VOLUME 6

November 1953

Number 6

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Omaha, Nebraska

January 26, 27, 28 and 29, 1954

American Society of Range Management

✶

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Volume 6, Number 6, · November, 1953

Journal of RANGE MANAGEMENT

Edith Schwartz Clements

B. W. ALLRED

Soil Conservation Service, Forth Worth, Texas

ANYONE who chooses Dr. Edith S. Clements as a subject to write about has so much material to select from that it is difficult to narrow the events of her career into a brief sketch.

Mrs. Clements was born in Albany, New York, but spent her childhood and youth in Omaha, Nebraska. She graduated from the Omaha High School, spent her first year of college at the University of Minnesota, and finished her education at the University of Nebraska. Here she specialized in Germanic languages, receiving a Fellowship in German on graduation. She was elected to Phi Beta Kappa and Sigma Xi, and after her marriage to Dr. Frederic E. Clements, then an instructor in Botany, studied for a Doctor's degree in Ecology and Geology. Shortly after Mrs. Clements received her Ph.D., Dr. Frederic was called to the Headship in the Department of Botany at the University of Minnesota, and later both Doctors Clements carried on ecological research sponsored by the Carnegie Institution of Washington.

This association has been appraised by Dr. B. C. Tharp, botanist in the University of Texas, as follows: "I cannot refrain from including brief mention of the teamwork that was responsible for the prodigious quantity and excellence of Dr. F. E. Clements' work. The teammate was, of course, Mrs. Clements—herself a competent Ph.D., botanist, artist, a loyal, efficient, sympathetic partner and a devoted wife. Never to my knowledge have two people been so continuously together over so sustained a period of time. Both Bessey-trained, they were thoroughly congenial professionally as well as temperamentally. Both vigorous workers, they had the advantage of constant counsel and advice, each of the other—a potent scientific partnership."

Mrs. Clements ascribes part of this happy combination to the fact that she liked to do things with her hands, whereas

EDITH SCHWARTZ CLEMENTS

her associate excelled in mental qualities. Proofs of this latter are not lacking in Dr. Frederic E. Clements' career that developed experimental ecology and its application to practical problems in forestry, farming, grazing, conservation, etc., together with an unusual number of noteworthy publications on these and related subjects.

On her part, besides being an adequate housekeeper, homemaker and dietitian, Mrs. Clements revealed herself as a competent stenographer and typist, auto mechanic, chauffeur, photographer and illustrator. Among these her own preferences are for illustrating and driving the car. The original plan for motoring was to share the driving with Dr. Frederic, but it early became apparent that he preferred looking at the vegetation rather than the highway, with the result that the automobile occasionally left the road and landed in the ditch alongside. Greatly to the satisfaction of both Doctors, Dr. Edith took over entirely thereafter, and can point to a record of over six hundred thousand miles of safe driving.

As for Mrs. Clements' career in art, she early showed a passion for her colorbox and paintbrush, with the result that the pictures in her story-books became studies in water color, even though a strait-laced aunt protested that it was "wicked" for a child of eight to paint on the Sabbath Day. Her mother was more lenient, fortunately, and Edith managed to escape her aunt's vigilant eye by crawling beneath the table or sewing machine, to carry on out of sight. A later interest was centered in pencil copies of pictures. The high school years were too busy for art, but Mrs. Clements admits that she was accustomed to relieve the tedium of history lectures in the University by ornamenting her note book pages with illustrations.

As for formal instruction in art, Mrs. Clements had comparatively little besides studies of still life in an art course in Minnesota University. Teachers of painting preferred representing a flower, for instance, with a few washes of color and viewing it from a distance. They could not understand why one should wish to paint each petal and stamen or other parts in detail, with the result that Mrs. Clements had to work out her own technique with water colors by trial and error. It is this combination of scientific knowledge of plant structure and skill in representation that has made Mrs. Clements' illustrations unique, especially in the delineation of wildflowers, and has resulted in the publication of several popular books with full page color illustrations.

The first of these, "Rocky Mountain Flowers," resulted from Dr. Frederic's conviction that technical keys for classifying species would benefit greatly by adequate illustrations in natural size and accurate coloring (2). This book is also rich in pen and ink drawings of details, and is in demand even though published thirty years ago. An edition of the color plates accompanied by simple descriptions, followed and is popular among visitors to the Rocky Mountain resorts.

The opportunities for travel by automobile back and forth across the country, afforded by association with the Carnegie Institution of Washington, resulted in Mrs. Clements being able to paint on the spot many of the most common and beautiful wildflowers of the West.

On the advice of a colleague in the Institution, these paintings were submitted to the editor of the National Geographic Magazine, and accepted for publication accompanied by a simple descriptive text (11). The National Geographic Society generously presented the

color plates to Dr. and Mrs. Clements who wrote a more adequate text and the resulting publication, "Flowers of Coast and Sierra," is now in its third printing (5). These successes led to a commission for Mrs. Clements to paint a similar series of illustrations for a book on "Desert Wildflowers" to be published by the Santa Barbara Museum of Natural History, but the Director's untimely death leaves these paintings in the archives of the Museum. However, another set of illustrations for the Midwest Flowers was accepted by the National Geographic Society and appeared in the August number of 1939, accompanied by a text by Dr. Frederic Clements (12). Mrs. Clements revised the text in 1946 and another wildflower book representing midwest and eastern flowers in now available (6). This has been found especially useful by nature lovers, students, and others in Nebraska, Kansas, Missouri and Texas. This will doubtless be the last such publication since color photography is taking the place of much of the "art" of the past, and Mrs. Clements' final contribution will be found in several color plates and a large number of her photographs which illustrate her publication of "Adaptation and Origin in the Plant World," by Clements, Martin and Long (8).

Publications with Edith S. Clements, as author, collaborator, illustrator, or editor:

(1) *The Relation of Leaf Structure to Physical Factors.* Thesis for Doctor's Degree, 1904; published by the American Microscopical Society under a grant from the Spencer-Tolles Fund. 102 pages; 9 full page plates of pen and ink drawings. (None available)

(2) *Rocky Mountain Flowers*, Frederic E. Clements and Edith S. Clements. Published by the H. W. Wilson Company 1914 and several later editions. 390 pages. 26 full page illustrations in color by E. S. Clements. (Still in print).

(3) *Flowers of Mountain and Plain.* By Edith S. Clements, author and illustrator. Published by the H. W. Wilson Company, 1915 and several succeeding editions (Still in print). 79 pages, 26 color plates.

(4) *Flower Families and Ancestors.* Frederic E. and Edith S. Clements. Published by the H. W. Wilson Company, 1928. 156 pages. 64 illustrations by Edith S. Clements in pen and ink.

(5) *Flowers of Coast and Sierra.* By Edith S. Clements, author and illustrator. Published by the H. W. Wilson Company, 1928, with succeeding editions. 226 pages. 32 full color plates (Still in print).

(6) *Flowers of Prairie and Woodland.* By Edith S. Clements, author and illustrator. Published by the H. W. Wilson Company, 1947. 83 pages. 24 full page color plates (Still available).

(7) *Genera of Fungi.* By Frederic Clements and C. L. Shear, published by the H. W. Wilson Company, 1931. Illustrated by Edith S. Clements with 58 full-page plates in half-tone. 496 pages. (Out of print).

(8) *Experimental Pollination.* By Frederic E. Clements and F. L. Long, published by the Carnegie Institution of Washington. 1923. 271 pages. 17 full-page illustrations by Edith S. Clements in half-tone.

(9) *Dynamics of Vegetation.* By Frederic E. Clements. Published by the H. W. Wilson Company, 1949. 296 pages, illustrated with 70 photographs by Edith S. Clements (Still available).

(10) *Adaptation and Origin in the Plant World.* By Clements, Martin and Long. Published by Chronica Botanica, 1950. 332 pages. Illustrated by photographs and drawings by Edith S. Clements and 2 color plates.

(11) *Wildflowers of the West.* By Edith S. Clements. 55 pages of test and 32 full-page color plates. National Geographic Magazine, May 1927. (Magazine article).

(12) *Floral Garlands of Prairie, Plain and Woodland.* By Edith S. Clements. 46 pages of text and 24 full-page color plates. National Geographic Magazine, August 1939. (Magazine article).

Root Development of Grasses on Revegetated Land

HAROLD HOPKINS

Associate Professor of Botany, Fort Hays Kansas State College, Hays, Kansas

THE impracticability of attempting to grow annual crops on all soils regardless of their capabilities has been proven many times. Perennial grasses, either native or introduced, have been shown to be the most profitable crop on many thousands of acres of rolling land in the Great Plains. The problem of establishing these grasses on land cultivated for many years and often badly eroded has been studied (Riegel 1944, 1947; Savage and Runyon 1937; Clarke and Heinrichs 1941; and others). Establishment has been reported in terms of basal area, rate of growth, yield, carrying capacity, and soil stability. However, despite the fact that the ability of grasses to withstand grazing and drought and to stabilize the soil depends somewhat upon the extent and development of their root systems, relatively little information on root development of reseeded grasses is available. The purpose of this study was to obtain quantitative data as to the extent of roots and amount of underground material produced by various grasses on soil being revegetated. Field work was done during the summer of 1950 on the college farm near Hays in west-central Kansas.

The development of the study of the roots of plants from an ecological point of view has been due mostly to the pioneer work of Dr. J. E. Weaver and his students. The science of grassland ecology has been advanced many years by progress at the University of Nebraska and much of the literature from these researches has become classic. As early as the second decade of this century, by the laborious method of the pick and shovel, accurate information on root systems was being made available to botanists throughout the world (Weaver 1919, 1920). Earlier literature indicates that others had been occasionally publishing the results of mere guesses as to the extent and nature of roots in the grassland. Many papers stressing the importance of root relations have been published in the last 30 years, but the literature is not reviewed here. The monolith method introduced by Weaver and Darland (1949a) was used in the present study.

Methods

Trenches 2.5 feet wide, 6 feet deep, and 12 feet long were dug with power machinery. The holes were later deepened where necessary to find depth of root extent. Soil columns 3 inches thick, 12 inches wide, and 4 or 5 feet deep were removed beneath representative clumps or sods of grass. The soil was removed from the roots by a process of soaking and washing. After the roots were clean of all soil, they were photographed, cut into 6-inch lengths, air-dried, and weighed. Crowns (arbitrarily considered from the surface to a depth of 1 inch) were weighed separately from the rest of the upper 6 inches. In addition, soil and plant material were removed to a depth of 4 inches from a typical half meter quadrat in each of the areas. Underground plant material was separated from the soil in a

manner similar to that of Weaver and Harmon (1935).

Results

This was not a controlled experiment; grasses were seeded for the primary purpose of increasing the productivity of the soil, and data are reported under existing conditions. No attempts have been made at detailed explanations of apparent discrepancies in development, since there were numerous variations in treatment, soil, and other factors of the environment. Weather conditions were generally favorable during the years that these grasses were becoming established. During the 10-year period from 1941 to 1950, rainfall was near or above average every year except in 1943. Obviously results would have been different had there been a series of years with deficient precipitation.

Buffalo Grass (Buchloe dactyloides)

Native—Two soil monoliths were removed from an upland area dominated by a mixture of blue grama (*Bouteloua gracilis*) and buffalo grass. The site had been ungrazed for 8 years and before this was only moderately grazed. The mature, uneroded soil profile typical of this area has been described (Albertson 1937). Roots of the grasses penetrated the silty loam soil to a depth of approximately 7 feet. Most extended vertically; comparatively few entered or emerged from the monolith, and these were mostly above 2.5 feet. Average air-dry weight of the crowns was 13.4 grams in the 3- by 12-inch sample. From a depth of 1 to 6 inches, weight of roots was 9.2 grams (Table 1). This 22.6 grams of material in the upper 6 inches of soil represented 76 percent of the total weight to a depth of 4 feet. Only 15 percent occurred below one foot. The effect of the great volume of roots near the surface in maintaining the organic matter and structure of the soil and in preventing erosion has been emphasized (Weaver and Harmon 1935). Extent to 4 feet and deeper is significant from the point of view of making use of available moisture and nutrients and enabling the plants to survive during drought, but the lower roots add little to the total weight of the root system.

Natural Revegation—This area was cultivated several years until 1920 when it was abandoned and allowed to revegetate naturally. During and after cultivation considerable erosion occurred. The soil profile was not well developed. The upper 8 inches had the dark brown color and granular structure of typical A horizon. The color from 8 to 12 inches was transitional, but at the latter depth it became abruptly and distinctly yellow and intermixed with a large amount of fragmented limestone. This material extended to the full depth of the roots (5.5 feet). The only evident change was an increase in the number and size of the rock particles with increasing depth. Etchings on the rock fragments indicated the importance of roots in decomposition of the parent rock. The B horizon was not developed. Mechanical analyses according to the hydrometer method (Bouyoucos 1936) showed the increase in clay ($<.002$ mm.) from near the surface to a depth of 2 feet was only from 28.5 to 34.4 percent. In comparison, where native buffalo grass was studied, increase was from 21.3 percent in the A horizon to 42.5 in the B horizon. The effects of this great difference were very evident in the structure of both A and B horizons.

The vegetation consisted of "islands" of buffalo grass surrounded by sand dropseed (*Sporobolus cryptandrus*); each occupied about half the area. The monolith was taken about 1 foot from the edge of an area dominated by buffalo

grass. Since these patches have been enlarging from the periphery at an average rate of 3 to 5 inches per year (unpublished data) the sample had not been established long. The root system was not well developed; crowns weighed only 2.3 grams and the next 5 inches, 6.4 grams. This was little more than one-third as much as was present in the upper 6 inches in native sod. Even so it represented 63 percent of the total weight of underground parts. Number of main roots decreased from 94 at 18 inches to 34 at 36 inches.

Seeded in 1942—The soil had a comparatively high clay content and was dry and hard when the excavation was made. Retarded moisture penetration was indicated by the relatively shallow lime layer which started at 14 inches and reached a maximum concentration between 20 and 24 inches. Roots extended to a depth of 6.5 feet. Total amount in the upper 6 inches was 16.3 grams. The high basal area characteristic of native buffalo grass did not occur here, and weight of crowns was only about one-third as great as crowns in native sod. However, there was an extensive mat of branched roots beneath the crowns in the 1- to 5-inch depth (Table 1).

Seeded in 1946—The topsoil in this upland area was dark brown and the profile was similar to that under native sod. Carbonate concentrations occurred from 24 to 36 inches. Roots extended to 7 feet but the root system was poorly developed. Extensive branching occurred

TABLE 1

Weight in grams of underground parts of native and seeded grasses at various depths. Seeding was done in the spring of the year indicated

GRASS SPECIES	WEIGHT OF UNDERGROUND PARTS AT DIFFERENT SOIL DEPTHS									
	0–1*	1–6	6–12	12–18	18–24	24–30	30–36	36–42	42–48	Total
Buffalo grass, native	13.49	9.23	2.44	1.44	1.00	0.88	0.70	0.47	0.09	29.74
Buffalo grass, natural revegetation	2.32	6.42	2.12	0.98	0.79	0.55	0.26	0.25	0.05	13.74
Buffalo grass, 1942	4.62	11.72	3.15	1.46	1.08	0.55	0.37	0.17	0.15	23.27
Buffalo grass, 1946	0.87	5.89	0.97	0.58	0.16	0.11	0.12	0.04	0.05	8.79
Blue grama, 1941	15.85	15.89	2.92	2.01	1.43	1.47	1.14	0.71	0.51	41.93
Blue grama, 1942	10.28	15.17	2.22	1.32	1.08	1.17	0.80	0.49	0.08	32.61
Blue grama, 1947	16.14	7.68	0.61	0.36	0.20	0.14	0.14	0.07	0.04	25.38
Blue grama—western wheatgrass, 1941	5.34	12.45	2.18	1.60	0.94	0.65	0.62	0.46	0.31	24.55
Big bluestem, 1945	24.56	17.90	3.79	1.83	1.41	0.87	0.98	0.87	0.57	52.78
Switch grass, 1941	3.32	31.52	6.25	3.27	2.85	3.30	2.29	1.78	0.67	55.25
Switch grass, 1948	4.87	2.49	0.77	0.38	0.19	0.16	0.14	0.12	0.12	9.24
Side-oats grama, 1942	7.49	14.95	1.71	1.07	0.79	0.51	0.60	0.42	0.27	27.81
Western wheatgrass, native	3.56	10.94	1.92	1.37	1.17	0.98	0.87	0.75	0.45	22.01
Western wheatgrass, 1948	2.71	4.88	0.68	0.61	0.34	0.09	0.07	0.04	0.03	9.45
Sand dropseed, natural revegetation	1.02	2.14	1.21	0.72	0.37	0.21	0.19	0.06	0.02	5.94
Kentucky bluegrass, 1945	0.72	13.30	2.01	0.40	0.24	0.13	0.06	0.02	0.01	16.89
Smooth brome, 1948	1.88	3.78	0.96	0.80	0.35	0.13	0.09	0.05	0.03	8.07

* Soil depth in inches measured from soil surface.

only in the upper 2 inches of soil. At a depth of 18 inches there were 28 roots in the monolith, and only 6 of these penetrated to 4 feet. This profile showed the poorest root system of any examined in buffalo grass. This is difficult to explain in view of the fact the soil appeared good and that the seeding had seeded. General appearance of the root system was similar to that of the 1947 seeding (Fig. 1B).

Blue Grama

Seeded in 1941—Erosion had been negligible on the nearly level land in the vicinity of the bisect, and the profile

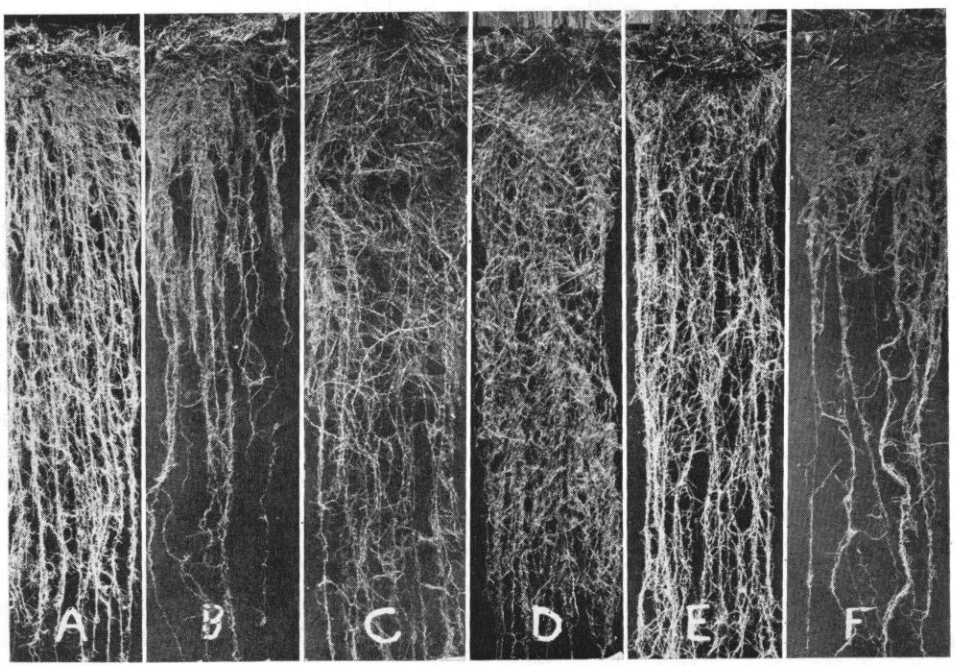

FIGURE 1. PHOTOGRAPHS OF GRASS ROOTS: (A) blue grama seeded in 1942, (B) buffalo grass in 1947, (C) big bluestem in 1945, (D) switch grass in 1941, (E) western wheatgrass from native range, (F) Kentucky bluegrass seeded in 1945. Samples are from soil monoliths 12 inches wide, 3 inches thick and 4 feet deep.

had 3 years to become established. However, growing conditions were unfavorable during June, July, and August, the period when buffalo grass makes most of its growth. Precipitation for the year was above average, but during these months there was a total deficiency of more than 5 inches. At this writing (April 1953) this grass is well established and is being utilized. It is likely it would have become established 1 or 2 years sooner had conditions been good during the year it was

was typical of an upland soil. The upper 12 inches was dark brown in color. Concentrations of carbonates occurred from 19 to 43 inches and consolidated limestone was present at 7 feet.

The grass had been mowed during late summer for several years and was grazed rather heavily during the year preceding the study. The root system was well developed. Crowns and roots to a 6-inch depth weighed 31.7 grams. Crowns alone furnished half this weight in correlation

with a high basal cover of 80 percent. From 6 to 12 inches, the weight was 2.9 grams and there were further decreases at greater depths (Table 1). A total of 75.6 percent of the total underground material occurred in the upper 6 inches of soil. Nevertheless, there were 150 main roots at an 18-inch depth and some extended to 7 feet. Decrease in weight at lower depths was due to smaller roots and less extensive branching. Total amount of vegetative material in the monolith was considerably greater than that produced by buffalo grass under all conditions sampled. This excellent development is an indication of what can be expected when either of the short grasses is planted on cultivated soil which has not become depleted.

Seeded in 1942—The profile was exposed on a northwest slope of about 4 percent and some erosion had occurred. Maximum concentrations of lime occurred at the relatively shallow depth of 20 to 24 inches. The poorer soil, in comparison to that in the 1941 seeding, was reflected in the less complete development of the root system. Extent of roots was 6 feet but total amount was 22 percent less than that of the earlier seeding. Weight of crowns was 10.2 grams. This is much more than that of buffalo grass on similar soil but would be expected in view of comparative growth habits of the species. Below the crowns variations became less evident (Fig. 1A).

Seeded in 1947—The sample was removed from a near level site where there had been little erosion. The grass occurred in large clumps, and basal area was only about 21 percent. The majority of roots did not grow directly downward as in a closed cover; many extended laterally and completely permeated the upper soil. This caused a decrease in the weight of roots at the 1- to 6-inch level immediately beneath the plant in comparison to the denser sod of the 1942 seeding. Roots extended to 6 feet, but there was comparatively little branching below 6 inches. Since the soil was in fair condition, the root system will probably soon be similar to that of the 1941 seeding.

Blue Grama—Western Wheatgrass (Agropyron smithii)

Seeded in 1941—These 2 grasses were planted in the same area as blue grama alone in 1941 and furnish an interesting comparison. The basal cover was only 13 percent as compared to 80 where wheatgrass was absent. These grasses together had developed a well branched and extensive root system, but blue grama furnished about 75 percent of the total weight. Effect of the wheatgrass was most noticeable in causing a reduction in the weight of the crowns from 15.8 to 5.3 grams, but there was also a decrease at all other depths. Total weight of blue grama roots alone was 41.9 grams, and that of the combination was only 24.8 grams.

Big Bluestem (Andropogon gerardi)

Seeded in 1945—The sample was taken midway on a long moderate slope. The soil was in excellent condition with apparent high content of organic matter to 18 inches. Upper portion of the typical B horizon occurred at 25 inches and maximum carbonate concentration was from 32 to 36 inches. Local concentrations occurred as deep as 5 feet and the columnar structure of the B horizon was still evident at this depth. These data indicate a deep permeable soil—an excellent medium for the growth of roots.

A monolith was removed from both a bunch and sod type of cover; data in Table 1 refer to the former. In each case root systems were extensively branched in the upper 18 inches. Crowns, roots, and rhizomes were so dense it was

difficult to remove all the soil. Weight in the top 6 inches was 42.4 grams. Many of the main roots extended almost horizontally for 12 to 18 inches at a depth of 2 to 6 inches (Fig. 1C). This was especially noticeable where buffalo grass was present as a competitor or where big bluestem occurred in bunches. Roots from adjacent plants extended horizontally through the monolith. Principal roots often had a diameter of 2 mm. to a depth of 3 feet or more and some extended to 8 feet.

Switch Grass (Panicum virgatum)

Seeded in 1941—The silty clay soil was similar to that where the 1941 seeding of blue grama was sampled. Switch grass had the best developed root system of any that were examined. Roots extended to 7 feet, where solid rock occurred, and were extensively branched at all depths (Fig. 1D). Crowns weighed only 3.3 grams due to the low basal area, but from 1 to 6 inches there was a dense mat of roots which weighed 31.5 grams. At 8 inches there was an abrupt decrease in the amount of material, but the weight from 6 to 12 inches was more nearly maintained to the bottom of the monolith than in any of the other samples. In fact, there was more root material at every depth than for any of the other grasses. The extensive branching so often limited to the A horizon occurred well into the subsoil. This correlates with results of Weaver and Darland (1949b) and may be a partial explanation for the ability of switch grass to grow and reproduce on upland soil usually considered as being able to support nothing better than a mixed-grass type of vegetation. The reaction of this artificially established vegetation to a period of drought remains to be seen. The great volume of root material was due to large roots and extensive branching since there were only 88 principal roots at a depth of 18 inches. The nearby blue grama had 150 roots at this depth, but the total weight was only 75 percent as much as for switch grass. This was despite the fact that crowns of blue grama were more than 4.5 times as heavy as those of switch grass.

Seeded in 1948—The soil was poor and a good cover had not been established. Bunches were small and scattered. Roots extended to 7 feet but had not produced the mat of roots near the surface characteristic of the older seeding. Total weight of material in the upper 6 inches was only 7.3 grams, but this represented 79 percent of the total to 5 feet. There were only 12 roots at 18 inches and 6 of these were present at 5 feet. As was true in the 1941 seeding, degree of branching below 8 inches did not decrease as much as with other species. It seemed generally true among all species where there were sufficient data, that the roots extended to their full depth before a well-developed system was formed at any depth.

Side-Oats Grama (Bouteloua curtipendula)

Seeded in 1942—The deep soil was similar in many respects to that described for the 1945 seeding of big bluestem. Roots extended deeper (9.5 feet) than those of any other grass but otherwise the root system was not so good as that of either switch grass or big bluestem. Material in the upper 3 inches weighed about 17 grams due to several short heavy rhizomes, but below this many extended laterally causing a marked decrease in the weights at lower depths.

Western Wheatgrass

Native—The sample was taken from a lowland area where wheatgrass occurred in a pure stand. The soil was typically alluvial with high organic content to 4

feet. Roots extended almost vertically from the rhizomes and crowns to a depth of 8.5 feet. Extensive branching in the upper soil, characteristic of big bluestem in the same area, did not occur. Even in the upper 4 inches there were many open places; this is undoubtedly partly responsible for the poor surface structure often encountered in soil where wheatgrass is dominant (Hopkins 1951). However, it does not mean that the root system as a whole was not good since there were 82 roots at an 18-inch depth and all were well-branched (Fig. 1E).

Seeded in 1948—The profile was exposed near the base of a long slope where there had been some deposition. The soil was dark and of good structure to a depth of 15 inches; typical B horizon began at about 30 inches. The root system was poorly developed, even though it extended to 7.5 feet. There were 50 roots and 6 rhizomes near the surface but only 25 roots at 18 inches. These were small and broke easily while being freed of soil. Weight of roots and stems in the upper 6 inches was only 7.8 grams, which was about one-half as much as in native wheatgrass. At lower depths the differences were even greater. Total weight of roots was about the same as that produced by switch grass seeded the same year. It seems significant that the latter was on poorer soil than was wheatgrass.

Sand Dropseed

Natural Revegetation—The sample was removed from the same area as buffalo grass on natural revegetation land. Sand dropseed occurred here as a part of the early grass stage of subsere succession (Weaver and Albertson 1944). The root system extended to nearly 6 feet, but amount of branching was poor. Weight of underground materials in the upper 6 inches was only 3.1 grams and that of the total root system to 4 feet was only 5.9 grams. This is in contrast to the adjacent invading buffalo grass and to native buffalo grass which had a total weight of 13.7 and 29.7 grams, respectively. Reseeded grasses had established themselves better in only a few years than had sand dropseed 30 years after abandonment.

Kentucky Bluegrass (Poa pratensis)

Seeded in 1945—The sample was taken in a nearly pure stand of Kentucky bluegrass about 2.5 feet from an area occupied by big bluestem. The grass is not considered adapted to this region except for irrigated lawns and was planted due to an error in seed labelling. Forage production has been small, but it has proven of some value in furnishing early spring grazing. The basal cover was low and crowns weighed only 0.7 gram. However, there was a dense mat of 13.3 grams of finely divided roots from a depth of 1 to 4 inches (Fig. 1F). Below this the amount was greatly reduced and partly replaced by those of big bluestem, which had large light-colored roots easily distinguished from those of Kentucky bluegrass. At a depth of 2 feet, fully 50 percent of the roots in the monolith were from big bluestem plants 30 inches distant. Root competition between these species has been described (Weaver and Voigt 1950).

Smooth Brome (Bromus inermis)

Seeded in 1948—Roots extended to 7.5 feet, but branching was inadequate to occupy the soil thoroughly. Even immediately under the crowns there was no mat of roots. Weight of all vegetative material in the monolith was only 8.0 grams; only the sand dropseed monolith contained less. However, smooth brome was sampled only on a relatively xeric hillside, and these data should not be

construed as typical of the species. Its excellent growth in mesic habitats indicates a much better root system.

Quadrat Studies

The importance of grass roots on the structure and organic matter, and thus the productivity, of the soil has been illustrated (Weaver and Zink 1946). They have also indicated the importance of the stem bases, which occur beneath or at the surface of the soil, in contributing to the organic matter. These have been included in the underground parts in this report. Degree of establishment and development of root systems have been described in terms of extent and amount of roots directly beneath the clumps or sods of grass. This is significant but does not disclose the degree of development in the spaces between plants. Amount of material in the entire upper portion of the soil is important in resistance to erosion and to competition from invading weeds. Distribution of roots in the upper soil of a climax grassland community is fairly uniform, even in the bunch type of vegetation, in that almost as many occur between clumps as directly under them (Weaver and Voigt 1950). However, this uniformity does not occur in subseres and would not be expected to occur on recently revegetated areas. Table 2 gives total weight of underground parts in the upper 4 inches per half-meter quadrat. This, of course, includes areas between as well as under the clumps of grasses.

Weight of buffalo grass underground parts was 221, 129, and 83 grams from seedings made in 1942, 1946, and 1947, respectively. Amount under native sod was 326 grams, but under natural revegetation it was only 150 grams (Table 2). It should be noted that the latter sample was taken near the center of an area dominated by buffalo grass (monolith was taken near the edge) and probably represented its maximum development under existing soil conditions. The difference between the 1946 and 1947 data indicates the significance of this information since differences in amount of roots of individual plants of the two seedings were small as shown by the monolith studies.

TABLE 2

Amount of underground plant material in the upper 4 inches of soil expressed in grams per half-meter quadrat

GRASS SPECIES	DATE SEEDED	WEIGHT
		(grams)
Buffalo grass	Native	326
	Natural revegetation	150
	1942	221
	1946	129
	1947	83
Blue grama	1941	236
	1947	199
Blue grama—western wheatgrass	1941	154
Big bluestem	Native	381
	1945	338
Switch grass	1941	285
	1949	77
Side-oats grama	1942	220
Western wheatgrass	Native	208
Kentucky bluegrass	1945	219
Smooth brome	1948	92

Roots of blue grama seeded in 1941 weighed 236 grams; blue grama and western wheatgrass planted together at the same time had produced only 154 grams on the same soil. This reduction in weight was also illustrated in results from the monoliths. Wheatgrass is not a desirable species where part of the reason for revegetation is to restore the organic matter and structure of the soil.

Native big bluestem produced 381 grams of crowns, roots, and rhizomes to a depth of 4 inches (Table 2). The ability of this grass to produce a large amount of material quickly when planted on good

soil was indicated by the 338 grams where seeded in 1945. Switch grass produced 285 grams on an upland soil in the 1941 seeding. In the relatively poor soil of the 1948 seeding, yield was only 77 grams. However, accurate conclusions cannot be drawn from these data until all the grasses are seeded at the same time and on the same soil and site. The importance of soil characteristics on amount of root materials produced has been emphasized by Shively and Weaver (1939).

Native western wheatgrass and planted Kentucky bluegrass produced approximately the same amount of material in the upper 4 inches. The important difference is that on the basis of monolith studies the 219 grams of the latter represents about 75 percent of the entire root system while the 208 grams of wheatgrass is less than 50 percent of the roots to a depth of 4 feet, and total extent was more than 8 feet. Thus, in periods of stress wheatgrass would surely be the strongest competitor. This merely illustrates that an accurate and reliable study of roots cannot be confined to the upper 4 inches or even to 4 feet but must include the entire system.

Discussion

It would be expected that the amount of underground material produced by a grass would be somewhat proportional to its value in restoring a soil to near its original productivity. The time required for the establishment of a good root system would be an indication of its ability to stabilize the soil. It is significant that in general the mid grasses have proven superior in both respects to the short grasses, even on areas formerly occupied by the latter. This, however, is not a complete endorsement for the taller grasses. Their excellent development has likely been made possible by certain changes in the profile following cultivation. These observed changes consist of a deepening of the B horizon leaving it more penetrable and accompanied by improved moisture relationships. Furthermore, the important item of competition from short grasses is eliminated. Probably as droughts occur these tall grasses will gradually thin and invasion of more resistant short grasses will occur. This then opens up the possibility of using mid grasses for high yields and maximum soil improvement in long-time rotations and a mixture of mid and short species for permanent pastures. The former would provide initial high yields and the short grasses would be readily available to provide a protective cover after periods of drought.

This study has verified the folly of allowing land to revegetate naturally rather than reseed it (Riegel 1944). It has also shown that it is important for soils to be reestablished to grasses while they are still productive. Those planted on eroded soils have failed to form the root systems necessary to stabilize the soil and restore productivity.

Summary

A study was made in 1950 of root systems of several species of native and introduced grasses near Hays, Kansas. Root samples of each grass were removed from soil monoliths 3 inches thick, 12 inches wide, and 4 feet deep. Samples were cut into segments 6 inches long, air-dried, and weighed. Material from the surface to a depth of one inch (crowns) was separated from the rest of the first segment.

Roots of native buffalo grass on a mature, upland soil extended to a depth of 7 feet. Air-dry weight of underground material in the upper 6 inches was 22.7 grams, which was 76 percent of the total weight to a 4-foot depth. This is compared to 8.7 grams under about 3 or 4

years of natural revegetation, 16.3 grams when seeded in 1942 and 6.7 grams when seeded in 1946. In every case there was an abrupt and considerable decrease in weight of roots below about 6 inches.

Blue grama seeded in 1941 had an excellent root system which extended to solid rock at 7 feet. Weight in the upper 6 inches was 31.7 grams. Similar weights for 1942 and 1947 seedings were 25.4 and 23.8, respectively. Inconsistency of these results with those from buffalo grass is due in part to heterogeneity of soils. Blue grama consistently produced a heavier root system than buffalo grass. Western wheatgrass and blue grama together produced a poorer root system than blue grama alone.

Big bluestem seeded in 1945 had formed a dense mat of crowns, roots, and rhizomes which weighed 42.4 grams in the upper 6 inches. Roots extended to 8 feet. Switch grass seeded in 1941 on an upland soil had the best root system examined. Extensive branching occurred at all depths. Where seeded in 1948, penetration was nearly as great (7 feet), but branching was not extensive and a mat of roots had not been produced near the surface. Roots of all grasses apparently extended to near their full depth before a well-developed system was formed at any depth.

Side-oats grama seeded in 1942 extended its roots to 9.5 feet—deeper than those of any other grass sampled. Many roots grew diagonally, thus causing a reduction in weight in the lower portions of the monolith. Roots of native western wheatgrass penetrated 8.5 feet. Total weight was less than for most grasses. Where seeded in 1948 the root system was poorly developed. Sand dropseed on "go-back" land and smooth brome seeded in 1948 on an upland soil also had poor root systems. Kentucky bluegrass seeded in 1945 had formed a dense mat of roots in the upper 4 inches of soil, but total extent was only about 3.5 feet.

Underground parts were also removed in each area from a typical 0.5-meter quadrat to a depth of 4 inches. These weights did not necessarily coincide with those from the monolith since the latter were removed directly beneath a clump or sod of grass. However, they are important in that they represent the extent to which the entire surface soil was occupied by roots. Soil from native buffalo grass, native and seeded big bluestem, and the 1941 seeding of switch grass all contained more than 250 grams of material. Switch grass and smooth brome, both 1948 seedings, yielded less than 100 grams.

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MID-CENTURY CONFERENCE ON RESOURCES FOR THE FUTURE

A major conference which will deal in part with rangelands, their use and development, is scheduled to be held in Washington, D. C. on December 2, 3 and 4, 1953. This conference, the Mid-Century Conference on Resources for the Future, is the first major project sponsored by Resources for the Future, Inc., a non-profit corporation organized last year to foster education and research in natural resources. It is conducting the conferences with the aid of a grant from the Ford Foundation.

The Conference, according to information released by Conference Director Norvell W. Page, is to be a working conference of the public forum type, called to survey the Nation's natural resources, the demands upon them, and methods of using and conserving them. While the Conference will not endorse or propose programs, it is hoped that the information gathered and view expressed will make an important contribution to program formulation, in both public and private undertakings, which will promote and safeguard the national interest.

Resources for the Future, Inc., has appointed eight steering committees which are lending expert aid in Conference preparation. Each group, selected so as to give a good cross-section of experience and viewpoints, has responsibility for a major segment of the whole natural resources field. Meeting in advance of the Conference, the committees are singling out issues of greatest current importance. These are being incorporated in section papers for advance distribution as discussion guides in each of the eight sectional meetings running concurrently during the last two days of the Conference.

Two of these sections, *Competing Demands for Use of the Land* and *Utilization and Development of Land Resources* should be of particular interest to members of the Range Society. Dr. Arthur W. Sampson is a member of the steering committee for the former and Mr. Waters Davis is a member of the steering committee for the latter.

History of Forest Service Grazing Fees

W. L. DUTTON

Chief, Division of Range Management, Forest Service, U. S. Department of Agriculture, Washington, D. C.

THE FILES of the Forest Service contain a great mass of information about grazing fees. Most of the material is in the form of correspondence and unpublished reports extending over almost half a century. Much of it is gathering dust in the National Archives. With few exceptions the men who took an active part in establishment of early day grazing fee policies are no longer with the organization. The purpose of this paper, therefore, is to present what are now little known facts about the origin and development of grazing fee charges on national forests.

Early Regulations

Provision for charging for grazing use of the National Forests followed transfer of the old "Forest Reserves" from the Department of the Interior to the Department of Agriculture in 1905. In that year James Wilson, Secretary of Agriculture, approved the following regulation, through authority granted by the Act of June 4, 1897 (30 Stat. 35; 16 U.S.C. 551):

Reg. 25. On and after January 1, 1906, a reasonable fee will be charged for grazing all classes of livestock on forest reserves. In the beginning the minimum price charged will be as follows, depending upon the advantages and locality of the reserve: From twenty (20) to thirty-five (35) cents per head for cattle and horses for the regular summer grazing season, and from thirty-five (35) to fifty (50) cents per head for the entire year; from five (5) to eight (8) cents per head for sheep for the regular summer grazing season; and from eight (8) to ten (10) cents per head for goats for the regular summer grazing season. These prices will be gradually advanced when the market conditions, transportation facilities, and demand for reserve range warrant it, but the grazing fee charged will in all cases be reasonable and in accordance with the advantages of the locality. An extra charge of two (2) cents per head on grown stock only, will be made for sheep and goats which are allowed to enter the forest reserves for the purpose of lambing and kidding.

From 1906 until 1910 there was little change in the fees, except that a few adjustments were made between forests and regions in order to assure like fees for like ranges. The regulations in 1910 provided for the establishment of cattle fees from 35 cents to 60 cents, raising the maximum limit 10 cents per head per annum, and of sheep fees from 10 cents to 18 cents yearlong.

In 1915 the regulation was again amended and the per annum fees were established at 40 cents to $1.50 per head per annum for cattle, and the rates for sheep at 25 percent of the rates for cattle.

First Study of Comparable Privately-owned Ranges

The year 1916 marked the first comprehensive attempt of the Forest Service to determine a fair compensation for national-forest range in comparison with similar private-land ranges. It was at this time, too, that comments by certain Members of Congress favoring increased grazing fees assumed noteworthy proportions.

After careful consideration by the Forest Service of the rental value of some 900 tracts of private land similar to national-forest range, the Secretary of Agriculture, under date of November 3,

1916, issued an order increasing the grazing fees from 12 to 20 cents per head for 1917 with the same amount of increase for each of the succeeding years of 1918 and 1919, provided no single increase or series of increases resulted in a fee in excess of $1.50 per annum. A minimum rate of 60 cents per annum was established. These were flat rate fees and the examples are on a cattle basis.

In 1920 the House Committee on Agriculture made efforts, in the form of appropriation riders and otherwise, to increase grazing fees by as much as 300 percent. The Forest Service, however, took the position that it would not be fair to change the fees during the life of 5-year permits which had been issued in 1919. In addition, it was felt that economic conditions surrounding the livestock industry in the West were too unstable to justify a hasty increase in fees at that time.

First Comprehensive Appraisal

As an alternative to the course proposed by the House Committee on Agriculture, the Forest Service suggested that a comprehensive study of the range values in the western States be made, with a view to determining a fair basis of compensation for use of national-forest ranges. The plan for the appraisal was worked out and approved by the Secretary of Agriculture in November 1920. C. E. Rachford, Assistant Chief of Grazing for the U. S. Forest Service at that time, directed the study.

In the early stages of this study several methods for applying the principle of a fair and reasonable compensation to the Government for the use of national-forest range were considered. Among these were cost of production, open competitive bid, study of a sample range in each locality, value of range in relation to market value of livestock, and the rental value of comparable privately owned lands. All were discarded in favor of the last named, i.e., rentals paid for comparable lands in private ownership.

The study included a survey of the rental value of over 2,000 tracts of privately owned and controlled land comprising over 20 million acres. Of these, 1,575 tracts or some 16 million acres were finally used for purposes of comparison with national-forest range lands.

The average per head per month rentals paid for the 16 million acres of privately-owned lands over a period of some 10 years ending in 1923 were 24.6 cents for cattle and 7.5 cents for sheep.

For the approximately four million acres studied but discarded, the average rentals per head per month were 54 cents for cattle and 14 cents for sheep.

Some ten thousand odd national-forest grazing allotments involving about 110 million acres were also surveyed and analyzed. Primary factors, such as forage, water, topography, and accessibility, influencing grazing values were graded or rated on both the privately-owned tracts and the national-forest allotments. For example, the water on a given cattle range was graded 100 percent if the cattle were required to travel one mile or less; 90 percent if travel was between one and two miles; 70 percent if travel was three to four miles; and 50 percent if travel was four to six miles. The grades for all factors were than averaged to obtain the final grade for the unit.

The basic value of the national-forest allotments was then determined by the following formula: The grade of the comparable privately-owned tract of land is to its rental price (in cents per head per month) as the grade of the national-forest allotment to be compared therewith is to X.

Recommended charges per head per

month for national-forest range resulting from the study as of the fall of 1923 averaged 18.1 cents for cattle and 6.2 cents for sheep. Actual charges per head per month in effect on the National Forests at that time averaged 10.4 cents for cattle and 2.9 cents for sheep.

These proposed fees were presented to approximately 9,000 national-forest permittees at about 400 meetings held throughout the western country. Permittees from New Mexico and Arizona attending the meetings, and numbering about 1700, were favorable. (Proposed fees per head per month for those two States averaged only 8.6 cents for cattle and 2.9 cents for sheep.) The great majority of the remaining 7,300 permittees agreed to the fairness of the method but, as a business proposition, were almost unanimous in opposing any increase at that time.

Casement Appointed to Review Appraisal

As a result of these objections the Chief Forester recommended to the Secretary of Agriculture that he select some competent man, wholly disconnected with the Forest Service, to make a thorough-going check of the appraisal. This recommendation was accepted, and Mr. Dan D. Casement, Kansas livestock breeder and leader in the industry, was selected to make the review with the understanding that the 1919 fee rate would continue through 1925 and 1926, except where the appraisal had shown the 1919 rates to be in excess of the value of the forage.

During the interim—1924–1926—the original appraisal was rechecked by the Forest Service and new data on current privately-owned land rentals added. In some instances these had been reduced below the previous ten-year average; in others the trend had been upward. The recheck also went further than the original appraisal in giving the permittee the benefit of any doubt which might exist as to the accuracy of the data. The result of the recheck and additional data was to recommend a still lower fee, so that when Mr. Casement began his assignment on January 2, 1926, the appraisal recommendations per head per month averaged 16.6 cents for cattle and 5.9 cents for sheep.

Mr. Casement completed his assignment June 30, 1926, with a report of that date. He made two important recommendations for reductions in the fees proposed by the Forest Service (1) "an arbitrary reduction from the appraisal fees for National Forests in Oregon and California to bring them to the same general level as the average fees proposed for" the Northern Rocky Mountain, Rocky Mountain, and Intermountain Regions; and (2) a general reduction, after application of No. 1, ranging from 10 to 40 percent of the increases proposed by the appraisal and "averaging in the aggregate 25 percent" of such increases. Mr. Casement also recommended that the general reduction be applied "in the manner that will best meet any unwarranted differences and discrepancies. . . ." Another recommendation was that the fees be related to the prices of beef and lamb after 1930.

In explaining his recommendations Mr. Casement said that the "conspicuously high fees" proposed for Oregon and California could not be justified "except on purely commercial grounds . . ." As to his recommendation for a general reduction he said: "My belief that social and economic principles have been and should continue to be applied in the administration of forest grazing leads me to recommend that precise recognition of these principles be given by a general reduction in the proposed fees."

Final Appraisal Fees

The Casement recommendations were applied. The results were discussed with representatives of the livestock industry in Salt Lake in January 1927, minor adjustments made and, on January 25, 1927, approved by the Secretary of Agriculture.

The following tabulation shows the relationship of the final fees per head per month established in 1927 to the per head per month fees (a) in effect on the National Forests in 1927, (b) on comparable privately owned lands in 1923, (c) recommended by the appraisal in 1923, and (d) recommended after a recheck in 1926:

	CATTLE	SHEEP
National Forest fees—1927	10.4	2.9
Privately owned land fees over 10-year period—1923	24.6	7.5
Original appraisal fees—1923	18.1	6.2
Appraisal recheck fees—1926	16.6	5.9
Final adjusted fees—1927	14.5	4.5

Increases called for by the final adjusted fees were applied in installments of 25 percent each during the years of 1928, 1929, 1930 and 1931, the full increase being effective in 1931. Under this schedule the average fee per head per month for cattle was increased from 10.4 cents to approximately 14.5 cents; for sheep from 2.9 to about 4.5 cents. Fees by Regions, Forests, and grazing allotments of course varied considerably above or below the average.

MARKET PRICE FORMULA ADOPTED

In 1933 the users of the National Forests urged that the previously recommended plan for relating fees to market values be made effective at once. Such a plan was approved by the Secretary on May 27, 1933, and provided:

1. That the average national-forest grazing fees of 14.5 cents per head per month for cattle and 4.5 cents per head per month for sheep in effect during 1931 be used as the basic fees, subject to adjustment each year in accord with fluctuation in livestock prices.

2. That the adjusted fees each year shall have the same ratio to the basic fees that the average price received by producers in the eleven western States during the immediately preceding year had to the corresponding average price during the period 1921–1930 ($6.62 per cwt.), inclusive in the case of cattle, and during the period 1920–1932 ($9.15 per cwt.) inclusive, in the case of sheep. Reducing this to an equation for cattle, we have: $6.62:14.5 cents::preceding year's beef cattle price:X. X equals current year's average fee rate. (A specific example of how local fees are computed is presented in a following section.)

3. That the cattle prices to be used in adjusting the fees shall be the prices received for beef cattle as compiled by the Bureau of Agricultural Economics, and the sheep prices shall be the prices received for lambs as likewise compiled by the Bureau of Agricultural Economics.

4. That in adjusting the grazing fees for 1933 in accordance with the provisions of the preceding paragraphs, 4.13 cents be considered the average price per pound for beef cattle for 1932, and 4.18 cents the corresponding price for lambs; that the average fee for 1933 as thus determined will be 9.05 cents per head per month for cattle, or 38 percent less than the average cattle fee determined by appraisal. For sheep the average fee in 1933 will be 2.05 cents per head per month, or 54 percent less than the average sheep fee determined by appraisal.

The approval of this plan marked an innovation in the past policy. While it

maintained the basic schedule of fees adopted in January 1927, it recognized that prices received by the producer year by year are indices to the ability to pay for a given commodity. It was understood that this plan had to be applied broadly because fees could not be subject to adjustment to meet special conditions affecting individuals or localities only.

Final agricultural price data are ordinarily published by the Bureau of Agricultural Economics in April, and in order that current year's fees may be calculated prior to the beginning of the forest grazing seasons, the B.A.E. furnishes the Forest Service with preliminary price data at the beginning of each year. These preliminary figures normally do not differ sufficiently from the final figures to make any difference in the charges.

TABLE I

Average National Forest grazing fees and livestock prices by years

YEAR	AVERAGE NATIONAL FOREST GRAZING FEE (CENTS PER HEAD PER MONTH)		AVERAGE PRICE IN DOLLARS PER CWT. PER CENT OF BASE PRICE*			
			Beef cattle		Lambs	
	Cattle	Sheep	Amount	Percent	Amount	Percent
1932			4.13	62	4.18	46
1933	9.05	2.05	3.43	52	4.85	53
1934	7.51	2.38	3.67	55	5.51	60
1935	8.04	2.71	5.96	90	6.84	75
1936	13.05	3.36	5.73	87	7.45	81
1937	12.55	3.66	6.84	103	8.62	94
1938	14.98	4.24	6.11	92	6.74	73
1939	13.4	3.3	6.80	103	7.49	82
1940	14.89	3.68	7.29	110	7.82	86
1941	15.97	3.85	8.64	130	9.39	102
1942	18.9	4.6	10.50	159	11.30	123
1943	23.0	5.5	11.70	177	12.60	138
1944	26.0	6.25	11.30	171	12.30	134
1945	24.8	6.03	12.10	183	12.90	141
1946	27.0	6.25	14.20	214	15.30	167
1947	31.0	7.5	18.40	278	20.20	221
1948	40.0	10.0	22.20	335	22.40	245
1949	49.0	11.0	19.40	293	22.10	241
1950	42.0	10.75	23.10	349	24.80	271
1951	51.0	12.25	29.10	440	31.10	340
1952	64.0	15.25	24.50	370	24.00	262
1953	54.0	11.75				

* Cattle $6.62, sheep $9.15.

Computation of Current Local Fees

Use of 1952 price data in computing the 1953 current local fee for a given range is explained as follows:

The 1952 average market price for beef cattle was $24.50 per cwt.; the base livestock price is $6.62 per cwt.

Base fees fully applied in 1931 as a

result of the appraisal study varied by individual forests and ranges. Assume a cattle range with a 1931 base fee of 12 cents per head per month.

Reducing these to an equation we have

$$6.62:12::24.50:X$$

X = 44.4 (or 44 cents when rounded off to the nearest cent, and becomes the 1953 cattle fee on the assumed range)

Stated another way, the 1952 market price of $24.50 per cwt. for beef cattle is 370 percent of the base market price for beef cattle. Therefore the 1953 fee to be charged on a range with a base fee of 12 cents is 370 percent of the 12 cent base fee, or 44 cents.

Included is a tabulation showing average grazing fees and livestock prices by years (Table 1).

Need for a New Appraisal

The present fee structure is based on a study undertaken more than 30 years ago. Some adjustments in base fees are needed in order to iron out certain inconsistencies which have developed over the years or which were inherent in the original appraisal. When or how this will be done has not been decided at this writing.

Acknowledgment

To Mary E. Price, Administrative Assistant in the Washington office Division of Range Management, goes most of the credit for searching out and assembling the material used in this paper. Her unerring help in checking dates and figures was a major contribution.

SOME INFILTRATION CHARACTERISTICS OF SAGEBRUSH COVER

(Abstract of a thesis submitted in partial fulfillment of the requirements for M.S. degree in Forestry at Colorado Agricultural and Mechanical College, Fort Collins, Colorado, June 1952.)

This thesis presents a study of some of the infiltration characteristics of sagebrush cover.

The relative infiltration capacities of sagebrush sites in various conditions were determined by Rocky Mountain infiltrometers. The data are from 38 plots located in northwestern Wyoming, southwestern Colorado, and southwestern Utah. These plots are representative of some common conditions found on sagebrush ranges.

This study is concerned with the determination of the effects on infiltration characteristics caused by: 1) grazing, 2) reseeding, and 3) burning of sagebrush range.

The relations noted in this study imply that disturbance of sagebrush range by heavy grazing, reseeding practices, or burning will reduce the infiltration capacity of the site. Related studies conducted on the plots in the course of the main investigations indicate that soil stability of the sites supporting sagebrush will also be reduced by heavy grazing, reseeding, or burning sagebrush range.

The author recognizes that applications of research findings such as these must be limited due to the small number of samples involved. However, trends and implications developed in this study can provide material of value for future range management research.

Merle H. Tigerman

Seedling Growth and Soil Drought Resistance of Northern Great Plains Legumes, Alfalfa and Four Grasses[1]

LOREN D. POTTER

Associate Professor of Botany, North Dakota Agricultural College, Fargo

VAST acreages of depleted western range lands and croplands are being reseeded to perennial grasses and legumes to increase the forage supply. The part of non-grass plants in these seeding mixtures has been much discussed and it is natural to consider the use of some native legumes. If they are to be used in reseeding operations, more should be known of their relative seedling resistance to soil drought. One of the principal limiting factors in reseeding operations in the Great Plains is the drought period which often strikes seedling plants one to several months old. On light soils especially, this drought is often the result of the drying of upper soil layers. Plants of rapid establishment and extensive root growth should have an advantage of survival as their roots extend into deeper and moist soil zones, keeping ahead of the drought.

Recent interest has led to a few investigations on the abundance and distribution of legumes in native grasslands (Whitman and Stevens 1952). Some 65 percent of the native legumes of North Dakota were mentioned as being palatable and of sufficient growth to furnish some forage, although in total providing only a minor percentage of the available forage. The general contributions of legumes in grassland flora to soil fertility and forage value are known but little specific information of the many species has been reported.

[1] Paper no. 7, Journal Series, from the North Dakota Institute for Regional Studies.

Some drought studies are available on cultivated legumes; Schultz and Hayes (1938) worked on legumes of sod and seedling stage but exposed to atmospheric drought of high temperature and low humidity.

This report is concerned with the comparative growth and reaction of seedling plants to a period of favorable soil moisture, followed by soil drought under controlled conditions in the greenhouse at North Dakota Agricultural College, Fargo, North Dakota. Comparison is made of twenty-three species of native legumes, plus alfalfa and four species of grasses commonly used in pasture reseeding. The germination of four species of native legumes, *Amorpha canescens* (lead plant), *Astragalus goniatus* (nickleaf milkvetch), *Astragalus striatus* (prairie milkvetch), and *Petalostemon purpureum* (purple prairie clover) was so low they were omitted from the analyses.

Materials and Methods

All native legume seeds were collected from plants in the field in North Dakota during the summers of 1949–51, cleaned, and stored at room temperature. The grass seeds were commercial seedhouse material for 1952. The alfalfa was Ladak alfalfa, F.C. 23905, U.S.D.A. All samples of legume seeds were treated in concentrated sulphuric acid for 15 minutes and then thoroughly washed in running water for at least one hour before planting. Hard coated legume seeds are common and this is a common practice to

insure more uniform germination. Grass seeds were subjected to the period of washing without the acid treatment to provide the same conditions for germination except for the acid treatment.

Twelve seeds of each species were planted in each of 420 one-quart waxed cardboard milk cartons, the tops of which had been removed and the cartons filled with Bearden sandy loam from which the principal root material had been removed by sifting through a window screen. After germination the number of plants in each container was reduced to nine. Germination was rather low in many species so that a standard number of plants per container was not obtained.

The bottoms of all containers were perforated with a stamping device to provide the same number and size of holes for moisture supply by subirrigation during the first 30 days growth. All containers were placed in metal tanks in which the water level was maintained at about three-quarters of an inch depth. During the first 30 days all trials were grown under favorable moisture conditions with the soil essentially at field capacity. Each treatment was represented by three replicate containers for each of the 28 species.

Treatment A—Plants were examined for height, green weight of shoot, dry weight of shoot, and dry weight of root at the end of the 30-day period of abundant moisture. At this time, all remaining containers were deprived of water supply until all plants in each container showed signs of permanent wilting with no sign of having recovered overnight.

Treatment B At the time of permanent wilting, the plants were examined in regard to height, green weight of shoot, oven-dry weight of shoot, oven-dry weight of root, and number of days to permanent wilting.

Treatment C—Plants were left in permanently wilted condition for one day, then water was added and plants maintained in soil near field capacity for three weeks at which time they were examined for percentage of plants recovering and the green weight of the living parts of the shoot.

Treatments D and *E* varied from *C* only in leaving the plants in the wilted condition for three and five days, respectively.

Results

A summary of some of the results is given in Table I, showing the averages of the three replicas. Those results which are significantly superior or inferior at the 5 percent level when alfalfa is used as a standard are so indicated.

The general growth characteristics of the plants after 30 days of optimum soil moisture and again after a period of drought to the point of permanent wilting are as follows:

Height

At the end of 30 days of optimum growing conditions the height of alfalfa was exceeded only by crested wheatgrass, intermediate wheatgrass, and bromegrass. This is to be expected because of their grass form; however, Russian wild-rye was inferior in height. No other legumes exceeded alfalfa in height. At the point of permanent wilting only crested wheatgrass was significantly higher, while among the grasses Russian wild-rye was still significantly lower. The legumes which had heights not significantly different from alfalfa after an optimum 30-day growth period were: *Astragalus lotiflorus*, prairie bird's-foot trefoil, long-leaved milk-vetch, wild bean, and false lupine.

Except for *Astragalus lotiflorus* these same species of legumes maintained heights equivalent to alfalfa until the point of permanent wilting under treatment B. permanent wilting, only Russian wild-rye was significantly lower in dry weight, all others being not significantly different from alfalfa. It is interesting to note that

TABLE I

Summary of growth features and drought resistance

GROWTH FEATURES	HEIGHT		DRY WEIGHTS				PLANT RECOVERY			REGROWTH		
			Shoot		Root							
Treatments	A	B	A	B	A	B	C	D	E	C	D	E
	centimeters		*milligrams*				*percent*			*milligrams*		
*Astragalus bisulcatus** (two-grooved milkvetch)*	*6.8*†	*8.7*	*23*	73	6	*30*	Not significant at 5% level	88	100	*259*	335	*242*
A. canadensis (little rattlepod)		*9.4*		80		*37*			100			484
A. caryocarpus (ground plum)	*2.4*	*3.4*	*19*	*19*	10	*19*		100	100	*110*	*94*	*128*
A. flexuosus (slender milkvetch)	*4.5*	16.0	*20*	50	7	*25*			100			*410*
A longifolius (long-leaved milkvetch)	11.2	17.3	*26*	*33*	9	*16*		100		*180*	290	
A. lotiflorus	8.3	*6.6*	*16*	50	6	*8*		100	67	*103*	339	*128*
A. missouriensis (Missouri milkvetch)	*2.8*	*4.4*	*10*	*23*	*3*	*8*		100	78	*74*	*108*	*103*
A. racemosus	*5.9*	*12.5*	*24*	64	9	*17*		100	100		515	*268*
A tenellus (looseflower milkvetch)	*6.6*	*7.6*	*19*	*17*	10	*11*		100	100	*205*	167	*304*
A. triphyllus (tufted milkvetch)		*2.8*		*16*		*7*		100	100	*93*	*123*	*85*
Hedysarum boreale (sweet vetch)	*5.9*	*8.3*	*20*	*26*	11	*28*		83	58	*205*	*98*	*24*
Lotus americanus (prairie bird's foot trefoil)	10.4	21.0	41	70	14	*20*		83	*0*	*267*	416	*0*
Medicago lupulina (black medic)		*6.8*		50		*15*			100			507
Oxytropis lamberti (purple loco)	*3.8*	*9.1*	*14*	43	6	*15*			100	*152*		*99*
Petalostemum villosum (hairy prairie-clover)		*9.5*		*28*		*13*		100			237	
Psoralea esculenta (tipsin)	*8.0*	*8.2*	42	*28*	14	68		*8*	*0*	*121*	*37*	*0*
Strophostyles leiosperma (wild bean)	13.5	20.2	**57**	**142**	20	41		80	42	*438*	346	*381*
Thermopsis rhombifolia (false lupine)	16.6	17.6	32	*20*	22	*29*		86	75	*76*	*44*	*42*
Vicia sparsifolia (prairie vetch)	*4.9*	*9.1*	30	63	10	53		100	100	*221*	223	*160*
Medicago sativa (alfalfa)	13.3	19.2	40	81	15	60		100	78	1816	357	747
Agropyron cristatum (crested wheatgrass)	**21.8**‡	**25.3**	*27*	61	18	46		93	94	*268*	170	*132*
A. intermedium (intermediate wheatgrass)	**22.1**	22.5	*27*	41	**25**	43		*78*	52	*245*	*141*	*145*
Bromus inermis (smooth brome)	**22.0**	22.0	*20*	38	**28**	62		96	74	*407*	398	*205*
Elymus junceus (Russian wild-rye)	12.4	*13.0*	*10*	*15*	*4*	*22*		*59*	61	*111*	*92*	*88*
Average	10.2	12.5	26	47	12	29		88	77	282	227	209
L.S.D. at 5 percent	3.7	4.4	12	46	9	22		22	45	679	207	324

* Common and scientific names follow O. A. Stevens, "Handbook of North Dakota Plants."

† Italics indicate results significantly inferior to alfalfa at the 5 percent level.

‡ Bold face type indicates results significantly superior to alfalfa at the 5 percent level.

Green Shoot Weight

No grasses or legumes were significantly greater than alfalfa in green weight at the end of the favorable growing period or at the time of permanent wilting.

Dry Shoot Weight

All the grasses were significantly lower than alfalfa after 30 days of optimum soil moisture. However, at the time of only five legumes were equal to or exceeding alfalfa in shoot weight at the end of the favorable growing season. They were prairie bird's-foot trefoil, tipsin, false lupine, prairie vetch, and wild bean. The last of these was the only one that was significantly greater than alfalfa. After a period of drought and at the time when permanent wilting was reached, ten species of legumes were equal to or exceeding alfalfa in dry shoot

weight. Five species which had been significantly lower in shoot weight under optimum soil moisture became equal to alfalfa by the time of permanent wilting. The species equal to or exceeding alfalfa in dry weight when the soil had been depleted of its available moisture were: two-grooved milkvetch, little rattlepod, slender milkvetch, *Astragalus lotiflorus*, *A. racemosus*, prairie bird's-foot trefoil, black medic, purple loco, prairie vetch, and wild bean. Again, only wild bean was significantly greater in weight than alfalfa.

Dry Root Weight

The comparative weights of roots are interesting in relation to reaction to drought, survival, and recovery ability. At the end of the 30-day favorable growing period only two species, Missouri milkvetch and Russian wild-rye, were significantly lower in root weight than alfalfa. Two species, intermediate wheatgrass and bromegrass, were the only ones significantly greater than alfalfa. All others were essentially similar in weight. However, at the time of permanent wilting, when growth had proceeded to the point of withdrawing all of the available moisture, no species was significantly greater than alfalfa in root weight. Furthermore, at this point only three legumes, tipsin, prairie vetch, and wild bean were essentially equal to the root weight of alfalfa. This inability of the majority of seedling legumes to maintain their equality to alfalfa in root system development during the period of soil moisture decline from field capacity to wilting coefficient is very noteworthy. This may in part explain the relative success of alfalfa. During this same time, three of four grass species maintained an equivalent weight of root system to that of alfalfa.

Recovery and Regrowth after Extended Periods of Drought

Treatments C, D, and E were a series of different drought periods at permanent wilting of 1, 3, and 5 days respectively before the renewal of soil moisture. By the end of the drought period, about 70 days after planting, the three annual species: prairie bird's-foot trefoil, black medic, and wild bean were in flower and fruit. Some pods contained ripe seeds. In spite of their mature condition, some of these annuals produced new axillary basal shoots upon receiving soil moisture after a 3 and 5-day period of permanent wilting. The reaction of the perennials varied with leaf morphology and degree of succulence, some had folded or rolled leaves, others were dried and stiff. The last portions to die were the terminal growing points and the axillary buds.

It is shown in Table I that a number of legume species had survival percentages equal to alfalfa. Increased periods at permanent wilting to the point where no species maintained complete survival might have revealed superior species under more severe drought. In the present experiment, however, with a 5-day period at permanent wilting only two of these species of high survival had green weights of regrowth that were not significantly lower than that of alfalfa. Among the grasses, none were significantly better than alfalfa in percentage survival and all were significantly lower in green weight of regrowth after the treatment of a 5-day drought at permanent wilting. Russian wild-rye was consistently the lowest and bromegrass was consistently the greatest in amount of regrowth capacity.

Root Nodule Development

The following observations were made on the seedling plants which were re-

moved from the soil at the end of a 30-day favorable growing period with the soil at nearly field capacity. Outstanding in the presence of nodules was wild bean. The species possessing nodules are listed below in decreasing order of the average abundance of nodules:

8.5 nodules per plant, very large	Wild bean
5.5 nodules per plant, large	Sweet vetch
4 nodules per plant, small	Two-grooved milkvetch, long-leaved milkvetch, and alfalfa
3 nodules per plant, large	*Astragalus racemosus*
0.3–1.5 nodules per plant, small	Ground plum, slender milkvetch, *Astragalus goniatus*, *A. lotiflorus*, Missouri milkvetch, *Astragalus tenellus*, purple loco, tipsin, and false lupine
0 nodules per plant	Tufted milkvetch, prairie bird's-foot trefoil, prairie vetch

Others of the twenty-four legumes were not available for sampling.

Summary

Nineteen native legumes and four species of grasses were compared with alfalfa as to seedling growth and resistance to soil drought.

Among the grasses, Russian wild-rye was consistently lowest in shoot size, root development, and drought recovery. After a favorable growth period of 30 days and a drought period, no grasses produced significantly higher forage yields per plant than alfalfa. Significantly higher results for grasses were expressed, however, in root weights of intermediate wheatgrass and bromegrass at the end of the favorable growing period. This advantage was decreased to root systems not significantly greater than alfalfa by the time of permanent wilting, which points out the steady development and taproot habit of alfalfa roots even under droughty conditions. In the amount of regrowth after drought, bromegrass was outstanding among the grasses, but did not exceed that of alfalfa.

Among the native legumes, no species was significantly greater in green weight of shoots than alfalfa at any stage in the study. Excluding the superior wild bean, from the end of the favorable growing period to the point of permanent wilting, the number of native legume species having dry shoot weights equivalent to alfalfa increased from four to nine. This indicates favorable relative growth rates for these native legumes under drought conditions. They were: two-grooved milkvetch, little rattlepod, slender milkvetch, *Astragalus lotiflorus*, *A. racemosus*, prairie bird's-foot trefoil, black medic, purple loco, and prairie vetch.

There was a significant decrease (relative to alfalfa) in the extent of root development from the 30-day old seedlings to the point of permanent wilting for all native legumes except for tipsin, prairie vetch, and wild bean.

In the ability to produce shoot regrowth after a 5-day period of permanent wilting, only little rattlepod and black medic of all the native legumes were not significantly lower than alfalfa.

In root nodule development, wild bean was outstanding, followed by sweet vetch, two-grooved milkvetch, long-leaved milkvetch, alfalfa and *Astragalus racemosus*.

In general, then, no native legume was consistently superior to alfalfa in growth during decreasing soil moisture or in drought recovery. Wild bean, an annual, was shown in this study to be superior to

alfalfa in herbage production in seedling stage after 30 days of favorable growing conditions and at the point of permanent wilting in light sandy loam soil, superior in root nodule production, but inferior in regrowth after a period of permanent wilting. The value of this annual in a reseeding mixture would depend on the possible increased soil fertility from its abundant root nodules which would be available for more than the first year, and upon its ability to reseed itself. Being an annual it never would develop the deep taproot of the perennial alfalfa and could not compete in regions of available subsoil moisture where alfalfa could continue growth as a perennial. Where this is lacking, as in many western areas, an annual may be more successful.

Also deserving of further field trials from the viewpoint of forage yield, regrowth after drought, and nodule development, are the native legumes: little rattlepod, two-grooved milkvetch, and *Astragalus racemosus*. Further trials of the latter two for range forage would be deterred because of their property of fixing selenium, common to western soils, which results in a poisonous toxicity.

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History of Grazing Industry and Range Conservation Developments in the Rio Grande Basin

E. R. SMITH

Regional Administrator, Bureau of Land Management, Albuquerque, New Mexico

(*Paper presented at the Sixth Annual Meeting, American Society of Range Management, Albuquerque, New Mexico, January 20, 1953.*)

IT IS PARTICULARLY appropriate that this panel discussion on "Ranges as Source Areas for Water for Downstream Use" be carried on in Albuquerque —here in the heart of the Upper Rio Grande watershed. For this area is the site of the earliest established irrigation and range agriculture in the United States; and that combination of activities remains as the most important characteristic of this watershed today. Furthermore, there is here displayed the classic example of what years of misuse and abuse of the surface resources in an upper watershed can result in for the generations that follow. I mean in terms of baffling physical problems to be solved and, more particularly, of threats to the continued economic stability of the people concerned.

In recent years the Upper Rio Grande watershed and its problems have received considerable attention from many individuals and agencies concerned with research, with planning, with action programs or combinations of all three. Quite naturally perhaps, major attention has concentrated in the main stem of the river and in certain tributaries, where the bulk of the population has attached itself to the irrigated land. It is there that the problems affecting water or created by water, which is the area's most important natural resource, become most pressing and most generally recognized. In fact nowhere in the West are the ills that plague irrigated land and the delivery of irrigation water more strongly in evidence than in that reach of the Rio Grande that lies in New Mexico. On the other hand, as most of us realize, similar situations, scarcely less aggravated, are to be found in many another watershed, large and small, in the semi-arid Western country.

Even the superficial observer of the situation here recognizes these various ills: the sedimentation of the storage reservoir that reduces its capacity and shortens its useful life; the aggradation of the main river channel and its tributaries, which not only results in actual floods but makes the flood threat yearly more severe, renders drainage systems inoperative, causes water-logging of irrigable land and increases greatly the maintenance cost of the irrigation system; and through it all, the enormous water losses that are induced in one way or another and which the agricultural economy can by no means afford.

When all these ills are analyzed I believe most students of the problem will agree that the root of our trouble here lies in the dislodgment of soil from its original site in the upper watershed and its progressive movement downstream from tributary channel to main channel and so to an ultimate resting place behind the Elephant Butte Dam. The results of this sedimentation process, that is, the outward manifestations or symptoms of the disease, are what have captured the popular imagination and attention to the

exclusion of all else. Millions of dollars have been applied in the past and many more millions in the future will be applied to highly skilled engineering efforts designed to give flood protection, to hold up sediment from entering the main channel and to reduce water losses. For such efforts all of us should have nothing but praise, for they are essential. But it should be pointed out and pounded into our consciousness again and again that such an approach limits itself to measures that are palliative at best. So long as the root of the trouble remains out on the upper watershed unattended to, just so long will these costly remedial measures in the main stem have to be continued and the equally costly rehabilitation of irrigation systems have to be repeated. To supplement and complement these necessary measures there is required a concerted effort by the responsible private, State and federal agencies to keep the soil in place on the upper watershed where it belongs or as near the original site as possible; in other words, we must attack the disease at its source. And more than the lip service that this idea has received so often must be forthcoming, if actual results are to be achieved.

And now, just where do the range and the use of the range enter the picture that we are considering? Over the years many of our most competent technicians in the land-use field have stated that misuse and abuse of the range and forest resources of the upper watershed are responsible for the marked severity of our sedimentation problem in the Rio Grande. Without attempting to assess the blame specifically, I have no doubt that they are in large measure correct. There are other equally competent technicians operating principally in the field of geology who state that larger, natural geologic forces are mainly responsible for our sedimentation problem and that unwise grazing use was merely the trigger that, when it was pulled, set those geologic forces in motion and gave them full sway.

Whatever may be the final verdict—and no doubt the truth lies somewhere between these two positions—all concerned, I think, will agree that intelligent, wise use of all the range, which in this case makes up the bulk of the upper watershed, is a prime essential if the sedimentation problem is to be tackled as effectively as it must be. And here it should be said that no sound conservationist makes extravagant claims as to what is possible in the way of holding up sediment or of restoring vegetal cover. He knows that millions of tons of sediment already dislodged and temporarily deposited in tributary and main channel will inevitably move down the country with each successive storm. He knows that it is impossible to "restore" vegetation that never occupied a given site. He is sure the cover used to be denser and of better composition in many areas but he is equally sure that an extensive area embracing various soil types and affected by various climatic factors never supported a uniformly excellent "sea of grass". Impatient with today's medieval philosophers who argue whether man or God is responsible, he maintains and proves to his own satisfaction that much indeed can be done over large areas to encourage vegetation, to hold the soil in place, to retard water runoff and to release water under control. He recognizes that this is a slow, painful, expensive process, but the course of deterioration over the years cannot be corrected over night by the waving of a magic wand.

Perhaps at this point we should consider briefly what has been the history of range use in the Upper Rio Grande watershed. Although Coronado explored this area in 1540, the Spanish made no

real colonizing effort here until 1598. They brought with them sheep, cattle and other domestic livestock—all of which were completely new to the pueblo Indians who were occupying the area and depending on irrigation agriculture for their living. From 1540 then, with certain intermissions, until the beginning of the Mexican period in 1821, Spanish occupation was practically continuous. From all accounts, until 1821 a purely subsistence economy existed in the area. No doubt livestock increased considerably in numbers but it still had to be grazed near the villages located in the main valleys for fear of attack from various Indian tribes. Accordingly, it appears that no great injury was done the very extensive range lands that lie at a distance from the river and its principal tributaries.

According to reports, during the Mexican period (1821–1846) the economy of the area remained pretty much a subsistence economy. At the same time, however, the human population was growing, and the markets for livestock on the Santa Fe trail and in Mexico became increasingly attractive. All of which resulted in building up the numbers of livestock, particularly sheep; and localized overgrazing in the vicinity of the towns and villages became more and more severe.

True enough, when the United States acquired New Mexico in 1846 the "subsistence" characteristics of the economy began to change to those of a commercial one, but until practically 10 years later it still remained unsafe to graze livestock very far from the settlements on account of marauding Indians. But from roughly 1855 onward both Spanish-American and Anglo-American operators extended their grazing farther and farther from the settlements. At the same time there occurred a great increase both in human immigration and in livestock population with all the added pressure on the land that that implies. Whereas in earlier years sheep had been the predominant class of livestock, now with the creation of army posts and the approach from the East of the railroads, cattle raising was greatly encouraged. With the actual coming of the railroad into the watershed in 1880 grazing operations developed even more rapidly and extensively, and so did irrigation agriculture and the cutting of timber. The importation of first-class breeding stock, the entry of Eastern capital in large amounts to finance the livestock industry and the commercialization of the industry identified with the Anglo-American operator deserve more space than we can give them here.

According to several researchers the all-time peak of livestock population in the Upper Rio Grande watershed was reached in 1900 with about 220,000 cattle and 1¾ million sheep. During the last sixty years there has been evident to trained observers a marked decline in plant cover with loss of the more palatable species. Runoff has become more and more uncontrolled and erosion has been enormously aggravated. True enough there have occurred severe droughts from time to time during that period but the decline in plant cover has been steady and continuous.

I suppose the first conscious move toward conservation in the Basin, that is, toward calling a halt to uncontrolled grazing and timber cutting and fire damage, was the creation of the Santa Fe National Forest in 1892. Other national forests, all occupying high mountain country in the watershed, were set up in later years. It is a fortunate fact that while those areas of 8000 feet altitude and over, practically all of which lie in the National Forests, produce 80 percent of our water in the Upper Basin, their con-

tribution of sediment is negligible. This is a tribute in considerable measure, I believe, to the insight and the foresight of the early forest officers and of those who followed them. No doubt management and control were often far from perfect, but a continuous effort to protect the watershed has gone forward to this day.

When the United States acquired what is now New Mexico under the Treaty of Guadalupe Hidalgo in 1846 it had honored the many private and community land grants that had existed here since their creation by the Crown of Spain.

The remainder of the territory consisted of unreserved, unappropriated public domain. But, little by little, large areas of public domain were carved out into national forests, into checkerboard grants to railroad companies to encourage railroad construction and into grants to the State when it evolved from territorial status in 1912. For many years until 1934, when passage of the Taylor Grazing Act placed it under control, the public domain was the only free range left. During that time it received no protection whatsoever. It lay at the mercy both of the villagers, many of whom had lost their community grants and their traditional pasturage, and of the commercial operator. Much of it in this watershed lies in the foothill areas and in the drier regions lower down. In contrast to national forest areas in general, the public domain furnishes small amounts of water and inordinately large quantities of sediment. The Rio Puerco sub-watershed is a case in point. There the public domain, Indian lands, State and private lands that make it up share the dubious distinction of furnishing about 6 percent of the water and 56 percent of the sediment that comes from the total watershed above the Elephant Butte Dam. This contrast, I submit, is one of the most appalling in any consideration of conservation problems. It is especially significant when we recall that portions of that subwatershed late in the last century were highly productive and supported many people.

Since the middle nineteen thirties all the various federal land-administering agencies, and later the landowners in the many soil conservation districts have recognized the problems in the upper watershed that we have described. They have worked through direct action, through cooperative agreement, through subsidy, through technical services in a continuous effort to achieve better land use, more effective range management and to supplement them with simple engineering structures or measures. They have left their mark on the country; and a good mark it is! While all these efforts have produced and are producing demonstrable benefits, the fact remains that they have been piecemeal. Until and unless some mechanism develops that will make possible a concerted effort on the part of all who are responsible, to inaugurate proper land use and the necessary remedial measures throughout the upper watershed, our major problems will, I fear, remain unsolved. The very commendable program prepared by the Department of Agriculture for runoff and waterflow retardation and soil erosion prevention represents the first concrete step in the desired direction. Let us hope that it receives the attention and support from Congress that it deserves.

With your permission I should like to make two brief personal observations, based on what experience I have had in the conservation field. As we have seen, much of this upper watershed is sick land. It needs protection and care. It is poor and deteriorated. Those of us who are responsible for this land, whether it is private, State or federal land, should be working steadily and aggressively to

improve its condition, to make it more productive.

I believe, however, we should be even more concerned with removing or reducing the threat that the condition of such lands constitutes to infinitely more valuable lands and improvements in the watershed below. Ultimately the accusing finger of the water users and of the general public will be pointed at us unless we have taken steps to discharge that real and heavy responsibility.

It is a curious paradox that the very people who are most aware of the perils that sedimentation holds for the downstream water user and who are trying to reduce those perils are the ones whom the water user most distrusts and criticizes. Perhaps this distrust will never disappear until demonstrable and acceptable evidence develops that will prove what are in fact the long range effects of proper land management and supplementary treatment on the net usable flow in the main stem. Many of the downstream users believe quite sincerely that more effective management and treatment on the upper watershed will diminish that flow. The conservationist is equally sincere in believing that such activity will in fact increase the volume and dependability of that flow. Here as elsewhere it is high time that research be inaugurated which will provide a convincing answer to the question.

The deterioration of many watersheds in the West and elsewhere, of which we have cited the Rio Grande as a classic example, is ordinarily attributable to many causes. There has not been a deep-dyed plot on the part of any single group to wreck the country. True enough, greed and selfishness and ignorance have played their part. But lack of continuity and of congruity in public land policies and laws throughout our history has contributed strongly. Also the kaleidoscopic pattern of land ownership, which so often exists, makes administration and the execution of a conservation program extra-ordinarily difficult. If we have been indulging in mutual recriminations I hope we will stop it. We need to concentrate all our energies in constructive effort to improve and stabilize our land and water supply and our dependence on them—both literally and figuratively speaking.

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The Range and Ranch Consultant, A Needed New Profession

LEON C. HURTT

Range and Ranch Consultant, 541 Evans Ave., Missoula, Montana

BUSINESS enterprises and the professions grow steadily more specialized, more complex and more competitive. Failure to keep step with rapidly changing developments often leads to bankruptcy. In recent years consultants have set up shop to analyze besetting problems, to advise and assist almost every kind of business and profession. Consultants in oil, mining, merchandising, legal, financial and many other fields have increased rapidly as obstacles therein multiply. Will the range livestock industry follow suit?

As one example, forest consultants listed (Society of American Foresters 1946 & 1950) increased from 44 in 1946 to 142 in 1950. Two of these firms listed up to 7 members in 1950. Specialized services offered vary from timber mapping and estimating, valuation and appraisals, protection, cost and economic studies, forest management, reforestation and on to a total of 21 categories. The growing need is recognized for advice and guidance in forestry—a field kindred to ranching.

But the demand for services of range and ranch consultants has lagged as compared to forestry and various other fields. Ranchers will, I hope, continue to be individualistic, but that attitude can be carried to extremes. Some ranchers mistakenly still feel that calling in a consultant to help find better ways to meet knotty problems would be a serious reflection on their judgment and ability. Yet they may not be abreast of all the recent advances in range management and reseeding. Some of the most progressive and successful ranchers have been first to employ consultants, which goes to show the fallacy of the old but persistent viewpoint. Thus, it is still a challenge which must be met by tact and by honest effective services on each job performed by a consultant.

The Need for Range and Ranch Consultants

Probably no business is faced by a more varied and imposing list of obstacles than the range livestock industry. Disastrous storms, droughts, unforeseen price fluctuations, disease, insect and other pests must be countered. A multitude of physical, chemical, biological and economic factors are involved in managing ranches for profitable and stable livestock production. Success, even survival through thick and thin, depends on avoiding the many pitfalls along the way. Some of the pitfalls are partially within control of the manager, but he can, if he will, minimize effects of most of them by skillful management.

Deteriorating soil and forage cover and subnormal production on too many ranches prove the urgent need to hasten better management by all available means. Range forage may provide up to 80 percent or more of the total feed used on the ranch. Even yet the skill needed in handling livestock too often over-shadows the emphasis needed on skill in handling the range. An experienced well qualified consultant can often be most helpful in changing wasteful or faulty management

to better practices, more suitable to specific situations. Management may account for the difference between one outfit with a 70 to 75 percent calf crop averaging well under 400 pounds at weaning, and a nearby outfit that weans an 85 percent or better calf crop averaging close to 500 pounds. Such an increase of up to 40 percent in calf production per cow unit justifies a determined effort for better management.

A consultant should supplement rather than duplicate the services of value given by bankers, county agents, or technicians from other state or federal agencies. On certain phases of a ranch operation these agencies now give invaluable service to some ranchers. But in the time available, none of them can adequately cover the whole complex field of ranch operations. A county agent commonly has 1,000 or more farm and ranch clients to service, from poultry, bees, speciality truck crops or small fruit farms to extensive sheep and cattle ranches. Time that he can spend on any one, aside from his educational, youth leadership and miscellaneous jobs, is necessarily limited. He cannot possibly follow through and adapt each new practice to every ranch in his area. On the other hand, the qualified consultant can carefully analyze each job and assist the busy operator to fit a new practice to his ranch. Agency technicians can contribute to plans and can furnish certain of the detailed help needed to activate sound plans.

Usually, there is a wide gap (Peck 1950) between the services available from public technicians and the overall plan of better management. Sometimes the rancher has the time, inclination and facts to fill this gap, but more often he is so tied down by day to day details of seasonal work that opportunities for progressive changes are lost or unduly delayed. The consultant can help bridge this gap between new practices and their application and thus be of major assistance to all concerned in the common goal of better production and management.

Fields of Service and Qualifications for Consultants

No one ranch operator or consultant can be really expert in every branch of range and livestock husbandry. Wide experience, knowledge and study are essential to find quickly the cheapest but best solutions to the varied problems that confront a range livestock enterprise. The best analysis and advice available will often find ways to increase production or reduce costs. Growing competition from areas of increasing livestock numbers, and growing use of meat substitutes all call for closer control of the ratio of costs to returns. Recent declines in cattle prices sharply accentuate this need.

Ranch organization and finance constitute one broad field in which the essential qualifications for a range and ranch consultant are largely of an economic nature. For such work he should have sound training in economics, in financial analyses, and in cost and production relationships. He should be able to soundly recommend alternatives in operating practices, in tax and inheritance options open to the rancher. For this field he need not be experienced in ranch appraisals, unless he plans to undertake this specialized work. Many ranch appraisers are already available but few of them are fully qualified for the broader phases of range and ranch consulting service.

Another broad field of service is concerned with actual ranch operations, embracing both land and herd management problems. In this, training in economic theory becomes secondary to

qualifications of a biological nature. However a consultant in this field should clearly recognize the need for favorable cost-benefit relationships in management practices. He should be soundly trained in soil and botanical sciences, should know intimately the growth requirements and use interrelationships of forage species and range animals. He should know also how conflicts in the welfare of plants and animals can be resolved or minimized by grazing. Practical experience in methods of handling range livestock based on their habits, and in many details of range management is indispensable. Finally the consultant should have a sympathetic attitude and full respect for ranching as a dignified and essential way of life for a large sector of our people.

Rules of Conduct

Confidence of clients and of associates is the real foundation for any profession. Ethical rules of conduct must soon be spelled out to guide practitioners of this new profession. A credo should develop in close harmony with a basic objective of Society of Range Management, i.e. "To foster advancement in the science and art of grazing land management, to promote progress in the conservation and greatest sustained use of forage and soil resources, . . . "

Consultants will be expected to follow a forthright course on controversial questions of range policy that may arise from time to time. Until rules of conduct are developed in further detail, the golden rule may be the standard. A determination to give more in terms of stable operations, than the fee charged his clients, may well be in this credo.

A Look Ahead

A great need and some hope can be seen for a substantial growth of range and ranch consulting, now barely started. The field is wide open. A dozen—possibly a score of hopeful souls have had the courage, or temerity, to announce as consultants. This guess indicates that the coverage for our range empire of about 728 million acres (U. S. Forest Service, 1936) is very thin at best. Even so, these few consultants have not been fully occupied. Unless more ranchers become convinced that consultants can give services worth more than the fee, the future for the profession is not very bright.

Those who stand to profit materially from such services will determine what the future will bring the profession. Every year a large number of new owners buy ranches with money from oil, mining, trade, aviation, the movies and other unrelated industries. Some of these have little or no experience or knowledge of ranch or range management. The foreman or manager may be also woefully short on qualifications needed for efficient management. A consultant often could be most helpful in safeguarding and improving the resources of such a ranch and in pointing out less expensive or more profitable methods, all without detracting from the pleasure or satisfaction of the owner. Indeed, such services may well increase satisfaction not only of the inexperienced rancher but to some old-timers who to great advantage, could make certain progressive changes in management practices. The need for and value of such services should become better recognized.

Summary

A few qualified consultants are now able to give valuable special services in range and ranch management based on thorough analysis of the whole operation. Such service does not duplicate but rather

supplements the limited time and help that county agents or other technicians can give to any one operator. With such help many inexperienced, also some experienced managers could better safeguard range resources, increase production or reduce costs and achieve greater stability for the tough years. Such services deserve fuller use by the western livestock industry that faces a threat of sharper competition and uncertain prices.

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A STUDY OF HAIRY GRAMA (*BOUTELOUA HIRSUTA*) ON THE EXPERIMENTAL RANGE, COLLEGE STATION, TEXAS

(Abstract of thesis submitted in partial fulfillment for an M.S. degree, Texas A. and M. College, Department of Range and Forestry, 1951)

Hairy grama grows in all of the various soils and open habitats, except those subjected to periodic standing water, in the Range and Forestry Department Experimental range of 1,000 acres near College Station, Texas.

The growth and size of the hairy grama plants was influenced by the depth of the top soil to the clay-pan. Those plants growing in the deeper top soils showed more vigor and size. Forage yields, varying from 1,293 pounds to 2,632 pounds per acre were correlated with depth of top soil, and physical and chemical composition of the soil. The observed stands of hairy grama, including the study areas, were on slopes and well drained areas.

Bisects and other root studies revealed that hairy grama only slightly penetrated the clay sub soil. Here the roots formed finely divided branchlets. Plants were observed growing in severely eroded sites, devoid of other vegetation, where its roots effectively held the soil against water erosion.

The growth of hairy grama varied greatly on hillsides, severely eroded areas, and thin top soils common to comparatively large areas. Nevertheless, this species was quite productive and aggressive. Therefore, it seems reasonable to conclude that hairy grama is ecologically well adapted to revegetate the open eroded native areas and abandoned fields of the Post Oak Belt of East Texas.

JOHN E. MCCALEB

Reseeding to Aid Conservation of Annual Forage Range

H. W. MILLER, O. K. HOGLUND AND A. L. HAFENRICHTER

Nursery Manager and Nursery Agronomist, Soil Conservation Service, Pleasanton, California, and Chief, Regional Nursery Division, Soil Conservation Service, Portland, Oregon

IMPROVING the quantity and quality of forage is the best method for achieving conservation on range lands. In the foothill section of California, the annual forage range has a short green feed period and varies widely in production from year to year (Bentley and Talbot, 1951). Fertilization lengthened the green feed period and reduced the fluctuation in production (Hoglund *et al.*, 1952). Reseeding of suitable sites with adapted and improved perennials is another means of advancing range conservation. The perennials have a longer green feed period and a more consistent level of forage production (Love and Jones, 1952). They usually have a more extensive and deeper root system than annuals. Establishment of perennials requires proper site selection, cultivation to reduce competition, precision seeding, and protection.

This paper reports the results of trials conducted by the Pleasanton, California Soil Conservation Service Nursery to determine the best and most practical methods for establishing perennials on the annual forage range.

This work was conducted by the Nursery Division, Soil Conservation Service, U. S. Department of Agriculture, Pleasanton, California, in cooperation with the University of California Agricutural Experiment Station, Davis, California.

METHODS

Work on the establishment of perennials was begun in the fall of 1943 at Sunol, California on typical annual forage range owned by the City of San Francisco Water Department. The annual rainfall averages 16 inches. Prior to 1920, the land had been dry-farmed to grain, but low yield resulted in its being abandoned and used for grazing. Weir and Storie (1936) rated the soil as grade 4 (35 percent) and tentatively mapped it as Positas gravelly clay loam. The site was placed in land capability classes III and IV in a recent Soil Conservation Service survey. Erosion had removed from 25 to 75 percent of the surface soil. A stiff, red clay subsoil, 2 to 8 inches thick, was present at depths varying from 6 to 24 inches below the surface. This clay pan retards the downward movement and retains moisture.

Four methods of land preparation were used. In two of the methods the initial tillage operations were started in the spring before the earliest annuals produced seed. A summer crop of sudan grass for hay was then seeded to complete the preparatory land treatment in one method, and clean fallow was used in the other. The sudan grass was fertilized with 100 pounds per acre of ammonium sulphate (20-0-0) at the time of seeding. In the other two methods used to prepare land for seeding, the tillage operations were started in the fall. The land was worked and seeded to red winter oats for hay and to purple vetch for green manure as preparatory crops.

After the season of preparatory treatment and following the first fall rains, the land was disked, harrowed, and rolled to

prepare a fine firm seedbed. Two types of seeding were used to plant an adapted mixture—drilling shallow with a 10-foot double-disk grain drill equipped with depth regulators, and broadcasting. The broadcast seeding was done with the same drill by pulling the spouts and letting the seed mixture fall directly on the ground. All broadcast seeded plots were harrowed and rolled after seeding. The same mixture was seeded on an unprepared check plot at the same time. All plots were 10 by 400 feet and laid out on the contour.

The mixture used was Harding grass (*Phalaris stenoptera*), 4 pounds; burnet (*Sanguisorba minor*), 3 pounds; and Mt. Barker subterranean clover (*Trifolium subterraneum*), 5 pounds per acre.

One-half of each plot was fertilized with 200 pounds per acre of ammonium phosphate-sulphate (16-20-0) at the time of seeding and each fall thereafter.

A new series of seedings was made each year for four years to check the effect of climate on establishment. There were no replications within years, although the trials were designed to obtain an estimation of soil variation.

Stands were determined by an adaptation of the inclined point quadrat method which allowed the results to be expressed in numbers of plants per square foot. Two hundred point quadrat counts were taken per treatment about two months after seeding. All plots were clipped twice during the establishment year in order to reduce competition from the resident annuals. Air-dry yields of these clippings were obtained. In the second and subsequent years, production was determined by taking four $\frac{1}{4000}$ acre quadrats, 3.3 by 3.3 feet, per plot at the hay stage of the perennials. The Harding grass and resident annuals were separated and weighed.

Results and Discussion

Good stands of all seeded species were obtained on all tilled plots. There was an average of slightly more than 20 plants of the seeded species per square foot and a little more than half of them were Harding grass. This is shown in Table 1. No seedlings of seeded forage plants were ever obtained from the unprepared land.

TABLE 1

The influence of methods of land preparation on the establishment of three planted forage species and the density of volunteering annuals

Treatment and crop	Plants per square foot			
	Harding grass	Subterranean clover	Burnet	Resident annuals*
Spring tilled				
Sudan grass..	11.75†	7.07	3.30	33.99
Summer fallow.....	13.68	6.49	3.53	30.03
Fall tilled				
Grain hay...	8.34	7.30	3.07	47.75
Purple vetch.....	7.80	6.41	3.34	77.42
Average...	10.39	6.82	3.31	47.30

* Annuals in order of importance were: *Festuca megalura, Hordeum murinum, Bromus rigidus, B. mollis, Avena fatua,* and *Erodium botrys.*

† Each value is the average of 32 determinations.

The data in Table 1 show that the method of preparing land for seeding influenced the number of seedlings that were established. The Harding grass stands were influenced more by land treatment than were those of subterranean clover and burnet. Preparing the land and growing a crop of sudan grass or fallowing was better for the establishment of the seedlings of perennials than preparation for and growing crops of winter oats or purple vetch. Spring tillage was used for the sudan grass and the fallow, but fall tillage was used for the oats and vetch. Spring tillage

followed by sudan grass or fallow was more effective in reducing the growth of resident annual forage plants than was fall tillage followed by a grain or green manure crop. The greatest density of competing annual forage plants resulted from the disking down of the vetch crop. The vetch contained annuals, and the method of land treatment by which vetch was grown kept all of the seed of the annuals on the plots. The winter oats contained a small amount of annuals, some of which matured and shattered seed before the oats were cut for hay. There were some broad-leaved annuals in the sudan grass, but they were less competitive to the planted species than were the annual grasses.

In Table 1, data for fertilized and unfertilized plots in each treatment were averaged because there were no significant differences in initial stand due to the use of fertilizer.

TABLE 2

The influence of method of seeding and fertilizer on number of plants per square foot 60 days after seeding

SEEDING METHOD	PLANTS PER SQUARE FOOT			
	Harding grass	Subterranean clover	Burnet	Resident annuals
Fertilized				
Broadcast...	9.23*	8.02	2.94	55.59
Drilled.....	10.58	6.12	2.35	46.00
Average...	9.90	7.07	2.64	50.79
Not fertilized				
Broadcast...	9.04	6.75	3.70	47.75
Drilled.....	12.87	6.35	4.23	39.83
Average...	10.95	6.55	3.96	43.79
Average for broadcast..	9.13	7.38	3.32	51.67
Average for drilled.....	11.72	6.23	3.29	42.91

* Each value is the average of 32 determinations.

The effect of method of seeding on the number of plants per square foot 60 days after planting is shown in Table 2. The effect of the seeding methods was similar on each of the four land treatments. More Harding grass seedlings were obtained by drilling than by broadcasting. The difference was 28 percent. More resident annual forage plants volunteered on the broadcast than on the drilled plots. More subterranean clover plants resulted from broadcasting than drilling. The results with burnet depended on whether fertilizer was used. The result with Harding grass was the most important, because this perennial was the one among the seeded species that later contributed the forage. Drilling was superior to broadcasting even though special care was taken to prepare a good firm seedbed for broadcasting. It was superior especially when unfavorable moisture conditions occurred in the 1947–48 season. The data are not shown, but in this season the average number of Harding grass plants obtained from drilling and broadcasting were 16.91 and 7.55, respectively.

More plants of Harding grass and burnet and fewer of subterranean clover and resident annual forage species were found when no fertilizer (16-20-0) was applied, Although the differences are small, this result, when combined with subsequent yield data, allows the conclusion that fertilizer should not be applied at the time of seeding.

The seeded species, Harding grass, subterranean clover, and burnet, did not produce enough growth to measure during the first season. Resident annual grasses, legumes, and forbs always volunteered and produced a measurable crop. The resident annuals were clipped twice, about March 15 and April 15, because they offered competition for moisture, plant nutrients, and light. The amount of growth was measured and the major

differences in kind of annuals were recorded. The differences in kind and amount of resident annuals were due primarily to the treatment of the land before seeding. The use of fertilizers increased the amount but did not influence the kind of annuals on the plots.

Table 3 shows the total average yield of the two first-year clippings for all 4 years. More growth was always obtained when fertilizer was applied. When fertilized, the production of annuals was greatest following the vetch crop and the least following sudan grass. When no fertilizer was used, the greatest yield was again from the vetch plot but the least was from grain hay. Growing a crop of sudan grass was effective in reducing competitition from volunteering resident annuals whether fertilizer was applied or not.

TABLE 3

The influence of preparatory land treatment and fertilizer on first year resident annual forage yields

	YIELDS OF VOLUNTEERING ANNUALS				
	Sudan	Fallow	Grain hay	Vetch	Average
	Tons per acre, air-dry				
Fertilized	0.99*	1.24	1.28	1.58	1.27
Not fertilized	0.70	0.70	0.55	1.09	0.76
Average	0.84	0.97	0.91	1.33	

* Each value is the average of 8 plots and is the total of 2 clippings.

Forbs were the dominant annuals on the spring-tilled plots (sudan grass and fallow) while grasses were dominant on the fall-tilled plots (grain and vetch). The annual grasses appeared to offer more competitition to the seeded species in the establishment year than did the forbs.

The yield of the seeded species was influenced by the previous land treatment and by the application of fertilizer. The yield was also influenced by the age of stand. The data are shown in Table 4.

The only seeded species that contributed to the harvested yield was Harding grass. Subterranean clover and burnet were absent from the fertilized plots. These two species are not shade tolerant and harvesting the seeded species as hay eliminated them. (In other trials not reported in this paper, where plots were fertilized with 16-20-0 and clipped to simulate grazing, an excellent stand of subterranean clover is present.) On the unfertilized plots, there was a stand of clover but it had passed maturity and dried so that it was a negligible part of the harvested forage. Only a few plants of burnet were in the stand due to a lack of adaptation.

The highest average yield of Harding grass was obtained when the plots were fertilized. The highest average production of this grass from the plots that were fertilized came from those which had been seeded previously to sudan grass or fallowed. On these plots, the Harding grass reached full production by the second growing season. When the land had been seeded to grain for hay or to vetch for soil improvement, however, the Harding grass did not reach full production until the fourth season, even when fertilizer was used. The reduction in the initial stand of Harding grass due to previous crop, as shown in Table 1, was responsible for this result. There were

more plants on the plots that grew sudan grass or were fallowed.

The data in Table 4 show that the yield of volunteer resident annuals was influenced more by the application of fertilizer and less by crop year and previous land treatment than was the perennial, Harding grass. The effect of reducing the stand of annuals by growing sudan grass or by fallowing was reflected in the lower average yield by the volunteering annuals. The effect was most pronounced in the second crop year, but the data indicate that the yields were lower throughout the entire period of this trial. This was probably caused by greater vigor of the Harding grass plants.

The data in Table 4 were used to determine whether or not there was a correlation between the yield of the Harding grass and the annuals. Significant negative correlations, $r = -.527$ $(N=16)$ for the fertilized plots and $r = -.500$ for the non-fertilized plots, were obtained. This indicated that there was competition between the two kinds of grass.

The average yields of both Harding grass and annuals fluctuated with the season regardless of the age of stand or previous land treatment. The data are shown in Table 5. The annuals fluctuated more than did the perennial. This was caused by the carry-over of the influence of one season on the perennial into the next. The effect of season on the volunteering annuals was direct and there was no carry-over effect. Rainfall and temperature were responsible for the effect of season. Of the two factors, rainfall appeared to be the more important.

The use of fertilizer not only increased the yields of Harding grass and annuals,

TABLE 4

The influence of preparatory land treatment, fertilizer and age of stand on yields of Harding grass and of resident annuals

Tons per acre, air-dry

CROP YEAR	FERTILIZED					NOT FERTILIZED				
	Sudan	Fallow	Grain hay	Vetch	Average	Sudan	Fallow	Grain hay	Vetch	Average
					Harding grass					
2nd	0.47*	0.54	0.16	0.17	0.34	0.20	0.23	0.10	0.09	0.15
3rd	0.41	0.45	0.25	0.25	0.34	0.27	0.29	0.20	0.19	0.24
4th	0.35	0.45	0.33	0.34	0.37	0.28	0.31	0.34	0.29	0.31
5th	0.50	0.48	0.37	0.44	0.45	0.28	0.27	0.45	0.43	0.36
Av.	0.43	0.48	0.28	0.30	0.37	0.26	0.27	0.27	0.25	0.26
					Annuals					
2nd	1.19	0.98	1.23	1.60	1.25	0.56	0.43	0.66	1.07	0.68
3rd	0.99	0.93	1.02	1.13	1.02	0.42	0.29	0.43	0.42	0.39
4th	1.10	1.15	1.26	1.37	1.22	0.37	0.31	0.49	0.63	0.45
5th	1.20	1.14	1.18	1.14	1.17	0.40	0.43	0.48	0.60	0.48
Av.	1.12	1.05	1.17	1.31	1.16	0.44	0.36	0.51	0.68	0.50

* Each value is the average from four seedings made in successive years.

but reduced the fluctuation in yield by season. The effect was greater with annuals than with Harding grass because there was no carry-over effect with the annuals.

The volunteering resident annuals in these trials were grasses. There were no broad-leafed annuals after the establishment year and only traces of bur clover.

duce soil erosion noticeably after the land was worked and seeded.

Growing grain hay, which is a winter crop in the area where these trials were made, required fall tillage. Even though an average of 1.12 tons of hay was produced, this crop did not reduce the resident winter annuals sufficiently to allow a vigorous stand of Harding grass and other species to develop.

TABLE 5

Average yield of Harding grass and annuals by season as affected by fertilizer

CROP	TREATMENT	YEAR OF HARVEST							
		1946	1947	1948	1949	1950	1951	1952	AV.
		Tons per acre, air-dry							
Harding grass	Fertilized	0.61	0.40	0.31	0.35	0.27	0.52	0.42	0.38*
	Not fertilized	0.25	0.27	0.18	0.22	0.29	0.36	0.45	0.27
Annuals	Fertilized	1.44	1.41	0.58	1.24	1.09	1.67	1.03	1.12
	Not fertilized	0.46	1.01	0.32	0.35	0.47	0.61	0.52	0.52
Total yield	Fertilized	2.05	1.81	0.89	1.59	1.36	2.19	1.45	1.50
	Not fertilized	0.71	1.28	0.50	0.57	0.76	0.97	0.97	0.79
No. of plots		8	16	24	32	24	16	8	

* These are weighted averages.

The data from these trials show that good stands of Harding grass were established in each of 4 successive years by preparing the land for a crop of sudan grass or by fallowing. Both of these methods require early spring tillage before the resident annual range plants produce seed. Fallowing apparently had no marked advantage over growing sudan grass on this land either for conserving moisture, increasing available nitrogen, or further reducing weed competition. In addition, the sudan grass produced an average of .38 tons of feed, which was equivalent to .95 AUM per acre if pastured. This feed was produced during the summer months when other forage on the range was dry. The stubble and roots of the sudan were sufficient to re-

An average of 1.41 tons of purple vetch was produced. The entire crop was returned to the soil. The principal result of this practice was to stimulate the growth of volunteering resident annuals, especially in the first season after seeding the perennials. This resulted in fewer Harding grass plants becoming established. The data in Table 4 indicate that the effect of adding 1.41 tons of residue per acre may have lasted as much as 4 seaons.

Estimates of dates of grazing readiness were made in each of 6 years, 1946 through 1951, on both fertilized and unfertilized Harding grass. An average grass height of 4 to 6 inches was used in determining range readiness. The average date the Harding grass in fertilized plots

was ready for grazing was December 15 and the green feed period averaged 23 weeks. The average date of grazing readiness on the untreated Harding grass plots was January 7, and the green feed period averaged 20 weeks. The date of grazing readiness of the Harding grass fluctuated more with the season in the unfertilized plots than in the fertilized plots. The greatest difference was in the 1948–49 season when the first effective fall rains were not received until December and temperatures were unusually low. In that season, the Harding grass on the fertilized plots was ready to graze 6 weeks before that on the unfertilized plots.

The adequate green forage period of the annuals averaged 6 weeks with grazing readiness being reached about March 15. When fertilized, the annuals were ready to graze about February 1 or 6 weeks earlier than the unfertilized annuals. Both fertilized and unfertilized annual forage dried up at the same time. This was about May 1 each year.

Summary

Trials to determine the best method for establishing a Harding grass-burnet-subterranean clover mixture on lands in the annual forage range of California were begun in 1943. The work was done near Sunol, on Positas gravelly clay loam. Average rainfall was 16 inches but fluctuated widely among the years.

Four methods of land preparation and two methods of seeding were used, with and without fertilizer. The treatments and plantings were repeated for four consecutive years and forage production was measured on each established stand for four years.

All of the seeded species were established when good methods were used, but the Harding grass was the only one that produced measurable forage, because the method and date of harvesting were unfavorable to subterranean clover and burnet.

No stands were obtained when no land preparation was used and the seedings were made directly into the stubble of the annual forage range.

The success in establishing the seeded species, as measured by plants per square foot, was governed by the degree to which land preparation and treatment suppressed the volunteering resident annuals.

Initial tillage in the early spring was superior to fall tillage in reducing the density of the resident annuals. An average of 32 plants per square foot 60 days after planting was obtained on spring-tilled land. Growing a crop of sudan grass or fallowing the spring-tilled land were equally effective in reducing the stand of the volunteering annuals. Spring-tilled lands were seeded in the fall of the same year.

Initial tillage in the fall followed by a crop of winter oats for hay or vetch for green manure, and seeding of the perennials the next fall, resulted respectively in 49 and 142 percent denser stands of volunteering annuals than when spring tillage was used. This reduced the stands of the seeded species, especially Harding grass.

Drilling was superior to broadcast seeding for the establishment of Harding grass. The average difference in stand was 28 percent, but when below-normal annual rainfall occurred the difference was 55 percent. Method of seeding did not have a great effect on the stands of burnet or clover.

There were no significant differences in initial stands of the seeded species attributable to the addition of fertilizer (16-20-0), but there was a consistent trend in favor of not applying fertilizer at seeding time.

Previous land treatment and the application of fertilizer influenced the yield of volunteering annuals in the establishment year. Fertilizer increased their production by an average of 69 percent. The increase was greatest on the fall-tilled land that grew vetch and least on the spring-tilled land that grew sudan grass. Forbs were the dominant annuals on spring-tilled plots, and grasses on those that were fall tilled.

Previous land treatment influenced the yield of Harding grass and the number of years required for it to attain full production. The average yield was higher on the spring-tilled land and full production was reached in the second growing season. Average yield on fall-tilled land was lower and full production was not reached until the fourth growing season.

The annual application of fertilizer (16-20-0) increased the production of Harding grass on all treatments and in all years. The greatest increase was on stands that reached full production in the second growing season.

The application of fertilizer increased the yields of annuals that volunteered in the Harding grass stands. The influence of the fertilizer on the yield of annuals was greater than on Harding grass but was more erratic among years. There was evidence that the effect of a seasonal factor influencing yield "carried over" in the perennial grass.

The advantage of growing sudan grass instead of fallowing in preparation for reseeding was that the sudan grass produced an average .38 tons of feed, equivalent to .95 AUM per acre if pastured. The Harding grass reached full production on land that grew sudan grass as soon as it did on the fallowed land.

Grain grown for hay in preparation for seeding produced 1.12 tons per acre but retarded the Harding grass from reaching full production until the fourth growing season.

The green feed period of the seeded Harding grass when fertilized averaged 23 weeks beginning December 15. When not fertilized, the Harding grass did not reach grazing readiness until January 7 and the green feed period averaged 20 weeks. In contrast, fertilized annual range reached readiness February 1 and the green feed period was 12 weeks.

Acknowledgment

The authors acknowledge the advice and helpful assistance of B. A. Madson, Director, Field Stations, California Agricultural Experiment Station; and L. R. Wohletz, State Soil Scientist, Soil Conservation Service; and review of the manuscript by W. R. Frandsen, Regional Range Conservationist, Soil Conservation Service; M. W. Talbot, Associate Director, California Forest and Range Experiment Station, Forest Service; and R. Merton Love, Agronomist, California Agricultural Experiment Station.

Comparative Costs

No studies of costs for preparing land and seeding were made. The method of using comparative costs of land preparation in large-scale operations as suggested by Stark, *et al.* (1946) was adopted. Data presented by Adams and Reed (1950) were consulted. Costs of disking, weeding, rolling, and seeding would vary between $6.10 and $7.26 per acre. Fall tillage followed by crops of grain hay or vetch was cheapest. Spring tillage followed by sudan grass was the most expensive, but the higher cost of the later method was more than offset by the value of the sudan grass crop. This method also resulted in good stands of perennials that reached full production 2 years sooner than the seedings in the fall-tilled land.

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IT'S STILL NOT TOO LATE TO GET A NEW MEMBER IN 1953

RANGE PHOTOGRAPHY CONTEST AND EXHIBITION

A range photography contest and exhibition will be held at the Seventh Annual Meeting of the American Society of Range Management in Omaha, Nebraska, January 26 to 29, 1954. There will be the following five divisions, the first four being black and white, and the last color:

1. Range landscape.
2. Individual range plant (without portrait lens).
3. Range conditions and fence-line contrasts.
4. Close-up (with portrait lens or higher magnification).
5. Color print, any size.

All entries must have been taken by a member of the Society. All black and white photos must be mounted, unframed, and 8 by 10-inch or larger. Any range subject is eligible with the provision that neither animals nor mechanical devices shall be the principal subject.

Photographs shall be accompanied by up to a 25-word description, plus name and address of photographer, typed on separate white background that can be attached to the bottom of the photograph with gummed tape from the back. These will be numbered at the meeting. (Names and addresses may be helpful to Society members in locating good photographs to illustrate publications.)

Individuals may enter not more than one photo in each of the five divisions. Photographs will be taken to and from the exhibition room by the member displaying them or by someone designated by the member who is attending the meeting.

Viewing members at the Annual Meeting will vote on signed ballots to be deposited in a conveniently located box. Voting will be for the one photograph the individual likes best in each division; and for the best in the show.—*H. W. Cooper*, Chairman, Display Committee.

Rodent Control on California Ranges

WALTER E. HOWARD

Lecturer in Zoology and Assistant Zoologist in Experiment Station, Department of Zoology, University of California, Davis

BECAUSE the grazing resource of this country is important to us all, it is desirable that those who are interested in conservation or range management acquaint themselves with some of the interrelationships of rodents and grazing on rangelands, and to determine for themselves the value of existing control measures designed to reduce or eradicate these animals locally. Few people believe that all field rodents should be protected; on the other hand, not many demand the complete extermination of any species of rodents. But there is considerable difference in current viewpoints on the degree of either protection or control that is desirable in different localities. As a result of this disparity in opinions, it is imperative that each situation be considered independently. We must avoid generalizations such as "All ground squirrels should be destroyed," or "The organized trapping or poisoning of any of these animals must be prohibited."

Material in this article is largely based on observations and data stemming from investigations conducted at the San Joaquin Experimental Range, O'Neals, California, maintained by the U. S. Forest Service in cooperation with the University of California (Hutchison and Kotok, 1942). The article has been prepared at the request of the editor, Joseph F. Pechanec.

As a result of the combined efforts of many investigators since 1934, including personnel from a number of departments in the University of California, U. S. Forest Service, U. S. Fish and Wildlife Service, California Department of Fish and Game, and others, the relation of rodents to the fauna and flora of this foothill rangeland is perhaps as well understood as any comparable area. There are more than 60 publications from the Range pertaining to zoological studies and about the same number on livestock operations and forage investigations.

Rangeland Concepts

Judgment as to the propriety of controlling rodents is a relative matter, for species that become a household or agricultural pest to one person may provide another with recreation or sport. For example, most people, including farmers, find pleasure in seeing ground squirrels on top of fence posts along roads, unless one finds their presence resulting in a depletion of his barley crop. A pocket gopher pushing its excavated soil into a mound is fascinating to observe, unless the scene is in the middle of one's lawn. To some, the main value of ground squirrels and jack rabbits is as targets for their .22 rifles. This disparity in viewpoints holds for other animals as well. It is conceivable that some city and suburban nature lovers may want all wild animals protected—except, of course, ants and mice that get into their houses, pigeons and starlings that deface their buildings and sidewalks, or moles and gophers that take up residence in their lawns. Thus, it is clear that with rodents and other animals which at times become pests, it is necessary to weigh the evidence carefully before passing judgment, and to be

tolerant and considerate of other people's relation to the situation.

Some confusion about different phases of rodent natural history stems from a widespread misunderstanding of the term, the balance of nature. Too often the term is thought to imply that there is some mysterious balancing force which maintains a sensitive and uniform population density of each species in a community. On the contrary, there is a regular oscillation in abundance of species; but, once the so-called natural balance becomes established, the fluctuations only occasionally bring about an extermination of a species, even locally, unless man is participating. Man, however, is part of the current balance as his influence is felt in varying degrees throughout the land and on much of the sea. He interferes with the balance by altering the oscillating pendulum and creating new situations that require additional adjustments between species. This alteration of the environment provides conditions suitable for new arrivals, causes the local extermination of others, and frequently changes the population density of many species, either by permitting them to increase or by bringing about a reduction in individuals. There is no chance of establishing the original climax types (actually man is trying to develop better types) and the former balance, unless man is completely removed. We approximate the former status in our national parks and primitive areas (although we extinguish natural lightning fires), but cannot begin to accomplish the preservation of original plants and animals on land where man lives, travels, or produces food and other materials. In fact, as the human population pressure increases it becomes necessary to alter the former balance more and more, in order to establish a set of conditions which will be even more responsive to man's needs.

A few examples of game animals will be used to show how man affects the population density of other kinds of animals as well as of rodents. Most of the former marsh habitats of ducks in the Sacramento Valley have been drained for agricultural purposes. On the other hand, much of the Pacific Flyway has been maintained because man plants large sections of this land to rice. In the same area agricultural development has brought about a considerable reduction in valley quail. But the introduced ring-necked pheasant has taken its place as a successful game bird on these lands, which have been converted to rice and other cultivated crops. The mourning dove is now more abundant in the state than it was before extensive agricultural development took place (Leopold, 1951). Too often it is overlooked that man is responsible for great increases in numbers of some kinds of animals—as well as reductions in density of other forms—whether they be game animals or those species that often become pests. Remedial measures are frequently necessary to increase the number of desirable species unfavorably affected by man's influences, or to reduce the increased numbers of the undesirable forms.

It is important to note that an increase in certain kinds of rodents is likely to occur whenever land is used, and *not* just when it has been abused by man. Plants are basic items of animal food chains and, since grazing and cultivation alter the composition and density of forage, a change in the fauna inevitably follows land use. On cultivated land all of the native forage is often lost, and a dense stand of one or more alien plants is established. But even light to moderate degrees of grazing will cause some and

often a considerable change in the original plant cover.

Many agricultural practices indirectly bring about an increase in abundance of certain kinds of wild animals. The planting of alfalfa or irrigated pastures often causes a manyfold increase in numbers of pocket gophers and meadow mice but at the same time eliminates a number of other rodent species. The increased density of these two kinds of rodents does not indicate either that the land has been abused or over-grazed; nor does it indicate that it is a waste of money to control the pests, for many a farmer has lost his crop by failing to control these animals when they became too numerous on otherwise properly managed land. Likewise, there is no reason livestock should not be raised on ranges where grazing stimulates an increase in numbers of ground squirrels and other rodent species. If a gopher should happen to move into our bed of tulips, I doubt if any of us would consider planting more tulips so that there would be ample for our needs as well as those of the gopher. On the contrary, we would more likely become greatly upset until the rodent was poisoned or trapped. Similarly, why should a rancher reduce his herd whenever rodents increase? After all, such high populations of rodents frequently would not be able to exist if they were not so well adapted to grazed ranges. If it were shown that a particular species would not become a pest unless the land was grazed too closely, this would of course be another thing. However, it is usually a relative matter in such instances, the rodent or rabbit species involved merely becoming more numerous the closer the land is grazed. And the presence or absence of certain rodent or rabbit species is not a good indicator of range condition, for wildlife numbers fluctuate greatly from year to year because of other causes than grazing intensities.

Sometimes it is difficult to know when control of a rodent species, such as ground squirrels, is justified. On most cultivated lands it has proved necessary to eradicate ground squirrels to protect crops; otherwise they become so numerous that little if any of the crop is left to harvest. If a squirrel or gopher burrow diverts precious irrigation water, an individual rodent can be costly. Not only in cultivated areas but also on ranges, it is becoming increasingly evident that livestock men cannot afford high squirrel populations, and that often it is good conservation and an economically sound practice to control these animals where they have locally become pests or "animal weeds."

The opinions most of us have regarding the beneficial or detrimental value of rodents and also predators, as well as other wild animals, are essentially determined by the manner in which the animals affect our livelihood or compete with our recreational or esthetic interests. Opinions on the interrelationships of rodents and their predators on grazed ranges are often expressed too strongly, apparently because little data are available. This is partly due to the fact that such data are not easy to obtain. The less the amount of evidence there is regarding conservation subjects, however, the more biased and emotional we seem to become over the issues. In fact, at present the "armchair" research in the literature about rodent control on rangelands greatly exceeds that based on field data.

For the protection of agricultural crops in California, ground squirrels, pocket gophers, meadow mice, rabbits, kangaroo rats (Storer, 1949), and rats and

mice (Storer, 1952) all require control measures. Where it has been demonstrated that disease-bearing rodents are involved in close proximity to human populations, the numbers of ground squirrels, chipmunks, and peromyscus are also reduced by control operations. Most rodent control baits consist of grains and strychnine, Compound 1080, zinc phosphide, thallium sulfate, or Warfarin.

Ground squirrels receive considerable attention in California because of their economic significance, although effective control measures now place squirrels second to pocket gophers as California's most important field rodent pest. The Annual Report of the California Department of Agriculture (40: 228–237) states that, in 1951, various official agencies in the state treated almost four million acres in economic control of ground squirrels. Approximately $300,000 was expended by all agencies on squirrel control, which amounts to about 7.5 cents per acre. The cost of the predator control over 56 counties, which included 6,252 coyotes, amounted to $385,000. For purposes of comparison, the annual grazing fees on this land during the same year ranged from $2.50 per acre on the better but still untilled ranges to one dollar per acre on steeper, rockier, brushier pastures.

Human population pressure has destroyed most of the original wild lands and forced us to manage rodents along with predators and game as a branch of agriculture. One might say that rodents and other kinds of wildlife are not really allied to agriculture, but rather a competitor with it. Many, in fact too many, examples of such competition can be found. Deer may damage vineyards, orchards, or even pasturage. Pheasants may destroy tomatoes. Ducks often deplete yields of rice and sometimes compete with lambs for pasturage, and even locally do considerable damage to vegetable crops. But many of the more recognized forms of agriculture also compete with each other. Livestock have to be fenced from row crops; chemical sprays occasionally are blown astray and damage other crops or kill bees being used for pollination or honey production. It is merely a matter of proper management and awareness of the economics of the situation, rather than competition between game and other types of farming. But, since there are forms of wildlife, such as rodents, that frequently become pests to agriculture, it is even more necessary to regard wildlife management as a division of agriculture, just as economic entomology, plant pathology, and weed control are intimately associated with agriculture.

Forage and Soil Relationships

Constant changes and adjustments between the different factors of environment, accelerated by grazing, result in a considerable upset in the former balance of nature. Selective pressure by herbivorous animals has undoubtedly operated in the balance before the advent of man by preventing more palatable forage species from evolving naturally on ranges. The same type of selection by wild animals of the more preferred vegetation is operating today. For example, in the interior of California it usually is considered impossible to grow dryland alfalfa unless pocket gophers are artificially controlled. (The reason gophers are not quite so serious with irrigated alfalfa is that flooding destroys many individuals, and the greater forage yields will support more gophers.) On rangelands, where attempts are underway to artificially establish more palatable forage species, wildlife frequently destroy many of the alien plants (Howard, 1950). The animals are especially attracted to some of the

introduced perennials after the annual plants have become dry if the seeds and seedlings survived their depredations.

How does cattle grazing at the Experimental Range alter the swing of the pendulum in the balance of nature to such an extent that some species of wildlife increase in numbers and become pests? This happens partly because livestock prefer certain species of forage plants to others. This results in an increased survival of the less desirable plants. But a more important reason is that there is less litter on grazed ranges, which in turn favors germination of broad-leafed plants, which are more desirable to rodents.

Experiments at the Range have shown that the quality of forage, which is essentially an annual-plant type, deteriorates when completely protected from grazing. If ungrazed, the forage cover tends to progress for an indefinite period through annual grass stages to become dominated by tall grasses, such as ripgut brome (*Bromus rigidus* Roth) and slender wild-oats (*Avena barbata* Brot.) (Talbot and Biswell, 1942). These species are coarse and relatively unpalatable to livestock. "Under light to close utilization by cattle, an earlier stage of succession is maintained with a more desirable mixture of species, including clovers and filarees" (Bentley and Talbot, 1948). Observations on the natural area at the Range, which has not been grazed by cattle since 1934, indicate that rodents and other wildlife are unable to maintain this earlier stage of succession without the assistance of cattle except on low-productive sites of shallow soil and around the margins of brush plants.

Not only does grazing by livestock affect the forage composition, but it also brings about conditions that result in an increase in number of squirrels and some other kinds of rodents. Linsdale (1946) found that ground squirrels disappeared after an area was protected from grazing but remained on adjacent grazed pastures. They appear to do better on grazed ranges also at the Experimental Range. Regardless of whether grazing is light or close, alteration of plant species and density of the forage cover by grazing often leads to an increased ground squirrel population. And this increase in number of squirrels may compete seriously with stock for forage. Some rodents respond differently, on the other hand, as there are fewer pocket gophers (*Thomomys bottae*) and almost no meadow mice (*Microtus californicus*) in pastures grazed by cattle as compared to areas protected from grazing at the Experimental Range. But the deermouse (*Peromyscus maniculatus*) and kangaroo rat (*Dipodomys heermanni*) seem to thrive best on grazed areas (Quast, 1948). Quast also found that the brush mouse (*Peromyscus boylei*) was least disturbed by cattle grazing. The species that were unfavorably affected or reduced in numbers by grazing were pinon mouse (*Peromyscus truei*), harvest mouse (*Reithrodontomys megalotis*), and possibly two species of pocket mice (*Perognathus californicus* and *P. inornatus*). Reynolds and Haskell (1949) found that the highest population of Price and Bailey pocket mice occurred in ungrazed stands of perennial bunchgrass. Others have shown elsewhere that grazing often brings about an increase in the numbers of certain rodents and rabbits (Bond, 1945; Buechner, 1942; Grinnell and Dixon, 1918; Kalmbach, 1948; Moore and Reid, 1951; Norris, 1950; Parker, 1938; Phillips, 1936; Reynolds, 1950; Taylor, 1930; Taylor and Lay, 1944; Taylor and Loftfield, 1924; Taylor *et al.*, 1935; and Vorhies and Taylor, 1933).

Just how rodents compete with the livestock for herbaceous forage is not entirely known. Evidently it is not merely the amount of food they consume,

but rather the type of food and the time of year when they take it. A stomach full of seeds certainly is not equivalent in food value to the amount of forage such seeds could have produced if they had been allowed to germinate and grow to maturity. Annual plants are prolific seed producers, but rodents may still reduce the forage yield of annuals by depleting the seed supply in numerous small areas that are only an inch or two across. Also, rodents and most other forms of vertebrate wildlife feed extensively on newly germinated forage. And again, the seedlings it takes to fill a stomach are nowhere near equal to the amount of forage that would be produced if those plants were allowed to mature. After many of the plant species once get a good start they can withstand a certain amount of cropping, but it appears that rodents thin and stunt excessively, hence reducing the total yield. Perhaps the rodents kill many of the plants by cutting below their growing points. Branson (1953) has shown that "... in general, the grasses in which the growing points reached a height that permitted their removal by grazing decreased as intensity of utilization increased, but grasses with growing points at the ground level usually increased." Rodents can graze at the ground surface.

Ground squirrels exert the greatest competition with livestock for herbaceous forage at the Experimental Range from shortly after the forage germinates until the peak of the growing season, for then there is surplus feed for all animals (Fitch, 1947 and 1948b; Horn and Fitch, 1946). Fitch and Bentley (1949) found that six ground squirrels caged in a one-half-acre enclosure annually reduced the yield of forage an average of 1,058 pounds per acre of dry material, more than ten times the amount the squirrels might actually have eaten. When they calibrated how much forage each ground squirrel, pocket gopher, and kangaroo rat ate or prevented from maturing in the enclosures, the data suggested that the natural field population of these three species which occurred in other pastures on the Range might be reducing the total annual herbaceous crop by more than one-third. To verify these findings not only by forage clippings on grazed areas but also in pounds of beef produced on poisoned and unpoisoned pastures, an additional seven-year, cooperative study on a pasture scale was started at the Experimental Range in 1948.

More studies are needed to determine the advisability of rodent and rabbit control on different grazed ranges (Fichter, 1953), and to determine whether it is a valuable conservation practice that should be accelerated in many areas where control is not now utilized in the range-management operations. Anyone interested in the animal ecology of rangelands cannot help but wonder if there are not some beneficial effects of rodents on ranges. From a practical viewpoint, however, their value can hardly be considered significant in the light of the known facts. Unfortunately, it is difficult to test experimentally the effects of burrowing rodents; it is easier to point out their shortcomings. Nevertheless, the relationships of rodents to soil cultivation, water percolation, soil fertility, soil aeration, destruction of insects, and control of weeds is at least of academic interest to most individuals concerned with range problems.

In California pocket gophers are the chief burrowing rodent. They probably excavate more soil annually than all the other 88 or so California species of rodents combined. Ground squirrels, even though their burrows are more conspicuous than those of gophers, usually occupy old established systems and dig relatively little. With regard to the burrowing ac-

tivity of these and other rodents, it appears that particularly plant roots, and the myriad of bacteria, protozoans, worms, crustaceans, arachnids, insects, and other small animals in the soil accomplish a more desirable form of tilling than rodents. From a geological standpoint, the pocket gopher may actually have a prior claim to the land where he is now so unwelcome. In his never-ending burrowing beneath the surface of the earth he has contributed to the building up of great agricultural valleys, such as the highly productive San Joaquin and Sacramento Valleys in California (Grinnell and Storer, 1924). On the other hand, he has contributed to the erosion of many acres of rich farm lands and man is also endeavoring to stop erosion of mountains.

The principal manner in which the burrowing activity of rodents seems to increase percolation of water is by channeling or draining the water through one of their burrows. In most instances when the surface runoff flows down burrows, it adds little additional water to the surrounding soil but reappears at some lower elevation. This condition too often results in extensive subsurface erosion, followed by cave-ins of the ground surface and the formation of gullies (Crouch, 1942; Gunderson and Decker, 1942; Longhurst, 1940). Many gullies in California on both tilled and untilled lands originated as a consequence of water being channeled down squirrel or gopher burrows. After such rodent tunnels become enlarged, the tops eventually cave in and deep gullies often result. It is important to note that this kind of erosion occurs under dense stands of herbaceous forage and is not necessarily brought about by grazing. The removal of woody vegetation on some soils, unaccompanied by rodent control, may promote these conditions. Once a gully gets started, it may be extended farther up hill by subsequent rainstorms. The above is not meant to imply, however, that rodent burrows are responsible for the formation of all gullies. Many result from other causes, such as cultivation of too steep slopes, automobile tracks, and livestock trails.

Forage ordinarily destroyed by squirrels, gophers, and other native species, if protected and made available to livestock, would be returned to the soil as fertilizer in much the same manner as by rodents. Many visitors to the Experimental Range notice the rank herbaceous growth in the vicinity of rodent burrows and harvester-ant mounds and, therefore, wonder if it would not be desirable to have more of these animals. The entire picture is difficult to show, however, for one cannot see all the potential forage that these animals have destroyed elsewhere to account for the concentration of waste products of seeds and other plant parts about the entrances of their homes. Likewise it appears questionable that rodents can be too important in controlling objectionable insects or weeds, but careful observations on these matters should be continued.

In an experiment to test the need for ground squirrel (*Citellus beecheyi*) control at the San Joaquin Experimental Range when feeding supplements to livestock, 900 pounds (2,180) of surplus potatoes were scattered on the range to sun-dry before being fed to the cattle (Howard and Wagnon, 1951). Within 18 days approximately 18 squirrels had removed every potato. Few potatoes were lost in a control pasture, however, where the squirrels had been poisoned.

The game manager as well as the farmer is interested in ground squirrels. In the valley quail investigations at the Range, Glading (1938) showed that ground squirrels destroyed more quail eggs than all other predators combined.

When he controlled squirrels, their chief predator, he demonstrated that a greater harvest of quail by sportsmen was possible. If quail are not being hunted, however, squirrel control is of little value in quail management, because any additional birds resulting from squirrel poisoning usually will disappear from other causes anyway. Increased production resulting from squirrel control (properly prepared poison squirrel bait will not harm quail) is of greatest value when the annual crop of birds is being harvested by man, as then the hunter can shoot the increased quail production resulting from squirrel control. With an increase in take of quail and control of squirrels, there is an increase in production of the birds.

Predator Relationships

A logical presumption regarding the question of reducing the number of ground squirrels might be to leave coyotes unmolested so that they would control the squirrels. Unfortunately this does not happen in California. Instead of uncontrolled coyote populations keeping ground squirrels at such a low level that they are no longer pests, it appears that squirrel populations which build up following grazing have merely extended the range and increased the number of coyotes, At least, according to Grinnell *et al.* (1937), certain ranges of coyotes in California have been extended by agricultural practices. These predators may feed extensively on ground squirrels, but they take only a fraction of the annual increase; the remaining are eliminated by various factors, including many other kinds of predators. And in areas where predators are not controlled, the combined influence of all the predators does not keep the density of squirrels at a low level on either cultivated fields or rangelands. Enough squirrels to compete seriously with agricultural interests often survive even the combined effects of all the different kinds of predators.

It is suspected that coyotes may exercise a greater influence on jack rabbit numbers than on squirrels, although there are no data to support this view known to the author. As with squirrels, the population of jack rabbits often increases when an area is grazed or put to certain other agricultural purposes and must be controlled.

Studies carried out at the Experimental Range provide some interesting information about the coyote-ground squirrel relationship. The material is not being presented as an example of the merits of coyote control, but rather to show what happened to the squirrel population when the coyotes were controlled. In 1936, when it was found necessary to reduce the coyote numbers on the Range to protect the calf crop (Fitch, 1948a; Wagnon *et al.*, 1942), 35 of these predators were removed. About 30 were trapped during each of the next three years. During 1939–1940 and 1940–1941 thirteen coyotes were removed each year. On subsequent years only a few individuals have been taken. The low population of coyotes presumably is now largely due to their being killed from eating ground squirrels that have been poisoned with 1080. But before the effective reduction in number of coyotes occurred, Fitch (1948b) estimated that about one coyote per 300 acres was present in 1939–1941. (It would make little difference, as will be pointed out in the discussion to follow, even if there had been several times this number of coyotes.) Fitch also showed that ground squirrels (*Citellus beecheyi*) made up about one-third of the diet of the coyotes.

Up to this point the data give the impression that the partially reduced population of coyotes existing on the Range in 1939–1941 might have been important

in regulating squirrel numbers; but it happens that the same ground squirrel population had a potential annual increase of about 5.8 squirrels per acre (Fitch, 1948b). Using Fitch's information as a basis, the coyotes were removing only 0.4 of the 5.8 squirrels or only about seven per cent of the annual increase. If there had been several times as many coyotes, they still would have destroyed only a small percentage of the squirrels. The red-tailed hawks, on the other hand, were removing almost eight per cent. Fitch found the rattlesnake to be the most important predator of ground squirrels at the Range. They were annually taking about two squirrels per acre or 34 per cent, which is five times the amount removed by the coyotes.

Even the combined effect of the three most important predators of ground squirrels at the Range—rattlesnakes (Fitch and Twining, 1946; Fitch and Glading, 1947), red-tailed hawks (Fitch *et al.*, 1946), and coyotes (Fitch, 1948a)—accounts for the destruction of only one half the annual increase of squirrels (Fitch, 1948b). Additional predators, disease, and unknown factors apparently were responsible for the disappearance of the remaining number of these rodents. It is obvious that if predators were able to eliminate completely one of their prey species, such prey would naturally become extinct. And if predators were able to keep their important prey species at low population levels, few predators would be able to survive. Coyotes merely remove some of the surplus individuals of their favored prey species. When conditions change and favor a prey species, both the prey and its predator species increase in number. The prey animals would of course become even more abundant if there were no predators, as has happened in Australia and New Zealand. But what the author wishes to emphasize is that even though the predators are a help, they often are not adequate, and artificial control of rodents is still necessary.

After the coyote population at the Experimental Range was materially reduced and maintained at so low a level that none or only a few could be trapped each year instead of 30 or more, there was no corresponding increase in squirrels. Instead, during some years ground squirrels and especially kangaroo rats and cottontails actually decreased appreciably in numbers. This reduction in the rodent and rabbit population density was not the result of coyote control, but is presented here as an example to show that other environmental factors are more important than coyote numbers in determining the density of squirrels present. Fitch (1948b) writes with regard to the Range, "... the available evidence suggests that coyote predation is not a determining factor in the trends of ground squirrel, cottontail, kangaroo rat, and gopher populations in this type of habitat, despite the fact that these small mammals comprise the bulk of the food and are taken in great numbers. Relations with range cattle are generally harmonious, but individual coyotes, which learn to kill small calves, may cause serious damage at times."

With regard to the coyote-ground squirrel relationships on the San Joaquin Experimental Range, the size of the coyote population is probably more dependent on the number of squirrels present than vice versa. This is because ground squirrels make up about one-third of the diet of the coyotes—a major part of their food—whereas the coyotes destroy but a small fraction of the annual increase of squirrels. Coyotes, in areas the writer has seen, cannot hold the density of ground squirrels at so low a level that they will not compete seriously with man's interests. In most instances the

squirrels have become numerous because of man's activities; hence they need to be controlled as do weeds in a garden. And the ground squirrel, as an agricultural pest in California, certainly is not the result of the coyote-control measures that have been practiced. This should not be interpreted as meaning that the coyote and other predators do not help man check rodent numbers, for they do provide valuable assistance, especially where man does not have sufficiently effective means of control for a particular rodent or rabbit species. They are not especially helpful with ground squirrels, however, for man has developed control methods for these animals that are more effective than predators, much as flyswatters and chemicals are used to control flies instead of just encouraging more birds and other predators of flies. There is no evidence known to the author to support the view that rodents and rabbits serve as buffers between certain predators and domestic animals, except for the brief period following the initial effective control of the rodents or rabbits that served as prey species.

There is a need of revaluation of the effects and methods of predator control in California and elsewhere. If the objectives of control were clarified and supported with an unbiased factual study over a number of years, there surely would be instances where more effective control measures could be adopted and others where certain practices could be modified with a saving of funds and better results. The subject of rodent and predator control can afford to be reexamined from the viewpoints of not only livestock and game interests but also those of conservation organizations which are attempting to preserve wildlife for its own sake. Such a study should be rewarding to conservationists as well as to agriculture and sportsmen.

In conclusion, our goal is good land management through maximum sustained yields from rangelands both in livestock and game. Original fauna and flora will have to be preserved in places such as national parks. Since man alters the balance of nature when he uses land, he has to introduce remedial measures to counteract the undesirable consequences of his disturbance of the former balance. An important step toward initiating these measures would be to eliminate the emotional stigma frequently associated with the words poison or control, as rodent control is often a good *conservation* practice to be adopted on ranges. Is it not possible that when we strongly oppose the artificial control of certain kinds of rodents and rabbits on rangelands in the interest of conservation, we are our own worst enemy? Another barrier to a more rapid acquisition of answers to the relationships of rodent control to land management stems from those few who are so dogmatic that they will not tolerate organized rodent or predator control anywhere. They object to control even though man may have been responsible for causing the increased numbers of animals that require abatement. It appears that by such zealous attempts to improve ranges by protecting all wild animals, we fight against the very thing we think we are fighting for. Basic research on the fundamental biological functions of animal ecology of rangelands is sorely needed, but a common impediment stems from a hesitation by some to be associated with worthy but "practical" problems in control. Instead of criticizing without evidence current range rodent control practices, let's be constructive by encouraging more research to put the subject on a better factual basis and to reduce the emotional convictions to a minimum.

Summary

Much of the material under the section on range concepts pertains to a philo-

sophical interpretation of rodent control on rangelands.

Plants are basic items of animal food chains and, since cultivation or even light to moderate degrees of grazing alter the composition and density of forage, a change in rodent populations inevitably follows land use. Some species decrease in density and even disappear locally, while others, such as ground squirrels, frequently increase in numbers and seriously compete with livestock for forage.

Sometimes pocket gophers or ground squirrels become abundant on slopes and cause gullies when water gets channeled down their burrows, causing subsurface erosion followed by cave-ins of the ground surface. Plant roots and microorganisms perhaps do a better job of soil cultivation than do rodents.

A partially controlled population of coyotes at the San Joaquin Experimental Range, one-third of whose diet consisted of ground squirrels, actually only killed about seven per cent of the annual increase of squirrels. Rattlesnakes accounted for almost five times as many.

In most instances, the type of research needed for zoological range-management problems is basic ecology or natural history, but whenever agricultural or practical interpretations are drawn from such studies the investigations are too often demurred. Consequently, teachers and graduate students alike are not attracted to this important field of research.

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RANGE PLANT IDENTIFICATION CONTEST

At the Seventh Annual Meeting of the American Society of Range Management in Omaha, Nebraska, January 26 to 29, 1954, a range plant identification contest will be conducted similar to the contests at each of the past three meetings.

Competition is becoming tougher; the school producing the winning team this year will have to be on its toes.—*H. W. Cooper*, Chairman, Contest Display Committee.

BOOK REVIEWS

THE AMERICAN GRASS BOOK. By Sellers G. Archer and Clarence E. Bunch, xxii, 330 pp., illus. University of Oklahoma Press, Norman, Okla., 1953. $3.95.

This book, which is written in very general terms and flowery language, is divided into six sections relating to grass culture in the United States.

The first section deals with a permanent agriculture based on grass and extols the value of grass in relation to the early history of the United States, the development and conservation of soil, and the prevention of floods. This section, written in general terms and almost poetic form, is apparently intended to impress the reader with importance of grass as it has affected our past and will continue to affect our civilization in the future. Although the importance of grass is not to be minimized, the authors overemphasize its role in the development of civilization. No single resource, but many resources properly combined by the intelligence of man and man himself, all must go together to build a high type of lasting civilization.

Section II deals with the planting of grass and although it has some excellent suggestions about this all-important procedure, the section as a whole is written in such general terms that the ranchmen or farmer reading it would have considerable difficulty in accomplishing the seeding operation under his own specific conditions.

The general ideas of complete planning and fitting the grass to the individual farm or ranch as conveyed in this section, are certainly in accord with the thinking of all progressive range managers.

The third section, which deals with the management of grasslands, is definitely too brief and non-specific to be of value to the student or professional range manager and is probably of little value to the agricultural producer as well. Many of the tables and charts give the impression that they are a projection of theory rather than the results of research. Some important phases of management are treated in as little as two short paragraphs and give an erroneous impression of their importance as well as the amount of research work which has been conducted on them. Examples of this may be noted in the sections pertaining to brush removal and pitting and chiseling. There are many books on management of grassland which fail to cover the subject thoroughly, yet here it is treated in only forty-one pages.

Section IV, dealing with seed production, and Sections V and VI pertaining to the description, adaptation, and management of various grasses and legumes are the valuable portions of this book and much information for both the producer and the professional range manager is presented in a condensed and readable manner.

A broad knowledge of grasses leads to better management of our grasslands and Sections IV through VI of the American Grass Book make a valuable contribution by summarizing all of the general information about the common grasses and legumes. These sections should be recommended reading for all who are interested in the production of grass.—*Robert L. Lang*, Associate Professor of Agronomy, University of Wyoming, Laramie, Wyoming.

SHANGHAI PIERCE: A FAIR LIKENESS. By Chris Emmett, xiii, 326 pp., illus. University of Oklahoma Press, Norman, Okla., 1953. $5.00.

This is a biography of A. H. Pierce, a New England farm boy who hired out as a Texas ranch hand for $200 a year in cattle. Shanghai Pierce, self-decreed Webster on cattle, progressed rapidly to one of the greatest and wealthiest cattle barons of his time, 1834–1900. The many dealings and misdealings of "Old Shang" are very interestingly portrayed and accurately substantiated and verified through letters, papers, and records from public libraries, and federal and state courts. At one time Shanghai Pierce professed that he and his company "owned nearly all the cattle in Christendom. . . ."

This is the story of "The Big Pasture Men," their first marketing of cattle by boat from Texas Gulf Coastal Region grass to New Orleans, and their many trail drives to midwestern railpoints. The book describes the dramatic career of a cowman who was "the symbol of his era, and passed away with that era. He was big; he was rich; he was selfish; but he could also be kind. His humor was as brilliant as that of any character Mark Twain ever fashioned; and his cunning, marked by apparent naiveté, was seldom matched. Business, whether involving a quarter-million-dollar loan or a twenty-five-cent pair of sox, was his lifeblood. His country, his state, his family—nothing was as important as 'that cow out there'." Recommended to all interested in early cattle raising problems of the Southwest and particularly those on the upper Texas Gulf Coast Region.—*John S. Williams*, Associate Professor of Agriculture, University of Houston, Houston, Texas.

PLANT ANATOMY. By Katherine Esau, xii, 735 pp., illus. John Wiley & Sons, Inc., New York, 1953. $9.00

This comprehensive volume brings together in logical and understandable fashion most of what is presently known of the anatomy of seed plants. The author, an outstanding researcher in this field, has not allowed problems of classification to complicate the presentation, and historical considerations are minimized. The less advanced student will appreciate the straightforward and clear style and lack of new technical terms. In fact, the author has obviously scrutinized existing terms for accuracy and usefulness and, in the opinion of this reviewer, has shown excellent judgment in adopting the most meaningful ones (synonymous terms are cited parenthetically where appropriate). The author also gives the meaning (again parenthetically) of Greek or Latin roots of technical terms, which adds materially to the readability of the book. Basic terms and concepts are explained clearly.

Subject matter is presented in an orthodox sequence considering first the cell and tissue types, and then the arrangement of structural elements within the plant organs (stem, leaf, and root). Organization is simple and coherent, each of the 20 chapters being developed as an organic whole: (1) The Plant Body, (2) The Protoplast, (3) The Cell Wall, (4) Meristems and Tissue Differentiation, (5) Apical Meristems, (6) The Vascular Cambium, (7) The Epidermis, (8) Parenchyma, (9) Collenchyma, (10) Sclerenchyma, (11) Xylem, (12) Phloem, (13) Laticifers, (14) The Periderm, (15) The Leaf, (16) The Stem, (17) The Root, (18) The Flower, (19) The Fruit, and (20) The Seed. As indicated by the chapter titles, the approach is toward angiosperms in general, rather than specific

families or groups. However, enough detailed examples are given to illustrate variability in form and structure, and to permit a student to interpret an unfamiliar structure and relate it to known tissue.

Each chapter is liberally illustrated with excellent diagrams and drawings, fully labeled. In addition, 90 pages of superb photomicrograph halftones, also fully labeled, are inserted at the end of the book. The majority of these were made by the author in the course of her extensive anatomical research. Sixty to 160 references listed at the end of each chapter support the descriptions and interpretations of the author and direct the advanced student or specialist toward wider reading. Two pages of general references are given at the beginning of the book. Both the author index and the subject index are extensive and apparently complete.

Although the book was not intended for the average range practitioner, those with an intellectual curiosity regarding basic structures, functions, and development of the various parts of the plant body will find it interesting and satisfying reading. Technical researchers concerned with identifying and evaluating response of specific plant tissues as, for example, in chemical control of noxious plants, will want it in their reference libraries. Many college students will undoubtedly use it as a text in their plant anatomy courses in the near future.—*Weldon O. Shepherd*, Southeastern Forest Experiment Station, U. S. Forest Service, Asheville, N. C.

EFFECTS OF HERBICIDAL APPLICATIONS ON COMMON PERSIMMON, *DIOSPYROS VIRGINIANA*

(Abstract of thesis submitted in partial fulfillment for an M.S. degree, A. and M. College of Texas, Department of Range and Forestry, 1951.)

Common persimmon is one of the principal woody invaders of pastures and idle cropland in the Southeast and Gulf States. Preliminary studies of the effects of herbicidal applications were made in East Central Texas.

Foliage-spray application of ester and amine formulations of 2,4-D, 2,4,5-T and combinations of 2,4-D and 2,4,5-T at 4,000 and 8,000 ppm. in water, oil and emulsion gave ineffective control of mature plants. However, each herbicide tested gave effective plant kill of root sprouts when applied at 8,000 ppm. in emulsion.

Effective control was obtained with stump-surface treatments made in late summer and winter with 2,4,5-T and 2,4-D esters in oil sprays containing 1 percent acid equivalent. Ammate solutions containing 1½ pounds per gallon were equally effective.

Basal applications with selective herbicides were more effective in the dormant season than in late summer and fall. Effective control was obtained with 2,4,5-T esters and combinations of 2,4-D and 2,4,5-T esters at 1 percent concentration in oil sprays applied basally to bruised trunks.

Results of this study indicate that a combination of foliage-spray applications on root sprouts and stump surface applications of selective herbicides could be recommended as a control method for common persimmon.

WAYDE K. FREY

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NEWS AND NOTES

Report on Meeting of Working Party on Mediterranean Pasture and Fodder Development

The Second Meeting of the Working Party on Mediterranean Pasture and Fodder Development was held at the Algerian Institute for Agriculture, Maison Carreé, (Algiers) from April 28 to May 2, 1953.

Twelve countries were represented by delegates: Algeria, Egypt, France, Israel, Italy, Libya, Morocco, Portugal, Spain, Tunisia, Turkey and United Kingdom (Cyprus). Dr. O. S. Aamodt and representatives of MSA and TCA were there as observers for the United States. FAO was represented by L. E. Kirk, Chief of the Plant Production Branch; R. O. Whyte, in charge, Pasture and Forage Crops; A. T. Semple, in charge, Range Management, Animal Production Branch; R. Rowat, extension specialist, Agricultural Institutions and Services Branch; all of the Agriculture Division; and W. R. Chapline, Chief, Forest Conservation Section, Forest Policy and Conservation Branch, of the Forestry Division. More than 60 technicians were in attendance.

Marcel Barbut, Inspector General of Agriculture in Algeria served as Chairman of the meeting.

The very active participation of the delegates shows a great interest in the problems and should greatly stimulate the research and other phases of work so urgently needed in the region.

The general conclusions and recommendations drafted by the Working Party meeting are briefly presented as follows:

1. There is need for more information on the amount and character of changes obtained by protecting natural vegetation from grazing, and the proper balance between number of grazing animals on a given area and the rate of revegetation and changes in botanical composition that will occur under different ecological conditions.

2. The speed of regeneration of the plant cover on deteriorated natural range can often be accelerated by reseeding. To guide such work there is need for studies to determine adaptable species and varieties of grasses or legumes and methods to be used in their establishment.

3. To facilitate comparisons between experiments made in different ecological environments, there should be an attempt to standardize methods which are adaptable to Mediterranean situations for the determination of range condition, forage productivity, and carrying capacity. A special study group should be set up to survey the existing methods and make recommendations to collaborating countries.

4. There should be a collection by the FAO Secretariat of all existing maps of Mediterranean countries which show the principal ecological factors such as total and seasonal distribution of precipitation, climatic zones, geology, soils, floristic zones and land use classifications. These maps would be available to workers in different Mediterranean countries.

5. Financial participation in pasture improvement programs on the part of the State, communes and cooperative organizations may facilitate adoption of new and indispensable measures for range improvement and management.

6. The acreage of fodder crops and pastures should be increased in arable rotations. This will not only contribute to total fodder resources but will also

make it possible to reduce overgrazing on uncultivated lands.

7. In zones which receive 300 to 400 mm. rainfall and which practice wheat/fallow rotation, the introduction of forage crops in place of fallow should be tried even though it cannot always be recommended without precautions.

8. When rainfall is between 400 to 550 mm., one can recommend either establishment of artificial pastures or introduction of forage crops in rotations.

9. Forage crops are not generally considered capable of competing under irrigated conditions with other cash crops. Under such conditions cultivation of forage crops should be developed to supply supplementary fodders indispensable to proper growth and management of livestock on semiarid grazing lands. The establishment and yielding potentialities of irrigated pastures also deserve attention.

10. Establishment of reserves of conserved fodder must be a primary objective throughout the Mediterranean area to facilitate a reasonably uniform level of livestock nutrition throughout the year, to be prepared for seasonal and annual fluctuations in forage production, and to assist in reducing pressure on natural grazing lands.

11. Reserves can be built up by conservation of good quality forage crops or by creation of standing reserves on arid and semi-arid rangelands composed of natural vegetation which has regenerated following protection or planted fodder trees and shrub producing foliage and fruit beyond the reach of animals.

12. Normal procedures of haymaking and ensilage are applicable throughout the Mediterranean region; economic considerations govern choice of the method to be adopted.

13. FAO will make available seeds of potential or proved value in the Mediterranean area for trial in field tests, small plots or observation rows. Each country will assist in building up the supply of seeds for these extended species adaptation trials.

15. Special attention should be given to species and varieties likely to be adapted to pastures in arid and semi-arid zones, and to fodder legumes suitable for growing in rotation with cereals. In addition to adaptability, these species should be evaluated for seed producing characteristics, method of harvesting and procedures for seed processing.

16. Steps should be taken to stimulate and organize the production of seed of species and strains already found to be promising in the Mediterranean countries or elsewhere under similar conditions.

17. Government assistance to institutions and specialized seed growers will be desirable and necessary for an initial period of a few years.

18. The Working Party was impressed with the importance of securing confidence, goodwill and active cooperation of rural peoples, and appreciated the importance of ensuring a steady flow of information from research workers to farmers. Agricultural research programs should be supplemented and supported by adequate educational and advisory services, properly staffed and trained, and the closest coordination and cooperation should be established and maintained between research and advisory workers.

(The above recommendations and conclusions have been summarized from available reports and news releases.—*Editor*)

Hawaii Cattlemen See Santa Gertrudis Cattle

Over 100 members and guests of the Hawaii Cattlemen's Association enjoyed a field day at the Herbert C. Shipman

Ranch at Volcano. They saw grass plots where many forages from all over the world are under test for adaptability. The first bunch of Santa Gertrudis cattle shipped outside the continental United States was on display. These one- and two-year old heifers and bulls were admired by the group. The majority of the people saw this breed of cattle for the first time.

Another highlight of the trip was a roping demonstration by Monte Montana, professional roper who played in the movie based on the life of Will Rogers.

To top off the program, a luncheon of Hawaiian and American foods was served at Fernhaven with Mr. Shipman as the genial host.—*E. Y. Hosaka*

Dr. Sampson Visits Hawaii

Dr. and Mrs. A. W. Sampson spent two weeks in June visiting ranches on all the major islands. They were accompanied by E. Y. Hosaka, Range Management Specialist at the University of Hawaii. Dr. Sampson gave informal talks at the Molokai Grazers Association, Maui Cattlemen's Association and at the Hawaiian Homestead Ranchers' Association meetings.

Dr. Sampson was very interested in the ecology of the ranges with narrow bands of different vegetation on the slopes of the mountains. The year-round grazing pastures composed of guinea grass, kikuyu, paspalum, Spanish clover, koa haole, white clover, black medic, rye, and cocksfoot impressed him greatly. Dr. Sampson was also amazed at the carrying capacity of the irrigated pastures planted to tropical shrub and grass. These pastures carry three head to the acre the year round with the animals making an average gain of two pounds per day.—*E. Y. Hosaka.*

Oregon State College

Charles E. Poulton has returned to Oregon State College after two years of educational leave to resume his duties in charge of the Range Management program under the Departments of Animal Husbandry and Farm Crops. During this period Mr. Poulton completed the course work and residence requirements at the State College of Washington for the Ph.D. degree with a major in ecology and a minor in soils.

During Mr. Poulton's absence, Dr. Donald W. Hedrick, a graduate in range management of the University of California and Texas A. & M. guided the Oregon State College Range Management program. Dr. Hedrick's background includes several years of experience as a range conservationist in the Soil Conservation Service as well as extensive ecological studies on brushlands in California. He is to continue as a colleague with Mr. Poulton in the range management work.

This expansion of staff will enable full development of the Oregon State College Range Management program. Both men will participate in research as well as teaching activities, each of which is jointly supported by the Departments of Animal Husbandry and Farm Crops.

The academic program includes a major in range management at undergraduate and graduate levels with numerous opportunities to build supporting minors in allied fields.

Range Society Members Abroad

C. Kenneth Pearse, chief, division of range research at the Southwestern Forest and Range Experiment Station, Tucson, Arizona, has accepted a 2-year assignment in Egypt under the Point IV program of F. O. A. He will have charge

of desert range development work in the agriculture division and will work with the Egyptian government in determining and initiating grazing management, range reseeding, water spreading, and other range improvement practices to increase the productivity of the rangelands in Egypt.

John R. Killough, area manager for the Bureau of Land Management at Worland, Wyoming is now in Tel Aviv, Israel on a 2-year assignment for F. O. A. as a grazing land management specialist in the branch of grazing and woodland development, use and management, agricultural division of the Point IV program. He will work with the Israeli government in establishing a grazing land use and management program for native and reseeded ranges in Israel.

E. J. Woolfolk, chief, division of range research at the Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Montana, is in Argentina for two months as a range management instructor in a short course on range and pasture management. This course is under the sponsorship of the Organization of American States and is being given at 3 locations in Argentina.

Walton M. Nixon, Regional Agronomist for the Gulf Coast Region of the Soil Conservation Service with headquarters at Fort Worth, Texas has left on a 2-year foreign assignment with the Mutual Security Agency (now Foreign Operations Administration) in Turkey. His assignment will be as agronomist with emphasis on forage and grasses. His headquarters are Ankara, Turkey.

W. L. Dutton, formerly chief of the division of range management of the U. S. Forest Service, Washington, D. C. and A. T. Semple, formerly in charge of range management in the animal production branch of the agricultural division of the Food and Agriculture Organization of the United Nations at Rome, have accepted a 15-month assignment with the British Government in Africa beginning about November 1. They will form a two-man mission to the British Colonies generally described as east and west-central Africa, south of the Sahara; including the Colonies of Kenya, Nyasaland, Nigeria, and Northern and Southern Rhodesia. Art's phase of the assignment will be to determine and recommend more efficient methods of livestock production to increase the yield of meat, hides and wool. Walt's phase is to determine and advise on methods of range and pasture management that will be effective in livestock production and at the same time maintain the soil resource.

Transfers, Promotions and Resignations

Harold R. Hochmuth, member of the Editorial Board for the Journal, has been transferred from his position as Chief, Branch of Land Classification, Bureau of Land Management, Washington, D. C. to the position of Regional Chief, Division of Lands and Minerals, Bureau of Land Management, Portland, Oregon. He succeeds Karl S. Landstrom, who has been assigned to the Washington staff of the Bureau of Land Management as Chief, Branch of Research and Program Analysis.

Ernest J. Palmer, newly appointed range conservationist in the Bureau of Land Management's Division of Range Management, Washington, D. C., will be responsible for the technical direction of

the halogeton control program. He was formerly employed by the Bureau of Reclamation as District Operations and Development Supervisor for the Big Horn District, Cody, Wyoming.

William G. Guernsey, former resident of Montana, has been appointed Regional Administrator for Region I of the Bureau of Land Management at Portland, Oregon. He succeeds Roscoe E. Bell, who is being assigned to a technical position in the Bureau's Alaska Region. Mr. Guernsey has been Assistant Regional Forester for the Intermountain Region of the Forest Service in southern Idaho, Utah and Nevada with headquarters at Ogden, Utah.

Wilkie Collins, Jr., Regional Agronomist for the northern Great Plains States of Kansas, Nebraska, North and South Dakota, Wyoming and Montana for the last 18 years has resigned from the Soil Conservation Service. He will manage a large ranch in southern California. He has been a leading agronomic authority on soil conservation and crop production in the Northern Great Plains area.

Elbert H. Reid, formerly Assistant Chief of the Division of Range Research, Forest Service, Washington, D. C. has been transferred to the position of Chief, Division of Range Research at the Rocky Mountain Forest and Range Experiment Station, with headquarters at Fort Collins, Colorado. Since the Southwestern Station has been consolidated with the Rocky Mountain Station, research in the territory administered from the Fort Collins headquarters will include Arizona, New Mexico and west Texas.

In Memoriam

Mr. Don Johnson, a member of the Nevada Section of the Range Society, met his untimely death in an airplane accident near Sheldon Antelope Refuge airstrip in northwestern Nevada on July 11.

Mr. Johnson was employed by the Nevada State Fish and Game Commission, in connection with their Pittman-Robertson program of big game survey work. He was a conscientious wildlife worker whose death will be keenly felt by the Nevada State Fish and Game Commission and all its co-workers.

MEETING OF JOINT COMMITTEE ON GRASSLAND FARMING

The Joint Committee on Grassland Farming is sponsoring an all-day Ranch Tour on November 15 and an Annual Meeting on November 16, 1953. The tour and meeting are to be held at Dallas, Texas, just preceding the annual meeting of the American Society of Agronomy.

An interesting tour and program for the annual meeting have been arranged. On the program for the annual meeting will be talks by Range Society members B. W. Allred, A. P. Atkins, Henry Biederman and D. A. Savage.

WITH THE SECTIONS

NEVADA

The Nevada Section had a 3-day meeting and field tour on June 9, 10 and 11. With over half of the total Section membership in attendance the meeting started at Caliente. Section Chairman Joseph H. Robertson counselled section members not to be reluctant to enter into the discussion of controversial issues because such discussion serves to stimulate thinking.

Several very interesting papers were presented during the first day. George Zappettini, in his discussion on halogeton research, stated that he believed that education and the adherence to good grazing management principles will ultimately prove to be the best treatment. Joseph Robertson, in a discussion of ecological changes on the range after 50 years in northern Nevada, showed by repeat photographs and vegetation descriptions that rather positive range deterioration had occurred since Mr. P. B. Kennedy visited and photographed the area in 1902. Robert Copple, in a discussion of climatic considerations in reseeding Nevada ranges, pointed out that possibilities for successful reseeding in areas of the same annual precipitation are quite different between northern Nevada which receives 30 percent of its precipitation in the summer and southern Nevada which receives 50 percent in the summer. Louis D. Hatch, in his discussion of wildlife management in Nevada, described the work on desert bighorn sheep at the Desert Wildlife Refuge near Las Vegas. William N. White discussed watershed planning of the Wilson Creek range unit as it is being carried out by the Bureau of Land Management. Ray K. Peterson described his Point IV assignment in Indonesia. Blaine Halliday discussed the pilot district program of the Soil Conservation Service. Odell Julander, invitation speaker from the Utah Section, presented a discussion of big game-livestock relationships on mountain ranges, illustrated with colored slides, tables and graphs.

One of the points of interest in the field was the Caliente pasture demonstration established and discussed by Ferren Bunker, Lincoln County Agent. Results from 12 permanent pasture plots near Caliente indicate that for the greatest carrying capacity, pasture mixtures should be limited to one or two grasses, and legumes should be selected for soil type and limited to 50 or 60 percent of the mixture.

Other features of the field tours were visits to the crested wheatgrass seedings made by the Bureau of Land Management on the Clover Mountain area, a demonstration of the range condition guide by Blaine Halliday of the S. C. S., natural range improvement under controlled grazing at Crystal Springs near Hiko, Nevada, inspection of a halogeton infestation near Hiko, and a stop at an alfalfa-grass pasture owned by the Stewart Brothers near Hiko.

The first stop of the trip, some 15 miles west of Caliente, was for the purpose of setting up along highway U. S. 93 on the Delamar range the first range type and use sign to be used on Nevada highways. Conceived by Chairman Robertson, it reads "Desert Shrub—Cattle Range" and is designed to inform out-of-state travellers of the value and use of Nevada rangelands (Fig. 1). The sign is patterned after highway regulatory signs and was made by the Nevada

Department of Highways for the Section at cost. Permission was granted the Section to install sign along road shoulder

desert-shrub type winter range grazed by sheep were examined.—From report by *William N. White*, Secretary-Treasurer.

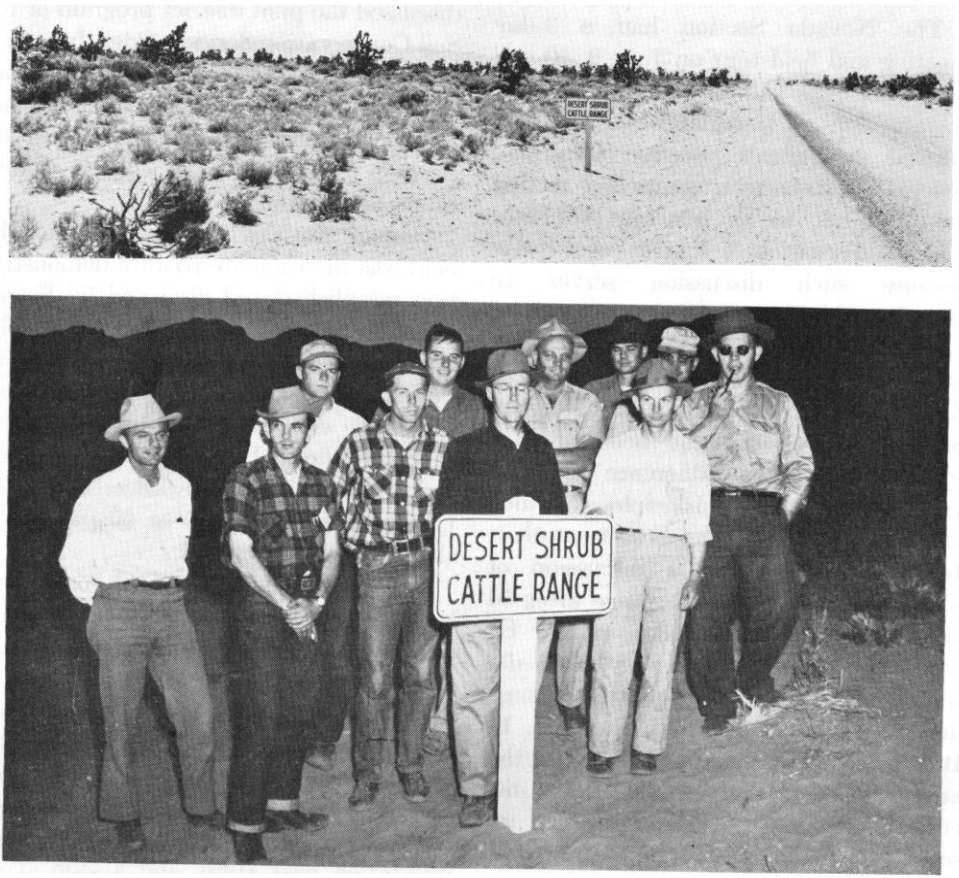

FIGURE 1. NEVADA RANGE TYPE SIGN. *Upper*—Range type sign along highway U. S. 93 about 15 miles west of Caliente. *Lower*—Nevada Section members who installed first sign. From left members are George Zappettini, Robert Zang, Charles Saulisberry, Richard Gerity, Richard E. Eckert, Joseph H. Robertson, Ray K. Petersen, William K. Cockrell, Willard C. Robocker, Marion Escobar and Alvin T. Bleak. Photos by *John M. Fenley*.

in exactly the same manner as highway signs are placed. The Nevada Section is currently sponsoring a project to erect signs on all the major range types which the main highways traverse.

The last stop of the tour was at the Desert Experimental Range near the Nevada-Utah line in western Utah. Here results of grazing studies which have been underway since 1933 on the salt-

Nevada Section Officers and Council Members determined by a recent election are as follows:

Chairman: John M. Fenley, P. O. Box 590, Las Vegas

Vice-Chairman: William N. White, 215 Claremont St., Reno

Secretary-Treasurer: Louis D. Hatch, Box 432, Las Vegas

Council Members:

Zone I—Ned A. Smith, P. O. Box 332, Winnemucca

Zone II—George Zappettini, P. O. Box 231, Tonopah

Zone III—Lawrence Settelmeyer, Gardnerville

Zone IV—William K. Cockrell, Cedarville, California

The Nevada Section at their business meeting on June 9 passed a resolution memorializing the memory of Section Member, recently deceased, Clarence E. Favre as follows:

"Be it resolved by the active members of the Nevada Section, American Society of Range Management, assembled at Caliente, Nevada on June 10, 1953, that Clarence E. Favre be memorialized as a range conservationist of extraordinary ability, energy and enthusiasm. Although he held many important assignments, Clarence's attitude was always democratic toward his co-workers. He knew Nevada Ranges as few others have. His enduring interest in the range problems is symbolized by his active membership in this Section up to the time of his death. We owe him a great debt and miss his energy and leadership at the council table and on the range."

Colorado

New officers of the Colorado Section elected in May 1953 are Carlton S. Fonte, 1050 Rood Ave., Grand Junction as chairman and Rowland G. Thompson, Bureau of Land Management, P. O. Box 209, Grand Junction as secretary-treasurer.

Arizona

The summer meeting of our Section was held May 28 and 29 on the Ft. Apache Indian Reservation. We had a good turnout of nearly one hundred. Each morning was devoted to the reading of technical papers, with a field trip in the afternoon. Everyone seems to like this arrangement.

The one central theme of our meeting this summer was juniper control for forage production and prescribed burning of ponderosa pine for stand improvement.

William L. Schroeder, in charge of range management on the Reservation, pointed out in his paper that juniper control was started on a small scale in 1936. It didn't actually get going until 1947. Since that time the Indians of the Ft. Apache Reservation, aided by PMA Federal-aid money and their Tribal Council, have spent approximately $275,000 on juniper control work.

Burning, spraying, chopping and bulldozing have been the methods used to eradicate the juniper. To date about 55,000 acres have been treated at an average cost of $5.00 per acre.

The field trip showed thousands of acres of good cattle range coming back after removal of the trees (Fig. 2).

The white men present on the tour learned a lot from their Indian friends how to practice good range management and make grass grow where juniper grew before. No reseeding was done; when competition was removed native grasses came back in abundance.

Harry Kallander, forester on the Reservation, gave an interesting paper on prescribed burning to prevent disastrous forest fires. This type of burning is still in the experimental stage. The objective of burning is to reduce the fuel in the form of pine needles, down logs, snags, and other material that feeds forest fires.

The field trip that followed showed some very interesting facts about prescribed burning. Many factors must be considered such as time of day, air

temperature, relative humidity of the air, relative humidity of the dead fuel, and wind velocity. All must be weighed carefully and even a small variation in any of these factors may cause damage and wipe out the margin of benefit obtained from burning.

Our annual winter meeting will be in December at Nogales. We would be very happy to have members of other sections attend. You'll hear some good talks, see some good country and above all we'll show you a good time.—*Danny Freeman*, Secretary-Treasurer.

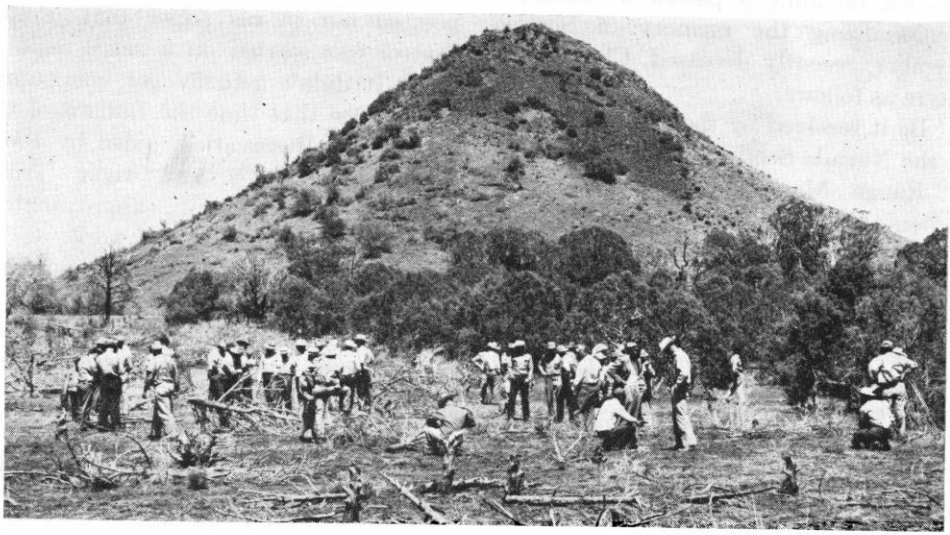

FIGURE 2. Arizona Section members on the Ft. Apache Indian Reservation inspecting range improved by juniper eradication.

The Arizona Section reports that it has done pretty well in increasing membership. At the end of 1952 they had 152 members. During 1953 they have gained 51 new members but lost 24 who failed to renew, making a net gain of 27 members.

The breakdown of present members is as follows: 87 ranchers, 31 Forest Service, 16 Indian Service, 8 Soil Conservation Service, 2 Bureau of Land Management, 3 Production and Marketing Administration, 5—State of Arizona, 16—commercial and others, 6—University of Arizona, and 5 students. The striking part of this breakdown is the strong interest and participation by ranchers. The Arizona Section can also claim the distinction of having two ladies as members.

Can any other section boast a higher percentage of ranchers or two women members?—*Ed.*

TEXAS

The famous old Mill Iron ranch near Childress was host to the Section at the summer meeting, June 26. More than 100 persons were present for the program which included a tour to points of interest on the ranch, discussions of various phases of management, and a picnic lunch furnished by the Mill Iron. The program committee, headed by Mr. H. M. Bell, and Mill Iron personnel cooperated together to develop a timely, informative program. Congratulations to these folks are in order for the excellent planning and execution of the meeting.

During the tour of the ranch, members saw blue panic grass plantings in almost every pasture. This drought resistant grass is used to provide a source of protein and vitamin A when the native plants are dormant. The ranch desires about 1 acre of blue panic to 5 acres of native range. Series of spreader dams have been constructed on many large, stabilized draws, and an acre or more of blue panic has been planted above each dam. Mr. Irvin Sealander, Mill Iron agronomist, pointed out that these spreaders can be successful only on draws that are stabilized by native vegetation.

FIGURE 3. Texas Section members hear E. R. Monson (center, foreground) discuss use of spreader dams in large draws.

The native range, though in a severely stricken drought area, was well covered by vigorous, desirable grasses. This is the result of proper stocking and a planned grazing program, as pointed out by Mr. Wm. E. Hughes, director of ranch operations.

After lunch Mr. Hughes briefly outlined the history of the ranch and the famous Mill Iron herd. The herd is made up of about 4,000 registered cows and 75 herd bulls. It is broken up into units of 200 females and 4 bulls, each unit of animals being placed on a separate ranch consisting of three to five pastures. So, actually, the Mill Iron ranch is made up of more than 20 smaller ranches, on each of which a family lives with one man in complete charge. The bulls are with the cows year-long. Calves are creep-fed for faster development.

Mr. George Taylor, S. C. S. Area Conservationist, outlined the history and development of blue panic in that area. Mr. E. R. Monson, Mill Iron grass specialist, discussed establishment and management of blue panic (Fig. 3). Once blue panic is established in a pasture, the fences are removed and the grass is grazed free choice with surrounding native plants.

Mr. A. H. Walker, Section Chairman,

spoke briefly concerning aims and accomplishments of the Society. He read a letter from Secretary of Agriculture Ezra Benson expressing Mr. Benson's regrets that he was unable to attend the meeting. Mr. Benson was in Lubbock observing drought damage and had been invited to meet with the section at Childress.

Mr. B. W. Allred, President of the Society, was present, and he complimented the Mill Iron management for the "well-upholstered" hillsides on the ranch.

This was the second of four planned meetings for the year. The first was held in the south Texas "brush country" at Winter Haven in May. The next was scheduled to be at Dalhart in the Panhandle August 26, and the fourth meeting will be on the Gulf Coast Prairie around Victoria in November.—*William J. Waldrip* and *Leo B. Merrill.*

Pacific Northwest

Undaunted by rains Friday, June 12, and in fine spirits reflecting good weather Saturday, June 13, over 100 Pacific Northwest Section members and their guests attended the Section's annual field tour in Central Oregon.

Bill Anderson and Bill Currier of the Soil Conservation Service, together with John Campbell and Bud Adams of the Gray Butte Grazing Association, served genially as hosts on the Friday tour to the Central Oregon Land Utilization Project. At the first stop we saw a really fine stand of crested wheatgrass and Ladak alfalfa planted in mixture. Bill Anderson explained the nature of the general range management problems of the central Oregon area. Bill Currier outlined the history of the crested wheat-Ladak seeding project with statistics, management program, seasons and degrees of use, rotation deferred grazing, etc. John Campbell described the earlier grazing history in the area and pointed out that when the dry-land wheat farms in the area were abandoned in the thirties, most everybody felt the lands would revert to sagebrush and rabbitbrush. "Instead, we have seen real restoration, by grass farming, to production (under use), beyond our greatest expectation."

Another stop was made at a point on a line dividing a planting of Fairway crested wheatgrass and a planting of Standard crested wheatgrass. The Fairway strain is spreading more rapidly under the rotation deferred system of grazing. Bill Currier outlined the history of these reseedings and discussed seedbed preparation, management, pasture statistics, beef gains, and palatability. Bud Adams discussed his problems in obtaining even grazing use by getting distribution through close management, including "cow sense" use of salt and riding.

In another pasture Bill Currier pointed out the results of one-way mowing, two-way mowing, and these in combinations with chemical spraying for brush control. Although sagebrush is a threat to range reseeding, rabbitbrush is more difficult to knock down; it sprouts rapidly from stumps and roots. On one area, brush had been knocked down with roto-beaters, and rabbitbrush has re-invaded.

Following lunch we had brief talks by Priday Holmes (livestock improvement program), Bud Adams (proper forage utilization), Millard Rodman (technical assistance), and Dave Costello (financial returns compared with various degrees of continuing use). Then we saw a planting of Whitmar beardless wheatgrass where John Schwendiman told of his experience and problems in developing wheatgrass strains. He discussed ad-

vantages and disadvantages of Whitmar. Millard Rodman outlined the use plan for this pasture this fall.

At the South Osborne seeding area we saw real recovery from heavy use on an old crested wheatgrass planting. John Campbell emphasized the need for protecting new seedings until they are firmly established.

After dinner at the Pilot Butte Inn Section Chairman Nadeau turned the meeting over to Toastmaster Herb Pollard. We were glad to welcome so many friends from Canada. We were happy, also, to have Past President Fred Renner and Ken Parker both from Washington, D. C.

Dr. A. L. Hafenrichter gave a very interesting after-dinner speech in which he described his extensive research with various strains of grasses from many points on the globe. He observed that range reseeding will become increasingly important, and warned that no "wonder grass" has been discovered or developed. He highlighted the need for additional research with grasses to better answer range management and range production problems.

A fine Buckaroo Breakfast at Dean Hollinshead's ranch was put on by the Bend Rimrock Riders. Then we headed toward Prineville and stopped at Millard Eakin's ranch near Powell Butte. Millard was County Grassman of the Year in 1952 and he has done an exceptionally fine job of grass farming, developing, and managing his land. He outlined his operations and his plans for further development. County Agent George Wood discussed the grassland program of the County.

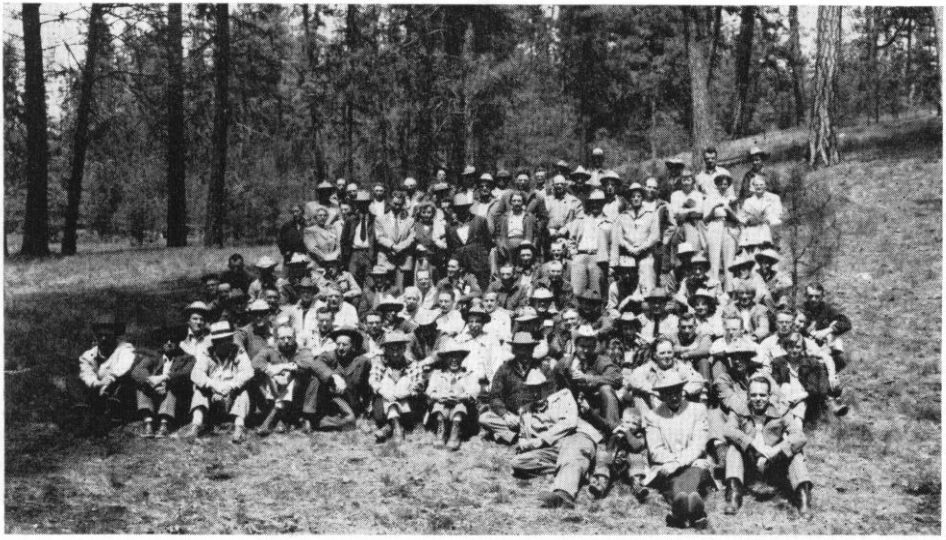

FIGURE 4. Pacific Northwest Section members after lunch at the Ochoco National Forest campground during their field tour.

We traveled on through the juniper woodland area over Oregon Grazing District 5 into the Ochoco National Forest where Vondis Miller, Supervisor, and Les Sullivan, Ranger, showed us the Crystal Creek sale area where some 700 acres on logged areas have been reseeded with timothy, orchardgrass, tall oatgrass and smooth brome. At another stop we watched a chipper and heard of a study

to be made this year to determine the comparative costs between burning and chipping logging slash. We saw other reseedings in logging areas and discussed multiple use of the forest resources, the need for early reseeding on disturbed areas, protection to reseedings and cooperative work being accomplished by the Forest Service working with the licensees and permittees for improved management.

After lunch at the Ochoco Campground (Fig. 4), Past President Renner summarized our field trip and said it was one of the best local section field programs he had been able to attend. Chairman Nadeau held a meeting of the Council for the Northwest Section to decide on several business questions. This ended the field tour and we offer our sincere thanks to the program committee for a job well done.—*W. James Anderson.*

METHODS AND RESULTS OF CHEMICAL TREATMENTS ON CERTAIN BRUSH SPECIES IN THE VICINITY OF COLLEGE STATION, TEXAS

(Abstract of thesis submitted in partial fulfillment for an M.S. degree, Texas A. and M. College, Department of Range and Forestry, 1949.)

Chemical treatments were made on stumps, sprouts, notches, trunk bases, and entire plants of post oak (*Quercus stellata*) and blackjack oak (*Quercus marylandica*); on stumps, sprouts, and entire plants of yaupon (*Ilex vomitoria*); and on entire plants of small winged elm (*Ulmus alata*). The chemicals used were Ammate and esters of 2,4-D and 2,4,5-T.

Ammate, applied in crystalline form, and 0.8 to 1 percent 2,4,5-T in kerosene both gave complete control when applied to freshly cut oak stumps in the spring or fall. A mixture of 0.5 percent 2,4-D and 0.5 percent 2,4,5-T prevented regrowth from all oak stumps when applied in late spring.

One part 2,4,5-T in 10 parts diesel or kerosene gave 100 percent kill when applied to freshly cut notches in the bases of oak trees in the spring. Fall applications were ineffective.

A solution of 0.8 percent 2,4,5-T in kerosene sprayed on the lower 18 to 24 inches of oak holes in spring or fall gave complete control.

Oak trees less than 8 feet in height were effectively controlled by spraying the entire plants with 0.6 percent 2,4,5-T in kerosene in the spring.

None of the foliage applications were effective when applied to sprouts which had been allowed to grow from stumps cut the preceding year.

The application of 0.6 percent 2,4,5-T or 2,4-D in kerosene on yaupon stumps, sprouts, and entire plants was very effective when applied in the spring. However, only the 2,4,5-T solution killed the plants when applied in the fall.

All chemical solutions sprayed on small winged elm trees in the spring gave high percentages of kill. These solutions of 2,4-D and 2,4,5-T varied in concentration from 0.3 to 0.6 percent.

Water is a less desirable carrier for 2,4-D and 2,4,5-T than diesel fuel or kerosene when applied on these brushy species.

Highest percentages of kill were obtained from applications made during periods of high relative humidity (60 percent or higher).

2,4,5-T is generally more effective than 2,4-D or mixtures of 2,4-D and 2,4,5-T when applied on oak, yaupon, and winged elm.

WILLIAM J. WALDRIP

SOCIETY BUSINESS

Highlights of Board of Directors' Meeting

The annual mid-summer meeting of the Board of Directors of the American Society of Range Management was held in the Shirley-Savoy Hotel, Denver, Colorado on August 3, 1953.

In attendance were B. W. Allred, President; Floyd D. Larson, Vice-President; L. A. Stoddart, Past President; Directors Harold Heady, Fred Kennedy, Vernon A. Young, David Costello, A. P. Atkins, and E. J. Dyksterhuis.

Also in attendance were Dr. Marvel Baker, Chairman of Local Arrangements Committee for the Omaha meeting, and Les Albee, Chairman of the South Dakota Section.

President Allred asked Vice-President Larson to act as secretary for the conference in the absence of W. T. White, Executive Secretary, absent because of illness.

The meeting was called to order at 9:10 a.m. and minutes of the January 23, 1953 meeting approved without reading.

As a number of those present were directly concerned, a few minutes were taken to review effects of continued drought of the central and southern Great Plains areas. Wyoming, Colorado and Kansas were reported as lightly to moderately affected. West Texas, New Mexico, Arizona, southern Nevada and parts of southern California were critically affected. Livestock numbers were down 95 to 98 percent of normal numbers in some west Texas counties. Irrigated pastures were reported as being increased on a large scale in California. Reports were that range forage production was good and generally favorable moisture conditions prevailed in Montana, North and South Dakotas.

President Allred reported that membership numbers appeared to be down; August membership was 2500 as compared to 2700 in January. A large number of delinquent members was believed the result of the new early suspension date of February 15 begun this year as compared to August 15 in previous years, and to less favorable financial condition of the livestock industry. This decline in membership is also being faced by other societies.

The Board passed a motion urging the Membership Committee to continue the 1953 drive for increasing membership, and to again appeal to society officers and section membership committees to increase their efforts to secure new members interested in the Society's objectives. It was the general consensus that personal contacts are far more effective than letters or broadsides of promotion literature in securing new members, and that local section meetings built around local range and pasture improvements and research information always brought in new applications for membership.

A question was presented relative to life members paying section dues. Secretary White was requested to report on the status of life members as section members at the January meeting of the Board.

The Board also requested an analysis and recommendation from the Executive Secretary as to whether interest on life membership funds should be placed in current operating funds or left to increase the life membership account.

The suggestion was made that a "Sustaining Membership" class might afford a better opportunity for those desiring to contribute more than the nominal membership fee towards the operational costs of the Society.

President Allred expressed some concern over the budget outlook, particularly the 1953 income from dues.

Following the reading of a report by Milo Deming, chairman of the Nominations Committee, President Allred raised a question as to whether the list of candidates should be reviewed by the Board of Directors before being submitted to the membership for vote. (Present By-Laws do not provide for this review.) It was the belief of the Board that ballots should not be mailed to the membership before August 1, the date established by the By-Laws as the deadline for submission of nominations by petition.

A report by Kenneth Parker, chairman of the Natural Resources Committee, was read. The Board passed a motion that payment of dues to the National Resources Council be withheld pending further study of Council organization and procedures in conducting business.

The report of the Committee on Awards was presented by Director McCorkle, chairman. The committee failed to reach any definite conclusions. Director Young believes members should be recognized who have contributed time and effort beyond the usual duty assignments in behalf of the Society. The Board passed a motion that merit should be recognized by the Society in some suitable manner. President Allred appointed a committee made up of L. A. Stoddart-Chairman, A. P. Atkins, E. J. Dyksterhuis and Vernon A. Young, to report at the January meeting as to how this should be done.

Pertaining to the Journal, letters from Editor Pechanec and Secretary White were read. These outlined part of the problem in changing the format of the Journal from its present size to 8½ by 11-inch trim size with a 3-column format. The Board felt that they had inadequate information at hand to evaluate the cost and merit of such a change. Further consideration is planned for the next meeting of the Board.

Two candidates were selected by the Board to fill positions on the Editorial Board for the 1954–1956 period. These men, Warren Whitman and John Cassady, will assist the newly selected Editor, Robert Darrow, in reviewing manuscripts for the March 1954 issue of the Journal.

The Civil Service Committee report by Chairman Don Hervey was read, and the Board passed a motion to establish a new Civil Service Committee to be charged with the specific objective of getting the Civil Service Commission to give an assembled technical range examiner or range conservationist examination, and that a list of candidates be established on a national or regional basis from which all agencies could recruit fully qualified range specialists without undue delays. The committee established for this purpose will be announced at a later date.

Vice-President Larson, chairman of the Program Committee, reported on the tentative program for the Seventh Annual Meeting of the Society to be held in Omaha, January 26 to 29, 1954, inclusive. Three full days of technical program are planned. In addition it is planned on January 26 to have the Board of Directors meet from 8:00 a.m. until noon, the section chairmen to meet from 1:30 to 5:00 p.m., and the business meeting for the Society to be held that evening. The

Nebraska Section will be the host and supply the chairman for the section chairmen's meeting.

Dr. Marvel Baker, chairman of the Local Arrangements Committee, reported good progress in making arrangements for the meeting.

The Board is asking their Program of the Future Committee to consider how the Society could best function in taking leadership in national affairs, particularly with reference to setting forth facts and data that would help in clarifying issues on important range problems. Several members of the Board expressed a need for the establishment of a group or committee to serve in the capacity of supplying accurate information and advice on range matters to the public.

A letter from former Editor R. S. (Bob) Campbell was read, expressing his appreciation for the life membership tendered him for his outstanding services as Editor of the Journal from 1950 to 1952, inclusive. In his letter Campbell proposed that the Society establish a fund to help pay for the additional cost of monographs and longer articles. Articles printed in the Journal without cost to the author are now limited to 8 pages. Contributions from members would be the source of such funds.

A proposal was made that the Society consider membership in the Agricultural Research Institute. The Board instructed Secretary White to write the Institute and apply for Class B membership.

The Board suggested that foreign and institutional addresses be omitted from the address list in future ballot distributions, and that institutions be not eligible for section membership.

The Board of Directors' meeting was adjourned at 6:10 p.m. to meet upon call of the President or at the stated business meeting in Omaha on January 26, 1954.—*W. T. White*, Executive Secretary.

Program—Seventh Annual Meeting

The Seventh Annual Meeting of the Range Society is being held in Omaha, Nebraska on January 26, 27, 28 and 29, 1954 with headquarters at the Hotel Fontenelle. The program for this meeting is shaping up rapidly and the following will give some of the highlights.

Tuesday, January 26:

Forenoon—Board of Directors' meeting
Afternoon—Section Chairmen's meeting with the Nebraska Section as host
Evening—General Business Meeting for the Society

Wednesday, January 27:

Forenoon—*Range Management in Central Plains*
- President's Address
- Talk by Guest Speaker
- Toward a Better Understanding of Vegetation
- Changes in Vegetation in the Central Plains Area in Relation to Drought and Intensity of Grazing

Afternoon—*Range Management in Foreign Lands*
- Grassland Management in New Zealand
- Range Management in Mexico
- Range Management in Turkey
- Problems in Range and Pasture Management in Eastern Australia
- Panel discussion period and questions concerning talks given during the day, using the day's speakers as panel members

Evening—Smoker for men
- Colored slide series entitled "Rangeland Flowers"

Thursday, January 28:

Forenoon—*Supplemental Feeding on Ranges and Pastures*
- Marketing Grass
- Utilization of Pastures in the Production of Finished Yearling Cattle
- Creep Feeding Calves
- Panel discussion and questions on the topics given in the morning program, with speakers as members of the panel

Afternoon—Visit to the Omaha Stockyards and Ladies Cooking School

Evening—Banquet and entertainment

Friday, January 29:

Forenoon—*Financing Range Developments*
- The Stockman's Case for Range Restoration
- Economics of Rangeland Development
- How Financial Institutions Can Help to Foster Range Developments
- General Range Clinic. Open discussion period on questions on any phase of range management. Questions to be directed to a panel of experts

Afternoon—*Current Events in Range and Pasture Management.*
- Entire afternoon devoted to short volunteer papers on current studies, investigations and findings

The detailed program for the meeting with the names of speakers and exact titles of papers will be presented in the January 1954 issue of the Journal.

PACIFIC NORTHWEST SECTION ANNUAL MEETING

The September News Letter of the Pacific Northwest Section announces that the annual meeting of this Section will be held at Penticton, British Columbia on November 16 and 17. An interesting program has been prepared, and the hospitality of our Canadian members is unexcelled. Members of other sections who are able to attend the meeting of this Section will certainly find it worthwhile.

ABSTRACTS OF THESES

AN ECOLOGICAL STUDY OF THE POCKET GOPHER (*THOMOMYS TALPOIDES TENELLUS* GOLDMAN) IN THE JACKSON HOLE REGION OF WYOMING

(*Abstract of thesis submitted in partial fulfillment for an M.S. degree, University of Wyoming, Range Management, Laramie, 1953.*)

The pocket gopher (*Thomomys talpoides tenellus*) was studied in Jackson Hole and in the mountains surrounding Jackson Hole in Teton county of Wyoming during a three month period in the summer of 1952. The base of operations for the study was the Research Station of the Jackson Hole Wildlife Park. The purpose of the study was to determine the inter-relationship between the pocket gopher and the condition of soil and vegetation on high mountain range lands, and to find out the truth of some of the conflicting viewpoints that exist concerning the pocket gopher.

The activities of the pocket gopher were observed in as many localities and situations in the area as possible. The summer and winter ranges of the Jackson Hole elk herd were examined and exclosures were studied to determine abundance of gopher activity inside and out. Other studies designed to learn as much as possible about the activity of the gopher included (1) occurrence of activity in different vegetational types, (2) quadrats for mound count designed to estimate the amount of soil brought to the surface by gophers in a given area, (3) slope measurements to determine maximum slope where activity occurs, and (4) mound revegetation studies.

The pocket gopher occurs in varying abundance in most of the plant communities in the Wildlife Park. The highest populations were found in open portions of aspen communities due to favorable moisture, soil, and food conditions.

There is one late summer period of apparent gopher inactivity in all areas studied and in the higher elevations there is another period in late spring when no new mounds are formed. The gophers are not dormant during these periods but carry on activity deeper and fill the upper tunnels with the soil excavated instead of bringing it to the surface. The maximum slope where activity was found was a 75 percent or 37° slope.

The size of mounds formed in the summer is directly correlated with edaphic conditions. Gophers make larger mounds in areas of deeper, more moist, and less rocky soil. The mound formation and digging activities of the gopher are not the primary or starting causes of erosion in this area but contribute to erosion once it has been started by other causes.

The activity of other wildlife have definite influences on the pocket gophers' population and activities. The winter feeding of hay and the maintaining of an overpopulation of elk leads to a very high winter concentration of elk on the winter range. The trampling due to this overconcentration of elk results in a different pattern of mound formation on the winter range than is found anywhere else in the area. While there are numerous summer mounds very few winter cores can be found. The maintenance of this overpopulation of elk has resulted in the overgrazing of portions of the elk summer

range. These overgrazed portions have a higher gopher population than areas not yet overgrazed. The increase of plants preferred by gophers as food due to the overgrazing is the probable reason for this increase in gopher population.

There was little or no difference in the gopher populations inside the exclosures studied as compared to areas outside these exclosures.

Revegetation starts on only a small percentage of gopher mounds the season they are made. There are two types of plants in this revegetation, those surviving covering by dirt and growing through the mound and those which start from seed in the mound. Both types of plants are important in the start of revegetation and eventual plant coverage of the mound.

Any details concerning this study may be found in the original copy of the thesis which is deposited in the University of Wyoming library and can be obtained on inter-library loan.

WILLIAM A. LAYCOCK

SEASONAL CHANGES IN VOLUME OF FORAGE IN THE RED DESERT

(Abstract of thesis submitted in partial fulfillment for an M.S. degree, Range Management, University of Wyoming, Laramie, 1953.)

For many years the primary use of the Red Desert of Wyoming has been winter grazing of sheep. Vegetation of the area particularly lends itself to this season of grazing. However, the main reason for strict adherence to winter grazing in the region has been lack of water for the sheep at other seasons. The animals could not be brought onto the area until there was sufficient snow to be used in place of stock water.

It has long been known that much of the forage produced during the summer months is lost when leaves and fruits of the shrubs and semi-shrubs fall to the ground and are lost under snow or are blown under shrubby vegetation out of reach of the sheep. It is felt that if it were feasible to develop stock water over a sufficient area so that seasonal use could be shifted to take advantage of forage earlier in the season, much valuable forage could be saved.

In 1940 a survey of vegetation in Sweetwater County was begun. Permanent quadrats were set up on each of ten vegetative types which had been surveyed and described in 1936. The square foot method of sampling described by Stewart and Hutchings, was used. Upon completing density estimates, measurements of grass leaf height and current growth of shrubs and semi-shrubs were taken. Density estimates and measurements were taken for each species within the quadrat. Sampling was done during the months of June, July, August, and September. For the years 1940–1944 inclusive, a single October sample was taken on each quadrat in 1941.

During the fall and winter of 1952–1953 this data was analyzed and computed to vegetative volume in cubic feet per acre. October results were computed on the basis of the single sampling. On the basis of precipitation alone, these October volume figures are probably higher than they would be normally since precipitation during the 1941 sampling period was 150 percent above normal for the region.

Charts and graphs prepared to illustrate this data show clearly that, when taken as a whole, per acre volume for all classes of vegetation, whether shrub,

semi-shrub or grass, increases to a peak in early August then drops steadily throughout the remainder of August and through September.

The greatest percentage of loss is by the semi-shrubs, and is followed closely by the shrubs. These two classes produce by far the greatest volume of forage within the region.

Where June volume is taken as 100 percent, indices show that total shrub volume in the region rises to a peak of 151.09 percent in August and falls to 97.34 percent in early October. Semi-shrub volume rises to a peak of 151.04 percent in August and drops to 67.57 percent in early October. Grasses and sedges as a group show less seasonal fluctuation in volume. On the basis of volume in June as 100 percent, the grass group rose to a peak of 193.92 in August and dropped to 150.88 percent in early October.

Average monthly per acre volume for each of the ten vegetative types studied showed little variation from the seasonal trend indicated by indices for the vegetative groups.

All data of the study indicates that earlier use of the area is contingent only upon development of water throughout the region. Considerable water development in the form of reservoirs and wells has taken place in the last few years. Both government agencies and private individuals have been active in the development.

At the present date, the Bureau of Land Management has constructed earthen fill dams in Sweetwater County capable of storing a total of 434 acre feet of stock water. Construction cost averaged $57.58 per acre feet of storage capacity. In addition, the same agency has completed five wells in the same county at an average cost of $1034.46 per well.

Further study is necessary before definite recommendations can be made but results of the present study warrant the following conclusions.

1. Volume of forage in the Red Desert of Wyoming drops rapidly following a seasonal high in early August.

2. Much of this forage decrease is due to the loss of leaves and fruits at maturity of the principal non-grass forage plants.

3. An unknown percentage of this leaf and fruit fall becomes buried under snow or is blown under shrubby vegetation and is unavailable to grazing sheep.

4. It is probable that little damage would be done to forage if the already mature vegetation was grazed earlier in the season.

5. Several agencies are active in water development in the region. If water development, on a scale wide enough to provide stock water for the entire region proves feasible, it may become possible to use the area earlier in the season, thus saving much valuable forage and relieving pressure on already overtaxed spring-fall ranges.

HAROLD F. HUNT

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JOURNAL OF RANGE MANAGEMENT

OFFICIAL

PUBLICATION OF

THE AMERICAN SOCIETY

OF

RANGE MANAGEMENT

VOLUME 6, 1953

Published Bimonthly by

THE AMERICAN SOCIETY OF RANGE MANAGEMENT

THE AMERICAN SOCIETY OF RANGE MANAGEMENT

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

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A BIMONTHLY JOURNAL TO FOSTER ADVANCEMENT IN THE SCIENCE AND ART OF GRAZING LAND MANAGEMENT

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