In This Issue

Past Performance and Future Potential of Black Grama for Southwestern Ranges ..... *Neal Wright and L. J. Streetman* 207

Some Characteristics of Soils and Associated Vegetation Infested with Halogeton ..... *W. C. Robocker* 215

Diet and Grazing Habits of Steers on Foothill Range Fertilized with Sulfur
L. R. Green, K. A. Wagnon, and J. R. Bentley 221

Effect of Gibberellic Acid, 2,4-D, and Indole-Acetic Acid on Seed Germination and Epicotyl and Radicle Growth of Intermediate and Pubescent Wheatgrass ..... *John N. Baker* 227

Fertilizer Effects on Hay Production of Three Cultivated Grasses in Southern Saskatchewan ..... *Mark R. Kilcher* 231

Adaptability and Yield of Eleven Grasses Grown on the Oregon High Desert ..... *C. S. Cooper and D. N. Hyder* 235

Herbage Production and Composition under Immature Ponderosa Pine in the Black Hills ..... *Charles P. Pase* 238

A New Method of Determining Forage Cover and Production on Desert Shrub Vegetation
Carl J. Goebel, Leonard Debano, and Russell D. Lloyd 244

Technical Notes

Grasshopper Infestations in Relation to Range Condition ..... *N. J. Nerney* 247

Minor Minerals and Other Nutrients in Louisiana Range Forage ..... *Don A. Duncan and E. A. Epps, Jr.* 247

The Effect of Nitrogenous Fertilizers on Cattle Distribution on Mountain Range ..... *D. R. Smith and R. L. Lang* 248

Book Reviews: Managing Southern Soils (*Vanderford*); **Modern Breeds of Livestock** (Briggs); **The Craftsman's Manual** (*Christopher and Christopher*); **A Flora of the Marshes of California** (*Mason*) 249

Current Literature ..... *Lee A. Sharp* 251

Society Business 253

With the Sections 254

Letters to the Editor 256

Range Student Roundup 257

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Past Performance and Future Potential of Black Grama for Southwestern Ranges[1]

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The possibilities of improving range and forage grass species for use in grassland farming is receiving renewed attention according to Beard (3)[2]. The need for range improvement in all aspects of grass improvement, brush and weed control, reseeding techniques, and management practices is generally accepted for the southwestern United States. Black grama, *Bouteloua eropoda* (Torr.) Torr., is one of the most important grasses of the arid and semiarid desert grassland. This paper is a review of the previous work on this grass to appraise its status, evaluate the factors limiting its use, and propose objectives necessary for improvement.

Descriptive Characteristics

Black grama is believed to be the most important forage grass on the 89 million acres of desert grasslands in Arizona, New Mexico, and parts of Texas, Oklahoma, Colorado, Utah, Nevada, and California (10). Black grama is a major species in Arizona and New Mexico, adjacent parts of Mexico, and possibly in southwestern Texas. The reviewers are of the opinion that it is of minor importance in the other areas of the Southwest. Hoover (42) presents a map showing the areas of major and minor distribution of black grama.

Black grama, a native grass, occurs abundantly over a wide altitudinal range and throughout the Southwest area and south into Mexico (19, 20, 40, 41, 45, 46, 47, 51, 52, 56, 57, 64, 77, 78, 81). It forms pure stands over wide areas of the region (29) and according to Humphrey (44), is dominant within the desert grassland which is sub-climax to a desert shrub climax (5). It is drouth tolerant both during seedling establishment, and as a mature plant, a quality indispensable to the establishment and maintenance of any of the major forage plants growing under prevailing arid and semiarid climatic conditions. It is palatable and nutritious, both in summer and winter, consequently it is particularly outstanding

FIGURE 1. Black grama-tobosa-yucca range in good condition in southwestern New Mexico. Black grama is a key species on many Southwestern ranges and was originally the mainstay of the range in many areas. The development of methods of increasing this grass on present ranges is an important objective of current research programs. *(Photo by R. R. Humphrey).*

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[2]*Numbers in parentheses refer to Literature Cited.*

as a year-round forage plant. Black grama, also referred to as wooly-foot or crow-foot grama (10, 36) is a tufted, branching, strong-rooted, long-lived perennial grass. It is readily recognized by the wiry, wooly-pubescent, usually geniculate and spreading culms (30). The creeping runners or stolons, which root at the joints and send up new shoots that later become separate plants, make the grass valuable for soil protection (10, 25). Technical classifications and descriptions of black grama have been presented by several workers (30, 35, 41). A practical description is presented by Humphrey, Brown and Everson (47).

Black Grama Range Research History

The need for range studies and experimentation was recognized at an early date. Shear (68) presents a review and summary of the work of investigating the various problems relating to the grasses and forage plants of the United States by the Department of Agriculture, Division of Agrostology, from the time of its organization in 1895 to 1901. He states that the southwestern region presents difficult conditions and problems and that *Bouteloua eriopoda,* "wooly-foot grama," is one of the most valuable range grasses in the region.

In 1900 an area of mesa land near Tucson was set aside by presidential proclamation for experimental range studies (31). This small range reserve was a cooperative project of the U. S. Department of Agriculture and the University of Arizona Agricultural Experiment Station. In 1902 the Santa Rita Range Reserve near Tucson was set aside by presidential proclamation (71). The Jornada Experimental Range near Las Cruces, New Mexico, was established by executive order in 1912. The Bureau of Plant Industry operated these ranges until 1915 when the administration of both ranges was shifted to the Research Branch of the U. S. Forest Service. Presently, the Santa Rita Range Reserve is used by the Forest Service, the Agricultural Research Service, and is available to the University of Arizona Agricultural Experiment Station. The Jornada Range Reserve is administered by the Agricultural Research Service. Previous work with black grama has been largely conducted at these experimental range reserves, where black grama is a major species of the native grass composition.

The U. S. Soil Conservation Service set up an evaluation program including the establishment of plant nurseries in Arizona and New Mexico in 1934. The primary purpose of this program was to study revegetation of rangelands in respect to soil and water conservation and flood control, with black grama being one of the species receiving attention for these uses. Operation of the Arizona Soil Conservation Service Nursery was delegated to the University of Arizona Agricultural Experiment Station in 1953, and at the same time the New Mexico Nursery at Albuquerque was disbanded.

Literature Review

The literature reveals that black grama has been under observation for many years. Most of the work on this grass has been concerned with facts pertaining directly to or associated with management. There have been few basic studies pertaining to the fundamental aspects of growth and reproduction. A selected bibliography on management of western ranges, livestock, and wildlife has been compiled (65) which includes the published work on black grama to that date.

Management

Griffiths (31) and Thornber (71) concluded that the poor condition of the Southwestern grama grass ranges at the time, near the turn of the century, had been brought about by overstocking.

In 1916 Wooton (80) presented the results of several years' work on black grama originally started by others (32, 33, 35). The author concludes that with complete protection from grazing the range recovered rapidly at first, with large gains being made in the first two or three years, and that complete recovery was reached in approximately 10 to 12 years. He points out that even light stocking resulted in doubling the time required for complete recovery as compared to completely protected areas.

A study reported by Jardine and Forsling (49) showed that on predominantly black grama ranges, drouth alone, if prolonged beyond the second year, killed 40 percent of the black grama plants and reduced the quantity of forage produced by the remaining plants by approximately 50 percent. Grazing tends to increase the effect of drouth; however, the authors (49) suggest that desired results may be obtained by reduction of stocking to 85 percent of the original carrying capacity the first year, to 60 percent the second, and to 50 percent the third. The ill effects of drouth on black grama are presented by Canfield (14) for a 21-year period. He found ample indication that a part of the forage produced in the more bountiful seasons could be carried over and used to supplement the less productive years. The ungrazed stems of black grama remain green for two or more seasons, making it, unlike its associates, a natural source of reserve feed. Canfield (16) later states that semi-deferred grazing provides for recovery after misuse, protection against drouth, utilization of the seasonally palatable forage, and a more stable carrying capacity.

Nelson (55) reports a 13-year study of the influence of precip-

itation and grazing upon black grama grass range and concludes that the test emphasized the ability of black grama to survive two drouth periods (1916-18, 1921-26). Ordinarily one favorable growing season appeared necessary to restore the vigor of weakened plants before marked improvement in the stand began. Black grama was found to compete successfully with associated species after depletion of stand by drouth, and to withstand conservative utilization by livestock, while heavy grazing resulted in gradual or extreme deterioration.

A summary of the records of studies of the effects of climate and grazing on black grama under three grazing intensities, conservative, moderate, and heavy, and on protected plots for the period 1916-56 are reported by Paulsen (62). He emphasizes the following points: a. the precipitation shows no general longtime upward or downward trend; b. at approximately 20-year intervals, rainfall was alternately about 10 percent above and below average; c. irrespective of the degree of grazing use, density was reduced to about the same point during extended drouths; d. density during years of more abundant rainfall is greatest on areas conservatively grazed; and e. the rate of recovery after drouth depends on the stand that remains to revegetate the area at the end of the drouth.

The most beneficial precipitation distribution for both density change and height growth consists of relatively dry winters between relatively wet autumns and springs (50). According to McGinnies and Arnold (51) the desert grassland group of grasses, including black grama, are very similar as to their water requirements.

It has been proposed (11) that types of stem structure reflect the moisture requirements and periods of growth of grasses. The *Bouteloua* species have solid stems, a characteristic that aids these species in surviving arid and semiarid conditions. Canfield (11) further concludes that this stem character is a criterion which may be employed in the selection of grasses for introduction into the Southwest.

Campbell (8) and Campbell and Crafts (10) state that proper utilization of black grama is essential to good growth and spreading, which means utilization of about 50 percent of the total growth on a weight basis or 70-85 percent of the height growth. He concludes that black grama should not be grazed until summer growth is complete if other areas are available for grazing. Making use of the winter and spring palatability of black grama encourages spread and promotes the use of other species palatable only when green (8, 10). The aim should be to graze moderately in good years and to reduce grazing in poor years in relation to production.

Campbell and Bomberger (9) conclude that at least two inches of stubble and 15 percent of the flower stalks must be left on the ground each year if a reasonably good stand is to be maintained. A 25 to 30 percent reserve left ungrazed at the beginning of the new growing season is recommended by Canfield (12). As a result of further studies, Canfield (14, 17) suggests a 15 to 25 percent balance of ungrazed forage at the close of the growing season as the best insurance against range deterioration and livestock losses due to drouth. He suggests that stocking on a sustained yield basis materially increases herd earnings and that a 20 percent reserve of forage is advisable as insurance against drouth. Culley (22) concludes that black grama should not be grazed closer than to within three inches of ground level. The differences of percentage of optimum ungrazed forage suggested by the various authors may be accounted for by variation of seasonal climatic conditions. Perhaps 25 percent of the forage produced may be the optimum reserve. An economic study by Culley (21) shows the yearround carrying capacity of predominantly black grama ranges varies from one cow to 23 acres to one cow to 60 acres. The results of clipping experiments on semidesert black grama range have been presented by Canfield (15). He concludes that persistent clippings of all herbage to a height of 2 inches or less ultimately results in critical deterioration through excessive wind and water erosion. The need for balanced livestock and forage production is presented by Darrow (24).

Canfield (12) reports on the desirability of semi-deferred grazing. He states that semi-deferred grazing by light stocking during the summer grazing season and heavier stocking during autumn, winter and spring months provided for yearlong use, and gave satisfactory results on extensive areas of black grama range. The effects of thirty years protection from grazing of mixed gramas and other species have been presented by Gardner (27). Little difference in species was noted between protected and unprotected areas although grass density on the protected area was 110 percent higher than on the unprotected areas.

A guide for measuring utilization of black grama and other range grasses is proposed by Pearse (63) using the percentage of grass plants that are ungrazed as a key to measurement of utilization. Valentine (72) proposes a modified scaling method for determining utilization of range grass plants, where the original observations are in percentage of weight removed instead of using a linear scale and converting to

weight basis. Several methods of establishing proper utilization of important forage species are discussed by Campbell (7). He states that regardless of the method of determining utilization, the figure obtained on a range must be compared with a predetermined proper utilization percentage for the important forage species. Also very careful observation of soil erosion, disturbance, and range condition are necessary for an adequate picture of utilization and its effects on the range.

Measuring utilization of range grasses including black grama by use of clipped quadrats is discussed by Culley, Campbell, and Canfield (23). The authors conclude that the method fails to completely simulate grazing by livestock, yet valuable indications may be obtained as to what constitutes proper utilization.

Reynolds and Bohning (67) report that black grama density was seriously affected by June burning, and it did not recover during the period of the study (1952-1954). The effects of mesquite density on the density of associated black grama are reported by Parker and Martin (60). On untreated areas for an eight-year period, grass density gradually decreased to a negligible percent, while the best herbage yields were obtained when mesquite alone was killed. Paulsen (61) found that soil physical properties were more favorable under black grama cover than under mesquite bushes. The soil under mesquite bushes was coarser, had a lower pore volume, was less favorable in respect to moisture relations for plant growth, and was more unstable.

Nutrition

Watkins (75) presents a review of literature dealing with the nutritive value of range forage grasses and concludes that it is known to vary widely. He states that these variations are due to a number of factors, such as species, stage of maturity, seasonal changes, fertility of the soil, elevation, moisture content, weathering and leaching, distribution of rainfall, and temperature. According to Stanley (70) there is a decline in protein, calcium, phosphorus, and carotene during the winter periods in Arizona range grasses including black grama.

A study by Watkins (73) shows phosphorus and calcium highest during the growing season, with approximately 75 percent of the phosphorus and 25 percent of the calcium lost during the winter months for many grass species analyzed. The analyses, which included black grama, indicate a greater deficiency of phosphorus than calcium in the range grasses of New Mexico. A later study by Watkins (74) showed that carotene content of black grama is moderately high during the growing season with sufficient carotene to satisfy the vitamin "A" requirements of range cattle. Watkins (75) concludes that the easily digested carbohydrate does not decrease and is not lost in the wintering and leaching process, making black grama a valuable roughage. Protein content was found to be high during the growing season. An average loss of 37 percent protein was found between October and March. Watkins (75, 76) further found that the phosphorus content was not sufficient to meet the requirements of cattle except for a short period at the peak of the growing season, while carotene levels were sufficient for beef cows even during the gestation and lactation periods. Watkins (75) indicates there is a relationship between available soil phosphates and the phosphorus of the forage. He suggests (75) that the quantity of amido protein present is a measure of wintertime plant activity.

Moderately high protein values for black grama are usually found during the winter, due largely to the light precipitation during the season (76). An early report (36) also shows the desirable nutritional qualities of black grama.

Cytology and Growth Behavior

Fults (26) reported 2n=21 while investigating three different seed sources of *Bouteloua eriopoda*. He reports many aneuploid chromosome numbers in this genus. According to Brown (6) the basic number of chromosomes x=7 was found for six species; (*Bouteloua chondrisioides*, 2n=24), (*B. eriopoda*, 2n=28), (*B. filiformis*, 2n=14), (*B. regidiseta*, 2n=28), (*B. trifida*, 2n=28) and (*B. breviseta*, 2n=28). He reports that these studies do not confirm the conclusions of Fults that the species of *Bouteloua* are largely aneuploid. Both authors point out that since relatively few plants have been studied, variation in chromosome numbers may be found by further search. Recent investigations indicate that the basic chromosome number is 10, rather than the previously reported 7 for the *Bouteloua* genera, although some forms with x=7 have been demonstrated (38, 39). Fults (26) states that the length of chromosome ranged from 0.25 to 1.50 microns with an average length of 1.00 micron, and there appeared in each complement two small spherical chromosomes which appeared to be characteristic.

From his studies Fults (26) concluded that the Southwest is near the center of distribution of the genus *Bouteloua* due to the predominance of low chromosome numbers coupled with the fact that the species are often dominant. Myers (54) points out the possibility of apomixis in some *Bouteloua* species due to the common occurrence of aneuploid numbers.

Growth and flowering responses as affected by photoper-

iod for several of the species of *Bouteloua* have been reported by Olmsted (58, 59). He states that black grama should be regarded as a short day plant as defined by Allard and Garner (1). It was found (58, 59) that the total number of tillers, tillers bearing inflorescences, and crown roots were inversely correlated with length of photoperiod; while average maximum height, average dry weights of roots and tops, and vigor of individual inflorescences were correlated positively with length of photoperiod. He states that experiments have indicated that winter chilling is unnecessary to bring about reproductive activity. According to Olmsted (58) the photoperiodic responses of black grama should be investigated in greater detail.

FIGURE 2. Black grama research plots at Tucson, Arizona. Studies are being conducted here to determine the factors affecting seed set. The seed habits of this grass are extremely variable, and the seed crop produced by native stands generally has low viability.

Reseeding

There are many range reseeding techniques and problems (2). Black grama has been little used for reseeding because supplies of good seed have been scarce and are not commercially produced due to poor seed production qualities (2, 25, 28, 42, 55, 69, 79). Campbell (8) points out that reseeding costs are high because seed is obtainable only from native stands where seed production is characteristically poor. Jackson (48) in studies with native seed obtained 0 percent germination, and an examination of the material revealed that there were no caryopses present, which emphasizes the poor seed producing capabilities of black grama. Black grama is slow to become established; however, plantings made on very dry sites have persisted through several drouth years (2).

Bridges (4) points out from his studies that failure to produce stands in the field is not due to lack of seed viability but to the lack of proper conditions for germination. Wilson (79) reports an average percentage of germination of 3.72 for two lots of 100 seed, each tested in duplicate and retested. Germination of 22 percent and purity of 37 percent have been reported (82) along with an intermediate seed longevity classification. Hulling or processing seed improves purity to 90 percent and germination to 65 percent (82). These varying results might indicate that laboratory germination procedures warrant further investigation.

Flory and Marshall (25) state that black grama seed cannot be separated readily from the straw, resulting in variability in quality. Although there are about 1,300,000 seeds in a pound, a pound of average quality bulk planting material may contain as few as 100,000 pure live seeds. A figure of 1,335,000 seeds per pound along with values of 300,000 seeds per pound when cleaned, and 500,000 as hulled or further cleaned have been reported (82).

Due to the generally arid conditions in black grama areas, planting in contour furrows or in connection with other water spreading, water concentrating, or water saving structures is a prerequisite for successful establishment (2, 25). About 12 pounds per acre of average bulk planting material is suggested (25), and a rate of 10-15 pounds per acre of unspecified quality has been proposed (82).

The transplanting of clumps of black grama as a means of revegetation of ranges is proposed by Glendening (28). He states that success can be achieved if a few simple rules are followed. Transplanting of clumps yields best results when done during July or August, when soil temperatures are reasonably high and the soil is well moistened to a depth of at least six inches. The use of the transplanting technique is also discussed but not recommended by Goodding (29) and Wilson (79). Both authors state transplanting is not practical for range improvement.

One of the difficulties of artificial range reseeding is pointed out by Reynolds (66). Rodents can cause damage; however, Reynolds (66) suggests that seed as small or smaller than black grama are not likely to be discovered and dug out. He further concludes that low perennial grass densities are associated with high kangaroo rat densities.

Status

Black grama possesses many desirable characteristics, making it an outstanding range grass of the arid and semiarid grasslands of southwestern United States. Black grama is a well adapted native, long-lived perennial. It can be maintained on the range. Although it is not as abundant as in previous years, its spread can be slowly accomplished by proper utilization and management practices. Black grama's soil protection qualities are most desirable due to the ability of the stem joints to take root, resulting in new plants, making not only a valuable soil protector but providing a means for spreading and revegetation. The drouth tolerance of this grass is exceptional in that this characteristic is effectively demonstrated through all growth stages; however, continued use and drouth can seriously deplete stands. It is a dependable forage plant with the ability to perform well under grazing. The literature indicates highest yield performance and persistence when deferred grazing is used, as compared to nonuse or heavy grazing.

The grass is characteristically nutritious at all times of the year, and in comparison with other forage species, the winter and spring nutritional values make black grama outstanding. It is a palatable forage and highly relished throughout the year, and is of particular importance during the dry spring period when other range species are harsh and parched. Unlike most of its associates, black grama is a natural source of reserve feed, since the ungrazed stems remain green for two or more seasons. This feature, coupled with management, minimizes drouth hazard and provides a more stable carrying capacity.

Evaluation and Objectives

This review indicates that many of the principles of black grama range management have been studied and that there has been a minimum of research on the more basic aspects of growth and reproduction. An evaluation of this information indicates that the one characteristic limiting the widespread use of this grass for range reseeding is its extremely poor and unreliable seed setting capabilities. Obviously, the key to its widespread use for reseeding hinges on the improvement of seed production.

In this instance the aim of the plant breeder should be to maintain the many desirable characters while improving seed production (37). Once the factor or factors limiting seed set can be determined, research will be needed on the cultural techniques necessary to produce seed in sufficient quantity for an economic product.

There is need for further investigation of the physiology, cytology, mode of reproduction, breeding behavior, and cultural practices of this grass in order to utilize the most advantageous breeding procedures.

There are no recorded data on the use of fertilizer in relation to reseeding or the effect on yield and nutritive value of black grama. Seed quality factors such as purity, germination, and longevity, reseeding practices, management techniques, and seed processing problems should be considered following the improvement of seed setting along with the development of breeding procedures. The elimination of seed production barriers, which at present are limiting, along with methods of establishing stands in hot, dry areas would allow black grama to take a prominent role in revegetation of the desert grasslands of the southwestern United States.

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Some Characteristics of Soils and Associated Vegetation Infested with Halogeton[1]

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Among the important problems in the entry of an exotic plant into a new area, whether it be for economic use or as an undesirable migrant, are its adaptability and the range of its adaptability in its new environment. Equally important is the synecology of the plant: its relations with other introduced and endemic vegetation and its position in the plant community where its ability to persist and reproduce will ultimately be stabilized.

Principles and theories concerning the geographic distribution of plants have been advanced and investigated for many years (4, 10, 11, 14, 19). An effort has been made to bring these studies together by Cain (7) and a statement of factors in plant ecology reduced to a mathematical expression of relations has been proposed by Major (13).

Specific attempts have been made to relate distribution of vegetation to the effects of individual environmental factors. Likewise, the use of plant indicators as a guide to environmental characteristics of a given site has been investigated a number of times, and the status of the approach was evaluated by Sampson (20) in 1939.

Effects and limitations of the edaphic factor of environment were dealt with from a theoretical viewpoint by Mason (15, 16). Studies on the relations between vegetation and soil characteristics have been emphasized in the Western States because of the salinity and alkali problems which have occurred with utilization of arid lands. Kearney *et al.* (12) published the results of one such study in 1914. Among subsequent investigations are those of Shantz and Piemeisel in 1924 and 1940 (22, 23) and of Shantz in 1925 (21). More recent investigations have been made by Billings (1, 2, 3), Fireman and Hayward (8) and Gates *et al.* (10).

It has generally been found that the highest pH and salinity conditions occur in the "flats" occupied by greasewood (*Sarcobatus vermiculatus*) and Nuttal's saltbush (*Atriplex nuttallii*), and that the lowest pH and salinity are found in areas of big sagebrush (*Artemisia tridentata*). The pH and salt content of soils occupied by shadscale (*Atriplex confertifolia*) have generally been intermediate between those of big sagebrush and greasewood.

It was apparent in comparing results of the investigations previously mentioned that each species and association had a rather broad range of tolerance for variations in edaphic factors and that the soils were extremely variable and heterogeneous. The modification of edaphic factors by existing vegetation (17) and local climatic conditions may have been considerable. The extent of changes in soil characteristics which have accompanied the changes in vegetation in Utah and Nevada in the last century is not known. Changes were noted (18, 25) more than 50 years ago, however, and those changes have been in the direction of worthless perennials, annual grasses and forbs on the one hand and loss of topsoil and accelerated soil erosion on the other.

Among those weedy annual invaders has been one of conspicuous note, *Halogeton glomeratus*. Following discovery of its poisonous properties in 1942 (9), it received widespread and immediate attention as a result of some sensational losses of sheep ingesting lethal quantities. At present, halogeton infests in varying degrees an estimated 11 million acres in the states of California, Colorado, Idaho, Oregon, Montana, Nevada, Utah and Wyoming. The area of infestation still appears to be increasing.

A study of the soils occupied by halogeton and some aspects of the vegetation endemic to those soils in Nevada and on the perimeter of the infestation was begun in 1954 as a part of an ecological investigation of the plant. The data presented here are the results of a study dealing with soils in particular and the vegetation in general. The climatic requirements and responses of halogeton and its more detailed relations with the associated vegetation are still under investigation.

Methods and Materials

Nevada was arbitrarily divided into seven regions, and an effort was made to collect the same number of soil samples from each of six vegetation associ-

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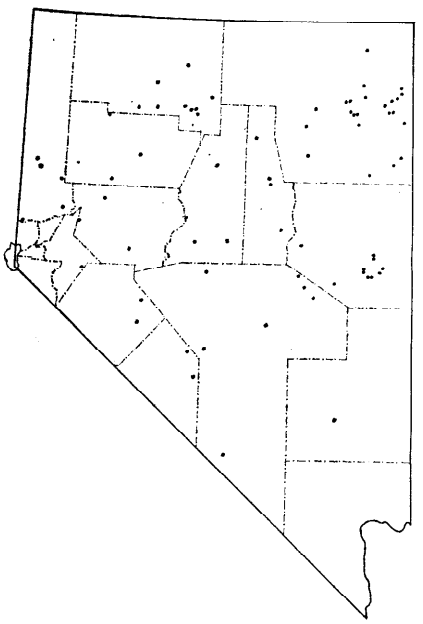

FIGURE 1. Sites in Nevada where soil samples and notes on vegetation were taken. Halogeton occurred or had occurred at all sites.

ations in each of the six regions where halogeton had been found. It had not been found in the seventh region, which included the southern desert shrub type of southern Nevada. In practice, the proposed procedure could not readily be followed since the native vegetation and halogeton were not uniformly distributed throughout the regions set up. The procedure was then modified to take samples of the soils where an important vegetation change occurred as well as from the vegetation associations ocurring in each region. A prerequisite of all sampling was that halogeton should occur on the sampling site.

It is characteristic of halogeton to occupy the soils of disturbed areas, as one would expect of a ruderal plant. These areas are amply provided by usual yearly "blading" of road shoulders and barrow pits by highway maintenance graders. These areas also occur in gravel pits, water courses and drainage ditches, and on stock trails and bed grounds. Spots of pronounced soil disturbance were avoided in this investigation, however, and samples were taken from adjacent sites.

The sampling sites in Nevada are shown in Figure 1. Areas of ecotones, and especially of alternes, are easily recognized by the clustered dots. In all sites sampled, halogeton occurred either as a general infestation or as an isolated spot. Vegetation associations or faciations arranged in order of the frequency of sampling were shadscale, sagebrush, greasewood, winterfat, juniper and Nuttall's saltbush. The area occupied by halogeton in 1957 included most of the Great Basin, in which the vegetation was predominantly of the Basin sagebrush formation.

The sampling was also done outside of Nevada in 1955 to the then existing perimeter of the area occupied by halogeton. This included most of Utah, western Colorado, the western part of Wyoming, the northern tip of the Bighorn Basin in southern Montana, the southern third of Idaho, the northeast corner of California east of the Sierra Nevada, and Oregon on the Nevada-Oregon boundary near Denio, Nevada.

On the northeastern edge of the perimeter in Montana, halogeton was found on a bed ground in a depleted stand of blue grama (*Bouteloua gracilis*). It was in a shadscale association in western Colorado on its eastern boundary and the same association had also been invaded on the southernmost extension of its area in southwest Utah. It was in both sagebrush and shadscale vegetation on its western edge. In the higher elevations, it entered into juniper-sagebrush associations. None was found in montane or sub-alpine vegetation.

Soil samples were taken at 0-6 inches and 6-18 inches, and the classification was made by screening out the gravel with a 1-mm. sieve. The texture of the remaining soil was then determined by the Bouyoucos hydrometer method (5). Electrical conductivity of the saturation extract (E.C.) was determined by use of a bridge (methods 3a and 4b of the U. S. Salinity Laboratory) (26), and pH on a soil suspension was determined by use of a glass electrode meter (method 21b). The soil was classified on the basis of mechanical separates according to the Soil Survey Manual classification (27). Range condition was expressed as an estimate of the amount of forage produced as compared with the maximum possible for the site (6) as follows: Excellent, 75-100 per cent; good, 50-75 per cent; fair, 25-50 per cent; and poor, 0-25 per cent. The degree of soil erosion was arbitrarily divided into four classes as follows:

None:	No evidence of soil movement away from or around crown of perennial vegetation. Litter essentially in place.
Slight:	Pedestal development clear, little evidence of active soil movement. Litter concentrated under plants.
Moderate:	Pronounced pedestal development, active rilling and cutting of soil surface, but no deep channels.
Severe:	Crown and roots of plants exposed. Pronounced rilling, cutting and channeling of soil surface.

Statistical comparison of conductivity of the saturation extracts of soils from all vegetation types at both levels was based on the logarithms of E.C. converted to ppm. pH comparisons were made by using the pH (logarithmic) values in the computations. Use of logarithms in the statistical analyses was based on

Table 1. Summary of chracteristics of soils in Nevada and on the perimeter of the area occupied by halogeton.

Type of vegetation	Depth (in.)	pH*	E.C. x 10^3*	Gravel (%)	Predominant soil type	Number of samples
Juniper	0- 6	8.1	0.8	36	Loam	4
	6-18	7.9	3.5	40	Loam	4
Sagebrush	0- 6	8.2	0.9	20	Loam	24
	6-18	8.1	1.6	29	Loam	24
Winterfat	0- 6	8.4	1.1	8	Loam	7
	6-18	8.4	2.4	9	Loam	7
Shadscale	0- 6	8.7	1.6	19	Sandy loam	35
	6-18	8.8	2.9	25	Sandy loam	35
Nuttall's saltbush	0- 6	8.6	2.8	5	Loam	3
	6-18	8.4	5.2	3	Loam	3
Greasewood	0- 6	9.3	5.6	7	Loam	10
	6-18	9.4	10.7	8	Sandy loam	10
No perennial vegetation	0- 6	8.3	1.2	2	Sandy loam	3
	6-18	8.6	1.2	1	Sandy loam	3
Average (or total)	0- 6	8.7	1.5	14	Loam	86
	6-18	8.8	2.5	16	Loam	86

* pH is based on an arithmetic mean and conductivity on a logarithmic mean.

recommendations of Snedecor (24) in order to satisfy requirements for a valid analysis of variance. A separate least significant difference was computed for each comparison.

Results and Discussion

It is to be noted in Table 1 that the numbers of samples in the various vegetation types differed, but the number of sites sampled in each vegetation type is similar in proportion to the relative sizes of the areas of the various vegetation types. The highest percentage of gravel in both of the sampling depths was in the juniper type, and the soil in general was in the classifications of loam and sandy loam.

Halogeton was not found on the sandiest class of soils, on which such species as Nevada dalea (*Dalea polyadenia*), hairy horsebrush (*Tetradymia comosa*), Indian ricegrass (*Oryzopsis hymenoides*), and desert evening primrose (*Oenothera caespitosa*) are found, although the opportunity for invasion was present in many cases. It might be assumed from this absence that halogeton required a soil of somewhat finer texture. A breakdown of the soils according to class showed a predominance of the medium-textured soils in the samples taken.

A tabulation of soil classification of sites occupied by halogeton (Table 2) indicated that sandy loam accounted for 32 and loam for 28 of the 86 observations (37 and 33 per cent, respectively), or taken as a group, loam and sandy loam accounted for 70 per cent of the total of the classes in the 0- to 6-inch depth. The same two classes included 49 (57 per cent) of the 86 observations in the 6- to 18-inch zone. Approximately 10 to 15 per cent of the sites had soils in the heavier clay loam to clay classes. However, since halogeton was found in soil classes ranging from loamy sand to clay in texture, it is assumed that it will grow in all these classes. The coarser soils appear to be more abundant in the Western States and this may partially account for the higher frequency of sandy loam and loam soils in sites supporting halogeton.

Table 2. The relative frequency of occurrence of various soil classes on sites occupied by halogeton.

Class	Depth (in.) 0-6	6-18
Sand	0	1
Loamy sand	7	8
Sandy loam	32	29
Loam	28	20
Sandy clay loam	6	10
Silt loam	5	6
Clay loam	6	7
Silty clay loam	0	2
Clay	2	3
Total	86	86

The distribution of pH (Figure 2) showed a definite mode—37 of the 86 observations in the 0- to 6-inch layer, with a similar distribution in the 6- to 18-inch zone—or 43 per cent, in the range of 8.2 to 8.5, corresponding roughly to the average pH of sagebrush and winterfat soils. This distribution class (8.2-8.5) together with the class immediately preceding (7.8-8.1) and the one following (8.6-8.9) roughly included the range of pH of soils in the sagebrush and shadscale associations. From this figure it would appear that halogeton had an optimum pH in the range of 7.8 to 8.9.

The conductivity of the saturation extract of the soils was generally below four millimhos or approximately in the range of juniper, sagebrush, winterfat, and shadscale in both depth zones (Figure 3). Examination of the summary tabulation (Table 1) shows that the predominant soil type under both sagebrush and winterfat was loam. Nuttall's saltbush and juniper were also growing on loam. It should be pointed out, however, that data were obtained on only three and four sites, respectively, for these two types of vegetation. The soils supporting juniper are probably best classified as gravelly loam. The shadscale complex ran to lighter textured soil, as did greasewood and the three areas of no perennial vegetation. The last category included an outwash fan, a railroad right-of-way, and a gypsum

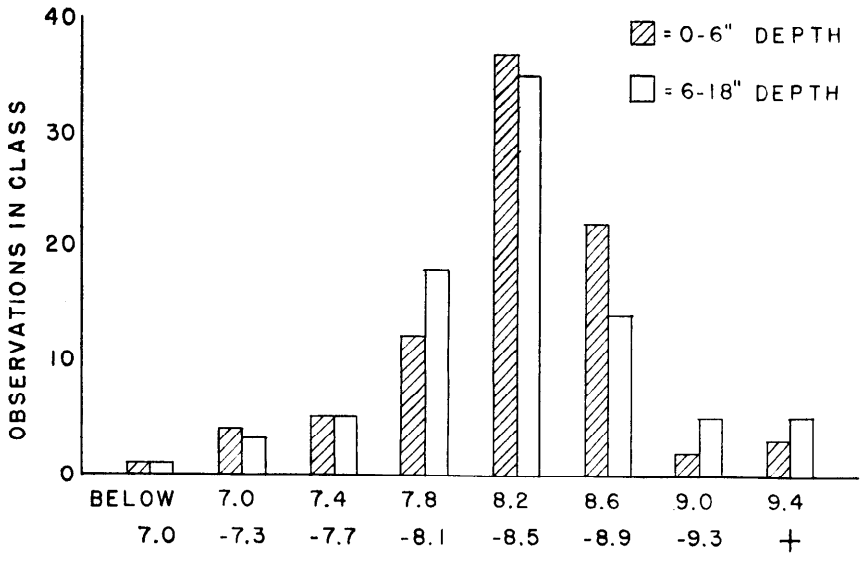

FIGURE 2. Distribution of pH of soils occupied by halogeton.

pit.

An examination of Table 3 indicates that in practically all cases where halogeton occurred, the perennial vegetation was not in vigorous condition and that on 70 per cent of the sites the condition was classified as fair or poor. The soil showed erosion from none to severe, and in 65 per cent of the observations it was either moderately or severely eroded. The halogeton plants were largest in shadscale and sagebrush, and the distribution of plants inclined more to specific spots than to a general distribution when a limited area was examined. It should be pointed out that occurrence of halogeton in vegetation classified as being in good or fair condition occurred most often in small areas of local disturbance. The exceptions to this were in winterfat, where a general infestation appeared to be the rule. This was true to a less extent in Nuttall's saltbush. However, the small number of areas of Nuttall's saltbush encountered in Nevada makes any general conclusion as to the competitive ability of that species questionable.

Statistical comparison of electrical conductivity and pH (Table 4) showed sagebrush soils to differ significantly and highly significantly from shadscale soils in the 0- to 6-inch depth and 6- to 18-inch depth, respectively, and significantly from Nuttall's saltbush soils in the 6- to 18-inch zone. In pH, the difference was significant between soils of shadscale and sagebrush at the 6- to 18-inch depth. Differences in soils for both electrical conductivity and pH were significant or highly significant under juniper, sagebrush, winterfat and shadscale, in both depths, when compared with greasewood. Nuttall's saltbush soils showed no significant difference from those of greasewood in either pH or conductivity. In comparison of the upper with the lower layer of soil in all vegetation types, there was a significant difference between the two only for the shadscale soils in conductivity. There was no significant difference in pH between the two zones.

It should be emphasized that the statistical interpretation of the data was based on only three sites in Nuttall's saltbush and a small number in both juniper and winterfat. If a larger number of samples had been taken in these three vegetation types, the difference probably would

Table 3. Condition of competitive vegetation, degree of soil erosion, and distribution and height of halogeton in each vegetation type sampled.

Type of vegetation	Condition of vegetation				Soil erosion				Halogeton			Total observations per type
	Excellent	Good	Fair	Poor	None	Slight	Moderate	Severe	Height (in.)	Distribution General	Distribution Spot	
Juniper	0	2	1	1	1	1	0	2	7	1	3	4
Sagebrush	3	3	7	11	2	4	8	10	8*	9	15	24
Winterfat	1	0	4	2	2	1	3	1	4	6	1	7
Shadscale	4	7	16	8	6	6	12	11	8*	14	21	35
Nuttall's saltbush	2	0	0	1	3	0	0	0	6	1	2	3
Greasewood	0	3	3	4	2	1	3	4	6*	5	5	10
Total	10	15	31	27	16	13	26	28	—	36	47	83
Percentage of total observations per attribute	12	18	37	33	19	16	31	34	—	43	57	

* Live halogeton absent from one sampling area at time of sampling.

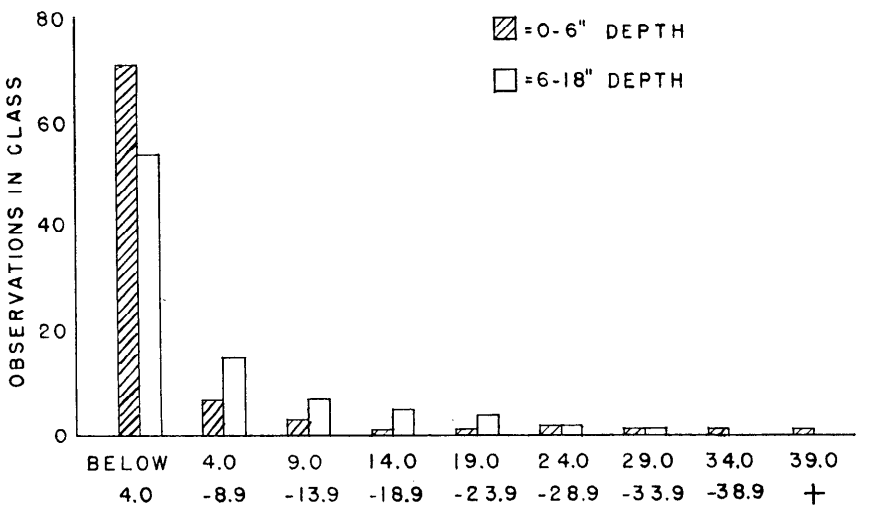

FIGURE 3. Distribution of electrical conductivity, expressed as millimhos (E.C. x 10^3), of soils occupied by halogeton.

have been significant or highly significant in comparison of E. C. in juniper and winterfat soils with those of Nuttall's saltbush.

An attempt to define an optimum pH or range of pH as well as an optimum concentration or range of tolerance of soluble salts as well as other soil characteristics by a habitat study method is complicated by factors other than the edaphic one. These are considered of primary importance in investigating ecological relations of annual plants in perennial vegetation. The first of these factors is the dependence upon sufficient seed in a given area during a particular growing season to insure a stand of an annual species, for the point inevitably arises in attempting to determine competitive relations as to whether the restriction or absence of an annual is a matter of competition or of inadequate seed dispersal when other conditions are favorable. A second factor is the amount and distribution of effective precipitation in that area during the given season. A third is the condition, density and type of competing vegetation, with its own particular seasonal demand for moisture. This last factor, together with the pH and soluble salt content, is directly related to precipitation and may be strongly modified by physiographic, biotic, and other climatic influences.

Summary and Conclusions

A sampling of Nevada soils during 1954 and 1955 on all major vegetation types infested with halogeton, together with additional sampling on the perimeter of the infestation in 1955, showed the plant to be practically confined at present to the northern desert shrub type. This does not, however, preclude its ability to grow in other formations under conditions favorable to its germination and development.

Halogeton was most often found on soils characterized by rather high pH, low salt concentrations, and medium texture and in the absence or reduced competition of other vegetation, particularly perennial shrubs.

The most frequent occurrence was on loams and sandy loams and in areas having big sage-

Table 4. Statistical comparison of pH and conductivity (E.C. x 10^3) of soils occupied by halogeton in different vegetation types.

Type of vegetation	Depth (in.)[1]	Mean pH[2]	Mean E.C.[2]	Sagebrush		Winterfat		Shadscale		Nuttall's saltbush		Greasewood	
				pH	E.C.	pH	E.C.	pH	E.C.	pH	E.C.	pH	E.C.
Juniper	0- 6	8.0	2.7	0[3]	0	0	0	*	0	0	0	*	*
	6-18	7.9	3.1	0	0	0	0	**	0	0	0	**	*
Sagebrush	0- 6	8.0	2.7	—	—	0	0	0	*	0	0	**	**
	6-18	8.0	2.8	—	—	0	0	*	**	0	*	**	**
Winterfat	0- 6	8.4	2.8	—	—	—	—	0	0	0	0	0	**
	6-18	8.3	3.1	—	—	—	—	0	0	0	0	*	**
Shadscale	0- 6	8.6	3.0	—	—	—	—	—	—	0	0	0	**
	6-18	8.5	3.3	—	—	—	—	—	—	0	0	*	**
Nuttall's saltbush	0- 6	8.5	3.2	—	—	—	—	—	—	—	—	0	0
	6-18	8.4	3.5	—	—	—	—	—	—	—	—	0	0
Greasewood	0- 6	8.6	3.5	—	—	—	—	—	—	—	—	—	—
	6-18	9.9	3.8	—	—	—	—	—	—	—	—	—	—

[1]Comparisons for each depth were calculated separately.
[2]Means are logarithmic. Averages on Table 1 are logarithms of *arithmetic means* for pH and antilogarithms of *logarithmic means* for conductivity.
[3]0 Indicates no significant difference.
* Significant at 5% level
** Significant at 1% level

brush and shadscale vegetation. These vegetation types were found on soils further characterized by having electrical conductivities (E. C. x 10^3) of 0.9 and 1.6 and average pH values of 8.2 and 8.7 for big sagebrush and shadscale types, respectively, in the top 6 inches of soil. E.C. in the 6- to 18-inch zone for these types averaged 1.6 and 2.9 and pH 8.1 and 8.8 for big sagebrush and shadscale, respectively.

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Foresters Meet at Salt Lake City

"Multiple Use Forestry in the Changing West" is the theme of the 1958 annual meeting of the Society of American Foresters which is scheduled at Hotel Utah in Salt Lake City, September 29 through October 2. More than 850 persons are expected to attend.

Keynote speakers are: LEMUEL A. GARRISON, superintendent of Yellowstone National Park, Wyoming; DON E. CLARK, regional forester, U. S. Forest Service, Denver, Colorado; and FRED J. SANDOZ, Booth-Kelly Lumber Company, Springfield, Oregon. Principal speaker at the annual banquet will be TOM GILL, executive director of the Charles Lathrop Pack Forestry Foundation, Washington, D. C.

Over 70 papers are scheduled for presentation at the technical sessions. A field trip will be made to the Davis County Experimental Watershed in the Wasatch Mountains on October 2.

Co-chairmen of the meeting are REED W. BAILEY, director of the Intermountain Forest and Range Experiment Station, and FLOYD IVERSON, regional forester of the Intermountain Region, Ogden, Utah.

Diet and Grazing Habits of Steers on Foothill Range Fertilized with Sulfur

L. R. GREEN, K. A. WAGNON, AND J. R. BENTLEY

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Availability of nutritious range herbage can be extended well into summer, when the dry vegetation on unimproved annual-type range is of low value, by fertilizing with sulfur. Cattle definitely prefer the dry herbage on fertilized range (Bentley 1946). Its better value has been shown by greater weight gains of steers during the summer in a study at the San Joaquin Experimental Range (Wagnon, Bentley, and Green, 1958). As part of this study, observations were made to learn whether the better quality of dry herbage might be due to differences in the species selected by cattle on fertilized ranges. Records of the diet and grazing habits of steers are reported in this paper, while effects of fertilization on herbage production and steer gains have been reported in companion articles.

Methods

In July of 1950 and 1951, two comparable groups of weaner steers were put into pastures that had not been grazed during the main plant growing season in the spring. Records of grazing habits and what the steers ate were made each year. One pasture of 46.5 acres had been fertilized in January 1949 with a mixture of superphosphate and and soil sulfur. The other pasture of 49.6 acres was an unfertilized control. The steers were kept in the pastures through the dry-forage season and into the winter season each year.

To sample vegetation in each pasture, nearly mature ungrazed herbage was clipped to a ½-inch stubble height on about 70 square-foot quadrats located at uniformly spaced intervals along grid lines throughout each pasture. Clipped material from individual quadrats was placed in paper bags, air dried, and weighed. Weight of each species was estimated. These were then totaled and averaged to determine average production of each plant species.

Additional herbage sampling was done to determine as closely as possible the diet of the grazing steers and to provide opportunity for close observation. Observers circulated among the steers a day or two until they were allowed within a few feet. Then, twice weekly during the summer and fall of 1950 and once weekly in 1951, observers spent the morning and evening grazing periods, from dawn until about 9:30 a.m. and from 4:30 or 5:00 p.m. until dark collecting herbage samples which simulated the livestock diet. At the same time habits of the animals were observed. Steers mostly shaded up during the hot part of the day.

Each animal was approached in turn and its grazing observed from a distance of 5 or 6 feet. Then a sample of the plant species and part that the steer was taking was collected from a nearby spot. In a 3- to 4-hour collection period about 100 grams of herbage, air dry weight, were collected. After additional drying the samples were weighed, and the weight of each species was estimated and composited by 2-week periods.

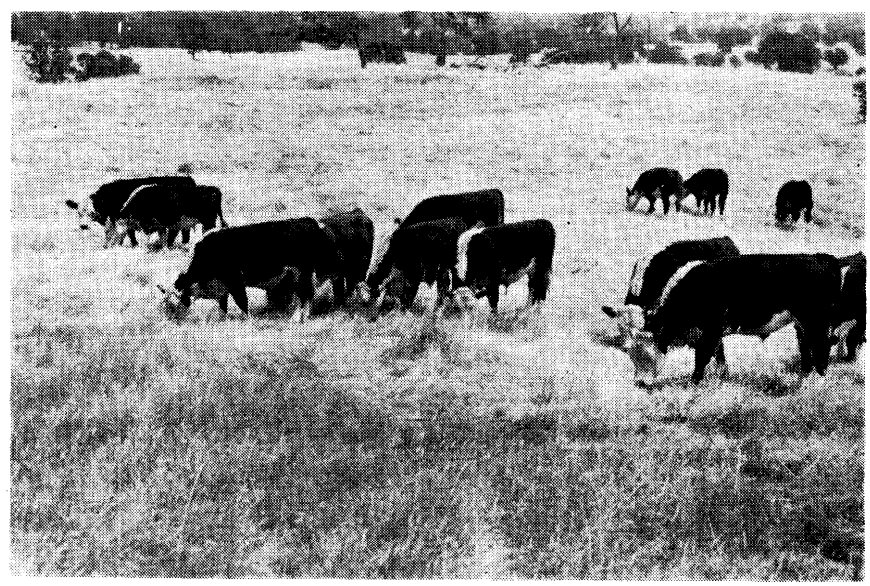

FIGURE 1. Typical group of steers grazing on fertilized range, August, 1954.

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

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

At each sampling period the observer noted the movement of the steers over the pasture, the sites on which they grazed, and the manner in which they grazed the different species. In 1951 the activities of all steers in sight were tallied at 15-minute intervals during the sampling periods.

Table 1. Percent of different species in the herbage crop and in the simulated diet of steers during the dry-forage season, July 15 to October 15 on fertilized and unfertilized range.

	1950				1951			
	Fertilized		Unfertilized		Fertilized		Unfertilized	
	Herbage	Diet	Herbage	Diet	Herbage	Diet	Herbage	Diet
Soft chess	9.5	7.7	6.9	28.0	15.3	20.4	11.5	33.3
Australian chess	3.4	.4	5.9	4.5	4.2	.8	4.5	1.7
Red brome	.9	2.3	3.7	7.7	.8	1.9	.2	1.5
Ripgut brome	.8	.7	3.8	10.5	.8	4.4	1.6	1.3
Foxtail fescue	12.4	11.1	8.9	15.2	48.5	46.8	36.6	38.5
Mediterranean barley	.1	1.9	.7	6.5	1.8	2.4	9.7	5.2
Other grasses	.7	.5	1.1	2.2	.1	.1	[1]	.6
Total grasses	27.8	24.6	31.0	74.6	71.5	76.8	64.1	82.1
Grasslike plants	.1	1.0	.5	3.1	.8	[1]	.9	2.5
Littlehead clover	[2]	65.5	[2]	2.1	4.2	3.1	.6	.3
Whitetip clover	[2]	2.7	[2]	7.1	5.7	18.4	6.9	11.8
Tree clover	[2]	1.0	[2]	2.1	3.6	.9	.5	.1
Total clovers	25.6	69.2	8.2	11.3	13.5	22.4	8.0	12.2
Spanish clover	2.5	1.3	.4	2.1	.6	.4	.7	2.1
Ground lupine	5.8	.5	6.1	.5	.2	[1]	.1	[1]
Other legumes	.6	.1	.4	[1]	[1]	[1]	.1	[1]
Total legumes	34.5	71.1	15.1	13.9	14.3	22.8	8.9	14.3
Broadleaf filaree	33.8	2.8	49.8	5.5	10.3	.2	23.7	.3
Miscellaneous forbs	3.8	.3	3.6	2.1	3.1	.1	2.4	.2
Total forbs	72.1	74.2	68.5	21.5	27.7	23.1	35.0	14.8
Browse	[3]	.2	[3]	.8	[3]	.1	[3]	.6
Total vegetation	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Less than .1 percent, or not in sample.
[2]Not differentiated in sample.
[3]Not sampled.

Grazing Habits of the Steers

In the unfertilized pasture the animals scattered widely and grazed in groups of two or three. They wandered about continuously, taking small bites of selected plants and appeared to be searching for something better.

In contrast, on fertilized range in 1950 the steers usually grazed as one group with little wandering. This group was gentler than the other. They grazed greedily and took large bites. Their diet was more easily sampled than the diet of the control group. In 1951 and later years steers on fertilized range were not as gregarious as the 1950 group but they scattered less than those on unfertilized range (Fig. 1). They were less gentle than the 1950 steers and grazed less greedily, apparently because the vegetation contained less clover.

Total time spent grazing and time spent grazing in the swales were less both years on fertilized range. This reflects the increased herbage production on other sites and improved forage quality brought about by fertilization. The difference in grazing time, ½ to 1 hour a day, was spent loafing around salt and water on the fertilized range, as the following tabulation shows:

Activity	Fertilized range	Unfertilized range
	(Percent of time)	
Grazing in swale	18.6	28.4
Grazing on slope	47.5	47.8
At salt and water	25.7	12.8
Shaded up or lying down	8.2	11.0
	100.0	100.0

In 1950, during the dry forage season, cattle spent more than half the grazing time on fertilized range in selecting littlehead clover (*Trifolium microcephalum*), which had grown luxuriantly over most of the slopes. The coarse stalks were eaten avidly and shattered leaves and stems were licked from the ground. At first some spots were grazed closely, while good clover plants on adjacent spots were ignored. By the middle of October, however, all of the clover had been closely grazed. On unfertilized range, cattle spent little time searching for any certain species on the slopes. At times they wandered about picking out the heads of soft chess. They grazed the swales a little closer than did the steers in the fertilized pasture.

In 1951, cattle were not selective on the slopes in either pasture, but they concentrated on whitetip clover (*Trifolium variegatum*) in the swales as long as it was available. They spent more time grazing in the swales than in 1950, particularly in the fertilized pasture.

On unfertilized range, acorns were eaten regularly during the fall and winter of 1950. Acorns were available because ground squirrels had been poisoned and did not compete with the steers. All blue oak acorns were taken as they became available, starting in late September, and live oak acorns in November. On the fertilized range the steers ignored the acorns until December and then consumed fewer than on unfertilized range. Consumption of acorns before supplemental feeding was started may have reduced gains of cattle on unfertilized range (Wagnon, 1946). A lessened desire for acorns with the dry forage may

be a benefit from sulfur fertilization. In 1951 ground squirrels harvested all acorns as they fell.

From the start of supplemental feeding in October 1950 until adequate green feed became available, cattle on unfertilized range followed the observer, or stood bawling around the pickup truck or feed trough for as much as half an hour. Cattle on fertilized range grazed normally whenever the observer drove his pickup into their pasture.

At the end of October 1950 early rainfall and moderate temperatures combined to produce "once in a lifetime" early winter grazing. Steers in both pastures concentrated on green feed, which after November 15, made up 95 percent of what they ate. In most years range cattle are forced to eat old vegetation longer into the winter season.

Species Grazed

On unfertilized range about the same species were taken each year during the dry forage season, but on fertilized range a big difference between years was noted (Table 1). On the fertilized range, diet depended largely on the relative availability of grasses and clovers. When clover was abundant over the slopes in 1950 it composed a major part of the herbage consumed by the steers.

Grasses, grasslike plants, clovers, and Spanish clover (*Lotus americanus*) were the preferred species that made up a greater proportion of the diet than of the herbage crop. These species produced 56 percent of the herbage, or 1,860 pounds per acre, in the fertilized pasture in 1950, as compared to 40 percent, or 1,140 pounds per acre, in the unfertilized pasture. In 1951, they made up 86 percent, or 3,692 pounds per acre, in the fertilized pasture, and 74 percent, or 1,839 pounds per acre, in the unfertilized pasture. Such an increase of preferred species by sulfur fertilization is worthwhile on foothill ranges grazed during the summer and fall.

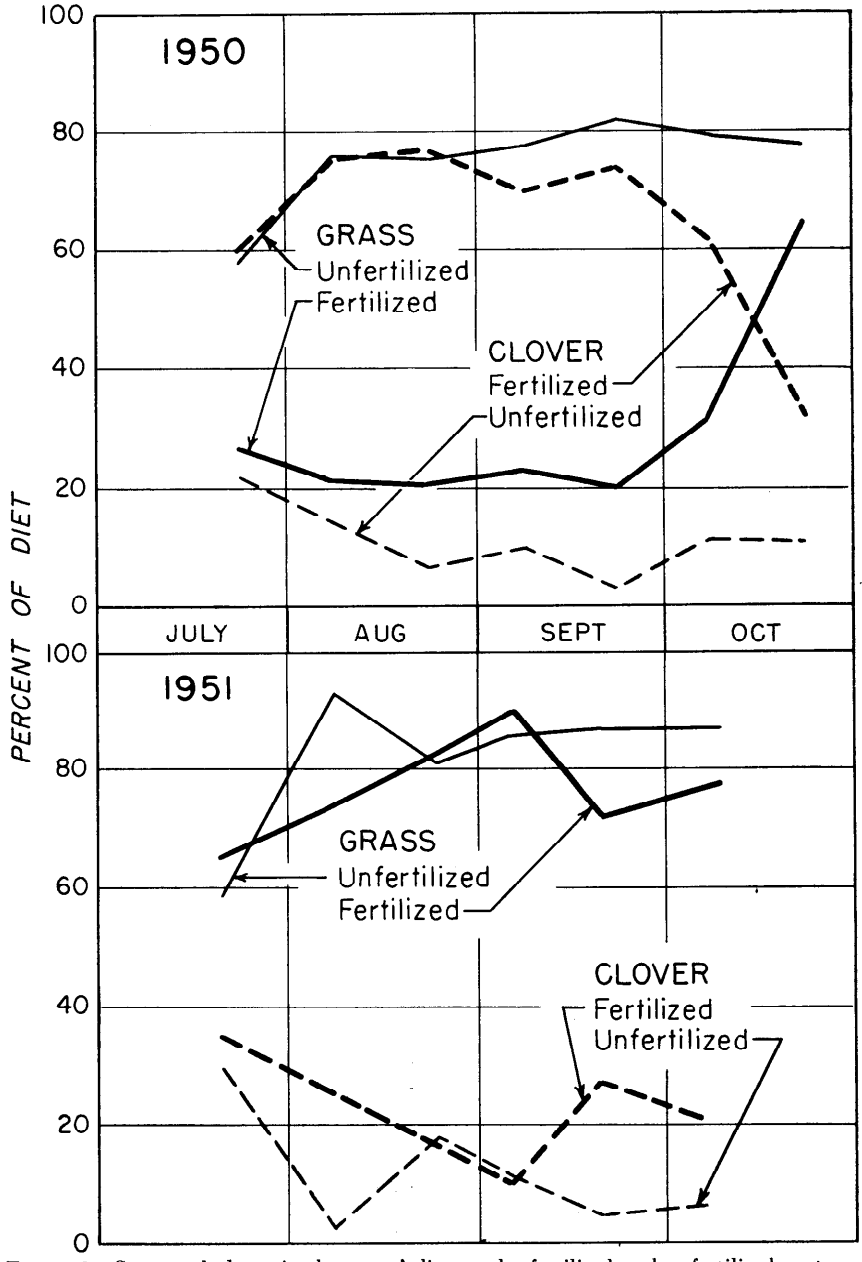

FIGURE 2. Grass and clover in the steers' diet on the fertilized and unfertilized pastures.

Grasses

Grasses, the staple food of cattle during the dry season on unimproved foothill range (Wagnon, 1941), ordinarily produce about 60 percent of the herbage (Bentley and Talbot, 1951). The percentage of grass in both pastures was well below this average in 1950 and above average in 1951 (Table 1). Yet, each year in the unfertilized pasture the grasses made up about 80 percent of what the steers ate during the dry season, after the supply of clovers had been reduced by grazing in July (Fig. 2).

In July, August, and September 1950, grasses made up only about 20 percent of the steers' diet in the fertilized pasture. In October, however, after the abundant supply of clover had been greatly reduced by grazing, more grass was taken. They ate mainly grass after green growth became available.

In 1951 a high proportion of grass was selected on fertilized range throughout the dry-forage season. An extremely large amount was available, 3,089 pounds per acre. Consumption of grass was comparable to, although slightly below, that in the unfertilized pasture.

Soft chess *(Bromus mollis)* was the favored grass, particularly on unfertilized range. It definitely was selected over other grasses until its supply was reduced by grazing.

Foxtail fescue *(Festuca megalura)*, the most abundant grass in the pastures, was not preferred when dry. Even so, in 1951 it made up 46.8 percent of the steers' diet in the fertilized pasture and 38.5 percent in the control pasture. Weather that year favored growth of foxtail fescue, and it was stimulated in the fertilized pasture by a high level of soil nitrogen. It was grazed in direct relation to its occurrence in the total herbage crop. Actually, this may indicate some discrimination against this species. If equally palatable with other grazed species, it should have composed a higher percentage in the diet than in the herbage crop because much of the total herbage was nongrazed species.

Some of the so-called undesirable grasses—red brome *(B. rubens)*, ripgut brome *(B. rigidus)*, and Mediterranean barley *(Hordeum hystrix)*—were grazed along with the other dry grasses. The steers did not discriminate against these species and in some cases appeared to select them. Australian chess *(B. arenarius)* was the only grass present in greater than trace amounts that made up a greater proportion of the herbage than of the diet.

Clovers

The native annual clovers are among the most palatable species on foothill ranges. They are more nutritious when dry than the annual grasses and the nonleguminous forbs (Gordon and Sampson, 1939). On unimproved range the bulk of the clover selected by cattle during the dry season ordinarily is whitetip clover, which grows in near-pure stands in swales, except during low rainfall years. Littlehead clover and others on slopes seldom grow in concentrated stands and are not definitely selected, but they are grazed along with the grasses.

Grazing of clover on unfertilized range followed this pattern in 1950 and 1951. Steers selected clovers in the swales until the supply was nearly exhausted. Clovers made up 20 to 30 percent of the diet in July and then dropped to about 10 percent or less (Fig. 2). For the entire dry-forage season, average percentages in the diet were 11.3 in 1950 and 12.2 in 1951 (Table 1).

In contrast, on the fertilized slopes littlehead clover was definitely selected throughout the 1950 dry-forage season. Sulfur fertilization had stimulated growth of this species so that it was abundantly available. This species averaged 65.5 percent of the steers' diet from July until the middle of October. Then consumption dropped because the supply was nearly grazed out (Fig. 2). Dry clover was ignored in November and December when the steers grazed on new green vegetation.

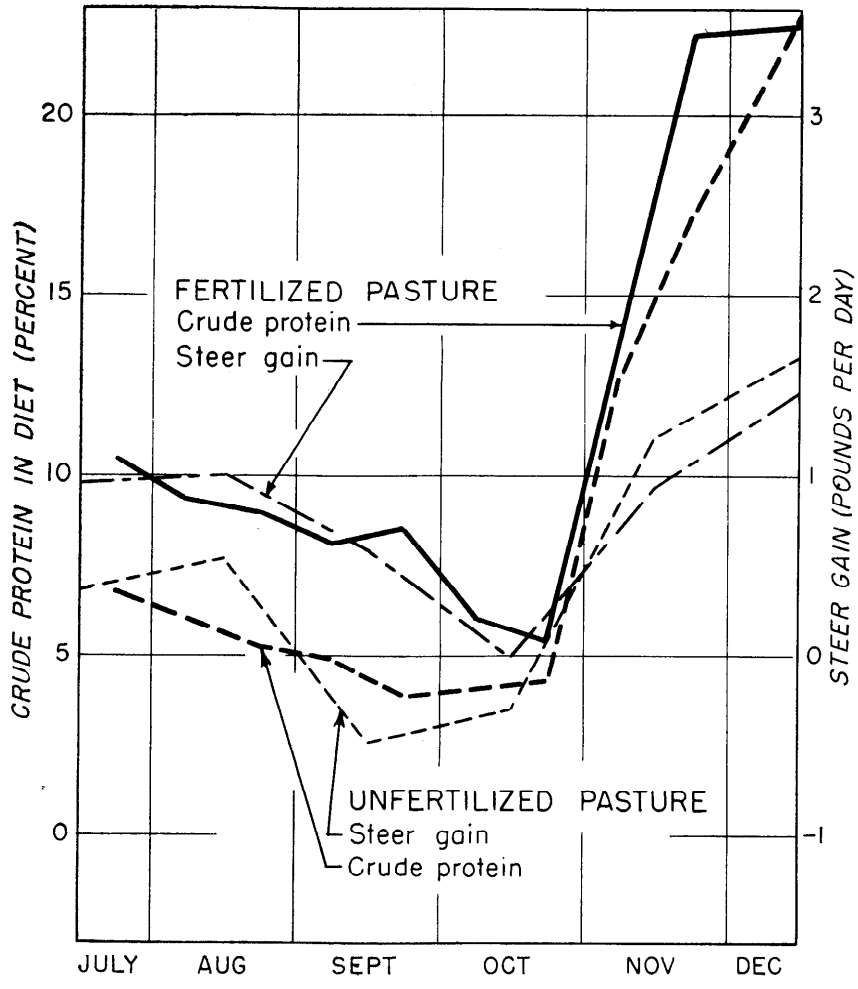

FIGURE 3. Crude protein in the steers' diet and average daily gain of the steers in the fertilized and unfertilized pastures, July-December 1950.

In 1951, the steers grazed about the same species on fertilized as on unimproved range. Littlehead clover was not selected, but it was not abundantly available because a long spring dry spell had sharply curtailed its growth. Whitetip clover in the swales was the only clover definitely selected. Clovers made up 22.8 percent of the herbage grazed on fertilized pasture but only 14.3 percent on untreated range.

Since then, general observations have shown that cattle selected more littlehead clover on fertilized dry-season range than in 1951. It has been closely grazed whenever abundant on the slopes. In "good clover years" it makes up a major part of the grazed herbage.

Other Legumes

Spanish clover was the only other common legume that the steers preferred. Because it remained green well into the summer, it was selected on both fertilized and unfertilized range.

Ground lupine *(Lupinus bicolor)* and the miscellaneous legumes, mainly species of *Lotus*, were generally avoided but sometimes grazed along with other plants. Therefore these legumes were valuable mainly for nitrogen fixation in the soil rather than for forage.

Bur clover *(Medicago hispida)* was present in only a trace amount. A few plants at one location in the unfertilized pasture were grazed during the first few days.

Forbs

Broadleaf filarees *(Erodium botrys, E. obtusiplicatum)* typically produce one-fourth to one-half of the herbage on foothill range, but in these tests filarees averaged not more than 5.5 percent of the cattle diet. The proportion would have been even lower except that plants growing on recently exposed gopher or squirrel mounds were more attractive, and large coarse plants were grazed to ground level. Broadleaf filaree is valuable as forage during the spring. But for ranges grazed yearlong, a low percentage is desirable. Sulfur fertilization improved the range by lowering the percentage of filaree in the cover.

The miscellaneous forbs were mainly small weedy species relatively worthless as forage on both fertilized and unfertilized range.

Chemical Composition of Grazed Herbage

Herbage selected from fertilized range was more nutritious than that from unfertilized range in both 1950, when clovers were abundant in the fertilized pasture, and 1951, when range herbage on both areas was mainly grass. Thus, the improved value of the diet on fertilized range did not depend entirely on its botanical composition. Instead, the nutritive value of both grasses and clovers was

Table 2. Chemical content of herbage simulating steer diet in the fertilized and unfertilized pastures in 1950 and 1951.

Season and date	Pasture	Ash	Crude protein	NFE-EE	Crude fiber	Calcium	Phosphorus
1950 dry forage season							
7/16-31	Fertilized	10.13	10.46	51.43	27.98	1.43	0.22
	Unfertilized	8.19	6.99	50.22	34.60	1.09	0.13
8/1-15	Fertilized	10.50	9.30	51.97	28.23	1.42	0.24
	Unfertilized	8.63	6.12	52.68	32.57	0.98	0.17
8/16-31	Fertilized	10.00	9.01	52.20	28.79	1.43	0.24
	Unfertilized	7.97	5.35	53.93	32.75	1.04	0.20
9/1-15	Fertilized	9.66	8.01	51.92	30.41	1.43	0.22
	Unfertilized	7.73	4.90	55.06	32.31	0.98	0.17
9/16-30	Fertilized	8.28	8.50	50.66	32.56	1.43	0.20
	Unfertilized	6.14	3.95	50.44	39.47	0.75	0.12
10/1-15	Fertilized	7.00	6.10	53.30	33.60	1.02	0.13
	Unfertilized	6.40	4.00	53.60	36.00	0.86	0.11
10/16-31	Fertilized	6.40	5.40	54.00	34.20	0.98	0.10
	Unfertilized	5.50	4.30	56.90	33.30	0.85	0.11
Average	Fertilized	8.86	8.11	52.21	30.82	1.31	0.19
	Unfertilized	7.22	5.09	53.26	34.43	0.94	0.14
1950 winter season							
11/1-15	Fertilized	9.00	14.00	44.10	32.90	1.80	0.13
	Unfertilized	8.40	12.90	46.80	31.90	1.04	0.33
11/16-30	Fertilized	11.60	22.20	40.50	25.70	1.47	0.29
	Unfertilized	11.30	17.20	45.50	26.00	1.57	0.51
12/1-31	Fertilized	11.70	22.50	43.80	22.00	0.99	0.28
	Unfertilized	11.80	22.80	44.30	21.10	0.95	0.30
Average	Fertilized	10.77	19.57	42.80	26.86	1.42	0.23
	Unfertilized	10.50	17.63	45.54	26.33	1.19	0.38
1951 dry forage season							
7/16-31	Fertilized	6.78	12.07	53.86	27.29	1.22	0.27
	Unfertilized	7.49	9.51	53.38	29.62	1.03	0.18
8/1-15	Fertilized	6.55	9.91	55.08	28.46	0.97	0.25
	Unfertilized	5.52	6.89	56.63	30.96	0.62	0.18
8/16-31	Fertilized	6.32	8.96	54.50	30.22	0.87	0.31
	Unfertilized	6.09	6.72	56.15	31.04	0.73	0.15
9/1-15	Fertilized	6.68	9.35	53.47	30.50	0.88	0.30
	Unfertilized	7.01	6.07	55.92	31.00	0.69	0.16
9/16-30	Fertilized	7.00	8.86	53.37	30.77	1.06	0.23
	Unfertilized	6.96	6.20	55.92	31.00	0.69	0.16
10/1-31	Fertilized	7.39	8.06	53.87	30.68	0.96	0.23
	Unfertilized	6.59	5.84	56.54	31.03	0.61	0.17
Average	Fertilized	6.79	9.54	54.02	29.65	0.99	0.27
	Unfertilized	6.61	6.87	55.69	30.83	0.72	0.17

increased by fertilization (Table 2).

Herbage sampled to simulate the diet of steers on fertilized range during the dry-forage season contained more crude protein and phosphorus than that from unfertilized range at each sampling period in both 1950 and 1951. This is a definite improvement because these are the two items commonly deficient in the dry herbage on unimproved annual-plant range (Guilbert and Hart, 1951).

Calcium percentage was high in samples from the fertilized pasture in 1950, when clovers made up most of what the steers ate. It was lower in 1951, when clovers were reduced, but was still above the calcium level of herbage from unfertilized range. Crude fiber was 5 percent lower and ash was 2 percent higher in samples simulating the predominantly clover diet of the fertilized pasture in 1950. These items were at about the same level for both pastures in 1951 when grass was predominant.

Crude protein in the fertilized pasture dropped to a low level in October 1950, when only dry vegetation from which the choice forage had been previously selected was available. In the unfertilized pasture in both years crude protein was below cattle maintenance needs throughout most of the dry-forage season.

The level of crude protein and phosphorus was well above minimum requirements in the diet in both pastures during November and December when new green vegetation became available.

Differences in crude protein accounted in large part for the greater gains on fertilized pasture. Rate of gain in both pastures closely paralleled crude protein trends in the herbage (Figs. 3 and 4). From July through September 1950, when crude protein in the fertilized herbage was 3 to 5 percent above that in the unfertilized, about 0.7 pound per steer day greater gain was realized with fertilization. Because new herbage became available in exceptional quantity in November and December 1950, steer gains were better than normal. The thinner steers on unfertilized range started to gain sooner and gained slightly faster than those on fertilized range.

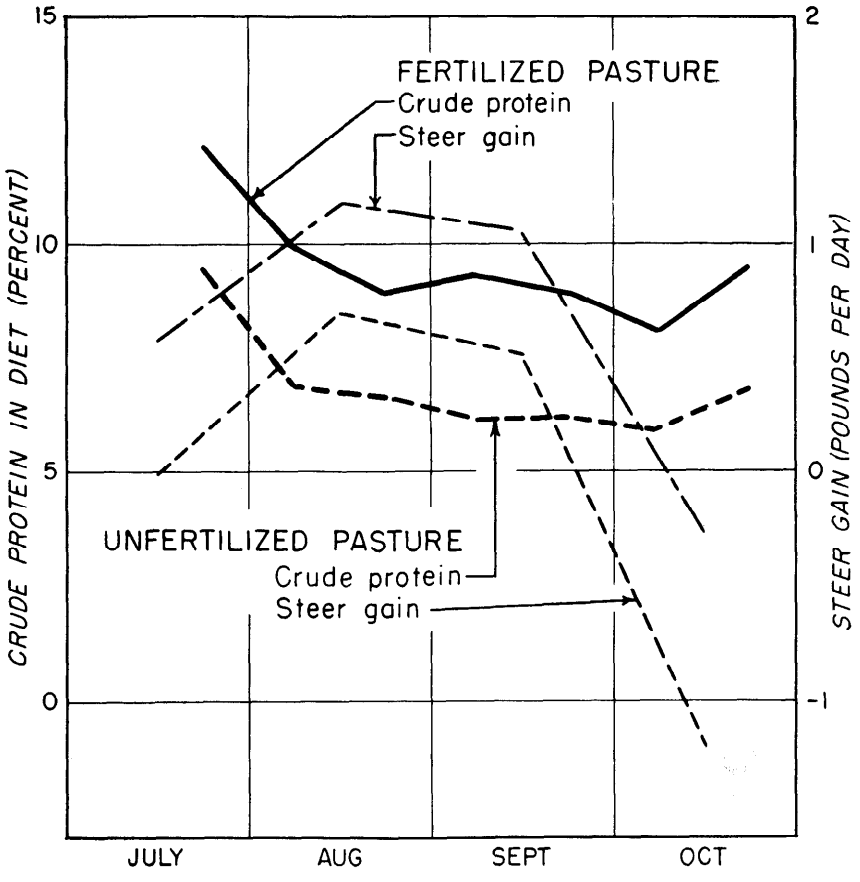

FIGURE 4. Crude protein in the steers' diet and average daily gain of the steers in the fertilized and unfertilized pastures, July-October 1951.

During the dry season in 1951 the crude protein in fertilized herbage paralleled that of the unfertilized herbage but remained about 3 percent higher (Fig. 4). Similarly, animal performance was parallel but about .6 pound gain per day higher in the fertilized pasture. Considerable weight was lost in October in both pastures without a change being shown in crude protein. Much of this loss in weight may have occurred late in the month after the herbage sampling was completed.

Crude protein of the steer diet was sufficiently high on fertilized range during July, August, and September to promote average daily gains of 0.86 pound in 1950 and 0.93 pound in 1951. In the unfertilized pasture, where crude protein was 3 percent lower, average daily gains were only 0.12 pound in 1950 and 0.40 pound in 1951. Fertilized range produced satisfactory gains during the summer without supplements being fed. Steers in the unfertilized pasture needed supplemental protein concentrates for efficient use of the dry forage.

Summary

A sulfur fertilized and an unfertilized range pasture in the annual plant type were sampled to determine total herbage and species production. During two

dry-forage seasons observations were made of steer grazing habits and the steers' diet was simulated by sampling.

Cattle on fertilized range grazed more as a group, wandered less, took bigger bites, picked up fewer acorns, and satisfied themselves in less grazing time. On fertilized range the abundant clover was grazed, and then grass dominated the diet. On unfertilized range, grass dominated throughout the dry forage season. One abundant plant, broadleaf filaree, was discriminated against. Fertilization reduced the proportion of this and other weedy plants, and thus improved the composition of range vegetation.

Herbage samples simulating diet on fertilized range indicated higher crude protein, phosphorus, and calcium. This was reflected in greater daily steer gains.

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Effect of Gibberellic Acid, 2,4-D, and Indole-Acetic Acid on Seed Germination and Epicotyl and Radicle Growth of Intermediate and Pubescent Wheatgrass

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Improvement of seedling vigor is considered one of the important objectives in most grass breeding programs. Grasses, in general, are slow to establish even under the most ideal environmental conditions. Increased vigor becomes even more important in establishment under the generally adverse environmental conditions of the Northern Great Plains.

Several investigations have indicated that increased seed size within certain species produced more vigorous seedlings. Rogler (1954) indicated a very close relationship between seed size and seedling vigor, as well as a high positive correlation between seed size and emergence of seedlings from deeper seedings with crested wheatgrass. Kneebone (1956) and Kneebone and Cremer (1955), working with some of the native species of the Southern Great Plains, found that the larger seed within a lot emerged faster and grew at a faster rate than smaller seed. These studies also indicate that the potential for improvement of this characteristic is much greater in certain species than in others.

Soil moisture is usually the limiting factor in establishment under dryland conditions, therefore, early and rapid root elongation would appear to be an important factor in overcoming this hazard. Most of the past studies have not taken into consideration the vigor of root elongation. This could also be correlated with seed size. A study of this relationship is now underway at the Wyoming Agricultural Experiment Station. The present studies, however, are concerned with the effect of certain hormone-type chemicals on the rapidity of germination and elongation of both the epicotyl and radicle in grasses.

Literature

Investigations on the effect of 2,4-dichlorophenoxyacetic acid on forage grasses mostly have been concerned with its effect on seed produced on sprayed plants. Bass and Sylwester (1956) indicated that 2,4-D applications on Kentucky bluegrass, when in the boot stage, markedly affected viability of the seed produced. Mitchell and Marth (1945) found that 2,4-D at rates equivalent to ¾, 1½, 2¼ and 3 pounds of the acid per acre sprayed on seeded seedbeds reduced emergence of redtop by 28, 83, 83 and 95 percent respec-

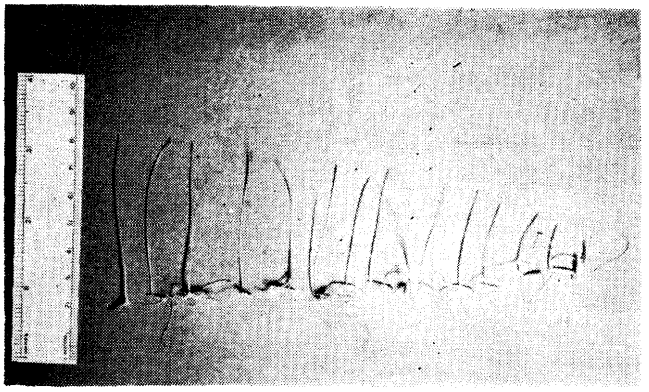

FIGURE 1. Intermediate wheatgrass, check.

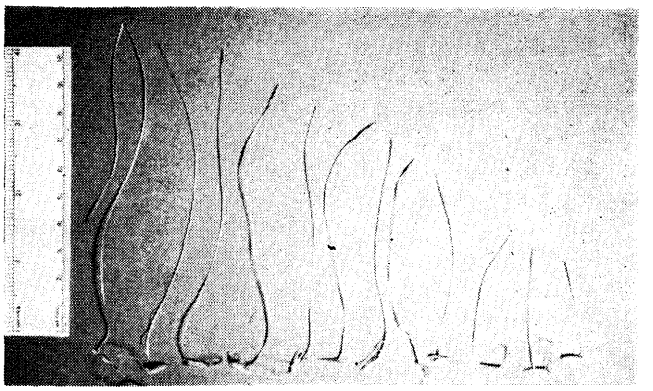

FIGURE 2. Intermediate wheatgrass germinated in a 100 ppm solution of gibberellic acid.

tively. Rates equivalent to ¾ and 1½ pounds of acid per acre increased emergence in red fescue, while heavier applications of 2¼ to 3 pounds per acre reduced emergence by 10 and 17 percent. On soil sprayed at a rate of ¾ pound per acre, a 14 percent increase in emergence of Kentucky bluegrass occurred. The heavier application, however, reduced emergence of bluegrass by as much as 32 percent. A reduction in growth of all species occurred for a short period after emergence. This reduction was of a temporary nature. Marth *et al.* (1948) found that 2,4-D (acid form) sprayed on grasses, even when seed was maturing, had no effect on germination of sound seed produced.

Gibberellic acid, a relatively new growth-promoting chemical has received considerable attention during the past few years. It has been suggested as a possible means of replacing the cold or vernalization requirement for flowering in certain biennials (5). The ability of gibberellic acid in promoting faster and greater growth on many plant species, including grasses, has been demonstrated by various workers in recent years (Leben and Barton, 1957; Wittwer and Bukovac, 1957). Bass, 1957, in studies conducted on the effect of gibberellic acid on germination of Kentucky bluegrass, Merion bluegrass and western wheatgrass, found no increase in total germination or rate of germination. There appeared to be some increase in the rate of elongation of the seedlings from certain concentrations; however, measurements were not made. Whaley and Kephart (1957), working with excised apical segments of both primary and adventitious seminal roots of maize, found that the root growth in certain genotypes of maize is significantly stimulated by gibberellic acid.

Beta-indole-acetic acid has been known for many years for its growth promoting and inhibiting characteristics. The effect of indole-acetic on seedling grasses or grass seed apparently has not been investigated.

Materials and Methods

This study involved the effect of various concentrations of 2,4-dichlorophenoxyacetic acid, Beta-indole-acetic acid, and gibberellic acid on germination and on radicle and epicotyl elongation of intermediate wheatgrass (*Agropyron intermedium*) and pubescent wheatgrass (*Agropyron tricophorun*). The chemical solutions were used as wetting media on germination blotters. Gibberellic acid and Beta-indole-acetic acid were used at concentrations of 50, 100 and 200 ppm.,

Table 1. Effect of gibberellic acid, 2,4-D, and indole-acetic acid on growth of radicle and germination of intermediate and pubescent wheatgrass four days after seeding.

Treatment	Intermediate		Pubescent	
	Mean growth in millimeters	Germination percent	Mean growth in millimeters	Germination percent
Gibberellic acid				
200 ppm.	6.98	78.33	6.46	81.67
100 ppm.	7.35	85.00	7.27	81.67
50 ppm.	8.68	76.67	9.32	81.67
Indole-acetic acid				
200 ppm.	1.28	78.33	1.19	55.00
100 ppm.	1.25	65.00	1.29	66.67
50 ppm.	1.29	70.00	1.23	75.00
2,4-D				
10 ppm.	4.93	81.67	6.99	81.67
5 ppm.	6.38	88.33	6.21	85.00
.5 ppm.	8.26	80.00	7.23	86.67
Check	7.45	86.67	7.99	83.33
LSD 0.05	1.60		1.60	

while 2-4-dichlorophenoxyacetic acid was used at .5, 5 and 10 ppm. All chemicals were dissolved in a small quantity of ethyl alcohol along with a few drops of detergent before preparing final dilutions. The same dilution of alcohol and detergent were used in the check treatments to make them comparable to the chemical treatments.

Twenty-five ml. of a given solution was placed in a four inch square germination dish containing three ordinary germination blotters. Twenty seeds of a given species were evenly spaced in each dish. Treatments were replicated three times. Seed was germinated in constant temperature chambers at 20° C. The chambers were lighted for a period of eight hours with sixteen hours of darkness. Measurements of radicle and epicotyl were made on the fourth and twelfth days after seed was placed in the germinators.

Table 2. Effect of gibberellic acid, 2,4-D, and indole-acetic acid on epicotyl, radicle growth and germination of intermediate and pubescent wheatgrass twelve days after seeding.

Treatment	Intermediate			Pubescent		
	Mean epicotyl growth in mm.	Mean radicle growth in mm.	Germination percent	Mean epicotyl growth in mm.	Mean radicle growth in mm.	Germination percent
Gibberellic acid						
200 ppm.	46.72	28.23	93.33	50.74	40.85	91.67
100 ppm.	73.40	32.34	90.00	54.40	43.10	95.00
50 ppm.	56.31	34.51	86.67	61.46	46.09	96.67
Indole-acetic acid						
200 ppm.	10.73	1.18	91.67	20.97	1.30	86.67
100 ppm.	12.68	1.43	83.33	21.17	1.43	95.00
50 ppm.	18.18	6.39	85.00	19.10	2.11	95.00
2,4-D						
10 ppm.	31.48	8.25	86.67	51.16	16.49	96.67
5 ppm.	49.38	11.25	96.67	55.70	21.19	95.00
.5 ppm.	49.38	24.63	95.00	55.55	41.22	95.00
Check	26.86	32.75	95.00	46.37	47.30	96.67
LSD 0.05	12.91	5.23		12.91	5.23	

Results and Discussion

Results of the measurements of radicle and epicotyl elongation are presented in Tables 1 and 2. On the fourth day no measurable epicotyl growth had taken place. Indole-acetic acid, at all concentrations, reduced radicle elongation significantly below that of any other treatment, including the checks. In both species the seeds germinated in the indole-acetic acid solutions showed no radicle growth, other than a short bud one to two millimeters long. None of the chemical treatments induced radicle elongation significantly greater than that of the checks in either species. Since gibberellic acid at 50 ppm. approached significance over the checks, and since a gradual increase in elongation takes place as concentration decreases, it may indicate that optimum concentration for root elongation had not been reached.

A factor of considerable interest, in both the first and second measurements, was the production of multiple and branched primary radicles at all concentrations of 2,4-D. Measurement in the experiment was made of only the longest single radicle. It is now felt that if total length had been taken into consideration, the 2,4-D treatments would have shown considerably more growth than any other treatment, including the checks. As many as five branched radicles were produced by some of the 2,4-D treatments.

Germination percentage was reduced slightly by all concentrations of indole-acetic acid at the first measurement. This dif-

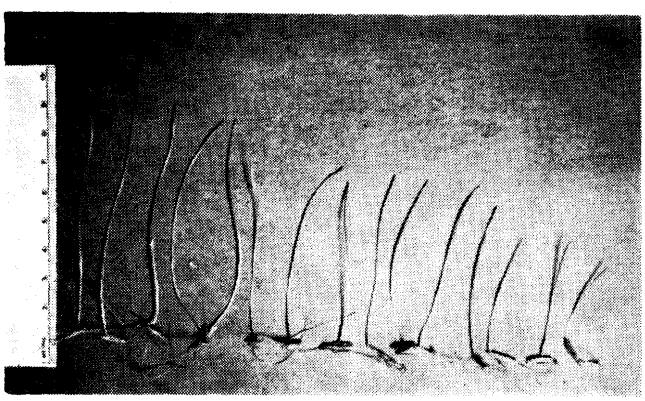

FIGURE 3. Pubescent wheatgrass germinated in a 2,4-D solution at a concentration of 0.5 ppm. Note the multiple radicle on many of the germinated seeds.

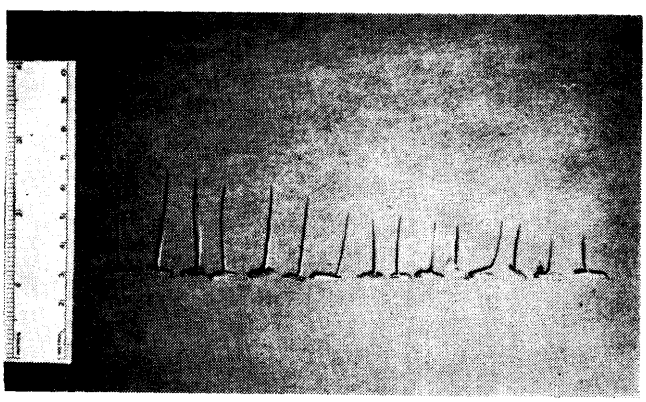

Figure 4. Pubescent wheatgrass germinated in an indole-acetic acid solution at a concentration of 50 ppm. Note that no radicle growth was made.

ference was not evident at the second measurement.

The second measurement, made twelve days after seeding, showed no appreciable increase in length of the radicles of the seed treatments of indole-acetic acid. The average length of the radicle in all three concentrations was two to four millimeters. The epicotyl growth of the indole-acetic acid treatments was significantly less than that of the other treatments, including the checks.

Gibberellic acid decreased radicle elongation only at the highest concentration of 200 ppm. Growth at this concentration was less than either the check or the two lower concentrations in both species.

Epicotyl elongation of intermediate wheatgrass responded differently to gibberellic acid concentration than did pubescent wheatgrass. All concentrations on intermediate gave significantly greater growth than the checks, with 100 ppm. being higher than either 200 or 50 ppm. There was no apparent difference in response of pubescent to the three concentrations. A concentration of 50 ppm. was slightly higher than the check.

2,4-D decreased elongation of the radicle at all concentrations in both species. Epicotyl elongation was increased at all concentrations except 10 ppm. in intermediate wheatgrass. There was no appreciable effect on epicotyl elongation of pubescent wheatgrass.

Germination of either species was not affected by any of the chemicals used.

Summary

The effects of gibberellic acid, 2,4-D, and indole-acetic acid on germination of seed and on radicle and epicotyl growth of intermediate and pubescent wheatgrass were tested.

Germination of the seed of the grasses was not affected by any of the chemicals at the concentrations used.

None of the chemical treatments increased radicle elongation significantly over that of the checks. Indole-acetic at all concentrations reduced radicle elongation. All concentrations of 2,4-D resulted in the production of multiple and branched primary radicles. Gibberellic acid reduced radicle elongation only at the highest concentration used, 200 ppm.

Epicotyl elongation in intermediate wheatgrass was increased by gibberellic acid and 2,4-D and inhibited by indole-acetic. Epicotyl growth in pubescent wheatgrass was not affected by gibberellic acid or 2,4-D, but was inhibited by indole-acetic acid.

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NOTICE

DR. HOMER L. SHANTZ died of a heart attack on June 23, while on a botany field trip near Rapid City, South Dakota. At the time of his death DR. SHANTZ was studying vegetation changes in the Northern Great Plains on a research grant from the Office of Naval Research. This was a re-survey of areas previously studied in the period 1908-1923.

A memorial statement on DR. SHANTZ will be published in a later issue of the Journal.

Fertilizer Effects on Hay Production of Three Cultivated Grasses in Southern Saskatchewan[1]

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The importance of cultivated forage crops in the Northern Great Plains continues to increase. Each year more stockmen are turning to, or extending, established cultivated forage crops for their winter feed requirements. Unfortunately, many of the dryland hay fields are composed of grasses only, notwithstanding recommendations to seed grass-legume mixtures. Grass alone becomes sod-bound quickly and resultant hay yields are low. This is attributable to an insufficient supply of available nitrogen in an area where the climate is usually the main uncontrollable limiting factor. Thus, it seems important to learn as much as possible about the factors which can be controlled.

Although fertilizer trials on cultivated grasses for hay in dry climates have been, and are being conducted, few results have been published. Most reports deal with fertilizer trials on grass-legume mixtures, or those which are grown on irrigated lands, or those which are grown outside the Northern Great Plains region. Rogler and Lorenz (1956) reported that nitrogenous fertilizer applications on native grassland in North Dakota increased yields and speeded the recovery of overgrazed fields. Stitt, *et al.* (1955) observed the benefits of fertilizer application to crested wheatgrass in Montana and found that 25 to 30 pounds of nitrogen per acre increased the hay yield of crested wheatgrass from 300 to 600 pounds per acre; however, a good deal of their work dealt with the response and influence of the volunteer sweet clover which was present in the stand.

The experiment being discussed in this paper was undertaken to measure the response of pure stands of crested wheatgrass (*Agropyron cristatum*), intermediate wheatgrass (*Agropyron intermedium*) and Russian wildrye (*Elymus junceus*) to fertilizer applications. It was conducted at Swift Current, Saskatchewan, which is near the center of the Northern Great Plains region. The climate at this point is classified as semi-arid with an average annual precipitation of 13.97 inches and a precipitation/evaporation index of 0.45. The soil is classified as a light loam, low in organic matter and available nitrogen, and a member of the chestnut or brown soil zone.

[1]*Contribution from Experimental Farms Service, Canada Department of Agriculture, Ottawa.*

Experimental Methods

Blocks of crested wheatgrass, intermediate wheatgrass and Russian wildrye were seeded in 12-inch spaced rows during May, 1952. Each block was 3x85 rods.

In October 1953, a fertilizer test was established on these three adjacent strips of grass. The experiment was designed as a random block with 6 fertilizer treatments plus a check. Five replications were used. Individual fertilizer plots were 40 feet wide by 9 rods long—the total width of the three grass strips.

One hundred and two hundred pounds of ammonium phosphate (11-48-0), ammonium phosphate-sulphate (16-20-0), and ammonium nitrate (33.5-0-0) comprised the 6 fertilizer treatments. The fertilizers were applied by drilling into the sod during October of each year from 1953 to 1956 inclusive.

Results and Discussion

Dry matter yields from the three grasses according to fertilizer applications are presented in Table 1. The 4-year average

Table 1. Four-year average dry matter yields of grasses in relation to fertilizers applied.

Fertilizer and Formulation	Application Rate in Pounds per Acre	Pounds of Element Per Acre		Tons Per Acre			Fertilizer Mean
		N	P_2O_5	Crested Wheat	Russian Wildrye	Intermediate Wheat	
Ammonium phosphate	100	11	48	.48	.31	.56	.45
(11-48-0)	200	22	96	.56	.42	.69	.56
Ammonium phosphate-sulphate	100	16	20	.59	.40	.59	.53
(16-20-0)	200	32	40	.82	.44	.67	.64
Ammonium nitrate	100	34	—	.74	.42	.67	.60
(33.5-0-0)	200	67	—	1.16	.62	.81	.86
Check—no fertilizer	—	—	—	.35	.24	.54	.38
L.S.D. (P= .05)				.14	.11	.21	

yield increased with increasing levels of nitrogen, irrespective of the source of nitrogen. As the phosphorus in the mixed fertilizers did not increase yield, the discussion following will be confined to the effects of nitrogen—irrespective of its source. Likewise, earliness of spring growth and darkness of foliage color were related to the increasing amounts of nitrogen applied.

The unfertilized check showed that intermediate wheatgrass outyielded crested wheatgrass and Russian wildrye. However, the response of crested wheatgrass to the higher levels of nitrogen was such that its dry matter yields were greater than yields of intermediate wheatgrass at the same levels of nitrogen. Russian wildrye did not yield as much as either of the wheatgrasses following any of the treatments, although its proportionate yield increases were greater than those of intermediate wheatgrass.

The highest yields were obtained in 1954 (Table 2) when the precipitation, particularly during the month of May, was high. The increases attributable to nitrogen applications were good for all species. Crested wheatgrass produced a maximum increased yield which was 3.7 times greater than that of the check, while Russian wildrye was 2.9 times greater, and intermediate wheatgrass 1.5 times greater. Although overall yields were less in 1955, the percentage increase of crested wheatgrass and Russian wildrye to nitrogen was as marked as in 1954. During 1956 and 1957, when the spring seasons were dry, the responses to nitrogen were quite small, with crested wheatgrass responding better than the other two grasses.

Yield responses of the different grasses in each year at the various levels of nitrogen fertilizer are illustrated by the graphs in Figure 1. It will be noted that the yield response lines for crested wheatgrass are steeper than those for the other two grasses indicating that more dry matter was produced per unit of nitrogen applied. In every year 30 pounds of nitrogen doubled the yield of crested wheatgrass, while 65 pounds tripled or quadrupled it. Russian wildrye yield increments were moderately good in 1954 and 1955, but very small in 1956 and 1957. Intermediate wheatgrass gave a response to fertilizer only in 1954.

For clearer yield response comparisons between species the 4-year mean yields at varying levels of nitrogen are shown in Figure 2. The crested wheatgrass line is the steepest, indicating that it responds better to increased amounts of nitrogen.

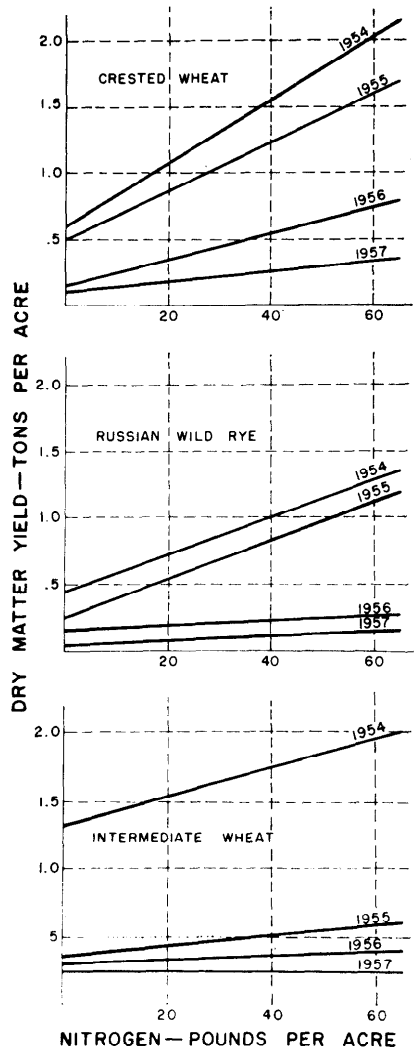

FIGURE 1. Yield response of each grass each year to various levels of nitrogen application.

Russian wildrye was somewhat better than intermediate wheatgrass in this respect. At the high level of nitrogen application the yield of crested wheatgrass was 3 times greater than that of its check, Russian wildrye was twice as much, and intermediate wheatgrass only half again as much.

The importance of yield increases by themselves cannot be properly assessed without subjecting them to cost analysis studies to determine whether it pays to apply fertilizer. Nitrogen fertilizer, even in its least expensive form as ammonium nitrate, costs about 15 cents per pound of elemental nitrogen. On the pre-

Table 2. Average dry matter yields of the three grasses in relation to fertilizers, years, and precipitation.

Fertilizer	Application Rate in Pounds per Acre	Pounds of Nitrogen	Tons Per Acre			
			1954	1955	1956	1957
11-48-0	100	11	.97	.42	.24	.15
	200	22	1.15	.55	.32	.19
16-20-0	100	16	1.02	.55	.33	.20
	200	32	1.33	.69	.34	.22
33.5-0-0	100	34	1.21	.63	.37	.21
	200	67	1.76	1.11	.34	.24
Check			.79	.35	.22	.15
Year Mean			1.18	.61	.31	.20
Annual precipitation in inches			19.71	17.31	13.15	11.80
May precipitation in inches			3.37	2.58	1.24	.13

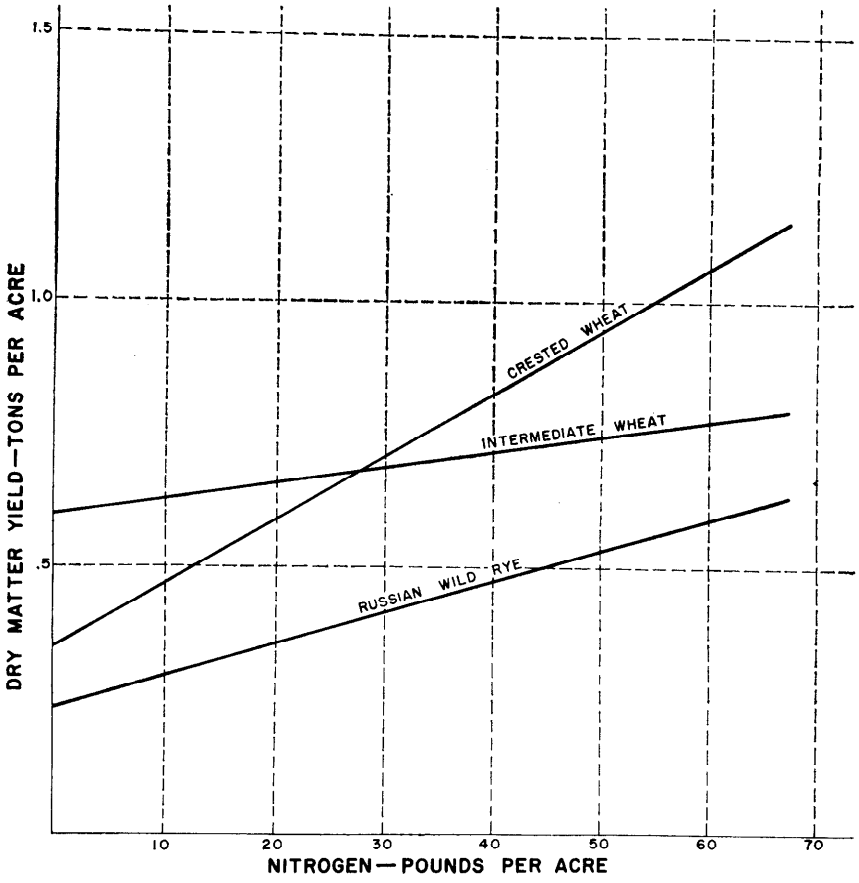

FIGURE 2. Four-year average yield response of each grass to levels of nitrogen application.

mise that hay is worth 15 dollars per ton then each pound of elemental nitrogen applied must produce 20 pounds of hay to pay for itself. Any yield increase short of 20 pounds per pound of nitrogen increases the cost of the extra hay. The pounds of hay return per pound of nitrogen applied obtained in this experiment are shown in Table 3. Many of the values shown are less than the required 20-pound level for economic returns. The influence of the latter two dry years will be noted. Crested wheatgrass yields were adequate for nearly three years out of four, Russian wildrye yields two years out of four, while intermediate wheatgrass yields were adequate only in the first year, when 20 or more pounds of nitrogen were applied.

The 4-year average cost of each additional ton of hay obtained from various levels of nitrogen fertilizer was computed and is illustrated graphically in Figure 3. Only crested wheatgrass produced additional hay at all levels of nitrogen at a cost of less than 15 dollars per ton. Additional hay of Russian wildrye cost an average of 24 dollars per ton, while additional intermediate wheatgrass hay cost anywhere from 30 to 90 dollars per ton.

The results from this 4-year fertilizer trial should not be construed as a recommendation for, or a condemnation of the use of fertilizers on grasses for dryland hay production in the Northern Great Plains region. Certainly there were early growth and yield increases due to fertilizer, but just as certainly the results point to the borderline nature of the economical returns. It does not appear that the use of fertilizers on grass for hay production in such an arid region will approach the steady performance obtainable from a mixture of grass and alfalfa. On the other hand there are instances where fertilizing grass for added hay production might play an important role. In his management program a stockman may, for a reason other than drought, be forced to face a short feed year. Rather than buy additional feed at high prices with long hauling distances, he may be wiser to grow it himself by applying fertilizer.

Another very important consideration in any fertilizer venture is the formulation of the fertilizer. If response is due sole-

Table 3. Pounds of hay increase for each pound of nitrogen applied.

Year	Pounds of Nitrogen Per Acre				
	11	16	22	33	67
			Crested Wheatgrass		
1954	52	49	32	47	47
1955	24	31	32	31	36
1956	15	25	15	20	9
1957	-2	15	7	6	4
			Russian Wildrye		
1954	33	26	35	20	17
1955	20	39	25	20	23
1956	-2	10	4	3	2
1957	2	4	1	5	3
			Intermediate Wheatgrass		
1954	16	14	33	20	24
1955	-2	5	7	5	8
1956	0	6	9	4	-2
1957	2	-2	8	2	1

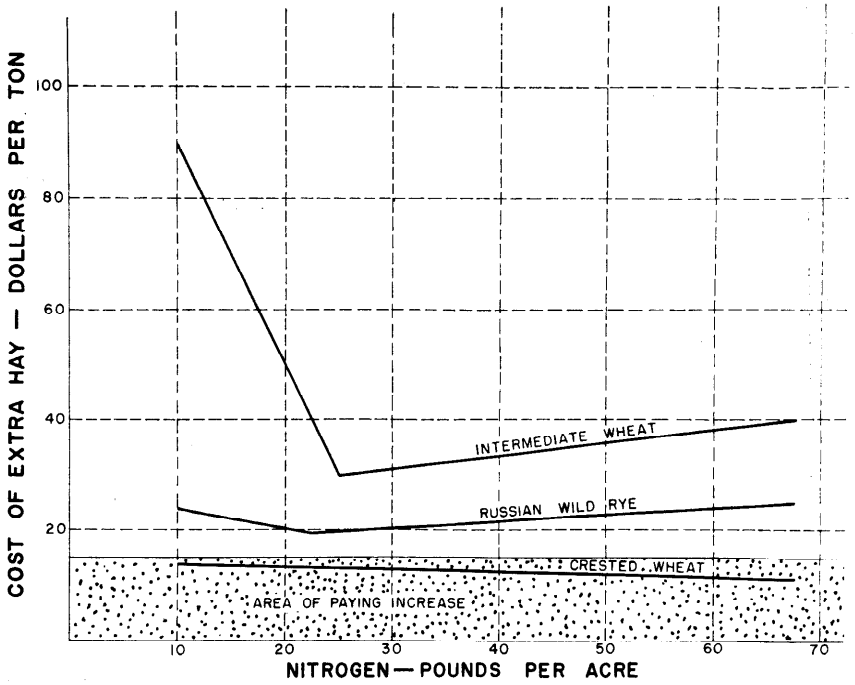

FIGURE 3. Cost of each additional ton of hay resulting from various levels of nitrogen application.

ly or mainly to nitrogen, then it is advisable to avoid the use of mixed fertilizers. The fertilizer to use in this case would be the one containing only nitrogen.

More than anything else these preliminary fertilizer trials emphasize the need for more detailed experimentation over a longer period of time with a greater number of plant species and varieties.

Summary

Pure stands of crested wheatgrass (*Agropyron cristatum*), intermediate wheatgrass (*Agropyron intermedium*), and Russian wildrye (*Elymus junceus*) were fertilized for four years at Swift Current, Saskatchewan, Canada. Commercial fertilizers, including ammonium phosphate (11-48-0), ammonium phosphate-sulphate (16-20-0), and ammonium nitrate (33.5-0-0) each at 100 and 200 pounds per acre were applied for dryland hay production studies.

None of the grass stands responded to phosphorus, but there was a general yield response to increasing amounts of nitrogen. Paying hay yield increases from applications of nitrogenous fertilizers on crested wheatgrass were obtained in most years. Increases in yield of Russian wildrye from nitrogenous fertilizers were economical during the first 2 moist years. Intermediate wheatgrass increases were economical only at higher levels of nitrogen in the first wet year.

Favorable precipitation, especially in May, is an important requirement for the successful and economical use of fertilizers on pure stands of cultivated grass hay in this part of the Northern Great Plains region.

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Research Grants Received at University of Arizona

The Range Management Department of the University of Arizona, now included as part of the University's newly organized Department of Watershed Management, has received two research grants. The National Science Foundation has provided $36,000 for the study of annual rings of desert shrubs. It is hoped that by determining the age of these shrubs through ring studies, new information on causes of brush invasion of range lands may be discovered.

The Charles Lathrop Pack Foundation has awarded a grant of $5,300 plus operating expenses, to be made available annually for a three year period. Research carried on under this grant will be in basic transpiration studies of range plants.

Adaptability and Yield of Eleven Grasses Grown on the Oregon High Desert[1]

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The most widely accepted grass for seeding ranges in the sagebrush-bunchgrass area is crested wheatgrass (*Agropyron desertorum*). This particular grass has been outstanding because it can withstand heavy use in the spring and because it does well in areas of low precipitation.

There is a continuous need, however, to search for more productive grasses. This need necessitates continuous testing of species and strains within species in adaptability trials. This paper reports the results of one such trial.

Experimental Procedure

The study was conducted on the range unit of the Squaw Butte-Harney Experiment Station. This unit is approximately 42 miles west of Burns, Oregon and lies within the Oregon High Desert at an elevation of 4,600 feet.

Soils of this area are mostly sandy loam of basaltic origin which are underlaid with a caliche layer varying from 2 to 4 feet below the surface. These soils are characteristic of much of the 96,000,000 acres of sagebrush range.

Temperature and precipitation is extremely variable. Average annual precipitation is approximately 11 inches, with most of it being received in the winter months. During the last 19 years the lowest precipitation recorded was 5.9 inches and the highest 18.1 inches. All months have experienced temperatures below 32° F.; however, the average frost-free period is 50 days. Average monthly precipitation and temperature for the period 1937-1951 inclusive are shown in Table 1. Seasonal precipitation during the years of this study are presented with herbage yields (Table 2).

Table 1. Average monthly precipitation and temperature at the range unit of the Squaw Butte-Harney Experiment Station (1937-1951 inclusive.)

Month	Precipitation	Temperature
	Inches	°F
January	1.19	23
February	1.05	29
March	0.80	35
April	0.65	43
May	1.28	52
June	1.37	55
July	0.27	66
August	0.54	64
September	0.69	58
October	1.11	46
November	1.17	35
December	1.36	28
Annual Avg.	11.47	45

Four strains of crested wheatgrass (*A. desertorum*), 2 strains of fairway wheatgrass (*A. cristatum*), and 1 strain each of siberian wheatgrass (*A. sibericum*), Whitmar beardless wheatgrass (*A. inerme*), tall wheatgrass (*A. elongatum*), big bluegrass (*Poa ampla*), and hard fescue (*Festuca ovina* var. *duriuscula*) were seeded at 10 pounds per acre in 5-row nursery plots in May, 1952. Rows were spaced 1 foot apart and were 20 feet in length. Plots were replicated 3 times and were sprinkled occasionally in 1952 to insure stand establishment.

On August 1, 1953, 1954, 1955, and 1956 herbage yields were obtained by harvesting 16 feet of the 3 center rows of each plot. In 1957 two levels of nitrogen (0 and 30 lb. N/A) were randomly assigned to one-half of each replication. Yield samples were taken on August 1 by harvesting 8 feet of the 3 center rows on each subplot. Yield samples were oven dried, and yields are expressed on an oven-dry basis plus 10 percent moisture.

Results and Discussion

Grass Yields

The 2 highest yielding grasses for the 5-year period were big bluegrass and siberian wheatgrass (Table 2). Differences among other species were not significant; however there was a tendency for both tall wheatgrass and Whitmar beardless wheatgrass to be higher yielding than crested and fairway wheatgrasses. Likewise, strains of crested wheatgrass appeared to be higher yielding than fairway wheatgrass.

Big bluegrass did not attain its peak in yield performance until the third and fourth growing season, whereas other grasses in the trial attained peak performance in the second growing sea-

[1]*A contribution from Squaw Butte-Harney Experiment Station, Burns, Oregon, which is jointly operated and financed by the Crops Research Division, A.R.S., U.S.D.A. and Oregon Agricultural Experiment Station, Corvallis, Oregon. (Formerly jointly operated and financed by the Bureau of Land Management, U.S. D.I., and Oregon Agricultural Experiment Station). This report is published as Technical Paper No. 1100, Oregon Agricultural Experiment Station.*

Table 2. Mean yields and relative rank of grasses on August 1 in each of 5 years.

Species	1953		1954		1955		1956		1957		Avg.	
	Lbs. per Acre	Rel. Rank	Lbs. per Acre	Rel. Rank	Lbs. per Acre	Rel. Rank	Lbs. per Acre	Rel. Rank	Lbs. per Acre	Rel. Rank	Lbs. per Acre	Rel. Rank
P. ampla	1421	(7)	1336	(1)	715	(1)	1977	(1)	1394	(1)	1372	(1)
A. sibericum	2129	(1)	820	(2)	486	(2)	1991	(2)	1115	(5)	1308	(2)
A. elongatum	2119	(2)	499	(5)	240	(11)	1630	(3)	1069	(6)	1112	(3)
A. inerme	1551	(4)	582	(3)	405	(3)	1315	(5)	912	(8)	953	(5)
A. desertorum												
Commercial	1492	(6)	406	(7)	317	(9)	1368	(4)	955	(7)	908	(7)
Mandan 571	1579	(3)	403	(8)	321	(8)	1258	(9)	1168	(3)	946	(6)
Nebr.-10	1506	(5)	453	(6)	341	(5)	1296	(6)	1236	(2)	971	(4)
Utah 42-1	1408	(8)	371	(9)	338	(6)	1260	(8)	1126	(4)	901	(8)
A. cristatum												
Commercial	1386	(9)	318	(10)	344	(4)	1163	(10)	858	(10)	800	(9)
A-1770	1276	(10)	252	(11)	270	(10)	1266	(7)	906	(9)	793	(10)
F. ovina var. duriuscula	1106	(11)	509	(4)	332	(7)	1043	(11)	701	(11)	780	(11)
Average	1543		541		374		1417		1040		983	
5% L.S.D.	629		310		180		431		296		358	
Oct.-June Precip. (in.)	12.47		9.78		5.79		13.23		12.99			

son. Following the second growing season, however, big bluegrass was highest yielding in all years. The yielding ability of this grass in comparison with other range grasses has been noted elsewhere (Hafenrichter, *et al.*, 1949). Big bluegrass began growth earliest in the spring. It has a winter growth habit (Schwendiman, 1956) and often becomes green in the fall and remains green throughout the winter.

On the basis of its performance in this trial big bluegrass could readily replace crested wheatgrass on many areas. However, it has one serious weakness. It is readily pulled up by grazing livestock. Attempts are being made to overcome this weakness through breeding to obtain a stronger root system.

Big bluegrass is also difficult to establish. Because of its small seed it cannot be seeded as deeply as the wheatgrasses and thus is more subject to drought in the surface layer of soil. Our experience indicates that it may be seeded very early in the spring to obtain stands.

Siberian wheatgrass is a close relative of and closely resembles crested wheatgrass. In this trial it outyielded crested wheatgrass in all years except 1957, when yields of the unfertilized grasses were comparable. The superior yielding ability of siberian as compared to crested wheatgrass has been noted at several dryland sites in Washington and Oregon.[2] On the basis of its performance in this trial siberian wheatgrass might replace crested wheatgrass on many of our drier sites. The species is in certified seed production in Oregon, Idaho, and Nevada, and it is estimated that total 1957 seed production was about 40,000 pounds.[2]

Tall wheatgrass yielded well in years with above average precipitation; however, in the extremely dry year of 1955 it was the lowest yielding of all grasses. This grass was later maturing than the other grasses and was always subject to drought prior to flowering. It is believed that tall wheatgrass is not adapted to this low rainfall area.

Whitmar beardless wheatgrass yields were comparable to those of crested wheatgrass. This grass is well adapted to this area but cannot be grazed as early in the spring as crested wheatgrass. It also has less seedling vigor than crested wheatgrass, and generally produces thinner stands.

Hard fescue was the lowest yielding of all grasses. This grass is a low producer and it is quite unpalatable. Its main use has been considered to be for conservation purposes. At the present time it is not considered to be of value in this area.

Precipitation-yield Relationship

Average yields of the grasses varied widely among years and were in proportion to the amount of precipitation received during the period October-June, inclusive (Table 2). With respect to precipitation, the relative yield rank of grasses (Table 2) is of interest. Both big bluegrass and siberian wheatgrass ranked high in all years regardless of precipitation. Tall wheatgrass ranked fairly high in the wetter years but ranked last in the dry year of 1955. Hard fescue tended to increase in rank in the dryer years and to decrease in rank in the wetter years. The commer-

[2]*Private communication with John L. Schwendiman.*

cial fairway wheatgrass ranked fourth in the dry year of 1955 but was ninth or tenth in the other years.

In testing range grasses the relationship of yield to precipitation is of much importance. The most desirable grass for this area is one which will produce good yields in dry years and respond to favorable years.

The influence of nitrogen fertilization upon grass yields is shown in Table 3. The response to nitrogen is striking and clearly illustrates that nitrogen is a major factor in the growth of range grasses when soil moisture is adequate. Soil moisture was not limiting through most of the growth period in 1957, which was an exceptionally good year.

The response to nitrogen varied among species as shown by the yield increase percentages listed in Table 3. The very poor response of hard fescue to nitrogen fertilization indicated that this grass may have a low nitrogen requirement. The response of tall wheatgrass to nitrogen was very poor. This is reasonable because its period of most active growth occurs later in the season than for the other grasses and at a time when soil moisture is rapidly becoming depleted. The magnitude of the response of a grass to nitrogen is dependent upon the availability of soil moisture and in particular on the availability of moisture in the surface foot of soil, for it is in this area that most of the nitrogen from a fertilizer application will be concentrated.

Table 3. Yields of 7 grass species with and without nitrogen in 1957.

Species	Nitrogen Treatment		Yield increase
	None	30 Lbs./Acre	
	Pounds per Acre	Pounds per Acre	Percent
A. sibericum	1115	3600	223
A. cristatum	880	2680	205
A. desertorum	1120	2800	150
A. inerme	912	2239	146
P. ampla	1394	3319	138
A. elongatum	1069	1792	67
F. ovina var. *duriuscula*	701	901	28
Average	1027	2476	

Conclusion

On the basis of the data presented both big bluegrass and siberian wheatgrass merit further consideration. Big bluegrass, because of its earliness and high yielding ability, could readily replace crested wheatgrass for range seedings if a strain can be developed which has a stronger root system. Siberian wheatgrass shows considerable promise and should be seeded on limited acreages for observation under grazing.

Until both of these grasses receive further evaluation, crested wheatgrass should continue to be the principal grass used in operations on the Oregon High Desert.

Summary

Four strains of crested wheatgrass, 2 strains of fairway wheatgrass, and 1 strain each of siberian wheatgrass, Whitmar beardless wheatgrass, tall wheatgrass, big bluegrass, and hard fescue were seeded in 1952. Herbage yields were measured in each of the succeeding 5 years. In 1957 the response to nitrogen fertilization was measured.

Big bluegrass and siberian wheatgrass were the two highest yielding species for the 5-year period.

Tall wheatgrass yielded well in good years but was a poor performer in years of low precipitation and is not believed to be adapted to this area.

Whitmar beardless wheatgrass is well adapted but cannot be used as early in the spring as crested wheatgrass and has weaker seedling vigor.

There were no significant differences among strains of crested or fairway wheatgrass.

Hard fescue is not believed to be of value because of its low yielding ability and low palatability.

Average yields of grasses varied widely among years and were in proportion to the amount of precipitation received during the period October-June, inclusive.

Nitrogen fertilization caused striking increases in the yields of all species except hard fescue and tall wheatgrass. The poor response of hard fescue was attributed to a low nitrogen requirement for this grass, and the poor response of tall wheatgrass was attributed to its most active growth period occurring later in the season than the other grasses and at a time when inadequate soil moisture limited the response to nitrogen.

It was concluded that if a stronger root system can be developed, big bluegrass would be preferred on many sites, and that siberian wheatgress may be substituted for crested wheatgrass, if grazing tests prove it to be tolerant of grazing. At the present time, however, crested wheatgrass is preferred in range seeding operations on the Oregon High Desert.

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Herbage Production and Composition under Immature Ponderosa Pine Stands in the Black Hills

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Approximately half of the 3.5 million acres in the Black Hills of South Dakota and Wyoming is dominated by ponderosa pine (*Pinus ponderosa*). The understory vegetation available to livestock and wildlife is strongly affected by this pine overstory. Timber management practices, while primarily designed to improve timber production and quality, exert a strong influence on the potential food supply for 60,000 to 80,000 deer and about 30,000 head of livestock. Under present management practices, these forested ranges produce an estimated 80 to 90 percent of the deers' annual food supply and 10 to 15 percent of the livestock's annual food supply.

Thinning as a silvicultural practice has been extensively used in the Hills. During the 1930's approximately 250,000 acres of second-growth pine were thinned by the Civilian Conservation Corps. At present, about 3,500 acres are thinned annually by the Black Hills National Forest. Thinning of dense second-growth pine stands on private land is encouraged by partial payment of cost through the Agricultural Conservation Practices program. An expanding pulpwood market may also increase commercial thinning in the near future.

[1]*Central headquarters maintained in cooperation with Colorado State University at Fort Collins. Research reported here was conducted in cooperation with the South Dakota School of Mines and Technology at Rapid City.*

Observations readily show that dense pine stands have little or no understory vegetation, but more open stands have varying amounts of grasses, forbs, and shrubs (Figure 1). In 1956 a study was made to determine if there was a consistent relationship between the amount and kind of understory vegetation and density of crown canopy, basal area, and pine litter produced by pine stands.

The influence of the forest overstory on herbage production has been studied in recent years, particularly in the southern pine belt. Gaines, *et al.*, (1954) found that herbage decreased on southern Alabama longleaf pine lands from 1,000 pounds per acre at zero basal area to 475 pounds at 110 square feet basal area, and then increased slightly as basal area increased further. Production generally tends to level off under the denser canopies (Halls, 1955; Gaines, *et al.*, 1954). Campbell and Cassady (1949) and Cassady (1951) found herbage production 5 to 10 times greater under very open savannah-like longleaf pine than in well-stocked plantations or second-growth stands. Read (1951) found that "poor" hardwood forest stands on south and west exposures produced 53 percent more herbage than the "good" hardwoods on the better north and east exposures.

Study Area

The Black Hills and Bear Lodge Mountains are located in southwestern South Dakota and northeastern Wyoming. The commercial ponderosa pine area, ranging from 4,300 to 7,000 feet in elevation, covers about 1.4 million acres. Annual precipitation is 18 to 30 inches within this zone, with approximately 75 percent falling during the growing season. Soils range from sandy loams to clay loams, and are derived from sandstones, limestones, schists, and granites.

Ponderosa pine makes up 95 percent of the commercial timber volume in the study area. White spruce (*Picea glauca*), generally found on moist northerly slopes at the higher elevations, accounts for the remaining 5 percent. Paper birch (*Betula papyrifera*) and aspen (*Populus tremuloides*) occupy cool, moist sites throughout the northern half of the Black Hills, often forming dense stands on old burns. Bur oak (*Quercus macrocarpa*) occurs commonly on the northern fringe of the Hills and in the Bear Lodge Mountains. Except for the mountain mahogany (*Cercocarpus montanus*) type in the western foothills, no extensive shrub communities are found in the Hills. Understory shrubs in varying amounts include common juniper (*Juniperus communis*) bearberry (*Arctostaphylos uva-ursi*), chokecherry (*Prunus virginiana*), snowberry (*Symphoricarpos occidentalis*), eastern hophornbeam (*Ostrya virginiana*), and hazelnut (*Corylus rostrata*). Understory herbaceous species include Pennsylvania sedge (*Carex pennsylvanica*), Kentucky bluegrass (*Poa pratensis*), roughleaf ricegrass (*Oryzopsis asperifolia*) poverty oatgrass (*Danthonia spicata*), pussytoes (*Antennaria* spp.) and goldenrod (*Solidago* spp.).

Methods

Thirty-one sample areas were located on timber sites within commercial pine stands. Locations were selected on the basis

FIGURE 1. Two adjacent ponderosa pine stands with same slope and exposure. *Left:* A 70 percent pine crown cover and 34 pounds of air-dry herbage per acre in 1956. *Right:* A 53 percent pine crown cover and 265 pounds of air-dry herbage per acre in 1956; stand thinned in 1933.

of estimated percentage of crown cover, with approximately five areas selected for each 10 percent crown cover class. Crown cover ranged from 0 to 71 percent. Basal area within the same stands ranged from 0 to 215 square feet per acre. (Basal area is the square feet of cross-sectional area per acre of all trees at breast height.) All sample areas were located in even-aged second-growth ponderosa pine having but one distinguishable crown canopy level. None of the sample areas had been logged or thinned within the past nine years.

Herbage production by species was determined by the weight-estimate method (Pechanec and Pickford, 1937). Twenty 9.6-square-foot circular plots were used at each sample area. The plots were located at 10-foot intervals on two parallel 100-foot transects. The transects were spaced 10 feet apart. Composition was based on air-dry herbage production.

Crown density was determined with a "moosehorn" crown density estimator (Garrison, 1949). Readings were made at the center of alternate 9.6-square-foot plots.

Basal area of the ponderosa pine stand was determined with a Bitterlich stick at a point midway between the two transects by using the method described by Grosenbaugh (1952). Four of the 31 basal area values were compared to subsequently calculated values, with an error of -5 to +16 percent.

Litter was collected from a one-square-foot sample at the center of alternate 9.6-square-

Table 1. Herbage production (pounds per acre air-dry) and composition (weight basis) under immature ponderosa pine in the Black Hills. 1956.

Species	Pine crown cover classes							
	0-19%		20-39%		40-59%		60-71%	
	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%
Fuzzyspike wildrye	59	4.3	0	0	0	0	0	0
Kentucky bluegrass	191	14.1	67	10.8	4	1.7	1	1.7
Little bluestem	20	1.5	1	.2	10	4.2	0	0
Poverty oatgrass	45	3.3	105	17.0	19	8.0	1	1.7
Prairie dropseed	122	9.0	3	.5	1	.4	0	0
Roughleaf ricegrass	111	8.2	23	3.7	19	8.0	12	20.0
Sedges	139	10.2	82	13.2	67	28.2	26	43.2
Other grasses (31 spp.)	210	15.5	44	7.1	11	4.6	1	1.7
Total grasses & sedges	897	66.1	325	52.5	131	55.1	41	68.3
Cream peavine	9	.7	2	.3	3	1.3	0	0
Goldenrod	24	1.8	9	1.5	tr.	tr.	1	1.7
Strawberry	24	1.8	3	.5	1	.4	0	0
Western yarrow	12	.9	20	3.2	2	.8	tr.	tr.
White clover	10	.7	12	1.9	tr.	tr.	0	0
Other forbs (58 spp.)	124	9.0	46	7.4	25	10.5	3	5.0
Total forbs	203	14.9	92	14.8	31	13.0	4	6.7
Aspen*	17	1.3	1	.2	5	2.1	0	0
Bearberry	93	6.8	159	25.7	6	2.5	5	8.3
Chokecherry	0	0	tr.	tr.	3	1.3	tr.	tr.
Common juniper	85	6.3	0**	0	30	12.6	1	1.7
Oregon grape	tr.	tr.	15	2.4	2	.8	3	5.0
Rose	11	.8	5	.8	5	2.1	tr.	tr.
Serviceberry	8	.6	1	.2	2	.8	tr.	tr.
Snowberry	29	2.1	19	3.1	16	6.7	5	8.3
Other shrubs (10 spp.)	15	1.1	2	.3	7	3.0	1	1.7
Total shrubs	258	19.0	202	32.7	76	31.9	15	25.0
Grand Total	1,358	100.0	619	100.0	238	100.0	60	100.0

*Aspen included in shrubs.

**Juniper was present in the area, but did not occur on the sample plots.

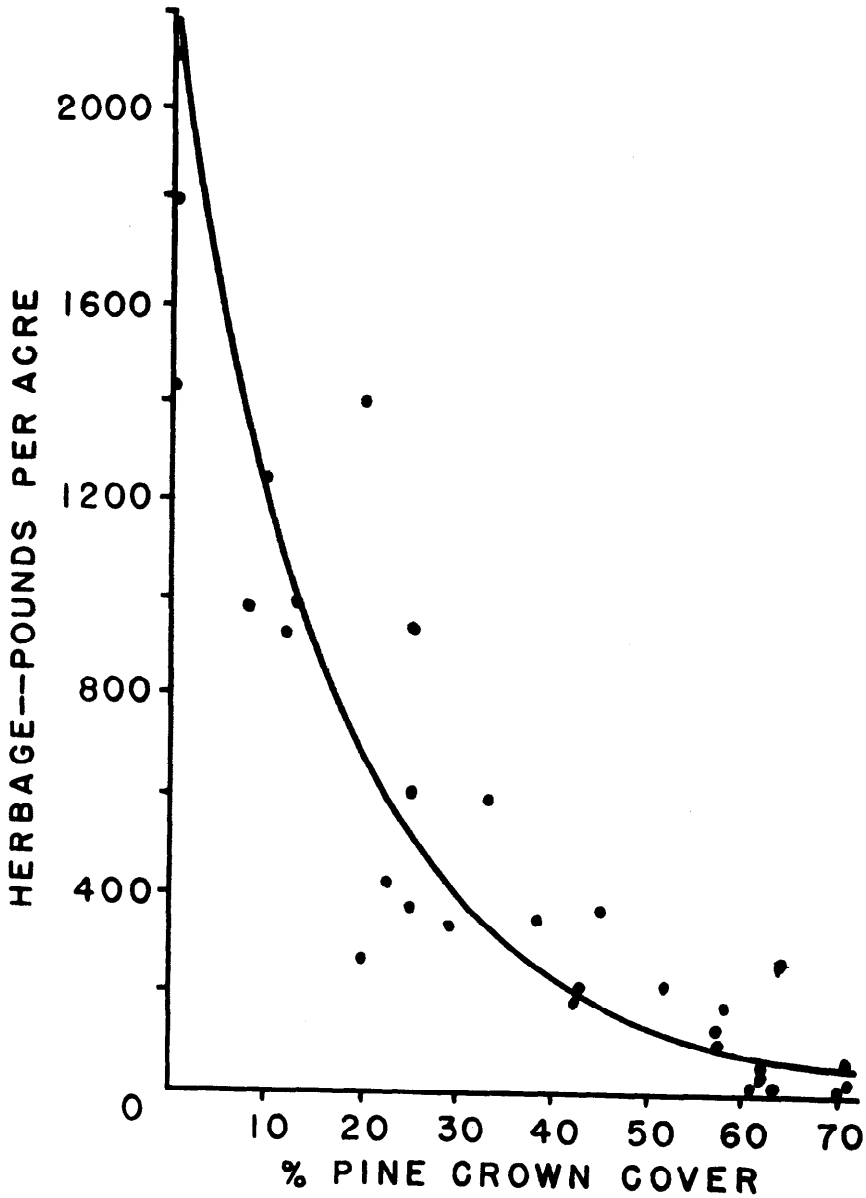

FIGURE 2. Production of understory vegetation as related to the density of the ponderosa pine canopy.

foot plots. This material was weighed in the field, and as with herbage, samples were taken for air-dry determination. Litter included all unincorporated organic matter from the pine overstory, pine needles, cones, bark, twigs, and small branches up to three-fourths inch diameter.

Herbage weights were transformed to logarithms, and statistical analysis followed Snedecor (1946).

Results

Herbage production decreased as crown cover increased. Although 2,160 pounds of air-dry herbage per acre was produced on clearcut areas, only 40 pounds per acre was produced under a crown cover of 70 percent (Fig. 2). This relationship is expressed by the equation $\log Y = 3.33545 - 0.02466 X$, where "Y" equals pounds of air-dry herbage per acre and "X" equals crown cover of the pine overstory in percent. The standard error of estimate was ± 0.29806.

All groups—grasses, forbs, and shrubs—increased as crown cover decreased (Fig. 3). However, grasses showed the greatest response in pounds per acre to reduction in crown cover; they averaged 25 pounds under the densest pine stands compared with 1,730 pounds on clearcut areas. Forbs increased from 5 pounds per acre under the densest pine stands to 305 pounds in clearcut areas, while shrubs showed the least response, increasing from 10 to 125 pounds per acre. (In constructing the family of curves in Figure 3, shrub and forb curves were calculated separately and then summed. The difference between this sum and total herbage production represents the production of grass and grass-like plants.)

A 40-percent crown cover approaches a normally-stocked stand of post-sized timber. Under such a stand, total herbage production was 225 pounds per acre. Grass production was 170 pounds, forbs 25 pounds and shrubs 30 pounds per acre, air-dry.

Herbage production and basal area also showed a logarithmic relationship ($\log Y = 3.22260 - 0.00936 X$). Dense crown cover was generally associated with high basal area. While basal area ranged up to a maximum of 215 square feet per acre (one plot), the maximum crown cover (71 percent) occurred between 150 and 180 square feet basal area. Combinations of high crown cover and high basal area were always associated with low herbage yields.

Herbage production also decreased as pine litter increased (Fig. 4). This relationship is apparently curvilinear, in contrast to the linear relationship found by Gaines, *et al.*, (1954) under longleaf pine in Alabama. In the Black Hills, ponderosa pine litter production ranged from 0 on clearcut areas to 19 tons per acre under dense pine canopies. Branches and small stems

smaller than three-fourths inch in diameter contributed substantially to the high litter values. Litter production greater than 10 tons per acre was usually associated with crown cover of 55 to 70 percent, and with basal areas greater than 110 square feet per acre.

Species reacted differently to changes in crown canopy (Table 1). Pennsylvania sedge and roughleaf ricegrass, abundant in the open areas, persisted under moderately dense (40-59 percent) and dense (60-71 percent) canopies. Poverty oatgrass, although abundant at intermediate crown densities, was relatively unimportant under either very open or very dense stands. Kentucky bluegrass, the most abundant species in openings, virtually disappeared at crown densities greater than 40 percent, as did fuzzyspike wildrye (*Elymus innovatus*) and prairie dropseed (*Sporobolus heterolepis*). Little bluestem (*Andropogon scoparius*) was erratic in occurrence, but was generally most abundant under open stands with southerly exposures.

Few of the 63 species of forbs persisted under even moderately dense canopies. White clover (*Trifolium repens*), American strawberry (*Fragaria vesca* var. *americana*), and western yarrow (*Achillea lanulosa*) were usually most abundant in openings, clear-cut areas or relatively open stands. However, goldenrod and cream peavine (*Lathyrus ochroleucus*) were persistent under moderately dense canopies.

Bearberry, common juniper, and snowberry were the most abundant of the 19 species of shrubs. Bearberry decreased sharply under crown canopies greater than 40 percent, while common juniper persisted under 40 to 49 percent crown cover. Snowberry decreased gradually as crown cover increased. Rose (*Rosa* spp.) and aspen were practically absent under dense canopies, while Oregon grape (*Mahonia repens*) was most abundant at intermediate to high crown densities. Serviceberry (*Amelanchier alnifolia*) and chokecherry, while not heavy producers on timber sites, were widespread and apparently persistent under moderate crown densities.

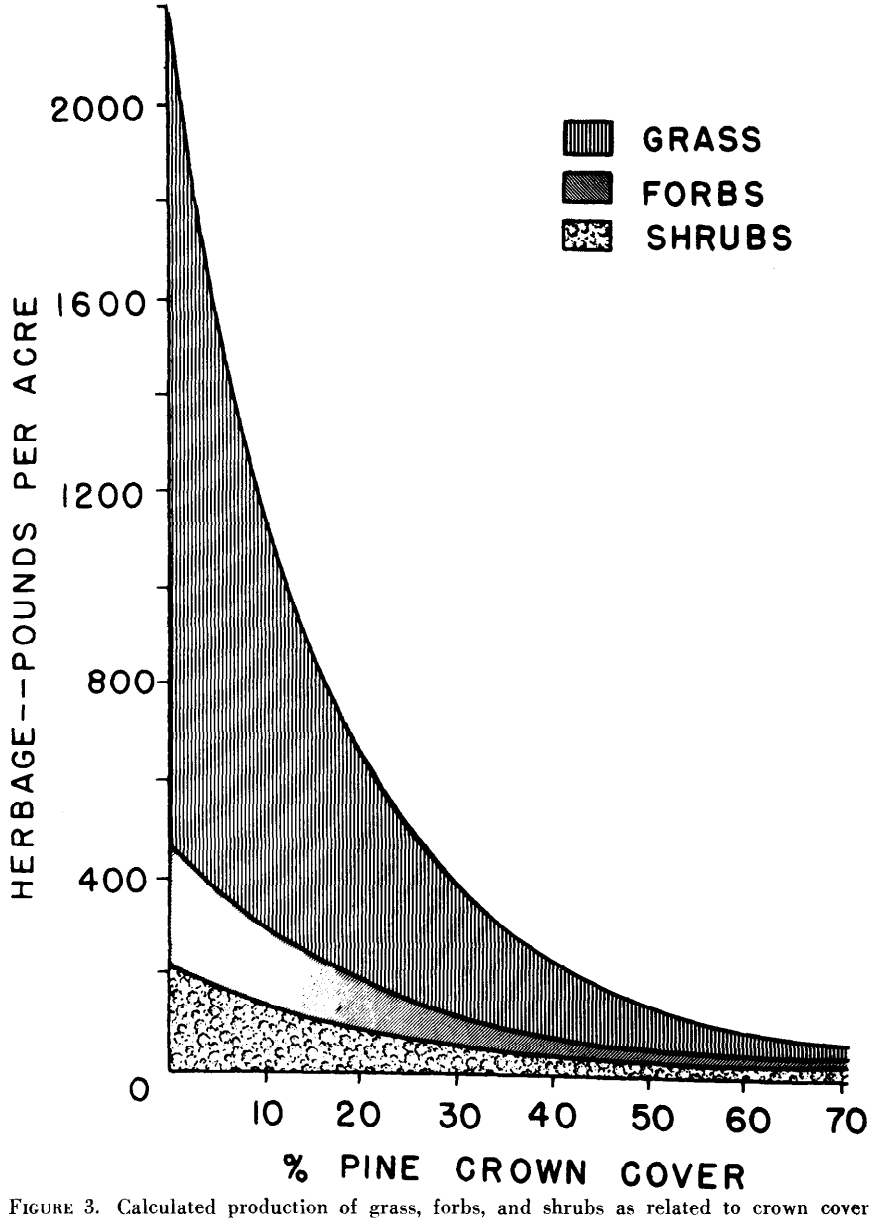

FIGURE 3. Calculated production of grass, forbs, and shrubs as related to crown cover of pine overstory.

The relative importance of species based on herbage produced changed as crown density increased. Sedges produced 10.2 percent of the total herbage under light crown canopies, but accounted for 43.2 percent of the limited production under dense stands. Similarly, roughleaf ricegrass rose from 8.2 to 20.0 percent and Oregon grape from a trace to 5.0 percent. Less shade tolerant species such as Kentucky bluegrass, fuzzyspike wildrye, and prairie dropseed decreased in percent composition as well as in actual production. Forbs occupied an ever decreasing part of total herbage production as density of the pine canopy increased.

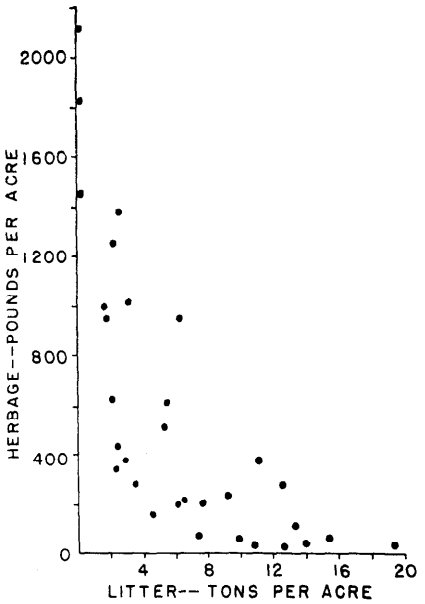

FIGURE 4. Production of understory vegetation as related to pine litter.

Discussion

Use of increased vegetation under thinned stands presents some management problems. Of the 1,300 pounds average difference in herbage production between open and dense stands, grasses and grass-like plants contribute 66 percent, while forbs contribute 15 percent, and shrubs 19 percent (Table 1). Much of this difference, therefore, would be most suitable for livestock use. Observations and a current preliminary study on livestock use of timber ranges indicate that cattle tend to avoid shade-grown vegetation where possible, even though apparently palatable species — *e.g.,* Kentucky bluegrass — are present. Sheep allowed free run of fenced suballotments in the timber type appear to graze shade-grown vegetation more freely. Intensive livestock use of this understory vegetation may lead to undesirable competition with deer for certain favored plant species.

Although all eight species of shrubs listed in Table 1 are important winter deer browse, bearberry, Oregon grape, and common juniper provide the bulk of the forage during the critical January-March period (Hill, 1946). The response of shrubs to more open pine stands was less than either forbs or grasses. This may be due to lack of an adequate seed source, inherent slow growth of some species, intensive use by deer, and perhaps other causes. In an explanatory study on the effect of silvicultural thinning on deer browse in the Black Hills, Bever (1952) concluded that with browse plants, the principal increase in production comes from parent plants in the area at time of thinning. This study supports Bever's conclusion. Absence of an adequate nearby seed source was thought to be a limiting factor in many cases. In such instances, thinning might have to be followed by planting of browse seeds or seedlings for maximum gains.

In the Black Hills, deer tend to winter at lower elevations but still within the ponderosa pine belt, generally preferring south and west slopes. These slopes, while of great importance to the wintering deer herds, are among the least productive for timber. Thinning such second-growth timber stands to and perhaps beyond accepted silvicultural standards appears to be one way of increasing the forage supply on critical deer winter ranges.

Summary

Herbage production was determined under ponderosa pine stands in the Black Hills in 1956. A logarithmic relationship was found between total herbage production and pine crown canopy, basal area, and pine litter. Total herbage production ranged from 40 pounds per acre air-dry under a 70 percent crown canopy to 2,160 pounds on clearcut areas. Grass, forb, and shrub production on clearcut areas was 1,730, 305, and 125 pounds per acre, air-dry, compared with only 25, 5, and 10 pounds under dense unthinned stands, respectively. Under thinned stands with a present crown canopy of 40 percent, grass, forb, and shrub production was 170, 25, and 30 pounds per acre, respectively.

Kentucky bluegrass, the heaviest producer under open stands and in clearcut areas, decreased both in pounds per acre and in relative importance as pine crown cover increased, as did little bluestem, prairie dropseed and fuzzyspike wildrye. The more shade-tolerant roughleaf ricegrass and sedges decreased in total herbage but increased in relative importance.

Bearberry, common juniper, and snowberry were the most abundant shrubs. Bearberry produced more pounds of browse than any other shrub under pine canopies of 0 to 40 percent. Common juniper was more persistent under denser pine canopies. Snowberry decreased gradually in production but increased slightly in relative importance as crown density increased.

Basal area ranged from 0 to 215 square feet per acre, crown cover from 0 to 71 percent, and pine litter production from 0 to 19 tons per acre.

Thinning immature pine stands on critical deer winter range to and beyond accepted silvicultural standards appears to be one way of increasing the forage supply.

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Some Effects Of Depth Of Seeding And Soil Compaction Upon Seedling Emergence Of Five Forage Species

Abstract of thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, in the Sub-department of Range Management, University of Wyoming, Laramie, Wyoming, January, 1958.

Some factors to consider under the methods of seeding range forage species are the many mechanical, biological and edaphic factors which affect seed germination, seedling emergence, and consequently the stand obtained. Depth of planting and soil compaction are primarily mechanical factors and are generally recognized as significant factors affecting emergence. Excessively deep or shallow planting may result in poor stands. A firm seedbed is recommended and further compaction of the soil around the seed is usually accomplished by a press wheel following the drill.

Depth of planting is associated with seed size and soil texture with the general rule of shallower coverage for small seeds than for large ones, and deeper coverage when planted in a sandy than in a clay soil. Little is known about the optimum amount of soil compaction or the variations in this factor which may be associated with seed size or soil texture.

A greenhouse study was conducted using a uniformly textured soil, to determine some of the effects of depth of seeding and soil compaction upon seedling emergence. The species used in the study, alfalfa *(Medicago sativa* L.), smooth bromegrass*(Bromus inermis* Leyss.), Russian wildrye *(Elymus junceus* Fisch.), timothy *(Phleum pratense* L.), and intermediate wheatgrass *(Agropyron intermedium* (Host.) Beauv.) were selected because they are commonly used in range reseeding and have a wide range of seed size.

Seeds were planted at five depths, surface, ¼, ½, 1 and 1½ inches. Soil compaction levels used on each depth were 0, 2, 4, 6, and 8 pounds per square inch (psi) of applied pressure. The study was divided into two treatments according to soil moisture. One treatment had a constantly moist soil and high humidity because the boxes in which the seedlings were grown had tightly fitted lids which prevented evaporation. In the second treatment, without lids, the seeds were germinated under variable soil moisture and low humidity conditions. Seedling counts were taken one week and two weeks after seeding.

Highest emergence for all species, pressures, and seeding depths was obtained in the closed box treatment. In all excepting the 1½ inch depth, the percentage seedling emergence was higher from the closed box treatment at the end of the first week than was attained from open boxes two weeks after planting.

Compaction levels had less effect under moist conditions and high humidity than under drier conditions and low humidity. The effects of compaction were less noticeable the second week than they were the first week after seeding. Seedling emergence from the 0 psi compaction treatment was significantly less than the other pressures tested. The 2, 4, 6, and 8 psi pressures were not significantly different in seedling emergence in either closed or open box the second week after seeding. There was a highly significant difference between pressure effects in the open box treatment at the end of the first week. In this instance, emergence from the 4 psi compaction was greater than other pressure treatments.

In comparing seeding depth regardless of the species or pressures used, only the 1½ inch depth showed significantly less emergence at both counting dates in the closed box treatment. Greater emergence differences between depths were obtained when seeds were germinated in the open box experiment. The first week results from this treatment showed that emergence from the ½ inch depth was highly significantly more than from all other depths; but by the second week after seeding, although the emergence from the ½ inch depth was greater, it was not significantly more than from the ¼ or 1 inch depths. Surface and 1½ inch depths in the open box, both counting dates, showed considerably less seedling emergence than the other depths.

The results obtained from this study indicate that soil compaction, depth of seeding, soil mosture and humidity all have some effect on seedling emergence. In the open box treatment, which more nearly approximates conditions found in the field than the closed box treatment, effects of pressure and depth were most noticeable. The shallow soil as used in this greenhouse study, dried rapidly, necessitating frequent watering which is unlike the usual field conditions found in much of the western United States and, consequently, this study did not simulate field conditions.—*Robert E. Adams,* Graduate Student, University of Wyoming, Laramie, Wyoming.

A New Method of Determining Forage Cover and Production on Desert Shrub Vegetation

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Research Assistant, Utah State University, Logan, Utah; Research Assistant, University of California, Berkeley; and Research Assistant, Utah State University, Logan, Utah.

Research into the utilization of vegetation by sheep and the nutritive content of the grazing sheep's diet on Utah's winter ranges from 1946 through 1948 by the staff of Utah State University led to the development and use of an improved method of sampling forage production in the saltbrush type of the northern desert shrub formation. (Green *et al.*, 1951; Sharp, 1949). This method is commonly called the "25-square-foot method."

It is the purpose of this paper to describe the method and present a preliminary evaluation of its field application.

The 25-square-foot method utilized the basic concepts underlying the range reconnaissance and square-foot density range survey methods (Stewart and Hutchings, 1936). It improves upon the former methods by use of a 25-square-foot plot frame sub-divided to facilitate plant cover estimating. The plot frame is mechanically similar to the coordinate method of mapping low shrubs (Pickford and Stewart, 1935).

The 25-square-foot method can yield information concerning plant density and forage production by species.

The equipment consists of a 25-square-foot frame (Figure 1) constructed of light steel tubing. The frame is hinged at the middle, so that it can be folded for easier carrying and is supported above the vegetation by six telescoping legs. Each leg is equipped with a lock screw and can be adjusted to vary the height of the frame from approximately 10 to 20 inches above the ground.

A sliding crosspiece, 1 foot wide and 5 feet in length, constructed of variously-sized welding rods is subdivided into 1/16-square-foot units. On a 25-square-foot plot, each 1/16-square-foot unit represent 0.25 percent of ground cover. The sliding crosspiece is used in five consecutive positions on the frame. The number of 1/16-square-foot units occupied by each species on each plot is estimated and recorded while observing the vegetation from directly above the crosspiece.

Forage production by each species can be determined by multiplying the number of 1/16-square-foot units occupied by each species by the average air-dry weight per 1/16-square-foot unit of that species. This average is determined by clipping, drying, and weighing a sample of the current year's growth from the species. The number of 1/16-square-foot units occupied by this sample is estimated and recorded prior to the clipping (Cook and Harris, 1950).

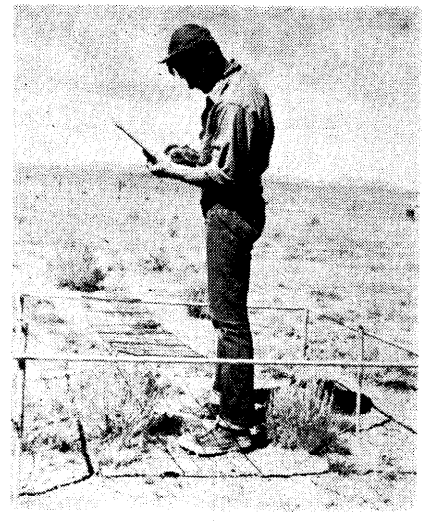

FIGURE 1. The 25-square-foot plot frame with the 5-square-foot sliding cross piece which was used to determine the percentage of ground covered by each species.

Methods and Procedure

Field Procedure

The study area was located in Curlew Valley, a typical salt-desert area in northwestern Utah.

The study was conducted on two pure vegetation types, shadscale (*Atriplex confertifolia*) and winterfat (*Eurotia lanata*). Field data were collected the fall of 1956, prior to the winter grazing season.

Thirty 25-square-foot plots were randomly selected in each vegetation type and three observers estimated each plot. Observer experience with the method varied. One had used the method for about six months, another briefly during the previous summer, and the third had had no experience. A short training period was conducted prior to estimating each type so that observers could compare estimates. After training, independent estimates were made by each observer. After all estimates for a given plot were recorded, the current growth was clipped from all plants. The harvested material was placed in paper bags for drying and weighing.

Office Procedure

The data collected were summarized and analyzed statistically to determine (a) the consistency among different operators estimating plant cover on identical plots, and (b) the relationship between the number of 1/16-square-foot units of plant cover and forage production.

The consistency of plant cover

Table 1. Analysis of variance for estimates of three observers on thirty plots of winterfat and shadscale.

Source of variation	Degrees of freedom	Mean squares
Shadscale		
Estimates	4	45.03*
Location	29	100.35**
Observer	2	0.22
Observer x estimate	8	0.58
Error	406	15.71
Winterfat		
Estimates	4	9.54
Location	29	47.91*
Observer	2	306.84**
Observer x estimate	8	0.27
Error	406	9.59

* Significant at the 5 percent probability level.
** Significant at the 1 percent probability level.

or density estimates by individual operators was tested by analysis of variance (Table 1). Simple linear regression was used to correlate estimates of cover with weight of herbage produced (Figures 2 and 3.)

Results and Discussion

Results from this study indicate that the 25-square-foot method is a useful tool for estimating plant cover of certain types of desert shrub vegetation.

Operators were consistent in estimating plant cover on shadscale, whereas, on winterfat they were more variable. (Table 1). In this experiment no significant differences were detected among operators' estimates of shadscale. For winterfat, however, the estimates of the three operators differed significantly. These differences probably were due to the inherent growth characteristics of winterfat plants which have irregular and poorly defined outlines. Shadscale peripheries are regular and well defined.

A definite correlation between plant cover estimates and herbage production was found. Figures 2 and 3 show the linear relationship between these two for shadscale and winterfat. The correlation coefficients for shadscale were highly significant for all observers. Actual variations in herbage production accounted for 90 percent or more of the variations in estimated plant cover. For each change of 1/16-square-foot in shadscale cover there was a corresponding change of 3.0 to 3.5 grams (95 percent confidence interval) of air-dry herbage production. Correlation coefficients for winterfat were significant for all observers. However, the correlations were not as high as those for shadscale. In this case only 44 to 60 percent of herbage production variations were accounted for by plant cover variations.

For each change of 1/16-square-foot unit in winterfat plant cover there was a corresponding change of 1.2 to 1.5 grams (95 percent confidence interval) of air-dry herbage production. It appears that the relationship between estimated plant cover and actual herbage is dependent upon the growth forms of the individual species.

In this experiment a series of entire 25-square-foot plots were clipped in order to measure correlations between plant cover and herbage production. Variability in growth forms among sites for a given species may necesitate measurements of correlations for each major area studied.

The subdivision of the plot frame into 1/16-square-foot units probably contributed to the observers' ability to estimate plant cover. The ability of men to agree upon density values for a given quantity of vegetation appears to increase with subdivision of a plot.

The method appears to be best adapted to intensive vegetation surveys on relatively small areas. Bulky equipment may restrict

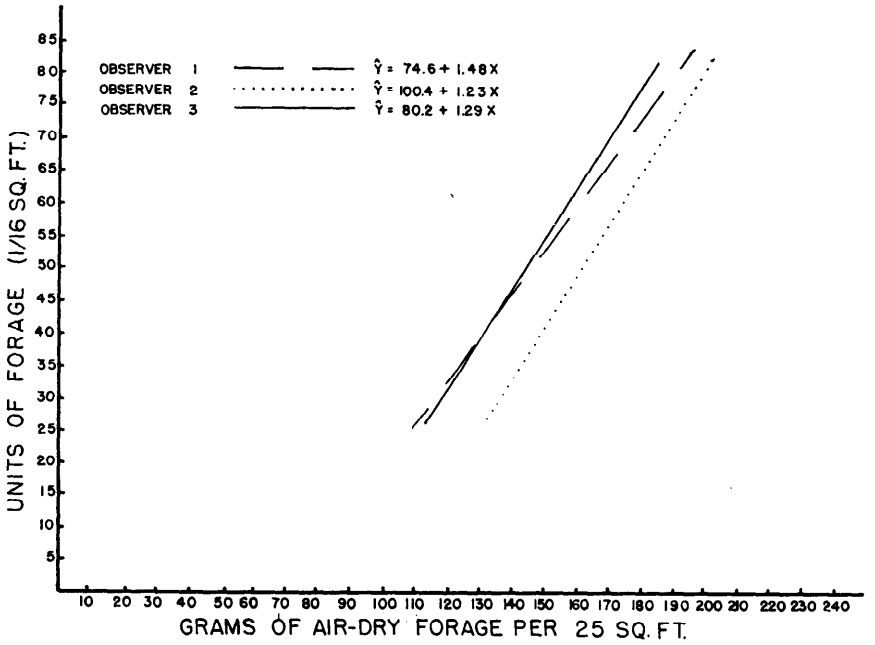

FIGURE 2. Regressions for three observers expressing relationships between plant cover and air-dry forage production (current year's growth) for shadscale.

its use in rough terrain which must be traversed on foot.

Summary

An improved method of sampling forage cover on desert shrub vegetation was developed by the staff of the Range Management Department of Utah State University. A study was conducted to determine the effectiveness of the method in obtaining a correlation of plant density estimates and forage production on two different vegetation types and the ability of three operators to obtain similar estimates of vegetation plant cover.

A significant correlation was found between plant cover and current forage production on both types of vegetation. Operators were found to be consistent in estimating density of shadscale, however, their estimates differed significantly in winterfat vegetation. This was attributed to the more irregular crown outline of winterfat compared to that of the shadscale.

The method appears to be a valuable research tool in estimating plant cover and herbage production. However, because of the bulky equipment that is used, it may be best adapted to intensive vegetation surveys on relatively small areas.

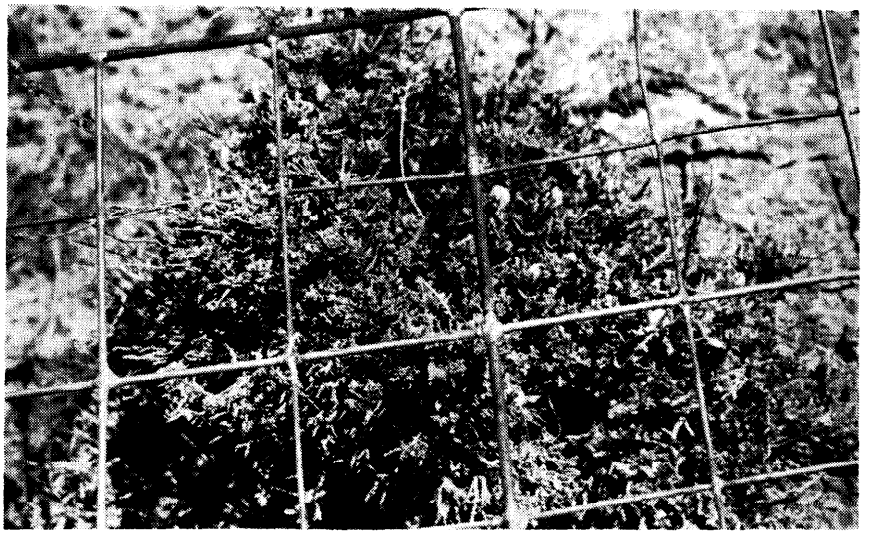

Figure 4. View of the 5-square-foot cross piece used to estimate the percentage of ground covered by each species.

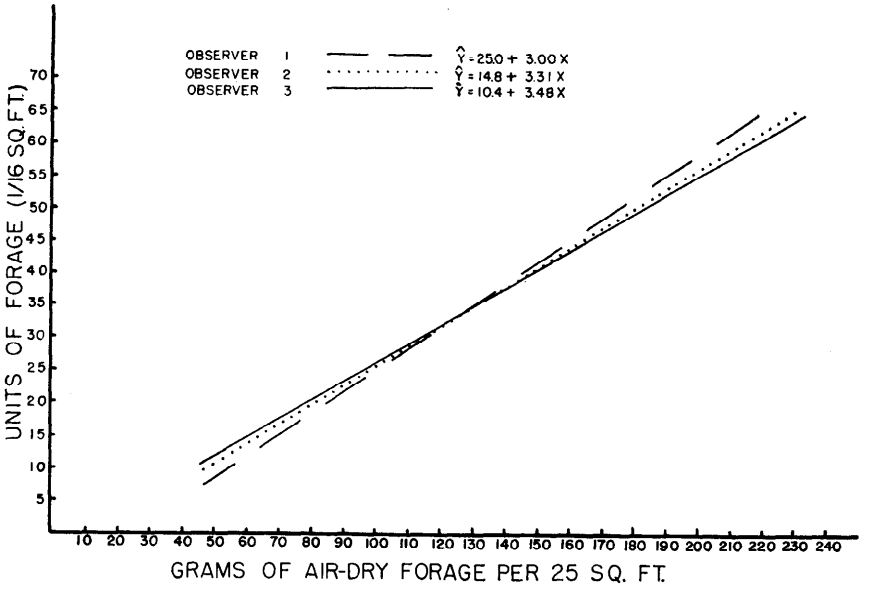

FIGURE 3. Regressions for three observers expressing relationships between plant cover and air-dry forage production (current year's growth) for shadscale.

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TECHNICAL NOTES

GRASSHOPPER INFESTATIONS IN RELATION TO RANGE CONDITION[1]

N. J. NERNEY

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Observations on range grasshoppers on the Ash Creek Flat area on the San Carlos Apache Indian Reservation in Arizona from 1953 to 1956 show that differences in population levels are due primarily to differences in the condition of short-grass rangelands. It was found that preferred habitats of economic grasshopper species were associated with poor rangelands generally dominated by low-growing weeds, and that populations of grasshoppers increased during years having normal or above-normal precipitation and declined in seasonal periods and years having drought conditions.

In 1953 adult populations ranged up to 18 and averaged 14 per square yard. The migratory grasshopper (*Melanoplus bilituratus*) was dominant. By late May grasshoppers were migrating in search of suitable food plants. Summer rainfall was below normal, and second-generation nymphs died from lack of food. About 20 percent of the unhatched eggs of *M. bilituratus* and *M. cuneatus* were desiccated.

In 1954 adult populations ranged up to 52 and averaged 21 per square yard. *Aulocara elliotti* replaced *M. bilituratus* in dominance because of the abortive hatch in 1953. Both early-spring and summer rainfall were normal or above, stimulating a good growth of annuals (mostly alfileria) on heavily grazed areas. The perennial grass cover showed decided improvement on rangeland having good management practices, such as rotation of pastures, seasonal distribution of the grazing load, limitation of the number of cattle to prevent overgrazing, and adequate and well-distributed watering tanks. The grasshoppers developed normally. Nymphs with peak populations of 90 per square yard completely devastated the vegetation on a very sparse perennial-grass area, and the grasshoppers destroyed seedlings as they appeared during the following summer rains.

In 1955 drought conditions prevailed in the spring, although soil moisture was sufficient for a good grasshopper hatch. Initial numbers with hatching incomplete averaged 23 and ranged up to 39 per square yard. *M. bilituratus* replaced *A. elliotti* as the leading species in the area where the vegetation was completely destroyed in 1954, because the low-feeding *elliotti* females had insufficient food in 1954 for egg production. Populations of early-instar grasshoppers declined about 50 percent because of unfavorable food-plant conditions. In late May about 70,000 acres of rangeland were treated with an aldrin spray, and the grasshoppers were controlled. Following good summer rains there was a lush growth of annuals, mostly grasses, in all the sparsely vegetated areas, and perennial grass stands were strengthened.

In 1956 there was sufficient soil moisture for grasshopper hatching and for the growth of preferred food plants during the spring. Low summer rainfall resulted in a spotty hatch of late- or summer-hatching species, and populations declined from lack of suitable food. Similar population changes were observed on other rangeland areas in Arizona. Grasshoppers competed with livestock for available forage and were at least partly responsible for the decline of short-grass stands in some areas. In a heavily grazed, sparse grass area about 70 percent of the herbage was eaten by an average of about 15 grasshoppers per square yard in comparison with about 20 percent by equal numbers in a moderately grazed, fairly good perennial grass area.

[1] *Abstract of a paper presented at the meeting of the Arizona Section, American Society of Range Management, Show Low, Arizona, July 30-31, 1957.*

[2] *In cooperation with the Bureau of Indian Affairs, U. S. Department of the Interior.*

MINOR MINERALS AND OTHER NUTRIENTS IN LOUISIANA RANGE FORAGE

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Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, New Orleans, Louisiana; and Feeds and Fertilizer Laboratory, Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana.

Tests in central Louisiana show that important forage plants of longleaf pine-bluestem ranges contain ample trace minerals during spring and summer. The investigations also revealed

that potassium is very abundant in the forage species tested. As in previous studies, calcium was found to be adequate and crude protein and phosphorus very deficient.

Four major native forage species were collected at the early, full, and mature green leaf stages of development. Pinehill bluestem (*Andropogon divergens*) is the most abundant grass in the gently rolling hills of central Louisiana. Slender bluestem (*Andropogon tener*) is more common in the relatively open flatwoods of southwest Louisiana. Narrowleaf panicum (*Panicum angustifolium*) was selected as representative of a large group of upland panicums found throughout the piney woods area. Swamp sunflower (*Helianthus angustifolius*) is the preferred forb on most longleaf pine ranges. These species were collected from two distinct soil types common in Louisiana, Beauregard very fine sandy loam and Ruston fine sandy loam.

The Feeds and Fertilizer Laboratory of the Louisiana Agricultural Experiment Station tested all samples for cobalt, iron, copper, manganese, zinc, molybdenum, magnesium, sulphur, potassium, calcium, phosphorus, and crude protein. Crude protein, phosphorus, and calcium were analyzed by standard procedures of the A.O.A.C. (1950), other minerals by the methods of Parks *et al.* (1943).

All species, at all growth stages and from both soil types, contained adequate amounts of all the minor minerals. There is no advantage, therefore, to using expensive minor-mineral supplements for beef cattle grazing on longleaf-pine bluestem ranges. Several of the minor minerals, especially cobalt, copper, and manganese, were present in rather large amounts. Since excessive quantities can be harmful to animals, indiscriminate use of trace-mineral supplements should be avoided.

Potassium also proved ample. As in previous studies, calcium was adequate. Phosphorus was deficient at all seasons and crude protein held up only in samples taken in spring and early summer—findings that corroborated those of Campbell and Cassady (1951), Campbell *et al.* (1954), and Fraps and Fudge. (1940).

The need for phosphorus and protein supplements and the ability of the native forage to supply adequate minor elements is being demonstrated in practical herd tests in central Louisiana. In these tests typical open-range cattle are put under a program of simple, yearlong range and herd management. Cottonseed cake is fed from early fall until late spring. Bonemeal and salt are kept before the animals yearlong. No minor mineral supplements are used.

The ranges are fenced and stocking is moderate. Calves are dropped from early December through March and weaned in August.

Under this management, cow weights have risen from 700 to 900 pounds in three years. Calf crops average over 80 percent, and calves weigh more than 425 pounds. In effect, beef production has been more than doubled.

These practical herd tests, together with the laboratory analyses, strongly suggest that minor mineral elements are not a limiting factor in beef production on longleaf pine-bluestem ranges. Native forage must be supplemented with crude protein and phosphorus, however, to maintain high calf production from range herds.

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THE EFFECT OF NITROGENOUS FERTILIZERS ON CATTLE DISTRIBUTION ON MOUNTAIN RANGE

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One of the most important problems facing range managers in the western states is non-uniform distribution of livestock. The problem increases in importance on ranges with high uplands with interspersed valleys and stream bottoms. Cattle have a natural tendency to congregate in the valleys and stream bottoms. As a result of this tendency, lowlands are frequently heavily grazed while adjacent slopes and hilltops remain lightly utilized.

Common range practices used to encourage cattle to utilize forage in rough areas include (1) development of salting, watering and supplemental feedgrounds within lightly used areas, (2) drift fences, and (3) range riders. Although one or a combination of several of these practices has been helpful in obtaining uniform grazing, much remains to be desired.

Studies conducted in 1955 on the Bighorn National Forest in-

dicated that the application of 67.5 pounds of nitrogen in the form of urea was effective in obtaining grazing on areas ordinarily used very lightly. The production of grass was not significantly increased.

Procedure and Results

On June 20, 1956, a strip of rangeland 350 feet wide and one mile long was fertilized with urea at a rate of 67.5 pounds of nitrogen per acre. The material used was applied by airplane to an area which received only 15 percent utilization in 1955.[1] Utilization checks, based upon leaf height of Idaho fescue made in September of 1956 showed 73 percent use on the area actually fertilized and 55 percent use of the adjoining non-fertilized area.

Table 1. Summary of analysis of variance of forage utilization on fertilized and non-fertilized areas in the Big Horn Mountains

Source of Variation	D.F.	Mean Square	"t" Value
Treatments	2	865.28	26.81**
Carryover *vs* current effect	1	597.54	18.52**
Check *vs* fertilized areas	1	1130.00	35.02**
Error	9	32.27	

** Indicates significance at .01 level.

On June 28, 1957, 30 acres of rangeland were fertilized with an aerial application of 200 pounds per acre of ammonium nitrate (33 percent N)[2]. Utilization checks, based on leaf height of Idaho fescue, were completed in September on the 1956 and 1957 fertilized areas and on an unfertilized check area. Each area was sampled four times, measuring 50 plants per sample. Mean utilization based on these data are as follows: check area, 29; 1956 plot, 41; and 1957 plot, 58 percent. These data were subjected to analysis of variance, and the results are presented in Table 1.

These statistics indicate that the application of 67.5 pounds of nitrogen per acre increased utilization of forage on normally lightly grazed areas and that the 1956 application had a significant carry-over effect upon livestock distribution in 1957.

[1] *Material furnished by the Allied Chemical and Dye Corp.*

[2] *Material furnished by the Phillips Petroleum Co.*

BOOK REVIEWS

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

Managing Southern Soils. By H. B. Vanderford. *John Wiley & Sons, Inc. New York. 378 pages. 1957. $4.75.*

This book was written primarily for agricultural students, farmers and farm leaders. Of the 16 chapters, one on Managing Grassland Soils and one on Classifying and Judging Land may be of particular interest to Southern Section members.

Other chapter headings are: Soils and Life, Nature and Properties of Soils, Soils in Southern Agriculture, Controlling and Conserving Soil Water, Preparing Soils for Crop Production, Liming Sour (Acid) Soils, Fertilizing Crops and Soils, Managing Soils for Field Crops, Managing Soils for Special Uses, Managing Soils in Dry Regions, Buying Farm Land, and A Forward Look.

A title such as "Conservation Farming in the South" would have more accurately conveyed the contents and type of this book. Land use capability is fully covered, but the more technical and perhaps more basic phases of soil science are generally only lightly or incompletely developed.

Proper logic is not always used. For example, Vanderford states, "The number of acres of land used for pasture has increased considerably (in the South) during the last decade." But the only proof, if intended for this purpose, is a table showing the 1954 acreages of land in crops and in pastures in each of the southern states and in all combined. The conclusion drawn is that there is more land in pasture than in crops in the South, which is quite different than showing any increase or extent of increase in pasture acreage. Actually, only a casual study of the figures presented on this subject suggest that even the conclusion stated should have reservations. It is true that there is more total acreage in pastures than in crops in the South, but over half of the total pasture acreage is in one state, Texas, and in 11 out of the 15 southern states listed, more land is in crops than in pastures.

This book has other weaknesses. Several statements fail to convey the thought that one feels the author wanted to put across. Oftentimes, in the development of a statement, the emphasis is charged to a different subject or phase than one started with, which is disconcerting to say the least, and inconclusive at best. Another brief example can be cited: "Since pastures produce the cheapest

feed for livestock, we must develop and improve pastures in order to obtain the high quality forage needed."

Forage recommendations are satisfactory only in a general way. *Lespedeza sericea* and kudzu, as recommended, may be adaptable to the poorer, dry land soil sites, but mention should have been made of the general inability to get satisfactory livestock production from sericea, and the lack of persistency of kudzu stands unless particular grazing management is practised. Similarly, tall fescue grasses is suggested for wet soil conditions but no mention is made of possible lack in forage quality, especially for milk production.

The section on grazing management is too brief and somewhat weak. While it is generally recognized that newly seeded pastures should not be grazed too early, undergrazing of such pastures may also cause permanent harm by allowing quick growing species to dominate and suppress species growing more slowly. The recommendation that enough fertilizer be applied to last four years when pastures are established, may be satisfactory on some soils and with some pasture species or mixtures, but annual or even more frequent fertilization is necessary on some soils and for some pasture species or mixtures. A saving feature of this and other sections is that readers are advised to seek information from their experiment stations for their specific farm situations.

The chapter on classifying and judging land should satisfy anyone interested in this subject.

An exception or at least a caution would have been advisable to the liming recommendation of orchard soils. Considerable harm (induced Zn deficiency) can be done to pecan orchards on the lighter soils of the Coastal Plains by overliming.

There is much repetition in statements and in photographs throughout the book. For emphasis, and as a principle of teaching beginners, this may be desirable.

This book contains numerous practical and common-sense suggestions. It also points out that soil and crop practices should vary not only with soil conditions and potentials but with the individual farmer's wishes and facilities. While many details are inadequately treated on soils and fertilizer practices as related to forage crops, there may be sufficient facts presented in this book to warrant its purchase. —*O. E. Sell,* Georgia Experiment Station, Experiment, Georgia.

Modern Breeds of Livestock. By Hilton M. Briggs. *The Macmillan Company, New York. Second Edition. 754 pages. 1958 $8.50*

This volume is a concise yet comprehensive encyclopedia of breeds of beef and dairy cattle, hogs, sheep, goats, horses and jacks. Each breed is discussed as to history, good and bad characteristics, and general worth in these modern times.

Outstanding individual animals are illustrated with excellent photographs. Charts and diagrams of pedigrees and lines add clarity to the written text. Noted individual animals and families are named and discussed. Also given are the methods of breeding and selection through which the breeds were established and improved. Wherever appropriate, mention is made of registry associations and breed magazines.

For easy reference, the book is divided into four divisions: I. The Breeds of Cattle; II. The Breeds of Hogs; III. The Breeds of Sheep and Goats; IV. The Breeds of Horses.

In this revised edition, a chapter covering Santa Gertrudis, Brangus, Charbray and Beefmaster cattle has been included. Material on American crossbred dairy cattle has added to the chapter on American dairy cattle. Three chapters formerly devoted to draft horses have been consolidated as a result of the diminishing importance of these breeds.

Dr. Briggs has brought "Modern Breeds of Livestock" completely up to date, and the book should be valuable to all who are interested in animal husbandry in general.

The book is well written and well organized and this reviewer found it interesting reading.

It might have been well, however, if the statement that Zebu cattle perspire freely had been labeled as controversial. Also, the claim that F_1 calves from Aberdeen-Angus crosses are 100 percent polled is subject to question.—*E. H. Vernon,* Iberia Livestock Experiment Farm, Jeanerette, Louisiana.

The Craftsman's Manual. By F. J. Christopher and Rosemary Brinley Christopher. *Philosophical Library, Inc. New York. Volume I-192 pages; and Volume II-192 pages. 1958. $20.00.*

For members of the American Society of Range Management who have a need for and take pride in working with their own hands to improve the places in which they live, this comprehensive British work is an excellent reference and source of information. The easily understood text material is profusely illustrated. Each of the twin volumes contain 8 page-size color plates (7½ x10 inches) and 64 black-and-white plates. Supplementing these are 217 annotated sketches appropriately depicting the subject at hand.

Volume I deals with the structure of the house and its maintenance. The variety of topics included is indicated by selected headings in the text: (1) home maintenance, (2) handy man's workbench and basic tool outfit, (3) main services, (4) interior house repairs, (5) exterior house repairs, (6) outbuildings, fences, gates and paths, (7) carpentry, (8) interior decorating, and (9) exterior decorating.

Volume II deals with the contents of the home. Instructions in this volume are devoted to such things as upholstery, cushions, curtains, bedding, floor covering, lamps, lampshades, picture frames and mirrors. The second volume also contains instructions in simple cabinet-making that is well within the scope of the average home handy man. In order not to repeat any of the information given in Volume I, parts of the descriptions in this volume refer to subject matter in the first volume. In this sense Volume I can stand alone while Volume II cannot.

Volume I refers to jobs usually done by the handy man and should, therefore, have included the section on cabinet making. Whereas, the section on interior decorating could have best been included in the second volume which caters to the

handy woman. In other ways, too, the arrangement of sections appears without a reasonable order of development. For example, the handy man is given instructions on house repairs, then carpentry, then skips to another volume to find cabinet-making.

The editors are to be commended for compiling descriptions, methods and processes for the multitude of "do-it-yourself" jobs which frequently crop up in and about the home. — *Ralph H. Hughes,* Southeastern Forest Experiment Station, Tifton, Georgia.

A Flora of the Marshes of California. By Herbert L. Mason *University of California Press. Berkley and Los Angeles 878 pages. 1957. $10.00.*

This book, which has been a long time in preparation, should prove invaluable for field work in the wet lands of the west. It is the result of work performed by Dr. Mason and his assistants on a Pittman-Robertson grant, sponsored by the California Department of Fish and Game, the U. S. Fish and Wildlife Service, and the Botany Department of the University of California. Although intended for use in California, it should also prove helpful in identifying plants in marshes elsewhere in the west. Its greatest value should be to wildlife managers and ecologists concerned with the waterfowl, fur-bearers, and other life of the marshes. The taxonomic problems encountered by those who work such areas have in the past been difficult to resolve, but should be less difficult now that this book is available. Because marsh edges have considerable value in forage production for livestock, this book should also prove useful to range managers.

Dr. Mason's ideas on vegetation are presented in the introduction, where he points out the problems encountered in attempting to group marsh plants into communities, and expresses a preference for classification by habitat. Unfortunately, the problems encountered in attempting to define and classify communities are also encountered when one attempts to define and classify habitats. Just as no two stands of vegetation are completely similar, so also no two habitats are entirely alike, and any classification must in part be arbitrary.

Most wildlife or range managers must identify plants at times of the year when neither flowers nor fruits are to be found. A key based on vegetative characteristics would be of great value. This book, like most others, does not fill this need. However, the excellent illustrations, mostly by Mary Barnas Pomeroy, should help greatly to identify the plants. Complete and useful drawings are available for a high percentage of the genera and many of the species.—*Raymond F. Dasmann.* Division of Natural Resources, Humboldt State College, Arcata, Calif.

CURRENT LITERATURE

Edited by Lee A. Sharp, College of Forestry, University of Idaho, Moscow, Idaho

RANGE PLANTS

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SOCIETY BUSINESS

Message From the President

Suggestions on Journal of Range Management policy have come verbally and in writing from several widely separated sources, one of the latest being the letter to the Editor by A. M. SCHULTZ in the May 1958 Journal. I am gratified that our members are sufficiently interested in the Society and the Journal to speak up. This is a sign of a live, active organization. The Sections should discuss the Journal and be prepared to present their reactions at the Annual Meeting in Tulsa, January 26-31, 1959.

The Board of Directors, meeting at Kamloops, B. C., in July 1958, discussed Journal policy at some length. JIM FINLEY and MEL MORRIS were asked to summarize the comments on the many considerations involved. Their statement is printed below.

R. S. Campbell
President

JOURNAL POLICY

Some criticism of the trend in editorial policy of the Journal of Range Management has come to the attention of the Board of Directors. In a democratic organization such as the American Society of Range Management, constructive criticism and suggestions for directing our efforts toward the study and application of improved range management practices are encouraged and welcomed.

We feel that the development of the scientific knowledge necessary to range management and the art or skill in applying this knowledge are equally important. Both are essential in bringing our ranges up to their best productive capacity.

Accomplishment of the Range Society's aims can be hastened by encouraging free expression of facts, ideas, and experiences by all segments of the Society membership, in all fields of range management. Certainly the importance of our goal merits the full cooperation and contribution by those capable of producing the best and most appropriate scientific articles, as well as by those who may contribute reports of applied management with sufficient merit to be published in the Journal.

As long as the Society is limited in its ability to finance more than one kind of publication, it will be impossible to fully satisfy all interests. Furthermore, we must recognize the difficulty of accumulating a sufficient backlog of either scientific discourses or articles on applied range management.

It is the consensus of the Board of Directors that over the year the Journal has maintained a standard of publication of exceptional interest and value to the readers as a group. The Board appreciates the fine work of the Editor and has full confidence in the judgment of the Editor and the Editorial Board in choice of material for the Journal.

Members, Board of Directors
JIM FINLEY
MELVIN S. MORRIS

RANGE MEN ABROAD

HAROLD F. HEADY, University of California, left for British East Africa in August for a year of research into the effects of both wild and domestic animals on grasslands. The work is sponsored jointly by the Department of Agriculture in Kenya through the Fulbright Program and by the Guggenheim Foundation. HAROLD will be headquartered at the East African Agricultural and Forestry Research Organization, Kikuyu, Kenya.

WITH THE SECTIONS

ARIZONA

The Arizona Section will hold its winter meeting in Nogales, December 5-6. Headquarters for the meeting is the Hotel Rancho Grande. CLARK MARTIN is chairman of the program committee, and WALTER ARMER is chairman of the arrangements committee.

Tentative plans for the meeting call for registration and council session on Thursday evening, December 4. A half-day tour and a half-day meeting is set for Friday the 5th, with Section banquet scheduled for that evening. The meeting will close with a half-day tour on Saturday, December 6.

JIM FINLEY (National Director), WAYNE KESSLER, and FRANK GYBERG attended the Summer Meeting of the Society at Kamloops, B. C., July 10-12.—*Wayne Kessler*

COLORADO

The first summer meeting of the Section at Trinidad was an interesting and enjoyable one thanks to the leadership of BOB SEARWAY, DON ROBERTSON, and JOE ALESSI; and to the fine cooperation of ranchers CLEO JACK and MERRITT MCDONALD. Twenty-seven members and guests attended.

The second summer meeting was held at the Manitou Experimental Forest and the Trout Creek watershed area, 50 miles west of Woodland Park, July 18-19. The meeting included a tour of the experimental forest to observe grazing and watershed research studies. DUDLEY LOVE reviewed current range and watershed management research at the evening program on July 19.

On the Trout Creek tour Saturday, JACOB JAUCH from Salida reviewed the history and explained the objectives of the Trout Creek project.

IDAHO

The Idaho Section held its summer field tour in southeastern Idaho, June 20-21, with the Lyman Richwine Chapter as host. The dinner and business meeting at Pocatello on June 20 featured a talk by A. E. NIELSEN, big game biologist with the Idaho Fish and Game Department.

The tour on June 21 included stops on the Fort Hall Indian Agency lands; at the FRED RINDLISBAKER ranch on Corral Creek to view improved range seedings; at the DELOS HUBBARD ranch, Chubb Springs, to inspect grass-alfalfa seedings; and at the WM. LLOYD ranch, Sulphus Canyon, to study grass seed production problems and inspect new range seedings.—*Paul A. Dalke*

INTERNATIONAL MOUNTAIN

The summer meeting and tour of the Section was held at Dillon, Montana, June 12-13. Guest speaker at the banquet was JACK BRENNER, who talked on "Grass and Nutrition." Following BRENNER'S talk, BILL BURDICK spoke on the methods used in arriving at the cause of nutritional problems. One hundred-fifty members and guests attended the session.

The feature of the tour was the stop at an area formerly dominated by big sagebrush, which had been brought back to a good grass cover by deferred grazing. The field had been used for spring and summer grazing up to 1952 and supported a waist-high cover of sagebrush at that time. Since 1952 the field was deferred from May 1 to December 1, but then had full winter use. Big sagebrush has been largely eliminated, and the cover now consists mainly of needle-and-thread, Sandberg's bluegrass, and Indian ricegrass.

The meeting was arranged by HOMER TURNER, ED ATKINS, and BEN SLANGER, with the help of others.—*A. Johnston*

KANSAS-OKLAHOMA

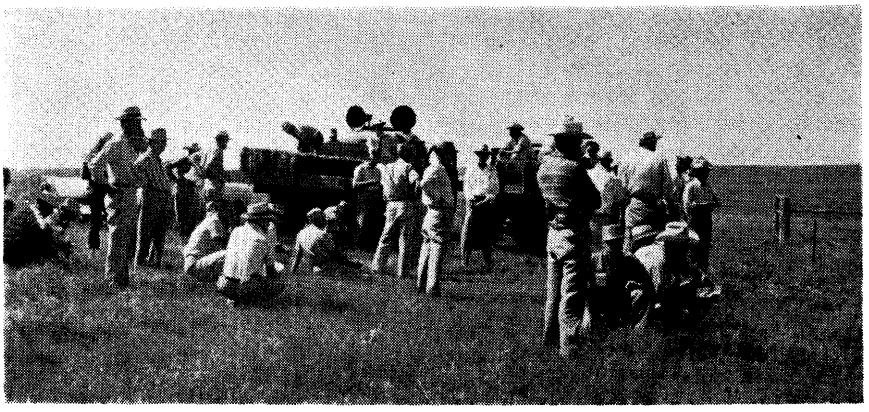
The spring meeting of the Section was held at Hays, Kansas, June 6-7. Discussion at the business session centered on the Great Plains grasshopper problem and on plans for the 1959 National Meeting in Tulsa. KLING ANDERSON was in charge of the meeting in the absence of DICK WHETSELL, Section chairman.

A tour of the Kansas State College research station and the Fort

International Mountain Section members examine an area of big sagebrush, part of which had been reseeded resulting in two to three times the carrying capacity of that shown in the photo. One hundred-fifty attended the meeting at Dillon, Montana, July 12-13. (*Photo by Jim Catter.*)

Hays State College pastures was conducted by JERRY TOMANEK and JOHN LAUNCHBAUGH. Ninety members and guests participated in the tour. Excellent examples of range relict areas were observed, and long time forage yields were discussed by DR. TOMANEK. DR. LAUNCHBAUGH conducted the group through the experimental range grazing trials and the grass seed production plots.

Chairman of the arrangements committee for the meeting was CHUCK SCHUMACHER. — *Clarence E. Kingery.*



Part of the group attending the Kansas-Oklahoma Section spring meeting at Fort Hays, June 6-7. Here the group is studying the ecology of range sites under the leadership of JERRY TOMANEK and JOHN LAUNCHBAUGH.

MEXICO

DEL DIA DE CAMPO: Con gran éxito se llevó a cabo el primer-dia de campo de nuestra Sección el pasado 21 de mayo, al Rancho Experimental La Campana, con asistencia de 43 personas. El programa resultó de lo más interesante, habiendo contado con la valiosa cooperación de los DRS. NORRIS Y VALENTINE, de New México A & M; de HUMBERTO REYES, de la Texas Hereford Assn.; y de ANGEL ALVAREZ, del Servicio Meteorológico del Estado. El concurso sobre clasificación de potreros fué sin du da también de gran interés, habiendo salido triunfadores el Ing. JOEL MALTOS y el DR. FOURNIER D'Albe. El agradecimiento de la Sección México a la Empacadora de Chihuhua por haber regaldo la carne para los sandwiches, y a las Sras. GONZALEZ Y OCHOA por haberlos hecho. Esperamos que el exito alcanzado en esta reunión sirva de estimulo para que, cada miembro tome interes en el desarrollo de nuestra Sección, con miras a lograr un mejor entendimiento y solución de los problemas prevalecientes en nuéstros pastizales.

Se tiene pensado efectuar el segundo día de campo probablemente para fines de Agosto del presente año. Contoda oportunidad daremos a conocer el lugar y fecha exactas. Nos gustaría recibir sugestiones a este respecto, escríbanos ollámenos a la Asociacion Ganadera Local de Chihuahua . . . Nos dará mucho gusto su participación.—*Oscar Ochoa* and *Martin Gonzalez.*

NATIONAL CAPITAL

MARION CLAWSON has been appointed chairman of the Section by the Council to fill out the unexpired term left by the resignation of WELDON O. SHEPHERD. SHEPHERD transferred June 15 to Ogden, Utah, as Chief of the Division of Range Management Research in that Region.

A Section field day was held June 6 at the Buck and Doe Ranch in Pennsylvania. Twenty-five members and friends attended. The ranch operation consists of 10,000 acres of grassland and 2,000 acres of rented land, which is pastured or cut for grass silage. This is part of the King Ranch operation, and cattle raised in Texas are fattened here before going to market.

The pastures consist of brome, orchard grass, Kentucky 31 fescue, and bluegrass. Cattle when marketed average approximately 1,200 pounds. Last year 1,000 head were wintered at the Buck and Doe.—*F. J. Pratt.*

NEBRASKA

The Nebraska Section is again a co-sponsor of the State Range Judging Contest. Other sponsors include the Soil Conservation Service, University of Nebraska Extension Service, and the State Association of Soil and Water Conservation Districts. All 4-H members, FFA members, and adults are eligible to compete in the contest. The State Contest was held on August 19 at the Fort Niobrara Wildlife Range, Valentine, Nebraska.

The 1958 annual Section meeting will be held at Mullen, October 2-3. —*C. H. Scott.*

NORTHERN GREAT PLAINS

Fifty-six members and their guests attended the business meeting of the Section in Glasgow, Montana, June 27. During the morning business session, funds were voted to assist Montana State College Range Club with a range project. The Youth Activities Committee was directed to study, investigate, and report on ways to give recognition awards for range management to deserving individual youth or youth organizations. Findings will be reported to Section Council, which is empowered to act on suitable findings.

LLOYD GOOD, of North Dakota, extended an invitation to come to western North Dakota for the annual summer meeting in 1959. The Section hopes to visit the relic areas recently discovered in the Little Missouri badlands of western North Dakota.

During the afternoon a tour of the Willow Creek Community Watershed was made. Various treatments for range improvement, including seeding, water spreading, and brush control were viewed. A chuck wagon dinner and entertainment were provided at the Pines Recreation Area on the shore of the Ft. Peck Reservoir, through courtesy of the Montana Flour Mills, Inc.

Saturday, June 28, the Section members toured the Ft. Peck dam and the Montana State Game Farm near the dam.—*Sterle E. Dale.*

TEXAS

The D. W. GRANT ranch, Rockport, and the Welder Wildlife Refuge, Sinton, were the sites of the July 11 Section meeting. Co-chairmen for

the day's activities were O. D. EDIGER and CALEB GLAZENER. At the GRANT ranch reseeded pastures on blowsand and coastal dunes were inspected. This land, which was heavily infested with sweetbay and live-oak, was rootplowed in January 1957 and seeded with a mixture of rhodes grass, bermuda, and buffelgrass. A high percentage kill of brush was obtained, and climax grasses now make up over 50 percent of the cover.

At the Welder Refuge game conservation work was inspected and the recently constructed facilities examined. A bus load of San Antonio businessmen joined the group at Sinton.—*Mrs. J. M. Fletcher.*

SOUTH DAKOTA

Three Section range tours have been held this summer, and two more are planned. On June 18 grass plantings in northwestern South Dakota were inspected under the leadership of RALPH COLE, Mobridge. ART MARTIN of Custer, conducted a tour of WOLFF's summer sheep range on July 25. ARMINE KUHLMAN, Newell, was tour leader on August 18, when several small range watersheds were visited.

On September 12 the State Game Farms at Spearfish will be inspected —tour leader is BUD NOVAK, Rapid City. The final tour of the season will be in the Stanley County range area on October 10, with MARCUS WULFF of Pierre as leader.

The Section is working to get the basic range manual for youth, "Range — Its Nature and Use," adapted to South Dakota conditions. Plans call for the printing and distribution of the manual by the State Extension Service with co-sponsorship by the South Dakota Section.

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.

Comment on the Journal . . .

Here is another "letter to the editor," inspired by the one written by Arnold Schultz and published in the May 1958 issue.

One comprehends what he wishes; such an arid technical publication can be justified by his reasoning. As he suggests, the country has various similar periodicals of vast erudition; in fact I subscribe to several of them. What bothers me is that they do virtually nothing for the country or for civilization as I see it.

Being a conservationist, I have thought, perhaps automatically, of this journal and the society back of it as having conservation as the basic objective. Maybe we all feel that way and simply have different viewpoints. What I am getting at awkwardly enough is that to me now conservation is *human* conservation rather than mere custodianship of grass or soil or water. It requires whatever approach will reach the most citizens, and above all, not the theorists but those actually using the land.

The scientific concept is of readjusting man to his habitat despite his dubious ability to modify it. The whole picture is human ecology rather than just one bracket such as plant ecology.

Let us grant, to be sure, that one's horizons change with age. I am now past the accepted retirement age, which is why I feel I must speak now or forever hold my peace. I was remembering that twenty years ago a botanist of undisputed qualifications was my mentor, so one day I asked him how he defined ecology. I have never forgotten his answer: "the most complicated way devisable for arriving at the obvious and unimportant." It at feast gives one pause. It startled me into remembering an equally trenchant remark by the irreverent Mencken. Some one asked him if he thought science would save civilization. His answer was that as yet science did not present the aspect of the Good Samaritan, but simply made him think of a dog sniffing tremendously at an infinite series of rat holes.

I did not set out to be disrespectful; I am trying to suggest that the Journal can be just another house organ for a small group of specialists, or it could possibly become an inspiration and a mentor to a large number of stockmen and conservationists in the broader sense I sought to indicate.

I am inclined to believe that one article by some bona fide rancher will advance the final objective more than two or three by specialists in ecology. Not that I believe in lowering our sights. But I should say that we are doing fine in our present approach.

L. C. Bolles
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Albuquerque, New Mex.

RANGE STUDENT ROUNDUP

University of Arizona

The close of school in May marked graduation for five of the 35 undergraduate Range Management majors —STANLEY TIXIER, JERI MOLER, BILL HICKS, JOHN MONTGOMERY, and DARRELL BRUNER. Three more, DICK ALBERT, DON RUSSELL and TERRY WHEELER completed their studies with the summer field trip that was conducted from June 2nd to June 21st. Eight students—JERRY VANDERMARK, DON RUSSELL, TERRY WHEELER, DICK ALBERT, BOB YOUNT, JACK SMALLHOUSE, JERRY ROBERTS, CHARLES LAWRENCE, with instructor ERVIN SCHMUTZ, studied range management problems and practices through central and northern Arizona, southern Utah and Nevada. The group observed projects including reseeding in burned over chaparral, juniper control, prescribed burning in ponderosa pine, watershed management, sagebrush clearing and reseeding, and grazing management practices on public lands and on several privately-owned ranches.

The University of Arizona Chapter of the Arizona Section of the Range Management Society, launched officially on the 15th of January with 32 charter members, claimed at the end of the school year 38 members, including both students and faculty. The monthly meetings featured talks by local ranch operators and research workers in the field of range management. The chapter is adapting the Range Society's manual *"Range, Its Nature and Use"* for use in Arizona. We shall try to interest vocational agriculture high-school teachers as well as the Extension Service, in this manual because a high school level publication on range management in this state is definitely needed. We hope that enough of these manuals can be sold to enable the chapter to pay the expenses of our plant identification team at the Society meeting in Tulsa next year.

The year has been an active one for range management graduate students. Five have been, and, still are, working on their doctor's degrees; seven on their master's. Most of these are working under scholarships or asistantships of some sort.

Three sizable research grants have been received by the University for work in various phases of range management. One, received in 1957 for basic research in root studies of range plants, was awarded by the CHARLES LATHROP PACK FOUNDATION. The award is in the form of a scholarship for $5,200 per annum and was granted to JOHN BLYDENSTEIN for work on his Ph. D. thesis. A second, also provided by the PACK FOUNDATION is for a total of $20,000 to be spread over a 3-year period. This grant is to stimulate basic research in transpiration of range plants. The major part of this will go directly to a graduate student as a scholarship while he works toward his Ph.D. degree. DAVID R. KINCAID, secretary of the University of Arizona ASRM student chapter has been selected to receive this award. A third grant of $36,000 has been made available by the NATIONAL SCIENCE FOUNDATION as a Post-doctoral grant for research in annual rings of desert shrubs. WES FERGUSON, who is currently completing his requirements for a Ph.D. in range management at the University of Arizona will continue his studies under the terms of grant.—*D. R. Kincaid, R. R. Humphrey.*

The University of Arizona's class in range ecology studying ecological aspects of range condition in the semi-desert vegetation type.

University of California

Range Management students in the University of California are required to spend four weeks studying field problems throughout the state. This year seven students made the tour between June 12 and July 9, where they learned the problems and solutions first hand from technicians in the field. Stops were made where the following California State agencies helped in the instruction: Agricultural Extension Service, Department of Fish and Game, Division of Forestry, and Agricultural Experiment Station. The federal agencies helping out were Forest Service, Bureau of Land Management, and Park Service. In addition several ranches were visited. Subject matter-wise many research and practical land management aspects were covered including problems in range improvement and management, forestry, recreation, wildlife, hydrology,

These students who have completed their junior year in range management at the University of California made a four week range tour of the state. They are, *left to right, bottom row*: FRED BERTETTA, JACK HOOPER, JOHN ROBISON; *top row*: CLAYTON WILLIAMS, LOUIS PLACE, PAUL CALVERLY, TED ADAMS.

and administration. PROFESSORS BISWELL, HEADY, LOVE, and WEIR took part in the teaching.

This summer trip is part of the requirements for a B. S. Degree in the Range Management Curriculum at the University. Other aspects of the curriculum which might be of interest are that most of the basic science courses are in the first two years and the range, botany, agronomy, animal husbandry, forestry and soils courses are in the last two years. Either the Juior or Senior year is spent on the Berkeley Campus of the University and the other on the Davis Campus. The range management trip is scheduled for students between the Junior and Senior years.

Colorado State University

Unforgettable Moments of 1957-1958

At the annual banquet of the American Society of Range Management in Phoenix, the Colorado State University Plant Identification Team received the first place traveling trophy. DON HUSS of Texas A & M admonished PROFESSOR A. C. EVERSON, the winning coach, "not to scratch the trophy". With both schools having won it twice, either could win permanent possession next year—and so the trophy is receiving excellent care. Members of the first place team were: LYNN HYLTON (first place individual with a perfect score), L. K. BROWN, DAN MACINTYRE and LAMAR SMITH.

Notable Achievements

LAMAR SMITH, who graduates with a B. S. in Forest Range Management in June has been awarded a Fullbright Scholarship to study in Australia. LAMAR was editor of the 1957 Colorado Forester.

LEONARD FELLER, senior in Forest Range Management, was general chairman of all Forester's Days Events, February 21-22, 1958. Principal speaker of the plenary session was DR. MARION CLAWSON of Resources for the Future, Inc., who spoke on "Problems in Future Land Use".

DAN MACINTYRE, Forest and Range Management senior, was President of the Forestry Club during the fall quarter. ROY MILLER, graduate student in Range Management, is currently President of Xi Sigma Pi.

PROFESSOR A. C. EVERSON was elected Chairman of the Colorado Section, American Society of Range Management, and DR. D. F. HERVEY was elected National Vice President.

FRANK SHIELDS served as President of the student chapter of the Range Society and also as student manager for the senior field quarter.

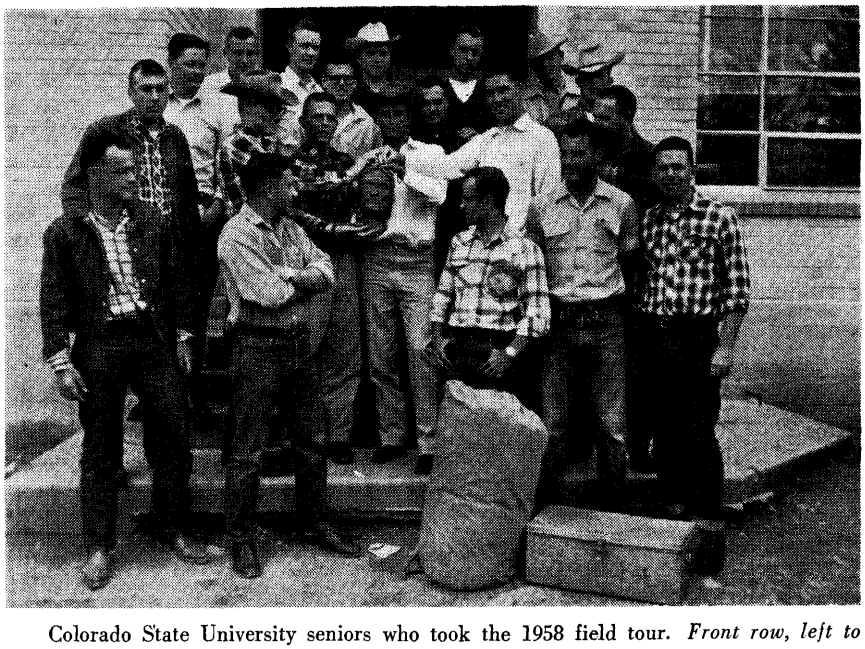
JACK MILLER headed up the Range Section of the Forestry Club in the Winter quarter, and LEE EDDLEMAN is the current Chairman.

Of Special Note

The 1958 Range Management Senior Class was the largest in the history of CSU—20 seniors were enrolled for the senior field quarter.

The Senior Field Quarter

Each year the senior range students leave the classrooms and venture forth into a schedule of field



Colorado State University seniors who took the 1958 field tour. *Front row, left to right*: ROBERT DELZELL, FRANK SHIELDS, ROBERT KLINE, JACK MILLER, and LOWELL BROWN, *Second row*: LAMAR SMITH, CARROL LEVITT, BILL KYLE, DICK COADY, BILL LITTLE, *and* LEONARD FELLER. *Third row*: BILL KENNEDY, LEE CARR, ED STARK, *and* ARTHUR CROOK. *Fourth row*: NED JEFFERIES, BILL PETERSON, BRUCE LINDAHL, BILL MCNALLY, *and* DAN MCINTYRE.

trips and practical exercises. An intensive management plan for a ranch near Fort Collins was completed, as was a range analysis on a national forest allottment. An extended field trip saw the students tour the Eastern Colorado Range Station at Akron; ranches owned by KENNETH CONRAD, MARVIN KNEISE, and STUB KERST, all in the Wray area; and the Southern Great Plains Field Station at Woodward, Oklahoma, under the guidance of superintendent E. H. MCILVAIN. Stops were also made at the Sandstone Watershed Project near Elk City, Oklahoma, and the Mesa de Maya Ranch in southern Colorado. A trip to western Colorado saw the group stop at Gunnison, Paonia, Fraser, and the Manitou Experimental Forest. Cooperating agencies and individuals furthered the training received by the range students. The tour was very beneficial and each of the twenty members of the group feels greatly indebted to all the individuals whose efforts made the trip a success.

Graduate Student Activities

Currently enrolled in the Graduate School studying for M. S. degrees are six students. TED HADDAN, is beginning a study at the Eastern Colorado Range Station on the comparison of intermediate wheatgrass against intermediate-alfalfa mixtures for grazing purposes. HENRY BOND is running an analysis on the revegetation and disintegration of pocket gopher mounds on Black Mesa, Colorado. R. K. GIERISCH, Range Specialist for Region Two of the U.S. Forest Service, initiated a Master's program during the winter of 1958. ROY MILLER is well underway on his project which concerns the effects of nitrogen fertilization on Nordan and crested wheatgrass. JOE SCHUSTER will spend the summer studying the relation of root development to grazing intensities on native plants on ponderosa pine ranges. REED SANDERSON is starting an anlysis of grazing activities and usage of native vegetation by jack rabbits at the Eastern Colorado Range Station.

Staff

PROFESSOR CHARLES TERWILLIGER, JR. returned to his teaching duties from a year of sabbatical leave at the University of Wyoming.—*Senior range management students.*

University of Idaho

Range management students were active in the Northern Idaho Chapter of the American Society of Range Management. The officers for the current year were two graduate students, ARNOLD BULLOCK as Chairman and JOHN DAVIS as Secretary-Treasurer. Officers elected for the coming year are JOE HELLE, a graduate student, as Chairman, and ED STAUBER, a senior, as Secretary-Treasurer. Several students participated in meetings of the northern Idaho Chapter. BOB KINDSCHY spoke on his range work with the Bureau of Land Management in Alaska and showed some fine Kodachromes of Alaskan vegetation. JIM EGGLESTON gave a paper on Bureau of Land Management range survey work in Wyoming and FRED MARTINSEN spoke on studies of bitterbrush in northeastern Washington.

The senior range field trip was held this spring under the direction of DR. E. W. TISDALE. The itinerary this year included western Montana, southern Idaho and eastern Oregon. Major stops were made at the National Bison Range near Moiese and in the Whitehall-Dillon area in Montana. In Idaho the U. S. Sheep Experiment Station at Dubois, the Wood River Grazing District of the Bureau of Land Management at Shoshone and a number of areas in the vicinity of Mountain Home, Boise, and Emmett were visited. In Oregon the major stop was at the Starkey Experimental Range near La Grande. Altogether this trip provided a good variety of range types, problems, and management practices on both private and public lands.

The graduating seniors this year are JIM EGGLESTON, DICK FISHBURN, FLOYD HALL, BOB KINDSCHY, HOWARD KOSKELLA, JIM PHILLIPS, ABB TAYLOR and NATHAN YOST. These men have all accepted positions with land management agencies following graduation.

The graduate student group this year consists of ARNOLD BULLOCK, JOHN DAVIS, JOE HELLE and JON SKOVLIN. BULLOCK is finishing up his work on the range nutrition project, and will return to employment with the Soil Conservation Service, JOE HELLE, who has just returned from a two-year term in the army, is on leave of absence from the Forest Service and will work on the range nutrition study. JOHN DAVIS is completing the third phase Service. JOE HELLE, who has just reseeded range in southern Idaho. SKOVLIN is now on the staff of the Blue Mountain Research Center at La Grande and is making a study of forage utilization by cattle and big game on the Starkey Experimental Range as his thesis problem.—*John Davis, Jim Eggleston.*

Montana State College

Fall quarter's activities included a senior trip to a ranch east of Bozeman and also a trip for the lower classmen to the southwestern big game areas of Montana.

The senior field trip was to the ART MILES ranch located twenty miles east of Bozeman, Montana. The group reviewed some range reseeding on intermountain foothills and irrigated pasture management under an electric fence system of rotation grazing.

The lower classmen surveyed the Gallatin winter game range near Yellowstone Park on the Montana-Wyoming boundary.

During winter quarter HERB FISSER, JACK JONES, and NORRIS COLE, accompanied by two Montana State College range instructors attended the 11th national American Society of Range Management convention at Phoenix, Arizona, to participate in the national range plant judging contest. No honors were taken but the team members were greatly impressed with the proceedings and the opportunities for meeting and talking to some of the noted range men.

Two slide series were made of the pictures taken during the trip to and from Phoenix and presented with great success at monthly meetings of the local range management club.

The local range management chapter constructed and entered a display at the Montana Winter Fair, March 8 through 13, depicting the effects of various grazing intensities on bluebunch wheatgrass through the use of potted plants and charts giving forage production data. The display stimulated a great deal of interest, and many questions concerning grazing intensities were asked by the spectators.

Junior and senior range students took a 4-day field trip during the latter part of spring quarter. Stops included a study of range fertilization trials conducted south of Ennis in southwestern Montana; Horse Prairie reseeding and management practices south of Dillon, Montana; an overnight stop at the U. S. Sheep and Range Experiment Station near Dubois, Idaho, where range burning, reseeding, and grazing management practices were studied. Stops the following two days were at various ranches near Dillon, Montana, inspecting range reseeding, rotation grazing, and other grazing management practices, with the aid of BEN SLANGER, S. C. S., of Dillon and BOB ROSS, Range Conservationist of western Montana stationed at Whitehall.

The seniors and graduate students spent three days on a 40,000-acre operation in the Deer Lodge valley viewing and discussing the range and livestock operations. The effects of both cattle and sheep use at varying intensities and seasons were viewed on rough fescue (*Festuca scabrella*) and mountain ranges. A management plan was constructed for the range operation giving consideration to water development, salting practices, range reseeding, construction of drift fences, livestock nutrition, parasite and disease problems, game influences, native hay production, and general grazing management techniques.

The juniors spent 2½ days in the upper Gallatin game range area. One day was spent on the Porcupine game range, where they worked with the point analyzer, took reproductive counts on the aspen groves of the area, and studied soil profiles. The next study area was on the Wapiti range, where they examined runoff and erosion measurement plots and reseeding studies, both on and off the experimental plots. The last day was spent on the Tepee Creek range where they took readings from a permanent transect by the PARKER 3-step method. Aspen groves and a reseeded area where contour trenching was being used as a measure of control of soil erosion were examined.

Social activities of the Club consisted of a dinner dance in conjunction with the Animal Industry Club. The purpose of the activity was to have students, students' wives, and faculty members and wives of both clubs become better acquainted. It is hoped this affair will become an annual one.—*Charles Dahlen, Herbert Fisser.*

Montana State University

Students specializing in range management at Montana State University School of Forestry carried a fair share of the student leadership of the School. The past year ED BLOEDEL was "Chief Push" of the Forester's Ball which was one of the best in history. DON NELSON was president of the Forestry Club and BOB JOHNSON was vice-president. BILL MCLAUGHLIN was elected president for the coming year. DON NELSON and DEEN BOE were two of the four foresters who graduated with honors.

Among other activities of the range students were participation in Conservation Week and helping with the exhibit shown by the International Mountain Section at the Phoenix meeting. The exhibit has been so well received that it has been shown three times in Missoula and once in Butte. It will be shown in two other Montana cities next fall.

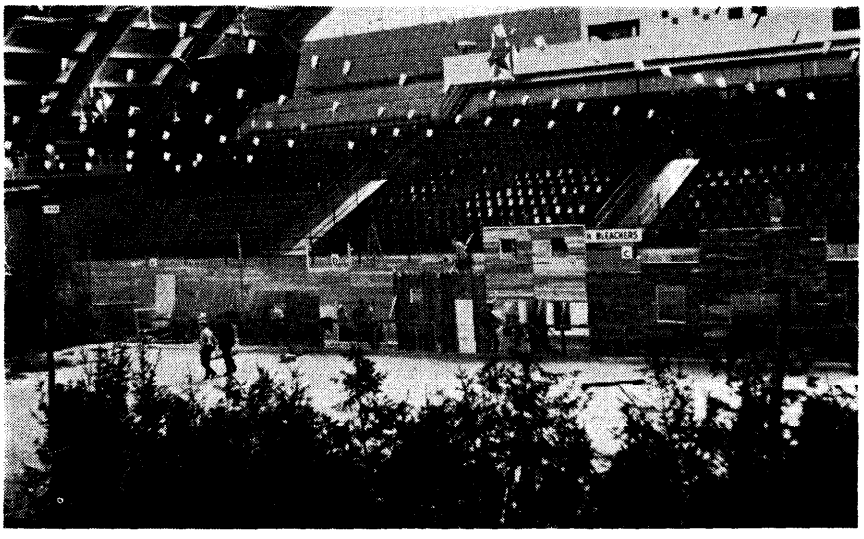
Other points of interest this year were the attendance of students at the Top Cut Sale and Show of Herefords, the Angus Show Case Sale, and the Institute of Indian Affairs in Missoula.

One experiment in orienting students in ranch operations in order to prepare them for better understanding of rancher problems was started this spring and will be expanded this fall. GARY MARBUT, a registered Angus breeder, and ED BANDY, a commercial Hereford producer, will provide students a chance to stay on their ranches on weekends to help in ranch work and to observe the work on a ranch through the fall, winter, and spring. This will be on a voluntary basis.

The Senior range trip this year was thoroughly enjoyed by the class. Some 4600 miles were covered over a period of thirty days. Ranchers and public agency men were very helpful in making the trip a success. Excellent weather and one of the best growing seasons in a decade were most helpful.

The summer rains of 1957 in Arizona and the unusually heavy late moisture for this year provide conditions for unusual plant growth. Species identification, range condition observation, livestock and range improvement, and development examples on the ground provide vivid material which students will long remember.

A description of the Forester's Ball follows. We hope you will be interested in it and use it. The experience in organization and leadership gained is considerable and valuable to all our students. The profits



The theme for the Montana State University's "Forester's Ball" was "America's Range Resource." In carrying out this theme the students constructed a complete wild west town in the Field House at M.S.U.

also contribute to a very useful purpose.

1958 Forester's Ball

The theme for the 1958 Forester's Ball was "America's Range Resource." This theme, being the first on range management in the Ball's 41 year history, brought out many new ideas for decoration.

The dance floor decoration committee constructed a "wild west" town, complete with wooden sidewalks and hitch rails, along one side of the huge dance floor in the M.S.U. Field House. Behind the buildings of "Dodge City" the bar, chow hall, chaperones room, and exhibition room were constructed.

The bar featured an old-time piano, an electric guitar player, and bearded, white-shirted, smiling bartenders, handing out free Coke and 7-Up and kisses to willing girls.

The chaperones were located in the "Dodge House" hotel lobby.

In one corner of the chow hall stood an accurate, hand built, replica of an old trail herd chuck wagon. From this, the dancers were served free coffee and Bar-B-Que sandwiches. One hundred fifty bales of hay were arranged near the wagon for seating.

The exhibition room in the center of town, behind MATT DILLON'S Jail House, was one of the outstanding features of the Ball. It housed several displays including, new cattle and sheep breeds, range condition pictures, poisonous plant pictures, western art paintings, big game animal food habits, a colored range type map; and a large composite display of forage plants and pictures of different phases of range management. The latter display was taken to the Society's annual meeting at Phoenix, Arizona, last January.

The other 3 sides of the dance floor, the walls dividing the buildings, and a passageway from the outside door to the dance floor, were lined with 2,000 Douglas fir trees cut during the fall by the handy axemen of the Forestry Club. Outside the Field House door, "Fort Dodge" was constructed out of pointed pine slabs and fir poles.

Dance series were announced by buffalo, cattle, and bronc riders (the numbers branded on the animal's side) thundering across the length of the Field House above the trees and the band.

Seven hundred couples attended the ball, which ran two consecutive nights, January 17 and 18, and featured as guest of honor, IRVIN "SHORTY" SHOPE from Helena. SHOPE, who has been painting a series of six 10 ft. x 6 ft. oil paintings for the Forestry School, depicting the development of forest and range management in Montana, unveiled his last picture in the series during the intermission program. The program also featured beard contest winners, a costume contest, a shaving contest between a straight razor and an electric razor, The Forester's Glee Club, and the Delta Gamma Can Can Girls.

The income of the ball supports the Forestry Club yearbook and the loan fund. The loan fund now has over $10,000 available for student needs.

ED BLOEDEL was Chief Push for the Ball. He is specializing in range management. Altogether about 4,000 man hours went into making the 1958 Forester's Ball one of the best in its history.

Range management students and staff members of the University of Nevada just before taking off on a 1200 mile trip to study range and range management practices in northern Nevada.

University of Nevada

A group of nine range management students went on a seven-day trip May 26-June 1. It was a trip of 1200 miles to study range and range management practices in northern Nevada.

Students taking the trip were RALPH HOLMGREN, TONY LESPERANCE, LEO MASINI. DONALD PARK, EDWARD PIPER, CLARK REBER, LESTER SWEENEY, and PAUL TUELLER. The students were accompanied by several members of the staff including H. M. KILPATRICK, Range Extension Specialist; GLEN FULCHER, Range Economist; and F. E. KINSINGER and J. H. ROBERTSON, Range Ecologists..

The tour followed U. S. 40 with extensive side trips. Several experimental projects of the Nevada Agricultural Experiment Station and of the A.R.S. were visited. Among these were areas of study on the ecology and management of Indian ricegrass and of winterfat.

Grazing beef cattle on extensive acreages of tall wheatgrass was observed in Lovelock Valley. In Paradise Valley along the Santa Rosa Mountains ranch operation was explained by ranchers RUDOLPH SCHWARTZ and ROBERT MACDAIRMID. Several examples of brush control, seeding and grazing experiments were also observed here.

The students were guests for one day of the W. T. JENKINS Company (cattle and sheep) at Battle Mountain. C. R. "CAP" MARVEL showed them examples of all seasonal ranges and explained the year round operation of both phases of the operation. A part of the extensive private holdings of this outfit is the 18,000-acre St. John's field. Fenced in the '80's, it is beautiful example of bunch-

grass, perhaps an outlying fragment of Palouse prairie. At Starr Valley near Wells, Nevada, BILL HYLTON took half a day to show his range and ranch developments. Bureau of Land Management and Forest Service officers went out of their way to make the trip informative and enjoyable.

The students will submit a report on the trip for credit during the summer.

Oregon State College

Enrollment in the range management program at Oregon State College has been growing in recent years and during the past year there were three graduate majors, six graduate minors, and eleven undergraduate majors in the department. Two research fellowships will also be available for this next fiscal year.

WILLEM H. C. SCHALLIG is presently working for his doctor's degree. His thesis subject deals with range ecology. CAROL EUGENE CONRAD is in the process of finishing his master's thesis on range condition methodology and expects to graduate in September, 1958. WALTER V. JOHNSON is presently working on his master's thesis subject of range utilization methodology and he plans to graduate in June, 1959.

JAY LOU WHEELHOUSE, 1959, was the recipient of the L. A. MCCLINTOCK Award made at the annual Agricultural Banquet at Oregon State College. The award, which memorializes L. A. MCCLINTOCK, an eastern Oregon rancher, is given annually to the outstanding junior in animal husbandry or range management. This award has been presented five times and a range management major has received it four times. VERNON E. COOK II, 1959, was chosen to be the Senior Speaker at the Ag Banquet, which further indicates that range students at Oregon State were well represented on the special awards roster.

Practice in the application of range management principles and demonstrations were available to the students on two field trips. DR. HAROLD L. SCHUDEL took his range improvement class to central Oregon at the end of the winter term to study different range improvement projects in and near the Ochoco National Forest.

The range methods class went on its annual field trip May 9, 10, 11, and 12, under the leadership of DR. C. E. POULTON. The purposes of the trip were to study vegetation-soil relationships in eastern Oregon and to obtain practical experience in the use of range methods and techniques. Stops were made at and near the Squaw Butte-Harney Branch Range and Livestock Experiment Station and in a game management area near Lapine, Oregon. During the stay at Squaw Butte, DONALD N. HYDER, Range Conservationist, led a discussion on the work being done at Squaw Butte. See the picture below.

JOHN THILENIUS has received an assistantship with the Wildlife Research Unit at the University of Idaho for graduate study during the coming year.

DAN E. CHAUVET worked with the Forest Service during the summer While VERNON E. COOK II worked at the Squaw Butte Range Experiment Station near Burns, Oregon. JOHN E. SELEY was employed throughout the summer by the Bureau of Land Management.

JAY WHEELHOUSE attended an Air Force summer camp in conjunction with his AFROTC program and FRITZ LEDEBOER attended the Army Officer's Candidate School.—*Vernon E. Cook II, Jay L. Wheelhouse.*

Texas A. & M. College

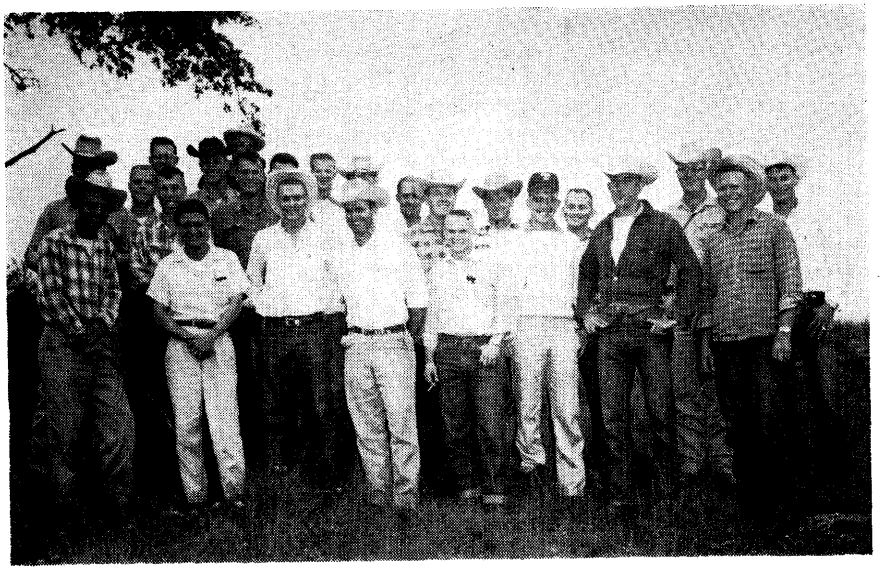
The Range and Forestry Club at Texas A. and M. College carried out a well-rounded program of activities during the year. Highlights included the Annual Turkey Shoot, the Annual Spring Barbeque, participation in Mothers' Day Open House, and Senior Day events and in the Range Plant Identification Contest at the annual meeting of the American Society of Range Management at Phoenix, Arizona.

The Annual Turkey Shoot was held early in November to obtain funds for financing the Range Plant Identification Team in its trip to the national Society meetings. Keen interest was shown in the Plant Judging Contest and Club faculty sponsor, DON HUSS, had a difficult time in selecting the team. Team members making the trip to Phoenix were ELLIS W. KLETT, PHIL J. PHILLIPS, JERRY PITTS, and ELMER E. WILLARD. PHILLIPS, the only sophomore on the team had the distinction of making third highest individual score. The team placed a close second in the national contest.

The Annual Spring Barbeque was held in late April at the Range and Forestry Club picnic area under the leadership of club president KIRBY TURNER. On Mother's Day the Club sponsored a picnic and showme trip on the Range and Forestry Area for the mothers and dads attending the Annual Open House. Demonstrations of brush control, range improvement and range condition evaluation were given by club members.

Junior and senior students had the opportunity to paritcipate in several 2 and 3 day field trips. Senior range management students had

DONALD N. HYDER, Range Conservationist, Squaw Butte Experiment Station, discusses a study on control of sagebrush reinvasion with the range methods class, May 1958.



Range and forestry class from Texas A. & M. on NORDEN's 7-11 Ranch at New Braunfels, Texas, where a survey was made relative to the effects of different intensities of grazing.

a 3 day trip to the Edwards Plateau for studies of combination grazing, to the Rio Grande Plains for demonstrations of root plowing and reseeding under the sponsorship of the Holt Machinery Company. They also visited the McFaddin Range in the Coastal Prairie near Victoria for evaluation of deferred grazing, proper stocking and control of running live oak.

The Forestry students visited the pine growing areas of East Texas for studies in silviculture and timber management as well as to obtain first-hand views of lumbermill operations.

The number of graduate and undergraduate majors in range management has not kept pace with the demand for trained personnel in the field. Graduating seniors this year are: THOMAS COPELAND, JOHN GUMERT, JOE NESSMITH, HENRY A. PEARSON, CHARLES A. RICHARDS, JR., ELLIS KLETT, CHARLES MICKELSON, VIRGIL MIDDLETON, JR., and CURTIS SCHULZE

Three students received the M. S. degree in Range Management and three Ph. D's. were awarded during the year out of a total of 23 graduate students enrolled in the department.

Graduate students on fellowships awarded by outside organizations included: THADIUS W. BOX, ROB and BESSIE WELDER Wildlife Foundation, Sinton, Texas; JOHN F. VALLENTINE and MORTON MAY, Texas Game & Fish Commission, Kerrville, Texas; RONALD GARDNER and DON DWYER, Phillips Agricultural Demonstration Project, Adams Ranch, Foraker, Oklahoma; JOAQUIN TORRES-MAS, Research Assistant in Agronomy at the University of Puerto Rico, is completing work on the M. S. Degree in Range Mangement.

Staff changes occurring during the year include the transfer of W. J. (DUB) WALDRIP to Seymour to be in charge of a new cooperative grazing management experiment for the Texas Agricultural Experiment Station, and the addition of B. J. RAGSDALE as Associate Extension Range specialist, to replace A. H. WALKER who was appointed State Agricultural Leader.

Utah State University

The newly organized Utah State University Student Chapter of the Utah Section of the Society of Range Management has enjoyed a very successful first year. We now boast of a membership totaling thirty students. The Chapter has participated in many worthwhile projects such as assisting in obtaining financial support for the range plant judging team, and the selection of Utah's top rancher of the year. Informative programs were presented to members and guests of the Chapter by A. C. HULL JR., Agricultural Research Service; J. R. PENNY, Bureau of Land Management; M. M. JUNEIDI, foreign student from Jordan; and FRANK JENSEN, district ranger on the Cache National Forest.

In January, eleven members of the Chapter attended the annual convention of the American Society of Range Management in Phoenix, Arizona. At this meeting DON NEBEKER, DICK PAGE, DENNIS JENSEN, and GARTH BAXTER took part in the plant judging contest.

For their outstanding work in conservation and leadership in the field of range management, the HEATON brothers; VARD, ROSS, GAIL, and LOYD, of Alton, Utah were presented with the top rancher of the year award.

On September 21, seventeen seniors in range management left on the annual senior field trip. This trip took them on a 1,800 mile traverse through the states of Idaho, Montana, Oregon, Washington, and Utah. Interesting stops were made at the U. S. Sheep Experiment Station at Dubois, Idaho; National Bison Reserve at Moiese, Montana; Soil Conservation Service grass nursery in Pullman, Washington; Starkey Experimental Range in Oregon; Experimental Forest at Idaho City, Idaho; and on annual grass range in southern Idaho. All in all the ten days were packed full of educational stops, supplemented with many memorial events.

Plans for the new Forestry Building have been drawn up and approved. Construction is scheduled to start early this fall with completion scheduled for fall of 1960. From the drawings presented it appears that the Range Management Department will finally have adequate facilities for teaching and research.

The staff in the College of Forest, Range, and Wildlife Management has been enlarged by the addition of two new members. DR. JOHN VALENTINE has joined the staff as extension Range Specialist. DEAN QUINNEY has joined the forest management staff. DEAN will handle forest economics and valuation.

The following men received Bachelor of Science degrees in Range Management in 1958: MARTEL APPLEGATE, ROSCOE BROWN, BERNARD BRUNNER, KENT CARROLL, ELMER DUNCAN, FRANK GROVER, RON HIBBERT, DARREL HOFFMAN, LYNN MITCHELL, DENNIS JENSEN, M. J. JUNEIDI, CHARLES MEYER, DON NEBEKER, DICK PAGE, TED RUSSELL, FRANK SAVAGE,

BILL SELBY, DARWIN SNELL, DON WARD, BOB WILLIAMSON, and ART WINTERS.

REX PIEPER, MONTIE WALLACE, KEITH ZOBELL, PHIL OGDEN, BOB TAYLOR, DAVID MEADE and JIM EDLEFSEN received Master of Science degrees in Range Management during the past year.

Near the end of spring quarter the Chapter sponsored a horse back ride on game-livestock range on the Cache National Forest in which twenty students and staff members participated. — *Bob Williamson.*

Washington State College

Students at Washington State formed an organization during the year and petitioned the Pacific Northwest Section of the A.S.R.M. for authority to function as a chapter of that group. Officers elected were: LAWRENCE HOWELL, chairman, and JERRY HILLIER, secretary treasurer. We also participated with the North Idaho chapter in their annual meeting at Moscow. JERRY HILLIER, graduating W.S.C. senior, presented a paper on the subject of "Managing California Annual Grass Ranges." We hope soon to have authorization from the section for chapter status.

Range students participated in Forestry Club activities, which provided the major source of extra-curricular and social and professional motivation.

The Fall Round-up brought students and faculty together for a traditional campfire fun-fest—a session of tall tales, songs and experiences was followed by eats of the sort popular with range men and foresters. The annual all-college "Activities Round-up" found the club preparing a camping scene as part of the general display. "Bunyan's Ball" was the year's big social affair. MR. HARRIS called square dances and round dances to the enjoyment of all present. Later in the year, the Foresters' Wives held another square dance for the club members.

Supervisor, ALVA W. BLACKERBY, Nez Perce National Forest, discussed "The Place of Wilderness Areas in Multiple Use Management," with the Club. This subject stimulated much interest among the members. Later, MR. BLACKERBY showed slides of Alaskan scenery, and told of his experiences there as a forest officer. MR. ED HEACOX, Chief Forester for Weyerhaeuser Timber Co., was guest speaker at our annual banquet, where our graduating seniors are traditionally honored. MR. JOHN NAGLE, our Department Chairman, gave a toast to each senior in turn.

The Club sent six delegates to the Western Forestry Club conclave at Berkley, California, where our stalwarts came off with second place in the contests. A tie auction was held to finance the trip. Next year, W.S.C. and the University of Idaho will cooperate to host the conclave here in the Palouse Hills.

Members of the Club initiated a new publication this year, which they titled "Forest Conservation." Articles covering important phases of Range, Forest, Wildlife, and Water Conservation were featured. The committee did a "bang-up job" from selling advertising and writing the manuscripts, to setting the type and rolling the presses. Conservation Week was the occasion for release of this first "annual" publication. Other activities of the week included the preparation of a conservation display in the Holland Library Foyer, and the continuous showing of conservation films.

Forestry Club officers were: RAY TAIPALE, President; BOB BURNS, Vice President; BILL DUGGER, Secretary; JACK RUCKER, Treasurer; CLIFF NOPP, Social Chairman.

Regular meetings were held on every third Tuesday throughout the school year.

The Department granted its first hour of graduate credit during the past year to BEN ROCHE. This is considered a milestone and a first step toward a graduate program. This first graduate course is taught by MR. HARRIS and is titled "Land Use."—*Emery Swan.*

University of Wyoming

Fall, 1957, activities for the Wyoming range students began with a get-acquainted party at the Connor Hotel in Laramie with a Dutch supper and card games. A group of 30 students attended the party.

On the evening of December 11th, the Wyoming range students were hosts at a dinner for visiting members of the W-25 Regional Technical Committee consisting of range management research leaders from 11 western states, as well as representatives of government agencies concerned with range management. The program was planned to allow the Wyoming range students to become acquainted with this fine group. The 45 present spent a pleasant evening of chatting and card games.

In January, 1958, the Range Plant Judging team consisting of AL DOBRENZ, GENE EGGLESTON, DUANE GALLINGER, and TOM RODDA, accompanied by their coach DIXIE SMITH, and a graduate student JOEL VERNER, traveled to Phoenix, Arizona, to attend the national meeting of the American Society of Range Management. The group planned their road trip to see some of the range areas of

Four Washington State College range students inspect grasses while on a lab field trip. *Left to right* they are: DON BENNETT, JIM ABBOTT, BOB GRAHAM, GEORGE LEIGHTON.

Four University of Wyoming students studying grass on range tour. *Left to right,* DUANE MICHAEL, FRED FICHTNER, AL LOCOZ, and LYLE ROLSTON. ROLSTON is chairman of the Student Chapter.

the southwestern United States. The team members felt that the contest was very successful as they received third place. The competition at this year's contest was a highlight of the meeting. It was encouraging that so many schools attended the national meetings where the students could become acquainted with one another.

As spring rolled around, 21 Wyoming range students and their instructor DR. ALAN A. BEETLE, took their annual range trip from April 4th to 13th. The tour this year consisted of a big circle through the southwestern United States.

After leaving Laramie in the early morning, the first stop of the trip was at the Manitou Experimental Forest in Colorado. The group saw research projects of range management, artificial revegetation and watershed management. Pasture studies of stocking rates and their results, along with the erosion studies on watersheds was a high point of interest. Lectures were by MR. DWIGHT SMITH.

The Jornada Experimental Range near Las Cruces, New Mexico, was the second major stop of the expedition. The group spent the night before, sleeping on the desert near Truth or Consequences, New Mexico. Jornada being the second oldest range experiment station in the United States, held an interest for the students in the effects of the drought upon the desert vegetation. FRED ARES was host at the Jornada Station.

On the way to the Santa Rita Experimental Range, the group stopped at the Chiracahua National Monument in southeastern Arizona. The weird rock formations and the Indian history, along with the vegetation type in this area was of interest.

April 7th found the group at Santa Rita, the oldest experimental range in the United States. A tour of the station was conducted by DWIGHT CABLE. Observation of the grazing management, mesquite control, and artificial range reseeding was of interest to the group. The group was surprised to wake the first morning with two inches of snow on the cactus.

A short tour of the University of Arizona campus was taken after leaving the Santa Rita Station. The students thought it was quite nice and some wanted to stay.

The next stop was the Boyce Thompson Southwestern Arboretum, west of Superior, Arizona. The group received a good idea of the complex desert vegetation in all its forms at this stop.

The class held their next stop at the Sierra Ancha Experimental Watershed near Globe, Arizona. Watershed management practices and installations were viewed. There was interest in the runoff and erosion research projects along with the Little Grand Canyon. Talks were by MR. BOB GIBBINS.

After leaving Sierra Ancha, the students visited two points of interest, a Zuni Indian village and the El Morro National Monument where the group spent the night sleeping out for the second time during the trip.

The following day the group was conducted on a tour by OWEN HICKS to some of the range projects on the Navajo Indian Reservation in New Mexico and Arizona. Stops here included Window Rock, Arizona and two stops near Shiprock, New Mexico.

The final stop of the trip was at Mesa Verde National Park in Colorado where the group toured the Museum and Indian cliff dwellings.

The students, as well as DR. BEETLE, would like to thank all the personnel of all the stations visited for their assistance and lodging accommodations.

An election of officers for the Student Chapter of the Wyoming Section of the American Society of Range Management was held on April 28 in conjunction with other school elections. Chairman-LYLE ROLSTON, Vice-Chairman-WESLEY SEAMANDS, Secretary-Treasurer- EUGENE EGGLESTON.

The 1958 officers took over their duties May 1. The Wyoming Student Chapter, being the first of its type to become an active group of the A.S.R.M. back in 1950, was reorganized after a lapse of four years. The present Wyoming Chapter has 21 paid memberships in the Society. A membership campaign is planned for the coming year.

Following is a list of the 1958 Range Management graduates from the University of Wyoming and their proposed location of work.

Ph. D. degree: Dixie R. Smith—University of Wyoming faculty.

M. S. degrees: Robert Adams—Bureau of Land Management, Rawlins; Richard Aro; Rolland Jorgensen; Marvin Shoop—Southern Great Plains Field Station, Woodward, Oklahoma; Wesley Seamands — County Agricultural Agent, Laramie, Wyoming; Joel Verner. (This

whole group was elected to associate membership in Sigma Xi.)

B. S. degrees: Neil DeLapp; Al Dobrenz—work on M. S. in Jackson Hole (voted outstanding student by Farm House); Verlin Duvall—Soil Conservation Service, Valentine, Nebraska (voted HonorBook by Agronomy Dept.); Eugene Eggleston — Work on M. S. in Gros Ventre and Big Horn Mountains; Duane Gallinger; Raymond Jorgensen—Bureau of Land Management (Lander, Wyoming; Leonard Larsen—work on ranch near Sheridan, Wyoming; Tom Rodda—Bureau of Land Management, Rawlins, Wyoming; Quintin Sulzle; Tom Thompson—Bureau of Land Management, Rawlins, Wyoming; John Baker—Graduate work. —*E. E. Eggleston.*

"Grass Magic"

by

NED W. JEFFERIES

"Grass magic"—that's what I'd call it. Unlike black magic, however, it is not the result of gimmicks. Grass magic is performed by several sandhills ranchers in eastern Colorado through the use of good management. These nonmystical practices have allowed their ranges and meadows to improve even during the recent drought. Let's see how these ranchers make this magic work for their ranges.

For example, Ken Conrad, ranching north of Eckley, depends upon moderate use and occasional summer deferment to keep his pastures and his cattle in top condition. His ranges support a good stand of the more desirable sandhills grasses—sand reedgrass, sideoats grama, sandhill and little bluestem, and needle-and-thread.

Conrad has found it is sometimes necessary to aid nature in replenishing his grass supply. In several instances, he has sprayed his sand sagebrush to release valuable moisture and nutrients to the grasses. A spray containing 1 pound 2,4-D ester per acre gave him more than 50 percent kill. Since sand sagebrush furnished him with some winter feed, Conrad feels that this kill is adequate.

On old fields, Conrad has reseeded native mixtures, sand lovegrass, Blackwell switchgrass, sideoats grama and various introduced cool-season grasses. Sand lovegrass has produced good stands and provides a large amount of feed. Of the introduced cool-season grasses, intermediate wheatgrass has performed best and makes good early feed. Conrad believes his reseeding has provided him with a valuable supplement to his native range.

Another rancher, Marvin Kniese at Laird, runs steers on a year-round basis. Unlike many steer operations, here the grass is coming back under an application of grass magic. He has found that by deferring his range during the late summer, he can encourage the growth and reproduction of the tall grasses. Kniese says, "This system of buying light calves 'right' in the fall and selling them the next summer is putting more money into my pocket than any other would, I believe."

This article is an example of student reporting. It was written as a class assignment in popular writing for newspapers and periodicals by Ned Jefferies, senior student at Colorado State University. The article was prepared after the writer had toured eastern Colorado on the annual senior field tour.—Editor.

Kniese manages his subirrigated meadows through a 3-year fertilization-deferment rotation. He fertilizes one-third of his meadow each year with nitrogen; this is cut late in the summer. Cutting late gives him a higher yield with a protein content similar to his unfertilized hay. He cuts this area early the second year and defers it the third year to let the stand re-establish itself. Kniese says that he believes this rotation gives a maximum production without endangering his grass stand.

A third rancher, Stub Kerst of Wray, is also a firm believer in deferment and moderate grazing. He plans to defer at least one pasture each year, and his cattle never eat themselves out of grass. Moderate grazing does not mean a smoothly mown pasture to Kerst, who likes to "leave plenty of seedheads to keep young plants coming." His range is a tribute to a man who understands grass.

Kerst has also greatly improved the meadowland on his ranch by his good management practices. He has found that early grazing on the sedges and early grasses has actually increased the total production of his meadows. This method of grazing reduces the competition given the later developing tall grasses. His meadow management also calls for occasional summer deferment to allow the meadow grasses to rest and reproduce. From the increased hay yield that he is obtaining, Kerst is confident that his management is working.

Men like these three are proving that the magic to bring grasslands back is available to everyone. Good management is the key to "grass magic."