade his range condition) had better have some additional source of income, for he is not likely to make much out of the livestock business. All of these things have been known and understood in a general way for a long time, but the reasons back of them were not always too clear.

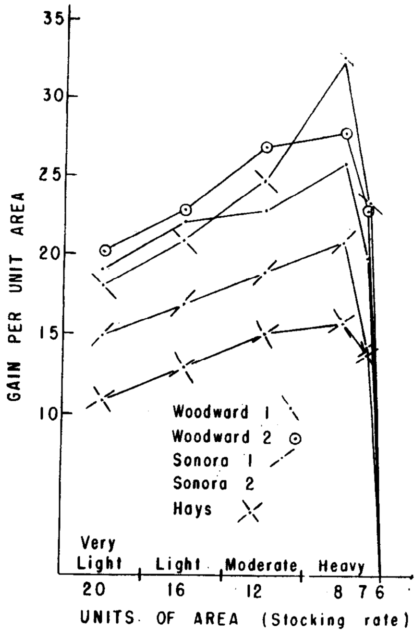

FIGURE 6. Gain data plotted against a standard stocking rate differential: values to the right and left interpolated.

Range Classification

The United States Forest Service has for some time used nine range classes based upon use of primary forage plants in various sections of the western states (Love, 1954). These have been designated as (1) unused, (2) slight, (3) light, (4) moderate, (5) proper, (6) close, (7) severe, (8) extreme, and (9) destructive. This implies a gradual decrease in range condition beyond "close" use. We have attempted a range classification in the Oklahoma tall grass prairie region based on a similar assumption and found it unrealistic. In this area, at least, there is a very quick jump from close use or heavy grazing to destructive grazing. We see little evidence of intermediate classes. This experience would be expected from the curves indicated.

Nor can we clearly detect so many classes to the light side of proper use. Generally speaking, in the Southern Great Plains we seem to have the following main conditions. (a) We have some ranges lightly grazed. These are primarily by nonprofessional ranchers such as oilmen, bankers, lawyers, doctors, etc. These would fit the Soil Conservation Service classification of "excellent". (b) We have some ranges properly used or nearly so. These belong primarily to the larger long-time operators who have learned by experience about what their ranges can and cannot do. In general, they are likely to be grazed moderately or occasionally lightly in the good years and heavily grazed in the bad years. This is a norm of operations in continental climates and is probably the best practical approximation to good or proper use that we can obtain on native rangeland. Such ranges would usually fit the Soil Conservation Service classification of "good". (c) We have very large acreages of range that are by turns heavily grazed and destructively grazed. These are perhaps mainly in the hands of small operators or farmers, but some of the larger ranchers have followed this practice, too. These may be classed as "fair" or "poor", but many such areas have degenerated to the point that to call them native grass ranges is to perpetuate a fiction. Such ranges are the object of serious concern to both action and research agencies in the region. Again, the reason why ranges go from "good" to "bad" so quickly is underscored in the shape of the performance curves offered in this paper.

Conversely, it would appear that if the curves are real and valid, they might be of considerable aid in the development of range classification systems.

Basic Ecology

A second use of the curves wolud be as an aid to the understanding of the ecological behavior of the vegetation in question under differential usage. As indicated above the per head curve is a functional expression of the nutritional plane provided the livestock. If values are displaced to the left, as in Woodward 1 and Woodward 2, this information is of value in the ecological interpretation of the vegetative changes that took place under the several degrees of utilization. If the values obtained are displaced to the right of expected, as in the Alapaha study, the nutritional value of the forage is clearly reflected. The same is true of the complex of interactions in the Sonora trials, where the values for the moderately grazed pastures were displaced downward from the expected values.

General Interpretation

If the curves are valid, they help to explain in a clear and graphic way some features of rates-of-grazing studies that have not been too clearly understood in the past. They show clearly why it is that the heavy grazing rates persist in giving higher gains per acre even at grazing rates we know to be detrimental. They show that there is very little leeway between maximum gains per acre and no gains at all per acre. Operators who habitually graze heavily may make the most beef per acre and the most profit, but they are also skating on the thinnest ice. With a bad growing season or two, they are the ones who have to take their stock to town and take a whipping at the market place. The operator who habitually grazes his pastures at a moderate rate has considerable leeway in either direction. He is far enough from the peril point that he can weather through most of the bad years in good shape. The operator who habitu-

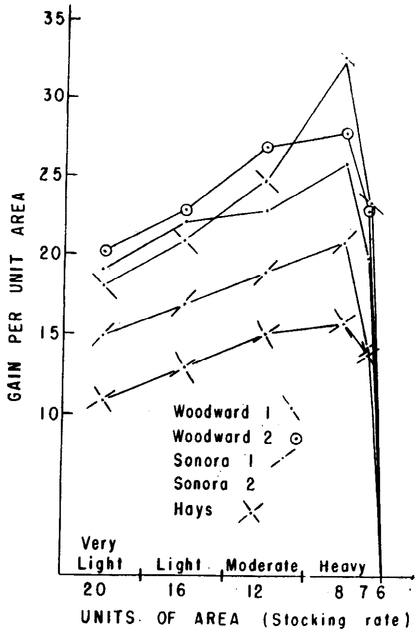

FIGURE 6. Gain data plotted against a standard stocking rate differential: values to the right and left interpolated.

ally grazes lightly (unless he is trying to upgrade his range condition) had better have some additional source of income, for he is not likely to make much out of the livestock business. All of these things have been known and understood in a general way for a long time, but the reasons back of them were not always too clear.

Range Classification

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A Generalization

Progress in science depends ultimately on the development of valid and useful generalizations. "The science and art of grazing land management" has had all too few valid generalizations up to the present time. The one proposed in this paper may not turn out to be valid, but at least is one attempt in that direction.

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LINCOLN ELLISON
(1908 - 1958)

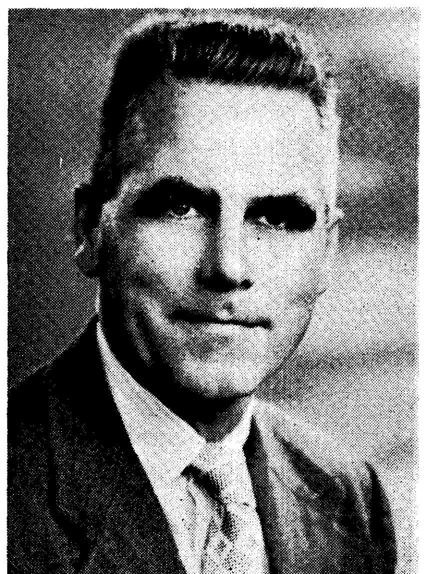
His many friends and associates were shocked by the sudden, tragic death of DR. LINCOLN ELLISON, Chief of the Division of Range Management Research, Intermountain Forest and Range Experiment Station, Ogden, Utah. "LINC" was caught in an avalanche on March 9 while ski-touring on Mt. Ogden about one and a half miles from Snow Basin, Wasatch Mountains.

LINCOLN ELLISON was born at Portland, Oregon, August 2, 1908. He received his B.A. degree at U.C.L.A., his M.S. from the University of Minnesota in 1938, and his Ph.D. from the same institution in 1948. "LINC" was a charter member of the American Society of Range Management.

DR. ELLISON's early years with the Forest Service were chiefly in Region One where he began his career in 1927. He directed research activities at the Great Basin Research Center, Ephraim, Utah, from 1938 until 1945, when he came to Ogden to take charge of range management research.

High among the many honors awarded him scholastically and professionally was a Fulbright Research Fellowship to Australia in 1951 and 1952 where he was affiliated with the Commonwealth Scientific Industrial Research Organization. He was a delegate to the Seventh International Grassland Congress at Palmerston North, New Zealand in 1956. He was a prominent member of Sigma Xi, honorary scientific society.

In recognition of his leadership and professional attainment he served as chairman of the Intermountain Section of the Society of American Foresters, chairman of the Western Section of the Ecological Society of America, member of the editorial board of Ecological Monographs, president of the Utah Academy of Sciences, Arts, and Letters,



LINCOLN ELLISON

member of the Awards Committee of the Utah Section and member of the national Program Committee of the American Society of Range Management. He recently was made a Fellow of the American Association for the Advancement of Science, and currently was a member of the Council of the Ecological Society of America and chairman of the Junior Academy Division of the Utah Academy of Sciences, Arts, and Letters. His writings and speeches in the professional fields of plant ecology, plant succession in relation to range management, and in related subjects have been widely published and acclaimed.

. . . .

His loss is felt keenly by his host of friends and his fellow workers in the Forest Service. He was held in high esteem by all who came to know him. Untiringly he gave of himself and his talents, and the lives of many have been greatly enriched by his wholesome philosophy of life, his outstanding leadership, and his wealth of knowledge. His contributions in the cultural, scientific, and more specifically the ecological world, have been many and will serve now as a fitting monument to his memory. His passing leaves a vacancy it will not be easy to fill.

Reed W. Bailey, Director
Intermountain Forest and
Range Experiment Station

BOOK REVIEWS

Edited by Donald W. Hedrick, Dept. of Animal Husbandry, Oregon State College, Corvallis, Oregon

The Federal Lands: Their Use and Management. By Marion Clawson and Burnell Held. *The Johns Hopkins Press, Baltimore. 539 pages. $8.50.*

Drs. Clawson and Held have prepared one of the most significant pieces of literature about the Federal lands and their management that has appeared in many years. It should be on the "required reading" list for those who work in public land management, students of resource management problems, and others who profess to know or do something about the public lands of this country.

The book is organized into an introduction, six long chapters, and two appendices, one of which deals briefly with laws and regulations pertaining to public lands. The other gives complete statistics on these lands. The six long chapters are broken conveniently into sections and brief summaries appear at handy places within the chapters. The text is amply illustrated by charts and short tables. A few pictures in the front of the book show the main types of Federal lands and their uses.

Different readers will find different things in this book to emphasize. Basically, the book deals with the rationale of management decision-making. The authors begin with the proposition that essentially the present Federal lands will stay in Federal ownership, an assumption with which few would disagree. They observe that the level of management has become more intensive over the decades and opine that still more intensive management is in order for the future. Here too, few would disagree.

The authors reason further that as more intensive management of Federal lands is in the offing, a more rational basis for making management decisions than now exists is needed. They look to the principles of economics to provide this basis. In the private business world, the principles of economics do provide a rational basis for pricing products and for guiding the kinds and amounts of expenditures to be made.

In many ways, operation of the Federal land resources is big business. The authors believe that prices for the products — forage, timber, minerals, etc.—are too low and that total revenue from these resources is too low. They believe also that expenditures for day-to-day management and for development of Federal lands are too low. Can the principles of economics be used to guide the management and investments put into Federal land in relation to the kind, quantity, and quality of goods and services produced on it?

In chapter 1, the place of Federal land in our society is reviewed and in chapter 2, its uses are described. In chapter 3, the present methods of policy formation and decision-making are set forth. In some respects, the latter is the most informative chapter in the book. For the most part, it was written by the senior author, from personal experience with public land management. Beginning students will learn much from the first two chapters, but chapter 3 provides valuable lessons in the realities of operating public land for many now working professionally in the field.

Chapter 4 examines how prices for products of Federal land are set, how revenues are used, and how investments are made. Price making for grazing, timber, minerals, and other products are discussed separately. The wide variety of pricing arrangements among them is noted and the historical background and functioning of each is examined critically. The authors conclude that the whole system of pricing and investment works badly, which, among other things, makes administration of Federal lands more difficult than it should be.

Chapter 5 carries this discussion further by examining the relationship between revenues and expenditures for each major type of Federal land, such as national forests, public domain, Oregon and California Lands, and national parks. The purpose here is to examine the economic rationale between revenues obtained and operating costs. Economic discipline would indicate a level of operating costs that would maximize net revenues, and further, that each expenditure should be at a level that would give the greatest revenue. The authors find that the data on revenues and expenditures hardly permit so rigorous an analysis, but conclude, ". . . that the level of expenditures on the Federal lands is far below the maximum revenue-minus-expenditure point; and even farther below a point where non-revenue-producing activities would be adequately provided for." They say further that the "balance-sheet" type decisions that would result from application of economic principles are largely absent from public land management.

The authors predict a new era in management of Federal lands. They advocate a "Federal Land Corporation" that could operate the public land in a more businesslike way than is possible under government bureaus. Such a corporation, they claim, would be sensitive to the demands for products from public land, could set prices in response to the demands, could incur expenditures more in relation to revenues, and could be freed from the dampering imposed by budgets and legislative appropriations. They recognize that possibilities for getting such a corporation are remote and suggest a continuation of public land management about as it is or with an administrative reorganization. Without a land corporation, they suggest a "Land Review Board" that would analyze management and policies continuously for the guidance of present agencies and the Congress.

There is much to think about in this book by Clawson and Held. Whether or not the reader agrees with the suggestions made, he will be impressed with the vast knowledge displayed of our public land system and how it works. The authors have laid bare the essential features of major problems in public land management with keen insight and have turned on them the searchlight of economic analysis. The book does not deal with the technical problems of public land management. Neither is it a book on the economics of public land. But it is informative, and it should be especially useful to those who work in public land agencies, those who are concerned with public land policies, students of land problems, and readers generally. It's a very well written book.—*M. L. Upchurch,* Farm Economics Research Division, Agricultural Research Service, Washington, D. C.

Poison on the Land. By J. Wentworth Day. *Philosophical Library Inc., New York. 246 pages. 1957. $6.00.*

Poison on the Land was written by a champion of wildlife, a man obviously dedicated to the noble sport of shooting, and to his country — England. The revolutionary changes in British land ownership policies accompanied by new farming techniques, and more recently the accelerated usage of farm chemicals, have developed into a definite menace to nearly all forms of wildlife in Britain.

Part I of this book outlines the overall problem of lower emphasis on game management brought about by disinterested land owners, clean tillage cultivation, spray-control of roadsides and hedges, and the reduction in the numbers of game keepers. Accounts are given of birds and mammals killed by deadly sprays intended primarily for insect control, and the question is raised concerning the unknown effects of lethal chemicals on the human population. The rabbit-killing disease *Myxomatosis* is thoroughly discussed pro and con along with a consideration of the fox and rat and how they have been influenced by the chain of events started by the catastrophic reduction in rabbit numbers. A comprehensive picture of river pollution in England today is presented.

Part II gives the reader a documented account of the value and future of upland game and other birds. This section like the first is salted freely with personal hunting incidents and local color. The unabashed criticism of various British agencies responsible for farm chemical regulation, predator control, and reforestation makes one curious to know if the author can find no good, or is there complete mismanagement of the game problem through bureaucratic bungling.

The second part is highlighted by chapters on the cash values of game (land rental values, money spent on guns, ammunition, etc.), on rearing and increasing upland game birds, on winter feeding, and on birds—good and bad—as far as the game raiser and farmer are concerned. Considerable information on intensive habitat management is outlined which should be of interest to game managers and to landowners who wish to increase pheasants and quail on their holdings in this country. The need for predator control, proper seasonal cover, year around feed supplies, and game stocking are discussed at length.

The effect of various practices on the "balance of Nature" is mentioned occasionally in the text. One wonders, after reading the wholesale habitat transformations and game introductions into Britain during the past several hundred years, whether the concept of Nature's balance doesn't have a rather loose meaning.

Although it is not intended as a basic reference the student will find leads to food habit studies of birds. On the other hand, the realist who is not easily swayed by the esthetics may look upon the entire work as the ramblings of someone who misses the good old days and will wonder why he is flogging a dead horse. Yet, the author presents much to support his claim that the fate of British wildlife is hanging in the balance and to feel that if this book plants a few seeds of thought and action, it will have served its purpose.—*J. L. Launchbaugh,* Fort Hays Experiment Station, Hays, Kansas.

Atomic Energy in Agriculture. By William E. Dick. *Philosophical Library, New York. 150 pages. $6.00.*

An international conference on the peaceful uses of atomic energy held in Geneva in August, 1955, was the stimulus which led to the preparation of this succinct volume. The author, a research biologist and editor of chemical journals, competently reviews the progress made in the application of atomic energy to agriculture, fashioning the framework of his text from a digest of the more important contributions presented at the Geneva Conference. Around these selected research reports related to agriculture have been developed an historical background and a perspective, orienting the lay reader in the application and importance of atomic energy to agriculture.

Chapter headings of the book reveal the essential ways in which atomic energy can and will lead to progress in agriculture: (1) Remaking crop plants with radiation, (2) photosynthesis: tracing the path of carbon with radio-isotopes, (3) the path of the other elements, (4) radioactive materials in the fight against pests, (5) radio-active tracers and forestry, and (6) atomic radiation and food preservation.

Recognition that exposure of plants to X-rays in regulated dosages would stimulate genetic mutation led to the development of the new science of radiation genetics. Since World War II, intensive studies of irradiation effects on crop plants have resulted in the production of disease-resistant forms of cereals and enlarged fruit size through preliminary radiation treatment of seed.

Radio-active isotopes have been found to be an important key to the secrets of life through their use in gaining a better understanding of the photosynthetic process. Isotope studies have shown that appreciable amounts of carbon dioxide are taken up through plant roots, that addition of phosphate fertilizers activate root growth and consequently increase the uptake of natural soil phophorus from the newly occupied soil areas, and that nitrogen may be absorbed by plant foliage from urea sprays. Radio-active phosphorus and potassium move downward in the plant following foliage applications; calcium, on the contrary, may accumulate in the leaves but does not migrate to other plant parts.

Atomic energy can be utilized in man's continual struggle against plant pests. Tracing the life habits of insect pests such as wireworms, grasshoppers, and mosquitoes is facilitated by radio-active tracers; information on their biology may reveal a weak link wherein control may be achieved. To cattlemen, the account of the experiments conducted by American scientists in breeding screwworms to extinction on the island of Curacao offers a fascinating challenge which presumably may be repeated in other situations.

In forestry, applications of atomic energy have been limited, but one phase of research in atomic energy has given significant contributions in an understanding of the movement of materials in the sapstream of trees. Trees in dense stands were found to have a high incidence of root grafting by the use of isotope tracers and the release of dissolved minerals from roots to soil was demonstrated by radio-autographs.

Disposition of radio-active wastes from atomic energy plants has been a matter of grave concern in the development of peacetime uses of this source of power. Waste fission products emit ionizing radiation which has the power to kill bacteria and fungi. Harnessing this sterilization power for food preservation offers a promising avenue of disposal. The potentialities in this field are being explored by the U. S. Army Quartermaster Corps and other agencies. The livestock producer interested in expanding the consumer outlets for meat will not appreciate the reports that cold sterilization by atomic irradiation under present methods renders meat and other food products distasteful. However, the outlook in this field is not entirely pessimistic and suitable processes may be forthcoming wherein waste fission products may be utilized.

To the range manager and the range livestock producer, the book may seem to offer little information of immediate practical application; for the future, it holds the promise of rewarding achievements in increased forage and livestock production through the use of atomic energy. The book is an excellent synopsis of the present knowledge in a fast-growing area of scientific disciplines; it is both readable and rewarding.—*Robert A. Darrow*, Dept. of Range and forestry, Texas A. and M. College, College Station, Texas.

SOCIETY BUSINESS

ELEVENTH ANNUAL MEETING

Phoenix, Arizona

January 28 - February 1, 1958

The Eleventh Annual Meeting of the American Society of Range Management was held at Phoenix, Arizona, January 28-February 1, 1958. Headquarters for the meeting were at the Westward Ho Hotel. Total registration for the meeting was 707.

Business meetings of the Board of Directors were held on January 28, 29, and 31. Highlights of the Directors' meetings are presented later in this report.

The Section Chairman's meeting was held on Tuesday afternoon, January 28, under the chairmanship of JIM L. FINLEY, Chairman of the Arizona Section. The chairmen and their representatives gave special attention to problems of membership, advertising in the Journal, and to the subject of increasing the number of rancher papers published in the Journal.

At the general business meeting of the Society on the evening of the 28th the principal topics of discussion were the financial status of the Society and the proposal to increase annual dues. A show of hands of the members present at the meeting indicated that annual dues of $8.00 would be generally acceptable.

President TISDALE pointed out that there was a need for greater continuity in office and cited the Pacific Northwest Section's proposal to succeed the Section Chairman by the vice chairman each year. No suggestions were forthcoming from the floor, and the matter received no further discussion.

Following the business meeting DR. HOMER L. SHANTZ presented "An African Safari". DR. SHANTZ illustrated changes in the native vegetation of Africa with slides taken over a period of years during several visits to Africa.

Regular sessions of the meeting started on Wednesday, January 29, with a six paper session on "Arizona as a Ranching Area." The afternoon session on "Range Management in Relation to the Livestock Industry" included a message of welcome by JACK WILLIAMS, Mayor of Phoenix, and the "President's Address" by E. W. TISDALE. The Thursday morning session featured "Range Watershed Problems of the West."

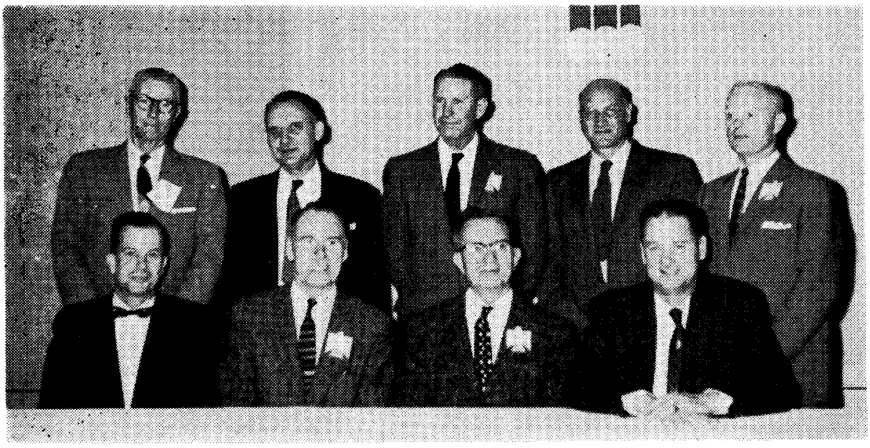
One split session was held Thursday afternoon with one assembly dealing with "Control of Undesirable Range Plants," and the other covering phases of the topic, "Reseeding Western Rangelands." Another split session on Friday morning included the "Technical Session" and "Big-Game Livestock Relations." The concluding session on Friday afternoon included six papers on the general topic of "Grazing Management of Rangelands."

On Saturday morning a tour by chartered bus was made of feed lots, packing plants, irrigation projects, and other points of interest in the Salt River Valley.

The program for the meeting was arranged by HUDSON G. REYNOLDS and his Program Committee. Local arrangements were made by FRANK C. ARMER and his committee. WAYNE KESSLER was chairman of the Displays and Contests Committee.

W. G. MCGINNIES presided as toastmaster at the annual banquet on Thursday evening, January 30. CARL SUNDQUIST from Honolulu was recognized as having come farthest to the meeting. Following an introduction by CLYDE DORAN, GEORGE BRADLEY presented a billfold to LORENZ BREDEMEIER in recognition of the Nebraska Section's achievement in showing the highest percentage increase in membership during 1957.

Awards were made to the winners in the Plant Identification Contest and the Photographic Contest at the



Officers and Directors of the Society at Phoenix. Seated, left to right, Don Hervey, director, Colorado; E. W. Tisdale, retiring president, Idaho; R. S. Campbell, president, New Orleans; Danny Freeman, past president, Arizona. Standing, left to right, Jim Finley, director, Arizona; Joe Wagner, director, Washington, D. C.; Kenneth Conrad, director, Colorado; Mel Morris, director, Montana; and E. Wm. Anderson, director, Oregon.

banquet. The team from Colorado State University won first place in the Plant Identification Contest with a score of 195 4/5. The Texas A. and M. team placed second, and the University of Wyoming third. High individual scorer was Lynn O. Hylton, Colorado, with a perfect 200. Second high scorer was Robert Ferraro from the University of Nevada with 196. Lowell Brown of Colorado State and Phil J. Phillips of Texas A. and M. tied for third place, each scoring 195½. Eleven teams and 40 contestants took part in the contest.

Grand Champion winner in the photographic contest was J. Kimball Hanson, Whiteriver, Arizona. Other winners in the black and white division beside Hanson were L. E. Bredemeier, Grant A. Harris, Clair M. Whitlock, and R. R. Humphrey. Winners in the color slide division were Jack N. Reppert, Bob Johnson, A. A. Beetle, Eric Granfelt, J. Kimball Hanson, and Don Huss.

Two outstanding entertainment features were provided at the banquet. These were the young Navajo Indian dancers in colorful costumes doing the Eagle, Hoop and War dances; and Gail Gardner of Prescott, Arizona, singing and reciting his own western ballads.

HIGHLIGHTS OF THE DIRECTORS' MEETINGS

President E. W. Tisdale presided at the Directors' meeting held at the Hotel Westward Ho, Phoenix, Arizona on January 28. Incoming President Robert S. Campbell presided at a special Directors' meeting held at the hotel on January 29, and again at the final meeting of the Directors on January 31. All officers and Directors were present at the meetings except Leslie R. Albee and John M. Cross, who were unable to attend the Society meeting at Phoenix. Major items of business and highlights of the committee reports are as follows.

Program of the Future: Harold Cooper, Chairman, presented several suggestions for increasing membership and recommended strongly that the Society should move toward the establishment of a permanent headquarters. Suggestions in regard to the Journal included the recommendation that monthly publication be established as a goal, that illustrations be increased and used more effectively, and that articles be abstracted and circulated to other publications.

1959 Convention City Preliminary Arrangements Committee: Chairman W. C. Whetsell stated that initial arrangements were underway for the meeting in Tulsa, Oklahoma, and that the meeting should be scheduled for the week of January 26-31. These dates were accepted by the Directors.

1960 Convention City Committee: William Meiners reported for the committee. Spokane, Washington was recommended for the 1960 meeting, but Portland, Oregon was interested in having the meeting. Final decision was left to President Campbell pending receipt of full information from both cities.

Committee on Cooperation with Youth Organizations: Karl Parker, Chairman, submitted copies of the completed range manual for youth groups. The manual, "Range, Its Nature and Use," is to be made available to Sections and to other interested groups for use as a basic manual in the preparation of state or Section manuals. Parker further suggested that a movie be prepared to supplement the manual. The Directors authorized Parker to contact Mr. Dahlin at Montana State College in relation to the development of a script for the movie.

Committee on Range Research Methods: Chairman C. Wayne Cook reported that the members of the committee are nearing completion of their task and that the book being prepared on methods should be in final form for submission to the Board at the 1959 meeting.

Nominations Committee: The Chairman, A. C. Hull, Jr., suggested a change in the Society By-Laws, which now provide that a person nominated by petition must be placed on the final ballot. His suggestion was that persons nominated by petition would still be subject to selection by the procedures of the nominating committee. The object of this change would be to prevent having too many candidates for any one office. The matter was referred to the By-Laws Amendment Committee.

Grassland Council: Lowell Halls reported that the Grassland Council (Joint Committee on Grassland Farming) had proposed a joint meeting with the Society. The Board recommended that the Grassland Council be invited to share part of the program at the Tulsa meeting in 1959. Lowell Halls, Don Hervey, and Pat McIlvain were named as a committee to arrange details of the program.

Life Memberships: By action of the Board the fee for Life Membership was raised to $300.00, effective immediately.

Mexico Section: The petition of the Mexico group for the formation of a Mexico Section was approved. There are 28 members in the Mexico Section.

Trail Boss Emblem: The Secretary was authorized to purchase 500 pins for resale to Society members. Design No. 1, gold filled, was selected as a result of the membership vote on the designs displayed at the Phoenix meeting.

Summer Meeting: Tom Willis of Kamloops, B. C. invited the Board of Directors to hold their summer meeting at Kamloops and extended an invitation to the Society at large to meet with the Pacific Northwest

Section at Kamloops on July 11-12, 1958. The invitation was accepted and the Board meeting was set for July 10, immediately preceding the Section and Society meeting.

Increase in Dues: At a special meeting of the Board on January 29 regular dues were raised from $6.00 to $8.00 per year, effective for 1959. Student dues remain at $4.00, and Foreign dues were increased to $8.50.

Budget: The budget for 1958 was approved as follows:

Estimated Receipts	$19,010.00
Estimated Expenditures	
Office of the President	200.00
Office of the Editor	600.00
Executive Secretary	8,558.75
Journal Publication	9,625.00
Total	$18,983.75

Editorial Board: The Directors appointed ARNOLD HEERWAGEN of Denver, Colorado, and W. R. HANSON of Calgary, Alberta, to the Editorial Board of the Journal of Range Management to succeed E. R. JACKMAN and C. A. RECHENTHIN, whose terms expired in 1957.

RESOLUTIONS

The following resolutions were presented by the Resolutions Committee and adopted by the Directors. The Executive Secretary was instructed to write letters to all named in the resolutions.

1. *Whereas:*

The Arizona Highways Magazine donated copies of this excellent pictorial atmosphere of Arizona; the Valley National Bank and First National Bank provided registration badges and donated generously toward contest prizes; the Salt River Valley Water Users provided luncheon for the students in the grass judging contest; the Westward Ho Hotel provided general assembly and committee meeting rooms and many services helpful in the functioning of a successful meeting; the Goldwater's Department Store of Phoenix provided favors for the Ladies luncheon; the Arizona Farmer-Ranchman provided Banquet programs; the Arizona Association of Soil Conservation Districts, Arizona Cattle Growers Association, Arizona Hereford Association, Arizona Wool Growers Association, Phoenix Clearing House Association, Arizona Section ASRM donated the prizes and awards for photographic and grass judging contests; the Arizona Cotton Growers Association, the Roosevelt Water Conservation District, Maricopa County Municipal Water Conservation District No. 1, Roosevelt Irrigation District, and the Arizona Cattle Feeders Association sponsored and financed the Valley Tour; the Phoenix Indian School provided entertaining Indian dancers for the banquet program; GEORGE PHIPPEN provided an impressive display of his realistic Western art; GAIL GARDNER provided very appropriate, original banquet entertainment; the Phoenix Chamber of Commerce provided helpful suggestions in the conduct of the meeting, in arranging housing, and in assistance on the registration desk; numerous local enterprises bought advertising in the Journal; The Arizona Cattle Growers Association featured the ASRM throughout the entire January issue of their publication "Cattlelog";

Therefore be it resolved:

That the American Society of Range Management expresses its deep appreciation of these excellent major contributions which resulted in a highly successful meeting with a record attendance significantly influencing the national stature of the Society.

2. *Whereas:*

The Local Arrangements Committee and its sub-committees arranged for and conducted an outstandingly well organized and proficient meeting and provided for numerous facilities helpful to those attending; the Program Committee arranged for a very interesting, and highly informative panel of topics and speakers; the Displays and Contests Committee arranged for a very successful and interesting representation of major range areas and conducted well organized, beneficial photographic and grass judging contests; and many other civic leaders, ranchers, business and interested local citizens contributed in various ways to the success and conduct of the meeting and to the facilities available to those attending;

Therefore be it resolved:

That the ASRM expresses its sincere appreciation to those loyal, hardworking members and friends.

3. *Whereas:*

The Society's Membership Committee, Executive Secretary, and Section Membership Committee members were prominently influential in obtaining a significant increase in the Society membership during the past year and, whereas an increasing membership is essential for the continued stability, effectiveness, and national stature of the Society;

Therefore be it resolved:

That the ASRM express its deep appreciation for the sincere interest and endeavor represented by this progress.

. . . .

Expression of Appreciation:

"I am sure that all the ladies who attended the 11th Annual meeting of the American Society of Range Management would like to join me in thanking Mr. Armer and his local committee for the entertainment planned for us. The tour was most interesting, the luncheon at the Paradise Valley Racket Club was unusual and delicious. The style show was enjoyed by all as were the favors donated by Goldwaters Department Store.

"Although probably not planned by the local arrangements committee, the day was made glamorous because BING CROSBY and PHIL HARRIS were having lunch in the same room.

"Thanks again for a splendid time."

Alma Clouston

REPORT OF THE EDITOR

The 1957 volume of the Journal (Vol. 10) contained 63 articles and technical notes with a total of 294 numbered pages. Paid advertising occupied approximately 9½ pages in the volume, and the total income from advertising was $1,135.83.

Two special issues were released during the year: the September Student Issue contained the Range Student Roundup and several papers adapted from Master's degree theses. The November Rancher Issue was devoted entirely to papers by ranchers from all sections of the range country. In addition to the 13 rancher papers in this issue, the program of the 1958 Annual Meeting of the Society at Phoenix and the Volume index and table of contents were included. Appreciation is expressed to all Section officers and members whose efforts made possible the production of the Rancher Issue.

Recognition is given to E. R. JACKMAN, Corvallis, Oregon, and to C. A. RECHENTHIN, Temple, Texas, for their counsel and assistance as members of the Editorial Board, 1955-57. New members of the Board chosen by the Directors for 1958-60 are ARNOLD HEERWAGEN, Denver, Colorado, and W. R. HANSON, Calgary, Alberta.

The Executive Secretary advertised for bids on printing the Journal, and a contract with the Nebraska Farmer Printing Company, Lincoln, Nebraska, was negotiated for the printing of Volume 11 (1958). The change in printers necessitated the adoption of new type faces.

Current Items of Society Business

Committee on Revision of By-Laws

A committee has been set up to consider proposed revisions in the By-Laws of the Society and to recommend such changes as seem desirable. The By-laws now in force are those amended to August 3, 1956 and published in the November 1956 issue of the Journal. Suggestions for changes in the By-Laws are welcomed, and can be addressed to the Chairman or to any member of the committee. All suggested changes must be in the hands of the committee by May 30, 1958, in order to meet the deadline set for submission of our report to the Board of Directors. The membership of the committee is listed along with other national committees in this issue of the Journal.

Special Society Business Meeting

There will be a special business meeting of the American Society of Range Management at 7:00 p.m. on July 10, 1958, at Kamloops, B. C., following the regular summer meeting of the Board.

The purpose of this special meeting is to present, discuss, and vote on whether proposed amendments to the Society By-laws shall be mailed to Society members for action in accordance with Article VIII of the present By-laws. This special meeting is necessary, if the proposed amendments are to be mailed to Society members with the regular election ballots next September.

Robert S. Campbell
President

Announcement

Spokane, Washington has been selected as the Convention City for 1960. The Davenport Hotel will be headquarters. Remember, we go to *Tulsa* next *January, 1959,* and to Spokane in 1960.

Robert S. Campbell
President

Message from the President

At a special meeting of the Board of Directors in Phoenix, Arizona, on January 30, 1958, the following motion was passed:

"That the annual dues for membership in the American Society of Range Management be raised to $8.00 for regular members; that student membership remain the same at $4.00; and that foreign memberships be $8.50, effective for the calendar year 1959."

This action was taken for the following reasons:

First, the Society should pay current expenses from current income. We should not spend next year's dues to pay this year's bills. In each of the past four years, the Society has spent from $3,000 to $4,000 of next year's dues to meet the current year's expenditures. We anticipate a similar situation in 1958. The Society has sufficient reserves to meet its obligations, but continued deficit financing is not a healthy situation.

Second, we must meet continuing increases in costs. For example costs of printing the Journal have risen every year in spite of many economies. The Journal cost $7,400 to print and mail in 1952, and $11,100 in 1957. The increase in membership has not begun to make up the difference in cost. The Journal should be expanded in both quality and content and eventually become a monthly publication.

Third, many Society activities need increased financing. The youth activities should be expanded. The Committee on Program of the Future has recommended that the Society start planning now to acquire a permanent home.

Fourth, the Society should pay for services rendered—our membership is already too large to continue indefinitely with a volunteer editor and with a "part time" executive secretary. The Society pays these two men a total of $1,400 each year for services that normally would cost several thousand dollars.

Society dues started at $3.00 in 1948, and the single October issue of the Journal was published that year. In 1949, annual dues were set at $5.00 to finance yearlong publication of the Journal and other costs. In 1954, the dues were raised to $6.00 per year but $0.75 of the increase was remitted to the Sections. Thus the national office has had an annual increase of only $0.25 in the past 9 years of mounting inflation. If the dues increase from $6.00 to $8.00 for 1959 seems high to you as an individual, just consider it in the light of the prices you pay for other things now as compared with 1949, and in terms of your income now compared to 9 years ago.

It is important for every member to understand fully the reasons for the increase. Each one must convince himself that the increase is needed and worthwhile. Each must be able to explain the increase to prospective new members. We must realize that it is a necessary step in the Society's continued growth.

R. S. Campbell
President

Society Representatives to Cooperating Organizations

American Grassland Council:

R. E. Williams
Soil Conservation Service
P. O. Box 832
Athens, Georgia

Agricultural Research Institute

K. W. Parker
Division Range Management Research
U. S. Forest Service, U.S.D.A.
Washington 25, D. C.

Society of American Foresters Annual Meeting

Elbert H. Reid
Rocky Mtn. For. and Range Exp. Station
Colorado State University
Fort Collins, Colorado

AMERICAN SOCIETY OF RANGE MANAGEMENT

National Committees for 1958

Program

E. H. McIlvain, *Chairman*
Agricultural Research Service
U. S. Southern Great Plains
Field Station
Woodward, Oklahoma
Kling L. Anderson
Hershel M. Bell
Roderic E. Buller
Farrington R. Carpenter
Don R. Cornelius
Dan Fulton
Lowell K. Halls
Harry J. Hargrave
Don W. Hedrick
Arnold Heerwagen
William D. Hurst
Hudson Reynolds
Weldon O. Shepherd

Local Arrangements

W. C. Whetsell, *Chairman*
Phillips Petroleum Co.
P. O. Box 66
Foraker, Oklahoma
A. P. Atkins
Bob Hartley
Hurlon Ray
G. C. Parker
Myron Hurd
Clarence Kingery
Darrell Grissom
Clarence Bunch
E. H. McIlvain
Charles Schumacher

Cooperation with Youth Organizations

Karl G. Parker, *Chairman*
Extension Service
Montana State College
Bozeman, Montana
Walter Armer
Lester Berner
Clarence E. Bunch
Grant A. Harris
Carl W. Herzman
Garlyn O. Hoffman
Alex Johnston
H. M. Kilpatrick
Liter E. Spence

Program of the Future

Melvin S. Morris, *Chairman*
School of Forestry
Montana State University
Missoula, Montana
C. H. McKinnon
Rudy Peterson
H. W. Cooper
Robert Casebeer
Lesile R. Albee

National Inventory of Range Management Research

Royale K. Pierson, *Chairman*
Bureau of Land Management
Department of the Interior
Washington 25, D. C.
Evan L. Flory
Richard E. Griffith
Donald F. Hervey
Wesley Keller
Ben O. Osborn
K. W. Parker
Fred G. Renner
E. W. Tisdale

Membership

Leon Nadeau, *Chairman*
Bureau of Land Management
Box 3861
Portland 8, Oregon
All Section Chairmen

Advertising

Morley E. Fox, *Chairman*
U. S. Brewers Foundation, Inc.
Room 314
First National Bank Bldg.
Phoenix, Arizona

1960 Preliminary Arrangements

William R. Meiners, *Chairman*
Colville Indian Agency
Nespelem, Washington
Fremont Merewether
Don C. Calhoun
Claude Dillon
Willard Fallis
Ramon Kent
P. C. McGrew

Elections

Frank W. Stanton, *Chairman*
Oregon State Game Commission
P. O. Box 4136
Portland 8, Oregon
Max T. Lieurance
Wayne West

Library and Depository

D. L. Goodwin, *Chairman*
College of Forestry
Utah State University
Logan, Utah

1961 Convention City

Laurence E. Riordan, *Chairman*
Colorado Game and Fish Dept.
1530 Sherman Street
Denver, Colorado
William D. Hurst
Howard Passey
Harold Josendal
Maurice W. March

Displays and Contests

Clarence E. Bunch, *Chairman*
Extension Service
Oklahoma State University
Stillwater, Oklahoma
Maurice D. Gamble
(Plant Identification)
Myron A. Hurd
Donald Huss
H. N. Stidham
(Photograph Contest)
R. E. Chiles
D. A. Dobkins

Nominations

E. William Anderson, *Chairman*
Box 798
Pendleton, Oregon
Frank Armer
W. R. Hanson
Paul L. Howard
Kenneth B. Platt
Laurence E. Riordan
Robert S. Rummel
E. W. Tisdale
Gerald W. Thomas

Range Research Methods and Techniques

C. Wayne Cook, *Chairman*
Dept. of Range Management
Utah State University
Logan, Utah
H. H. Biswell
E. H. Reid
Charles Shelby
L. A. Stoddart
M. L. Upchurch

Civil Service

Joe A. Wagner, *Chairman*
1504 Timber Lane
Falls Church, Virginia
B. W. Allred
Harold F. Heady
G. M. Kerr
Gene F. Payne
W. O. Shepherd

Revision of By-Laws

E. W. Tisdale, *Chairman*
College of Forestry
University of Idaho
Moscow, Idaho
B. W. Allred
A. P. Atkins
J. D. Freeman
D. A. Fulton
J. F. Pechanec
F. G. Renner
L. A. Stoddart

WITH THE SECTIONS

NORTHERN GREAT PLAINS

An informal breakfast meeting of the Section was held at the YMCA in Phoenix during the annual meeting of the Society. Eleven members were present. Plans for the season's activities were discussed.

The Summer Section Meeting will be held at Glasgow, Montana, June 27-28. Registration begins at 9:00 a.m. on June 27 at the Roosevelt Hotel. JOHN KILLOUGH of the Bureau of Land Management is in charge of the program.

Seven committees have been appointed to carry on the work of the Section. These are: Research Needs, Nominations, Elections, Newsletter, Section Affairs, Youth Activity, and Membership.

Section membership at the end of the year was 131. This Section had the fourth greatest percentage increase last year of all the Sections.

CHARLES W. CROSBY, B.L.M., Miles City, has transferred to this Section from Section I. WALT HOUSTON, Section Chairman, has returned to Miles City from Logan, Utah, where he has been doing graduate work at Utah State University.—*Sterle Dale.*

PACIFIC NORTHWEST

Forty members of the Section attended the national meeting of the Society in Phoenix; 30 were in attendance at the Section breakfast held during the meeting.

The Summer Field Meeting will be help in Kamloops, B. C., July 11-12. The Directors of the Society will meet at Kamloops on July 10, and an invitation has been issued to the Society at large to meet at Kamloops with the Section. BILL PRINGLE is chairman of the Summer Field Meeting Committee.

The Winter Section Meeting will be held at Spokane, December 1-2, 1958. KENNETH A. BURKHOLDER is chariman of the Winter Meeting Committee.

Twelve other committees have been appointed. These are: Nominations, Program, Membership, Publicity, Curriculum, Range Plant Handbook, Range Camp Advisory, Oregon Range Camp, Washington Range Camp, Displays, Research, and Awards.—*Chet Bennett.*

UTAH

Officers of the Utah Section for 1958 are:

Chairman: ORVAL E. WINKLER, Forest Service, Logan.

Vice Chairman: NEIL C. FRISCHKNECHT, Forest Service, Ephraim.

Secretary-Treasurer: GARTH M. COLTON, BLM, Brigham City.

Councilmen: OWEN M. DESPAIN, Forest Service, Logan; ARTHUR D. SMITH, Utah State University, Logan; J. WELLS ROBBINS, Rancher, Scipio.

Eight committees have been appointed to carry on the activities of the Section for this year. These include Program, Publicity, Membership, Projects, Awards, Nominations, Historical, and Conservation Week. As part of the effort of the Membership Committee blank membership forms have been sent to every member of the Utah Section.

The Utah Section took part in the Utah State Conservation Week Program, April 7-12, through a joint session with representatives from the Society of American Foresters, Soil Conservation Society of America, and U.S.U. Forestry alumni. A professional session on watersheds, and the influence of access roads on wildland management, range and rancher, watersheds, timber harvest, and big game management was held at Utah State University on Saturday morning, April 12.

Two distinguished members of the Section died recently. J. PERRY EGAN, State Game and Fish Director, died following an illness of several months, and LINCOLN ELLISON was killed by an avalanche while skiing.

C. J. (CHET) OLSON, who recently retired from the Forest Service, has become Director of the State of Utah Parks system. JOHN WALLENTINE has assumed his new position as Utah Extension Service Range Specialist Aid Forester. HAROLD CRANE is the new Director of the Utah State Department of Fish and Game.

The Student Chapter of the Utah Section at U.S.U. now has 25 active members.

WYOMING

Twenty-one Section members attended the breakfast meeting of the Section at the San Carlos Hotel at Phoenix during the national meeting of the Society. Items considered at the breakfast meeting included the possibility of providing financial assistance to the Wyoming Plant Judging Team, displays, membership, and the possibility of sponsoring an award for some range project in the state. WALLY JOHNSON was appointed as chairman of a committee to investigate this possibility.

The Wyoming Range Management Scholarship Fund stood at $844.00 as of April 1, and it is apparent that the goal of $1,000 will be reached this year.

The Summer Field Meeting of the Section is scheduled for July 18-19, 1958, at Lander. Section members W. M. JOHNSON, MORTON MAY, A. A. BEETLE, RICHARD ARO, ROLLAND JORGENSEN, JOEL VERNER, MARVIN SHOOP, and DIXIE SMITH are giving papers at the meeting of the Colorado-Wyoming Academy of Science meeting at Denver, May 9-10.—*A. A. Beetle.*

Section Chairmen:

Be sure to send in your rancher articles. We have none on hand now, and we can print one or two each issue. Rancher articles for the Rancher Issue should reach the editor by 1 September, 1958.

SECTION CHAIRMEN AND SECRETARY-TREASURERS FOR 1958

Arizona

Wayne Kessler	Theodore L. Moeller
422 State Office Bldg.	121 Glenrose Street
Phoenix, Arizona	Phoenix, Arizona

California

R. Merton Love	Walter E. Howard
225 Hunt Hall, U. of C.	Field Sta. Admin., U. of C.
Davis, California	Davis, California

Colorado

A. C. Everson	Dwight R. Smith
Colorado State University	Colorado State University
Fort Collins, Colorado	Fort Collins, Colorado

Idaho

W. P. Lehrer	Paul Dalke
University of Idaho	University of Idaho
Moscow, Idaho	Moscow, Idaho

Kansas-Oklahoma

W. C. Whetsell	Clarence E. Kingery
P. O. Box 66	P. O. Box 1377
Foraker, Oklahoma	Oklahoma City, Okla.

Nebraska

Don Burzlaff	Charles W. Staveley
Ft. Robinson Res. Station	Box 706
Crawford, Nebraska	Chadron, Nebraska

Nevada

Richard J. Holland	Russell D. Lloyd
1800 Wilder Ave.	University of Nevada
Reno, Nevada	Reno, Nevada

New Mexico

Erasmus W. Williams	Howard C. Abercrombie
Box 1052	Box 548
Tucumcari, New Mexico	Tucumcari, New Mexico

Northern Great Plains

Walter R. Houston	Sterle E. Dale
Box 810	Forsyth,
Miles City, Montana	Montana

International Mountain

Homer Turner	Alex Johnston
730 South Pacific	Dept. Agr. Exp. Station
Dillon, Montana	Lethbridge, Alberta

Pacific Northwest

William R. Meiners	Roderick Scurlock
Colville Indian Agency	Colville Indian Agency
Nespelem, Washington	Nespelem, Washington

South Dakota

Otto J. Wolff	Les Albee
912 South Patrick	806 Colorado S. W.
Rapid City, South Dakota	Huron, South Dakota

Southern

Fred A. Peevy	Harold E. Grelen
Box 1192	110 Oakland Circle
Alexandria, Louisiana	Brewton, Alabama

Texas

Jack M. Fletcher	Meril G. Carter
P. O. Box 658	P. O. Box 270
San Antonio, Texas	Uvalde, Texas

Utah

Orval Winkler	Garth Colton
320 East 7th North	273 South 2nd West
Logan, Utah	Brigham City, Utah

Wyoming

Harlan Tulley	Alan A. Beetle
P. O. Box 889	University of Wyoming
Sheridan, Wyoming	Laramie, Wyoming

National Capitol

W. O. Shepherd	Robert Harris
U. S. Forest Service	U. S. Forest Service
Washington 25, D. C.	Washington 25, D. C.

Mexico

Oscar Ochoa	Martin H. Gonzales
Priv Cuahtemoc 405½	Edif. Union Ganadera
Chihuahua, Chih.	Despacho 201, Chihuahua,
Mexico	Chih., Mexico

Mr. Robert S. Campbell, President
American Society of Range Management

Dear Bob:

Thanks for your kind letter complimenting our "Team" on their work of preparing for the January meeting of our A.S.R.M. in Phoenix, Arizona.

Our Arizona Section certainly did appreciate the privilege and honor of being host for the occasion, and assure you we keenly enjoyed our association with the many fine members who attended.
We hope "You All" will come again soon.

Our kindest regards to you President Bob, and all the members of our society, whose aims and work are so important to the existence of mankind.

Jim Finley, Director A.S.R.M.
(Past Chairman Arizona Section)

NEWS AND NOTES

Colorado Gets $50,000 Grant for Watershed Study

A grant of $50,000 to help initiate a complete, full-fledged instruction and research program in watershed management—first of its kind in the United States—has been made to Colorado State University. Announcement of the grant was made jointly by William E. Morgan, president of the University, and Arthur N. Pack, president of the Charles Lathrop Pack Forestry Foundation, which made the grant.

Details of the program will be worked out by University officials and Tom Gill, Washington, D. C., executive director of the foundation, when Gill visits the campus in May. The program calls for establishment on July 1, 1958, of a watershed management unit as an integral part of the College of Forestry and Range Management at the University.

National and international importance is envisioned for the watershed management unit. In addition to the grant by the Pack Foundation, assistance will be given by the U. S. Forest Service through the Rocky Mountain Forest and Range Experiment Station which is headquartered on the campus. Raymond Price, director of the station, states that U. S. Forest Service personnel will participate in research activities of graduate students enrolled in the unit.

Colorado State University now offers an option for an undergraduate major and a master's degree in watershed management in the college of forestry and range management. But under plans for the new unit, a separate undergraduate major will receive emphasis, the master's program will be strengthened and within a few years a doctorate study program in the field will be established.

Progress in the Great Plains Program

More than 1,000 farmers and ranchers either are starting on complete farm or ranch plans in the newly launched Great Plains Conservation Program or have applications awaiting action.

The USDA's Soil Conservation Service reports 66 of these plans for faster application of soil and water conservation have been launched in seven states. (Texas, North Dakota, Nebraska, Kansas, Oklahoma, New Mexico and Colorado).

The contracts signed involve 74,399 acres of farm and ranch lands, an average of 1,100 acres per unit. Cost-sharing is guaranteed by the Federal government to cover periods of conservation work of from three to 10 years.

Texas, with 65 of its westernmost counties taking part, leads with 51 contracts signed for units totaling 42,588 acres. Oklahoma, with 14 counties, is next with seven contracts and 17,020. New Mexico reports four contracts on farms totaling 6,466 acres.

Regrassing practices lead at present in the interest of farmers and ranchers, with cost-share help provided in most of the 10 States at about 80 percent of the cost of establishing grass. There is much interest too, in water conservation practices. Many of the soil conservation practices which a plan may call for must be applied at the owner's own expense.

IN THE FIELD

Howard E. Ahlskog, Forest Supervisor of the Kootenai National Forest, Libby, Montana, since 1953, will transfer to the supervisorship of the Boise National Forest, Boise, Idaho, on March 1. He will succeed Kester D. Flock who is retiring.

Robert L. Casebeer of Boise, Idaho, has been appointed to the staff of the Intermountain Forest and Range Experiment Station as range conservationist. He will be stationed at Boise to work as a member of the Boise Research Center staff. Bob has for the past several years been working with the Idaho Fish and Game Department.

William P. Dasmann, game manager, biologist, and game management supervisor for the California Department of Fish and Game during the past 11 years, has been appointed Chief of the Division of Wildlife Management, Forest Service, for Region 5, with headquarters in San Francisco. Mr. Dasmann succeeds Fred P. Cronemiller who retired on January 31.

Gilbert S. Doll, Forest Supervisor of the Ashley National Forest, Utah, since 1955, has been promoted to Assistant Chief of the Division of Water, Recreation and Lands at the Regional Office in Ogden.

Howard C. Lee, staff assistant on the Boise National Forest, has been promoted to Supervisor of the Black Hills National Forest, South Dakota. He succeeds Grant A. Morse who is transferring to San Francisco, California.

Dr. Loren D. Potter, professor of botany (ecology and range management) at North Dakota Agricultural College, has been appointed chairman of the Department of Biology, University of New Mexico, Albuquerque. The appointment is effective next September.

Dr. Edwin A. Davis has been appointed by the Crops Research Division, ARS, U. S. Department of Agriculture, to conduct physiological studies related to control of chaparral. Work is cooperative with the U. S. Forest Service. He will be headquartered at Arizona State College, Tempe, Arizona.

A committee of the Columbia Sheep Breeders' Association of America met at the U. S. Sheep Experiment Station, Dubois, Idaho, on January 30. They reviewed the research work of the station and discussed various aspects of sheep improvement with the staff at Dubois. Members of the committee attending were W. A. Denecke, Bozeman, Montana; Ernest White, Rollins, Montana; Martin Bradford, Spanish Fork, Utah; and U. S. Archibald, Gillette, Wyoming.

Harold D. Kerr has been transferred from Columbia, Missouri, to Pullman, Washington, to be associated with Dr. W. C. Robocker in research on the control of rangeland weeds. Work is cooperative between the Crops Research Division, ARS, U. S. Department of Agriculture and Washington Agricultural Experiment Station.

Dr. Donald A. Price, who has recently completed his Ph. D. degree at Oregon State College, has been appointed to the position of Animal Husbandman at the U. S. Sheep Experiment Station & Western Sheep Breeding Laboratory, Dubois, Idaho. Dr. Price will work on range management nutrition of sheep at Dubois.

Mr. and Mrs. Dan Fulton of Ismay, Montana, visited at the Sheep, Goat, and Fur Animal Research Branch at Beltsville, Maryland, February 13.

Dr. A. A. Hanson, Acting Head of the Grass and Turf Section, Forage and Range Research Branch, visited Colombia, South America, in October 1957 to review the forage research program that has been initiated by the Rockefeller Foundation. The research work which is conducted in the Colombian Department of Agriculture involves studies on adaptation, forage mixtures, management, including, soil fertility and weed control, grazing practices, and breeding red clover, ryegrass, and the forage sorghums.

Twenty-one members of the Arid Pasture and Range Section of Crops Research Division of ARS participated in a 2-day range research work planning conference at Phoenix, Arizona, January 27-28. The entire group also attended the annual meetings of the Range Reseeding Equipment Committee and the American Society of Range Management.

Clee S. Cooper, Research Agronomist in the Crops Research Division of ARS at Burns, Oregon, has transferred to Bozeman, Montana, effective February 3. At Bozeman, Cooper will conduct research on irrigated pastures and their utilization by livestock in cooperation with Montana Agricultural Experiment Station and the Animal Husbandry Research Division of ARS. At Burns, in cooperation with Oregon Agricultural Experiment Station, Cooper conducted research on native flood meadows and developed recommendations for meadow improvement.