In This Issue

American Society of Range Management

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

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

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LETTERS TO THE EDITOR

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

SHOULD THE A.S.R.M. REMAIN SILENT?

It is gratifying to see your announcement that the Journal of Range Management is to be opened to letters to the Editor. Hereby I raise some questions of interest to members of the Society.

Mismanaged range lands are one basic reason for some maladjustments that afflict American agriculture today. The dust bowl winds of the "dirty 30's" helped to dramatize that fact. This spring brings a repeat performance. Our surplus wheat, so troublesome in recent years, is another result of unwise use policies on range lands. As an operator I well know that many progressive range operators now do a very good job of range management and ask for more research guidance, but too many still do not.

Range management, like some other aspects of resource conservation, is now in a disturbing state of confusion. Secretary Benson has made a generalized statement favoring accelerated research. He also advocates greater local and state participation in better management of our natural resources but just how this is to be financed and accomplished is not yet entirely clear. The Secretary has made far-reaching organization changes in the Soil Conservation Service and elsewhere in the Department. Four long-established Forest and Range Experiment Stations have been combined into two super-stations and further consolidations across regional limits are feared. Certain range research functions have been transferred to another centralized agency with less field experience and organization to handle them with top effectiveness.

A columnist recently reported that 9 out of 12 men from the top command in the Department of Agriculture have quit after policy rows or for other reasons not always fully understood. Do these rows and important but sudden reorganization moves made without full public airing indicate that the USDA is now coming under autocratic rule? Has Departmental approval of pending legislation of questionable effects on good conservation been a factor in the existing confusion? Do these changes and uncertainties ahead explain why the morale of lesser departmental workers is now at a new low ebb?

A few years ago when the U. S. Department of Agriculture and several Western states started a good though belated effort to give range research and management the recognition and support that they deserved, the American Society of Range Management was organized to foster and promote that program. This Society can hardly remain unconcerned with the developing changes just mentioned briefly that so directly affect the field in which its operating and professional members are involved.

It would seem that the responsible voice of our Society should command some consideration when important range policy matters are being decided. Just what and how we should do it is a big question now. It deserves careful thought.—*Leon C. Hurtt*, Range and Ranch Consultant, 541 Evans Ave., Missoula, Montana. (*Received March 20, 1954*)

CHANGING YOUR ADDRESS?

If your plans for the next few months include a change of address, please give us advance notice for our circulation records. We need your old address, your new address and your roster number. Please allow thirty days for the change to be effected on our mailing list. Notice of change should also be sent to your Section Secretary.—W. T. White, Executive Secretary.

Journal of RANGE MANAGEMENT

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Editorial

A Continuing Appraisal of Range Management

PREVIOUS editorials in the Journal have assessed the progress made by the Society in its short span of years. These have been appraisals of past accomplishments and suggestions for future progress. The Journal, being the medium for expression from those who have a primary interest in range management, is also the proper place for an evaluation from time to time of progress in the composite discipline we call range management.

No complete appraisal can be made at any one period of time. Range management is dynamic and is becoming increasingly larger in scope. The writer in the pages of the Journal once attempted to define range management and was challenged by many readers, all of whom had varying definitions. This is just an indication that range management is a broad body of knowledge bound together by a common goal—management of wild lands for profit or greater use by society whatever that use may be. When knowledge assembled from studies of soils, plants, animals and climate is correlated with the economic and physical environment superimposed by man's activities we arrive at range management. We are, however, prone to forget that man's activities are becoming increasingly important in their effect on the management aspect of range management.

The body of knowledge which we call range management was set upon its course about 50 years ago. Certainly there must have been a need for specific study and application of these studies to management of range or wild lands. A look at the record will disclose many important research findings which have resulted in improvement of soil and forage conditions by management. Of equal importance, perhaps, has been the development of understanding between the land user, the rancher, the Federal and state governments, the wildlife enthusiast, and the public generally. These relationships do not exist in perfect harmony but the foundation has been laid. For this the American Society of Range Management can assume some degree of responsibility.

Management of the range is the end product of research and rule of thumb techniques. To coordinate effort leading to "management", we must know, at least approximately so, what the management goal should be. Additionally, the conclusion may be reached that any management goal presently envisaged is but an intermediate step to a changing use or demand for the land.

Of recent years the range manager has given increased attention to the attitude of society regarding the use and management of uncultivated lands. In the last analysis the objectives of our society will dictate the goal for the management of range lands. The manager who analyzes the operation of economic processes has taken the initial step toward the establishment of a management goal. For private lands the immediate goal will be an economic return. For public lands the return may be a measurable economic return or a return of tangible benefit to the public. These are primary goals which must be preceded by prior goals. Good range management must precede the goal of greatest use or return from the land.

We can look back a few years when domestic stock used at will most of the western lands. There seemed no need for a consideration of any other use—the Nation demanded meat, hides, and wool. Production of livestock was the goal of range management at that time. Since then range management has become of age and does not consist solely of managing lands for domestic livestock production. Producing livestock from native forage certainly is a most important aspect but it has been supplanted in many areas by other demands made on the lands.

It would appear that on much of the western lands the primary goal will be to produce plant cover and

H. R. HOCHMUTH

forage for livestock production. This will be so regardless of whether the land is in public or private ownership. Nevertheless some range lands will be managed for other than livestock production. In this instance these lands will probably be in some form of public ownership. This is not so because public ownership is the only desirable type of ownership but because the multiple use demanded of the land is best served by a combined holding.

Examples can be cited where state agencies are purchasing privately owned lands to provide more range for big game herds. This is not just a whim of responsible public officials. They are acting in response to an economic demand of the people for greater access to hunting and recreation, and for which the return may be greater than for other uses. This is a problem of the management aspect of range management. Or is it range management?

This writer is not attempting to make a case for any particular type of land ownership. The point to be made is that we have approached the time when applied effort in the field of range management can logically be separated into two or more distinct activities. The alliance will be close but the intermediate goals may vary. Initially we might separate range management into range science and land management. Range science would include and provide the basic physical information necessary to adequate management of wild lands. This field is too comprehensive to detail at this time. Land management should be the activity that correlates the basic information and adapts it to management goals. Land management should also set the management goals from studies of the economic and social requirements of society for the land. It matters little whether the manager supervises lands in public or in private ownership. The primary economic use of the land will dictate the management goal. In addition, the physical aspects of the land will affect the economic use to a large extent although not wholly so.

The gap between basic research and practical application to achieve a management goal for land is much narrower today than a decade ago. Nevertheless management techniques and management planning have not progressed at the pace set by basic research. Now more than ever before there exists a need for individuals trained to manage wild lands using the available scientific and economic facts.

Range management, as taught in the colleges and universities, places emphasis on the biological and associated animal sciences. This training is basic, but for those individuals interested in management in the sense used here, further training in the social sciences is necessary. Management of land to produce an economic return or to serve a specific goal of society is the final result of the applied management technique. Formal training in this aspect of range management has been neglected.

The Journal of Range Management should reflect the interests of the members individually and collectively. A study of past issues of the Journal indicates a dearth of articles on the "management" aspects of range management. Perhaps the land administrators and managers have not had the incentive to formal presentation of their knowledge. Must we lose a large body of knowledge which if disseminated would be indicative of the practical application made of basic research?

This short appraisal of range management is not presented as a critique of past progress or accomplishments. The many contributions made by research and the outstanding articles published in the Journal are proof of progress made in accumulating basic information. However, there appears to be a neglected area of activity in range management. This area of activity can be termed management science as contrasted to range science.

I believe the Society and the colleges and universities should give greater thought to development of the management aspect of range management. It is a field of activity that is not as precise as basic biological research. But it is in this activity that the fruits of range science can be realized and the best use of land can be planned and reached—*H. R. Hochmuth*, Bureau of Land Management, U. S. Department of the Interior, Washington, D. C.

Call for Papers for 1955 Annual Meeting

Members who wish to present papers at the annual meeting in San Jose, California, January 25–28, 1955, are invited to offer them now.

Titles and approximately 200-word abstracts should reach the Program Chairman by August 1st to permit consideration by the Program Committee.—*Kenneth W. Parker*, Chairman, Program Committee, U. S. Forest Service, Agricultural Building, Washington 25, D. C.

Improved Pasture for Spring and Summer, Range for Fall and Winter

ARTHUR D. MILES
Rancher, Livingston, Montana

INCREASED forage production on the range, and improved pasture have enabled us to wean heavier calves and lambs, run more head of livestock and reduce the costs of operation. Improved pasture has increased carrying capacity and weight gains; winter ranging has reduced the cost of wintering.

Our steep and broken range lies above 5000 feet in South Central Montana. Much of the twenty to thirty inches of precipitation falls as snow. During storm periods, snow will accumulate to a depth of two or three feet on the level, but the strong winds and warm chinooks provide open grazing during most of the winter. The grass association resembles the Pacific bunch grass type of bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*).

Most of the increase in livestock production has resulted either directly or indirectly from improved pasture. The carrying capacity of improved pasture is twice as great as good native range. Better August gains are made on improved pasture. The elimination of spring use and the deferred summer use afforded by improved pasture, have increased range forage production.

Crested wheatgrass pastures, sown on the lower south slope benches after two crops of barley, were the first to be established. The original purpose of the crested wheatgrass pastures was to reduce the losses from tall larkspur (*Delphinium* spp.). During the first three years of running cattle, 15 head out of a herd of 50 died of larkspur. Since crested wheatgrass has kept the cattle off the range during the larkspur season (May and June), we have had no larkspur losses the past seven years, even though we've increased the herd to 200 head.

Calving is started in February, instead of March in order to escape the difficulty of engorged teats that result when calving on crested wheatgrass. The calves born in February and March are able to take the full flow of milk when they are turned to crested wheatgrass the first of May.

New and practical management suggestions from a young Montana rancher based on experience. An article full of useful information and stimulating suggestions for the rancher and technician alike.

Nursing cows on improved pasture become fat. Because of their good condition, the calves are kept on them longer in the fall. Cows in good condition winter easily on the range and less supplement is required.

Not only does improved pasture increase carrying capacity, but greater gains are possible. Yearlings summered on improved pasture weigh 900 lb. compared to those summered on Idaho fescue grassland weighing 750 lb. Considering the investment in cattle, the cost of wintering and the ease of looking after cattle on pasture, it is a question if it pays to turn out on range in summer.

For summer grazing we are establishing orchard grass (*Dactylis glomerata*) and alfalfa (*Medicago sativa*) on favorable moisture sites of the range, and on crop land no longer needed for hay production. The deep-rooted alfalfa and orchard grass furnish succulent pasturage during the dry August, drawing on winter-accumulated moisture. Orchard grass-alfalfa pastures produce 5 animal unit months per acre, of grazing a year, and crested wheatgrass 3 animal months.

Winter Ranging

The range no longer needed for summer grazing is used to carry the cattle and sheep through the dormant season of production, fall and winter. The sheep used to go on full hay ration the middle of December. We now keep them on the range until the first of April. The cattle range out through February. Supplements are fed after the first of January, and the cattle and sheep winter well on the range.

We ran out of grass the first few years of winter grazing. We had grass left, but it was scattered throughout the inaccessible parts of the range. Since a grazing plan has been adopted to reserve the closer, snow-free sites for winter use, we have had an abundance of winter grass.

Cattle winter better on areas with little brush. They tend to congregate in the brush and consume little feed during stormy weather. On brush-free areas, they find protection in the swales and are always on good feed.

Relatively little difference has been found between north and south slopes in maintaining the stock. The amount of area the snow will blow off determines the amount of grass available.

The animals are fed supplements on areas of the range that have an abundance of grass as a means of obtaining distribution (Fig. 1, *l.*). Four-wheel-drive trucks with winches have made all areas of the range accessible. Afternoon feeding of the supplements seems to en-


FIGURE 1. *Left.* Cows are supplemented on south-facing slopes in February. *Right.* Cattle use this electric-fence lane to water grazing the 500-acre north-facing slope in winter. Because of the limited area around water, cattle return to grass areas to manure.

courage the animals to consume more grass.

The cattle range out farther from water in winter than they do in summer. Our water is spring fed and stays open during the day. (Fig. 1, *rt.*) The sheep do well without water when there is snow, even when supplemented with hay.

Good quality alfalfa hay is used as a supplement, supplying digestible protein for one-third less cost than pelleted concentrates. Much less range grass is consumed when alfalfa is fed as a supplement. Sheep do well in the early winter (January) with ⅓ pound of oats or barley. The ability of sheep to select the portions of forage plants with higher protein and their appetite for the high-protein browse plants allow them to balance their diet better than cattle. The cattle satisfactorily utilize coarse grass that sheep leave, when fed a protein supplement.

Sheep are considered better rustlers than cattle because they paw away the snow and their wool affords them protection from the icy winds. Cattle will rustle if turned into areas of tall grass after heavy snows. It is necessary to accustom the animals to the method of handling desired. Animals that are used to being fed all winter need to be trained to rustle.

Wintering on the range is less expensive than feeding straight hay, even though some additional expense is incurred hauling the hay to the range. We feed one half as much hay by wintering on the range.

In severe winters such as 1948–1949 we stretch our hay supply by feeding our reserve of oats and barley. Oats and barley will replace 2 pounds of hay per pound fed, and make a better reserve than large amounts of hay carried from one year to the next.

Range Type Cow

Better distribution over the range can be obtained with cows that have the ability and desire to range out. Heavy cows with large feet find it difficult to move over our steep and rocky range. Cows that range out utilize distant areas. Greater forage production with increased carrying capacity results from the even grazing of range type cows.

Cows are judged for ease of wintering and size of calf they produce. Cows that cannot maintain their condition in winter are culled. We are breeding toward a cow that has a capacity and appetite to consume large amounts of coarse grass in summer and bulky matured grass, coarse hays and straw in winter, and has a long lactation period that corresponds to our season of green grass.

Wild and nervous cows, although they range out, generally stay thin and produce light weight calves. We prefer cows that take their calves with them to graze, as opposed to those that hide their calves and run back to them frequently during the day.

We select bulls from cows that produce growthy calves under our conditions. Replacement heifers are selected after they have raised two or three calves. Poor milkers and poor keepers are culled.

Sagebrush

Sagebrush (*Artemisia tridentata*) and other noxious plants are increasing on the range (Fig. 2, *l.*). The sagebrush grows in areas of snow accumulation that are heavily grazed. The grass in the snow areas

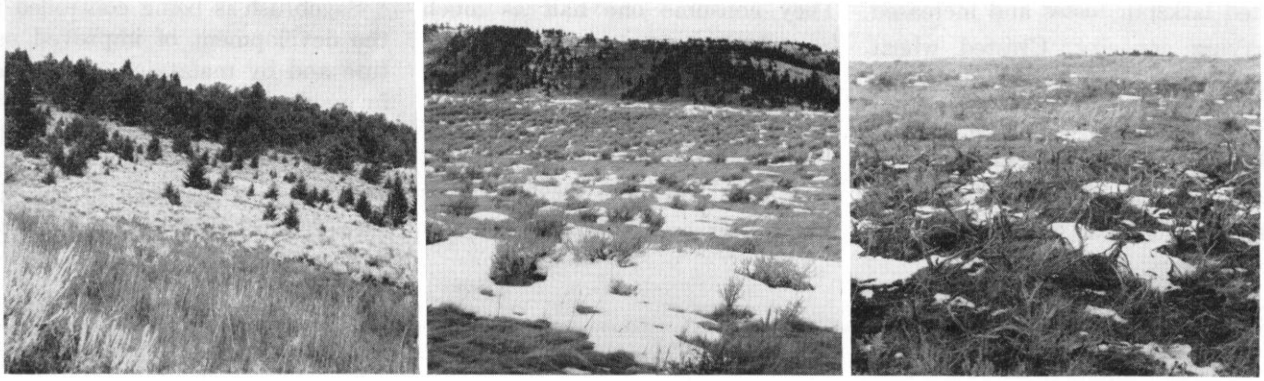

FIGURE 2. *Left.* Grazing results in a change of cover from grass to sagebrush and then to forest. *Center.* Sagebrush holds snow and delays spring melt. Palatable feed is available on snow-drift areas while snow-free areas have mature coarse grass. *Right.* Cattle tend to tramp out sagebrush. Hay was fed on sagebrush plants in this area during the previous winter.

is six weeks later than on the adjacent snow-free areas (Fig. 2 *cen.*). The stock will not touch the unpalatable mature grasses until the snow-accumulation areas are grazed bare.

Our method of dealing with sagebrush is twofold: (1) the level sites of snow accumulation are plowed and sown to summer grass, and (2) the season of grazing is changed on other areas from spring and summer to fall and winter (Fig. 2, *rt.*). In the fall, the grasses are all at the same stage of maturity. In the winter, the heavy snow cover prohibits the grazing of the snow-accumulation areas.

We believe the cheapest method of controlling sagebrush is to maintain forage competition. Improved pasture or properly grazed range maintains a competitive cover that sagebrush and other weeds are not able to invade. Since the natural mortality of sagebrush is high, and, since it is easily killed by burning or spraying, the problem is one of establishing and maintaining adequate competitive cover.

Range Fertility

Nitrate fertilization, as supplied by manures and legume residues, has shown marked response on our range. It appears that nitrates alone could double forage production. Fertility may be as important as intensity of grazing in maintaining a good grass cover. We look to better utilization of animal manures and more legumes as low cost methods of supplying nitrates and phosphates.

Much of the cow manure is wasted in areas of deciduous brush. As a solution to the problem, we have: (1) fenced the cattle out of the brush in some areas, and (2) removed considerable brush along with the development of improved pastures.

Cattle do as well in brushless pastures, seek the high ground when the flies are bad and do not form the habit of camping in the brush. Fall and winter grazing affords better manure distribution since the cows camp on snow-free flats.

We have introduced sweet clover (*Melilotus officianalus*) into many of the range areas. Sweet clover has perpetuated itself on some parts of the range for over 20 years. Allowing for production of seed and managing for seedling establishment are factors in maintaining sweet clover. Sweet clover maintains itself best under light spring and heavy winter use.

Considerable possibilities are seen in other legumes. Montana common alfalfa (*Medicago sativa*) has been established in heavily-disked sagebrush. Alfalfa reseeds itself under spring and winter grazing on the range. Alsike clover (*Trifolium hybridum*) maintains a fair stand on once-cultivated north slopes that have been under sheep grazing for 25 years. Some of the native legumes, such as lupines (*Lupinus* spp.), grow in dense stands, but their ability to fix nitrates is not known.

At the present time little response has been obtained from applications of phosphate to range areas that have partial stands of legumes. It is thought that phosphates may help to maintain the balance of legumes and grasses.

As the fertility elements of the original organic matter are utilized in plant growth, just as happens under cultivation, the supply of accumulated phosphates and nitrates is depleted. In order to increase organic matter, it seems that a supply of phosphates as well as nitrates would be necessary.

Deep rooted plants may supply phosphate with less cost than purchased fertilizer. Sweet clover has been shown to be valuable in this respect. Its roots penetrate deeply (ten feet) into the soil and absorb potash and phosphate that is unavailable to the roots of other plants.

Summary

On a high foothills Montana ranch, improved pasture has elimi-

nated larkspur losses and increased carrying capacity. Crested wheat grass is utilized for spring pasture, the deep-rooted orchard grass and alfalfa for summer forage. The cattle and sheep winter on the range no longer needed for summer grazing. They consume one half as much hay wintered on the range as when wintered on hay alone.

A cow that will range out is recognized as desirable. Cows are being bred that will raise sizable calves and winter on available feeds.

Sagebrush is being controlled by the development of improved pasture and by maintaining the range in good condition. Phosphates and nitrates are recognized as constituents of organic matter, and it is believed that they can be supplied cheaply by deep-rooted legumes.

A Variation of Deferred Rotation Grazing for Use under Southwest Range Conditions

LEO B. MERRILL

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During the past several years there has been considerable discussion regarding the relative merits of deferred rotation grazing. Much of the material presented is unfavorable to this system of use.

In any system of grazing, however, there are many factors to be taken into consideration. As was aptly stated, (Sampson 1951) "It becomes clear that regional and local conditions have much to do with the results achieved."

The majority of rotation grazing studies have been conducted on two or three-pasture systems and most of these systems concentrate livestock on one pasture while the remainder are resting. It would seem that as rainfall diminishes such a system becomes more and more hazardous since, during the period of concentrated grazing, a pasture might be damaged to the extent that it could not recover during the ensuing rest period.

The three-pasture rotation system, with grazing concentrated on one pasture, was used in the studies of Dickson, *et al.* (1948), Frandsen (1950), Rogler (1951) and McIlvain and Lagrone (1953). In all of these studies except that of Frandsen there appeared to be little advantage, if not a definite disadvantage, in deferred rotation grazing as far as livestock gains were concerned. However, most of these studies indicated that vegetation improved under rotation. The example of deferred rotation given by Frandsen has no period of time in which livestock were concentrated for more than 46 days on a pasture producing green vegetation. This concentration was always followed by a period in which vegetation was allowed to make at least 92 days' growth. This system of grazing apparently gave favorable results.

Procedure

A deferred rotation system was established at the Ranch Experiment Station on the Edwards Plateau of Texas in a comparison with continuous grazing at three rates of stocking. This study has been carried on for a period of four years, from July 1, 1949 to June 30, 1953, using a combination of three classes of livestock—cattle, sheep and goats. Under the yearlong grazing system, three rates of stocking were employed, namely, heavy at 48 animal units per section, moderate at 32 animal units per section and light at 16 animal units per section. Under the deferred rotation system, four 60-acre pastures were set up as a rotation unit in which a combination of cattle, sheep and goats was used at a moderate rate of stocking, or 32 animal units per section.

In the rotation system (Fig. 1) each pasture is grazed 12 months, then rested 4 months. In Figure 1 the pasture which is rested during any period is enclosed by heavy black lines. The rest period comes at a different season in each succeeding 16-months grazing cycle. Thus, during any given four years'

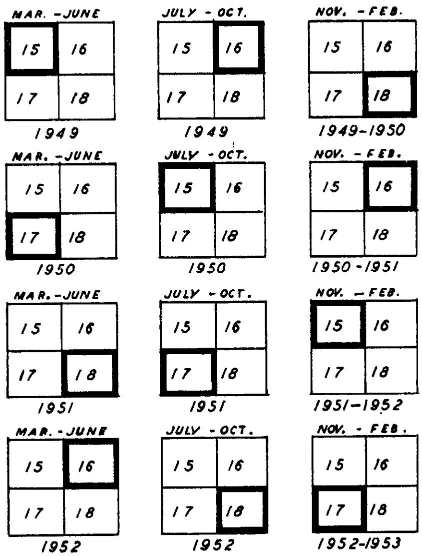

Figure 1. Grazing system on rotation pastures showing deferment sequence.

grazing, each pasture is deferred once during each of the 4-month seasonal periods. This allows some plants to set seed and gain vigor. Under this system only one group of livestock is moved every four months. The stocking rate on each of the three stocked pastures during any given 4-month period is 43 animal units per section. When the acreage of the deferred pasture is included for computing stocking rates in the four pasture rotations, the rate is 32 animal units per section overall.

Rainfall

During the first year of the study, 1949–50, the rainfall was 26.97 inches, which was above the average of 24 inches for the station. The three years following were characterized by a severe drought. The yearly rainfall for the three years, 1950–53, was 14.61 inches, 6.96 inches and 4.91 inches respectively.

Results

Reaction of Livestock to Deferred Rotation as Compared to Yearlong Grazing

In the first year of this study, 1949–1950, rotation grazing showed little evidence of being superior to yearlong grazing. At a stocking rate of 32 animal units per section for both systems, steers made a gain of 285 pounds per head under rotation grazing and 283 pounds per head under the yearlong system. On the other hand, sheep made slightly less gain under rotation than under yearlong grazing, or 35.0 and 37.2 pounds per head, respectively.

In the three years following 1949–1950, the trend has been for livestock weights to increase in the rotation pastures above those under yearlong stocking, except for 1952–1953 in which steers in the rotation pastures gained only 143 pounds per head while those in the yearlong-grazed pastures gained 175 pounds per head. The weight gains

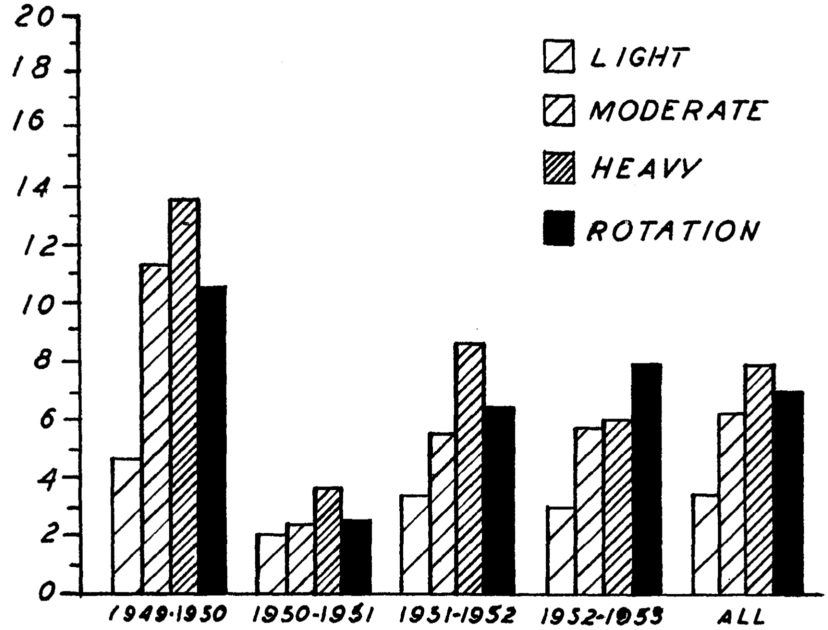

FIGURE 2. Per-acre gains for sheep under continuous and deferred rotation grazing.

of sheep in the rotation system have steadily increased as compared with those under yearlong grazing.

Per-acre gains of sheep under yearlong and rotation grazing are shown in Figure 2. During the first year of the study, 1949–50, the highest gains of 13.5 pounds per acre were obtained from pastures grazed yearlong with 48 animal units per section, followed in order by gains of 11.2 pounds per acre from yearlong stocking at 32 animal units per section, 10.2 pounds from rotation grazing at 32 animal units per section and 4.3 pounds from yearlong stocking at 16 animal units per section.

In 1952–53, sheep on the moderately stocked rotation pastures made the highest gains of 7.9 pounds per acre, followed by the heavily stocked, yearlong-grazed pastures with a gain of 5.8 pounds per acre, and the moderately stocked yearlong-grazed pastures with 5.6 pounds per acre. During the entire four-year period, the highest annual gain of 7.8 pounds per acre was made on the heavily stocked pastures grazed yearlong. The second highest weight gain of 6.8 pounds per acre was made on the moderately stocked rotation pastures, followed in order by the moderately and lightly stocked yearlong-grazed areas with gains of 6.1 and 3.1 pounds per acre, respectively. In succeeding years, however, the advantage in gain per acre held by the pastures heavily grazed yearlong steadily diminished, while the deferred rotation pastures made consistent gains.

Figure 3 shows the per-acre gains obtained from steers under the various systems of grazing. The results are similar to those obtained from sheep, except that the steer gains of 7.7 pounds per acre under rotation grazing exceeded those from all other systems of use during the second year. Yearlong grazing at the moderate stocking rate showed the second highest gains of 5.7 pounds per acre, followed by heavy grazing with 4.9 pounds and light grazing with 3.8 pounds per acre. During the year 1952–53, the per-acre as well as the per-head gains of steers declined in the rotation as compared with moderately stocked, yearlong-grazed pastures. During the four-year period of 1949–53, nearly identical gains of 9.7, 9.8 and 9.9 pounds per acre

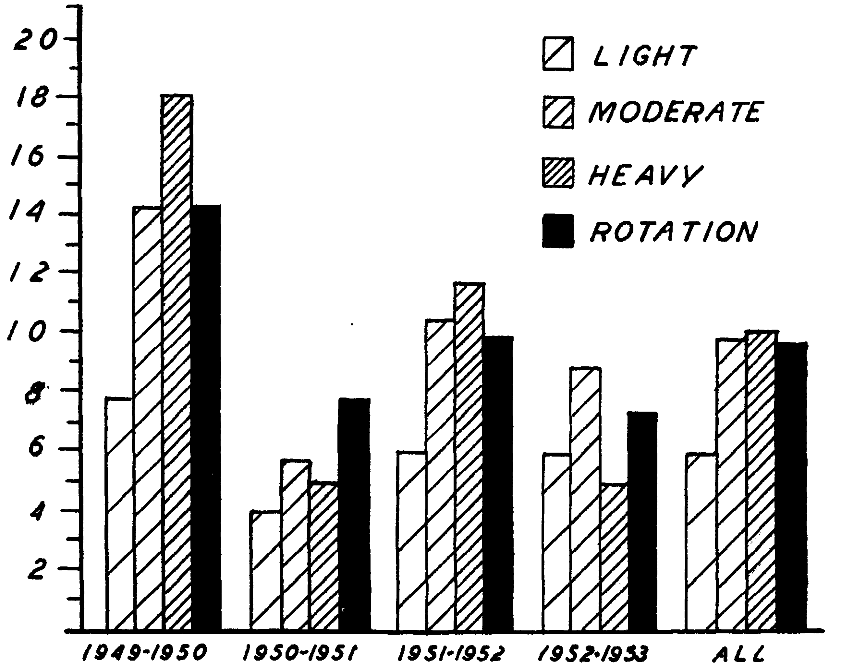

FIGURE 3. Per-acre gains for steers under continuous and deferred rotation grazing.

were obtained from the moderately stocked rotation pastures and the yearlong moderately and heavily stocked pastures, respectively.

In May 1953 a severe tornado passed through the rotation pastures and destroyed practically all of the grass on approximately one-third of the area. Decline in steer weights on these pastures during 1952–53 is attributed to this cause. The storm did not strike the moderately stocked, yearlong-grazed pastures and thus the vegetation was not disturbed as on the rotation areas.

Vegetational Response

Plots were established on all pastures for determinations of vegetational trends under the various systems of grazing. The initial survey indicated that all pastures had a similar cover of grass. The composition of this cover during the first year of the study was as follows:

Curly mesquite grass	77 percent
Hairy triodia and red grama	13 percent
Needle grasses	6 percent
Desirable bunch grasses (side-oats grama, hairy grama, silver bluestem, little bluestem, fall witchgrass, Texas winter-grass and others)	4 percent

The vegetational composition had changed very little on most pastures by the fall of 1952. However, the greatest improvement was made on the moderately stocked rotation pastures and on the lightly stocked pastures grazed yearlong. The bunch grasses, lightly utilized, were seeding and the seedling grasses were establishing themselves in the areas. In the moderately stocked pastures grazed yearlong, the bunch grasses were grazed more closely, and, although the mature plants were seeding, few grass seedlings were becoming established. There was no evident reseeding on the pastures heavily grazed yearlong.

A survey of grass survival made recently following three years of severe drouth showed a marked difference in the amount of grass which survived under the several systems of grazing. Curly mesquite grass, which in normal years comprised 77 percent of all grass cover, suffered death losses under yearlong grazing of 91, 89 and 85 percent, respectively on heavily, moderately and lightly grazed pastures. The moderately grazed rotation pastures showed a 78% loss in grass cover. However, this was true only on the areas not damaged by the tornado.

Summary

The rotation system used is simple in application, since it is necessary to move only one group of livestock every four months. Under this system each pasture is grazed 12 months and rested 4 months. The rest period comes at a different time of the year in each rotation cycle.

No definite advantage in livestock gains has been found on deferred rotation pastures as compared with those grazed yearlong at the same stocking rate. However, the vegetation on the rotation pastures is obviously improving more than that on the yearlong grazed areas. There is, therefore, a steady trend toward improved range conditions as well as increased financial returns on these pastures.

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Grassland Management in New Zealand[1]

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GRASS production in New Zealand is basic, not only to agriculture but also to the entire national economy. On a land area (66 million acres) slightly smaller than that of Colorado, but with only a little more than 42 million acres occupied, New Zealand supports a sheep population (33 million head) greater than that of the United States plus about 5 million cattle and smaller numbers of hogs, horses and goats. This entire livestock population is a product of the pastures. Even the pigs are grazed and supplemented with skim milk and whey from the dairy industry.

Of the 2 million acres under cultivation, more than one-third is in "plantations" of introduced timber trees, chiefly Monterey pine (*Pinus radiata*), and nearly one-third is in temporary pasture crops, leaving only about one-half million acres for cash field crops.

In New Zealand, "grassland agriculture" is not simply a term designating some far-distant goal toward which to strive. Theirs is, in fact, a grassland agriculture in the highest sense, an agriculture in which the operation of all but a few specialized farms (fruit, truck, tobacco, etc.) is based on grass production and utilization. Grassland agriculture has in some cases been carried too far. The economy of the nation and the welfare of the farmers themselves would be benefited by wider use of cultivated food crops in rotation with the grasses. It is now necessary to import substantial quantities of such staples as wheat despite the fact that the average wheat yield is more than 40 bushels per acre and yields of twice that amount are not uncommon. New Zealand farmers exhibit a reluctance to plow up grass that is comparable to the resistance encountered in America to the seeding of cultivated lands to perennial pasture.

Situated almost exactly halfway around the globe from Great Britain, its principal market, New Zealand has had to stress low production costs to compete with much nearer sources of meat and dairy products. High pasture production and efficient utilization of the forage have made this possible. No grain is fed to livestock, but perennial pastures are supplemented with temporary grazing crops in addition to hay and silage made from the pastures themselves during the flush of spring and early summer growth.

> A perspective of the grazing problems and management practices in the hill country pastures of New Zealand—a country in which grass production is basic to the entire national economy. A view of grassland agriculture under intensive management.

Efficient utilization of pasture forage by stock is stressed. Nothing is gained by producing a big forage crop unless it is turned into animal products. The entire agriculture is geared to that idea. Pastures account directly for 95 percent of New Zealand's exports and for more than 60 percent of its total production.

The New Zealander's attitude toward pasture, which may at first be a little difficult for an outsider to understand, was summed up by Dr. E. Bruce Levy, former head, Grassland Divisions of the New Zealand Department of Scientific and Industrial Research, at a meeting of the New Zealand Grassland Association in November 1952, when he said, "I don't like to see any crop harvested if it can be grazed off by stock." That statement carries several important implications that show why New Zealand is a leader in grassland farming:

1. That sheep and cattle can make better and more efficient use of green, growing vegetation than of harvested crops.
2. That at least as much feed can be produced with pasture as with harvested crops.
3. That grazing is the basis for build-up and maintenance of soil fertility, while the removal of crops has the opposite effect.
4. That it is far less costly to let the stock harvest the crop than to cut and haul it, store it, and perhaps even process it before feeding it and hauling manure back to the land.

Total output of pasture products is high. In 1951 New Zealand's 1,880,000 dairy cows produced a little more than 1⅓ billion gallons of milk containing nearly 500 million pounds of butterfat (N. Z. Dairy Board, 1951). Total annual meat production is more than one-half million long tons, and wool production is about 400 million pounds a year (N. Z. Gov. Official Yearbook, 1950). For each acre occupied (including the 9 million acres of waste land on farms and the 14 million acres of montane tussock grassland) the output in 1951 was 9 pounds of wool, 12 pounds of butterfat and 30 pounds of meat,

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plus additional quantities of milk, hides, other animal products and cash crops.

The high producing capacity of New Zealand pastures is due largely to a climate favorable to both plants and animals. Lying far enough from the equator to escape the heat of the tropics, its climate is further tempered by the sea so that low temperatures, too, are avoided. Most of the country receives ample moisture, although the area lying east of the Southern Alps in South Island is relatively deficient in rainfall. Elsewhere the precipitation in the occupied portions is mostly between 30 and 80 inches annually and is rather well distributed over the year.

New Zealand perennial pastures may be grouped into two broad categories: (1) the improved pastures grown on flat to undulating "farm" land and (2) the hill country pastures. The former may, in turn, be divided into permanent and temporary improved pastures. The hill country pastures include the natural tussock grasslands and those sown on land formerly forested.

Improved Pastures

Perennial, improved pastures are made up of plantings of the "English grasses" and legumes, the cool season species, chief of which are perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). Other important ones are cocksfoot (*Dactylis glomerata*), short-rotation rye-grass (*Lolium perenne* x *L. multiflorum*), crested dogstail (*Cynosurus cristatus*), timothy (*Phleum pratense*), prairie grass (*Bromus catharticus*), and red clover (*Trifolium pratense*). These improved pastures are highly productive and are used chiefly for dairy and fat lamb production and to fatten beef animals. Their management is intensive and not a range enterprise. Therefore, it will not be considered in detail in this discussion.

Hill Country Pastures

The hill country pastures of New Zealand fall into two categories: (1) those sown on land originally in native cover and (2) native tussock grasslands. The sown pastures, according to Levy (1951), occupy some 18 million acres of which 12 million have replaced forest, 4 million have replaced tussock, and 2 million have replaced fern or scrub. These acreages include the intensively managed, improved pastures on the flat to gently-sloping land. There is no sharp distinction based on intensity of management, the improvement being carried as far up the slopes and into the "back country" as is economically feasible.

The Sown Pastures

Hill country pasture that has replaced forest or scrub and fern lies mostly in North Island where the native vegetation was predominantly rain forest except for a limited amount of tussock grassland occupying the elevated, central volcanic plateau. These sown grasslands have been developed largely over the past 80 years and there still remain some 3 million acres of standing forest and 2 million acres of scrub awaiting development. Also awaiting development are at least 2 million acres once sown to grass but since allowed to revert to secondary growth. Data are not available on the extent to which tussock grassland can be converted to sown pasture but the acreage is considerable.

Converting the forest to grassland was based on fire. Between the years 1880 and 1910 very large areas of hill country forest were cut and burned (Cameron, 1952). The forests were felled during the winter and burned in the spring when the entire mass was dry enough to give a hot fire, one which would make a "white burn." The grass seed was sown directly into the fresh ash as soon as possible, but if the burn was not made until early summer, a sowing of white turnips might first be made. The grass would then be sown among the turnips as they were being grazed off in the autumn.

Heavy seeding rates were (and still are) the rule, 30 to 40 or more pounds of seed being applied per acre. The major species have been perennial ryegrass and white clover, but many others also have been added to mixtures, including cocksfoot, crested dogstail, Kentucky bluegrass (*Poa pratensis*), browntop (*Agrostis tenuis*), danthonia (*Danthonia pilosa*), and, more recently, the newer short-rotation rye-grass. In the warmer northern parts paspalum (*Paspalum dilatatum*) is widely used, while white and red clover are used throughout. Lotus (*Lotus uliginosus*) frequently is added to mixtures in wet areas, and subterranean clover (*Trifolium subterraneum*) in drier ones.

Burned areas might not be sown to a uniform mixture. Often the relative amount of browntop was increased in the drier sites and perhaps some Chewing's fescue (*Festuca rubra* var. *commutata*) added, whereas these two and danthonia might be left out altogether on more favorable sites, with timothy and alsike clover (*Trifolium hybridum*) used in their place. The annual suckling clover (*Trifolium dubium*) and certain *Medicago* species are sometimes sown, but the burclovers are not favored as the burs tend to contaminate the wool.

The newly-sown "bush burn" pastures were fenced as soon as possible and grazing was started about two months after seeding because it was necessary to graze off and tread out the new fern and scrub growth that otherwise would overwhelm the grass. Where the fern and scrub were especially persistent, the ratio of cattle to sheep was one to five or one to seven, but "where the country was comparatively easy to hold, one cattle beast to 10–15 sheep was generally regarded as sufficient" (Levy, 1951).

The botanical composition of the pastures on these once forested areas varies according to the soil fertility and grazing use. Where it has been maintained by fertilization and proper livestock management, the sward is made up mostly of perennial ryegrass, cocksfoot, crested dogstail and white clover. From three to six ewes per acre can be carried throughout the year if some phosphate is applied as topdressing.

Less carefully maintained pastures and those on less fertile areas may contain small amounts of the above species, but they also will have much browntop, danthonia, Yorkshire fog (*Holcus lanatus*), sweet vernal (*Anthoxanthum odoratum*), lotus, suckling clover and weeds. They can carry only one to three ewes per acre plus perhaps one steer or cow for each eight to fifteen sheep. The poorer and drier sites are likely to be dominated by danthonia along with sweet vernal, hairgrass (*Vulpia* spp.), ratstail (*Sporobolus capensis*), New Zealand ricegrass (*Microlaena stipoides*) and annual clovers.

Levy and Suckling (1949) pointed out that the majority of the deforested hills in the North Island are potentially almost as highly productive as the lower, flat and undulating country, capable of grazing four to six ewes and fat lambs per acre. To achieve this productive state requires the fertilizer ingredients from the excreta of at least three to four sheep per acre. Such fertility must come originally from clovers and phosphates. Under proper grazing management it is made available to the grasses throughout the season after passing through the digestive tracts of the animals.

This being a forest climate, natural succession is first to fern and scrub and ultimately to forest. Stocking with sheep alone will not prevent the development of scrub and, in spite of much time and effort spent in brush eradication, some 2 million acres already have reverted to this secondary growth. The cattle are, in effect, the "implements" for consolidation of the soil and "crushing out" the scrub and fern growth. They also prepare the pasture for the ewes and lambs by "cleaning up" roughage during the autumn and winter so that the new fresh spring growth will be free of old tops and succulent enough for best utilization by sheep. Cattle, then, are not kept in the hill country primarily for the profits they bring when marketed, but to "do a job of work," to "keep the pastures in order." Often they are kept until three or four years of age before being taken to the "easy country" to be fattened on grass for market. Usually they do not bring direct profits, as do the sheep, and farmers may attempt to do without them in order to run a few more sheep. This leads to deterioration.

The most successful grazing management in the hill country consists of rotational grazing with rather heavy concentrations of animals for relatively short periods. "Spelling" (deferment) to create shade at the ground surface encourages the better grasses and discourages the fern and scrub seedlings. It is not uncommon to "spell" an area for an entire growing season and then to graze it off rather closely with cattle in the winter. Another fairly common practice is to graze the sheep year-long and rotate the cattle grazing as required to "keep the pastures in order," or to graze the cattle on a yearlong basis and rotate the sheep grazing. "Set stocking" (yearlong or season-long grazing) is less likely to succeed than rotational grazing, but is widely practiced.

The hill country of North Island is capable of great expansion in livestock production through the development of its pastures and the intensification of its grazing. New and better power equipment is extending tillage onto slopes formerly considered far too steep to work. Large disks and plows are now available to turn under brush 10 or 15 feet high. In this land of ample moisture, liming, fertilizing and reseeding will double or even quadruple the carrying capacity as the soil fertility is "built up" by legumes and grazing management. Extensive development schemes to accomplish this on government lands are now under way.

Farther up the slopes and in the back country, much is being done through grazing management alone However, soil fertility remains a serious problem for without phosphates the legumes will not thrive and thus grass growth falls off, allowing fern and scrub to encroach. To meet this need for legumes and improved soil fertility, much hill land has been topdressed by hand and some by means of blowers that distribute fertilizer by wind blast over considerable distances (Hamblyn, 1949 and Cameron, 1952). Neither method has given entirely satisfactory distribution and both are costly. More recently a system of aerial topdressing and aerial overseeding has been developed. Today many thousands of tons of superphosphate are applied to hill lands by light planes that land on air strips the farmer himself develops, often on some narrow but relatively flat ridgetop where the fertilizer can be hauled by truck or wagon (Lynch, 1950, 1951). Legume seed, too, is being applied in this manner, and a great extension of this practice can be expected. Extensive application by means of large aircraft operating from a few main centers is being contemplated.

Expansion and intensification of land development and grazing in the hill country will greatly increase New Zealand's output of animal products. They will permit direct increase through the produc-

FIGURE 1. North Island hill country pasture with bulldozed access track, typical of areas fertilized by aerial topdressing. (*Courtesy Grasslands Div., N. Z. Dept. Sci. and Ind. Res.*)

tion of greater numbers of animals. They will also permit the raising of dairy replacement stock away from the intensive dairy farms of the "easy country" which many workers believe should be reserved for milking cows and for fat lamb production, the replacements all coming from the hill pastures.

Native Grasslands

The tussock or bunch-forming grasses dominate nearly 14 million acres, mostly on the relatively dry, eastern slopes of the Southern Alps. These are mostly crown lands, grazed on an extens ve ranching basis, but they, too, have in part been converted to sown pasture. There also exists a smaller area of tussock grassland in the volcanic region near the middle of North Island which is not a climax grassland but a subsere, dating from the period of volcanic activity that ceased there some 2300 years ago. The dominant species are medium to large grasses that occur as fairly widely spaced tussocks with various forbs and shrubs growing under and among them.

The tussock grasses are mainly species of *Festuca*, *Danthonia*, *Poa* and *Agropyron*. They vary in palatability, some being quite harsh and coarse, but the early settlers soon discovered that new, fresh growth following fire was taken readily by stock. Also, the fires reduced the size and vigor of shrubs and other coarse plants, allowing the native forbs and certain introduced grasses and legumes to spread. As a result, burning has greatly altered the character of the native grassland, weakening the tussocks, opening up the turf, and allowing great increases in soil erosion.

The tussock grasslands, according to Barker (1953), consisted of two general types: (1) a tall tussock grassland on the higher slopes dominated by large, coarse tussock grasses, and (2) a low tussock grassland dominated by smaller and less coarse species and occupying a relatively lower altitudinal zone. Intermixed with the tussock grasslands, occupying the shady, north-facing slopes and the lower gullies, is an evergreen forest dominated in places by species of *Nothofagus* and in others by species of *Podocarpus*.

Land in the high country is not privately owned but is held by the state, the sheep stations being leased on a long-term basis. The lease holders appear to be in complete control and are not required to practice conservative grazing or any other form of range improvement, but are required to obtain a permit before burning. This is an extremely difficult rule to administer, however.

The tussock grasslands once extended down the slopes and across the coastal plain to the Pacific. The coastal plain has been developed largely for arable farming and improved farm pastures, but the lower eastern slopes and valleys of the Southern Alps, known as the "high country", are still tussock grassland. They are used primarily for extensive grazing of sheep, grazing use extending up the slopes to an elevation of 5000 to 6000 feet or a little more. Very little vegetation occurs beyond that elevation and none at all much above 7500 or 8000 feet. Timber line is at 3500 to 4000 feet and above that a narrow zone of snowgrass, a large, coarse *Danthonia* tussock.

The "high country" is used mainly to graze Merino sheep, kept almost solely for their wool. Weather conditions are rather severe and death losses quite high. The lambing percentage is relatively low, so the natural increase usually is not much more than sufficient to maintain the wool flock of ewes and wethers. On the lower slopes, where the environment is less severe, the sheep are mostly crossbreds, the Romney of the lowlands being crossed on the "cast-for-age" ewes.

Grazing of these native grasslands is on a yearlong basis, some 5 to 10 acres per sheep being required in the high country. The lower slopes and valleys are utilized for winter grazing because snows do not lie on them for long periods. After shearing in the spring, the sheep are put in the higher paddocks, the wethers going to the highest and steepest ones and the ewes with lambs to those less difficult to graze. Shearing in the high country is mostly with "the blades" because mechanical shearers tend to remove the wool too closely, leaving the sheep more susceptible to early spring cold spells. The wethers generally are shorn earlier than the ewes and are turned into the higher paddocks.

Much of this high country is steep. Erosion, characterized by shingle slides, becomes severe where the grazing is not carefully regulated. Heavy movement of shingle into the fast-flowing streams presents a serious problem in the valleys below. It is believed by many conservationists that certain of the most erosive areas should be closed to grazing for watershed protection.

The tussock grasslands on the higher and drier sites do not promise economic response to fertilizers and overseeding. Levy and Suckling (1949) have emphasized that if depleted montane tussock is to be regenerated, there must be strict control of fire and rabbits and livestock must be excluded for several seasons. Since most of this grassland is on crown lands, the government could enforce such measures, but only at the expense of greatly reducing, temporarily at least, the livestock population of the high country. Such enforcement would bring strong opposition, but is probably the only practical solution.

While improvement of the high country consists mainly of regulated stocking and the control of burning to prevent further depletion of the tussock grasses, research is showing that the gentler slopes and valleys can be seeded to improved legumes and grasses and that responses to lime and fertilizers are good. Development by plowing and the establishment of improved pastures is being carried out in areas with as little as 20 inches of precipitation annually. The species sown are the ones used in North Island with tall oatgrass (*Arrhenatherum elatius*) being added in drier sites. Other introduced grasses, such as various species of *Agropyron* and *Bromus* and a number of the native species, are being tested. Just as in North Island, overseeding and topdressing are being carried farther and farther into the hills.

FIGURE 2. Loading a light plane for aerial topdressing. Rapid mechanical loading devices minimize the time planes are on the ground. (*Courtesy Grasslands Div., N. Z. Dept. Sci. and Ind. Res.*)

Irrigation is beginning to play a role in the improvement program, small valleys being put to improved pastures or supplemental feed crops and watered by flooding or by overhead irrigation. Even rather steep pastures are being developed for "wild flooding", the water being spilled over the low banks of small field ditches located at intervals along the slopes.

A unique method of hill land improvement consists of building up the fertility and establishing legumes on the steep lands by means of livestock. Heavily fertilized paddocks in the valleys are "closed up" to allow the legumes to mature seed. Cattle are then pastured briefly on these and driven to the nearby slopes where their excrement deposits both plant nutrients and legume seed. Marked improvement may be noted after one or two seasons of such treatment. This method is, of course, not limited to the tussock grasslands.

Predators and Other Pests

Predators, in the usual sense, are not known in New Zealand since the country had no indigenous mammals except the native bat, although the Maori had brought the Polynesian rat and dog in the 14th century (N. Z. Dept. Int. Affairs, 1945). Early explorers, according to Wodzicki (1950), brought various plants and animals. Later, sealers and whalers operating from shore bases, brought still others, including pigs, goats, horses, cattle and sheep.

The only one of these that could be classed as a predator is the pig. It has multiplied in the wild and often destroys young lambs in the early spring, besides damaging pastures by rooting. There is, however, one other predator, the kea, a native parrot that inhabits the high tussock grassland. It attacks sheep, tearing at their backs until the fat over the kidneys is exposed. Keas eat the fat and leave the sheep to die. Needless to say, both pigs and keas are hunted by sheepmen.

There are many pests in New Zealand, most of them introduced. The worst one, perhaps, is the rabbit, introduced by early settlers from the British Isles. In some areas it has denuded the land so completely that the only remaining vegetation consists of scabweeds (*Raoulia* spp.) that grow in patches so close to the soil surface that they resemble great, ugly scabs, hence the name. The economic loss from the depredations of rabbits runs into millions of dollars a year. During the 10 years ending June 30, 1943, nearly 126 million rabbit skins were exported. They represented considerably fewer than half of the number destroyed (N. Z. Dept. of Agric. Livestock Div., 1947).

Vast sums have been spent destroying rabbits. They have been brought under control in some areas, but in others they still are limited only by their own destruction of the available feed supply. Organized control is carried on through local "rabbit boards" that subsidize, in part at least, the cost of eradication by professional exterminators.

Another introduced pest (that harms the forest more than the grazing land, however) is the deer. Like rabbits, deer multiply rapidly and have become so abundant in some sections that professional "cullers" are employed by the government to keep the numbers down. On the higher mountain slopes, chamois and tahr have also become troublesome, as has the wallaby in some localities.

Among the serious pests of New Zealand pastures are the grass grubs (*Odontria* spp.) and the grass caterpillars (*Oxycanus* spp.), which cause severe losses of stands on lighter soils throughout the dominion (Kelsey, 1952). Extensive research is pointing to chemical and biological control and control by improved cultural practices.

Weed pests, too, are a problem. Introduced shrubs such as gorse (*Ulex europaeus*), broom (*Cytisus scoparius*), blackberry (*Rubus fruticosus*) and the native manuka (*Leptospermum scoparium*) often occupy depleted pastures, while Nasella (*Stipa trichotoma*), an introduced tussock, is spreading unchecked in others. Research on eradication by various means, including chemicals, and on control by management is being pressed. Biological control of manuka with a scale insect (*Eriococcus* spp.) is giving promising results, while blackberry is controlled somewhat by the hordes of "wild" goats that inhabit certain areas. They take enough of the plant to check its spread by layering.

Losses of stock from plant poisoning are not great in New Zealand although many species of poisonous plants do occur, most of them introduced. Conner (1951) has listed eight important poisonous species, half of them introduced, and 109 additional species known to be poisonous but less important in livestock losses. Of these, only seven are native. An additional 70 species, including 20 natives, are suspected of being poisonous.

Livestock diseases and parasites take a certain toll but there is available a rather adequate veterinary service, and research in this field is being actively carried on. Strict quarantine of all imported animals for a long observational period has prevented entrance of certain diseases, notably rabies. Compulsory, annual dipping of sheep helps control ticks and other surface parasites. An adequate program of extension education, not only on problems of diseases and parasites but also on all phases of livestock and pasture production, is in effect.

Roads and Tracks

The extremely steep terrain makes it difficult in many places to travel over the pastures except afoot or on horse back, and even the latter method may be impossible on the steepest slopes. This makes any management operation extremely difficult. However, the development of "tracks" bulldozed into the steep slopes is proceeding throughout the back country to permit easier access to the pastures for fencing, weed eradication, fertilizing, rabbit control and mustering. The versatile Land Rover, the British counterpart of the American jeep, has aided greatly in this respect.

Fencing

Since neither sheep nor cattle are herded as are sheep in the United States, but are grazed free in the paddocks, adequate fencing is a necessity for proper control of grazing. Sheep-tight fence is costly and often difficult to build in the steep hill country. It is not uncommon to transport the posts and wire to the site on pack animals or even to carry them by hand in the steepest places. Nevertheless, New Zealand pastures are, on the whole, rather well fenced despite the fact that fencing in the steepest and most remote areas may cost $2000 or more per mile (Cameron, 1952).

Soil Erosion

The nature of the vegetative cover has been greatly altered. On the steeper slopes the introduced grass cover has not been capable of preventing accelerated erosion, except where extremely careful management has maintained a vigorous and productive sward. Organized efforts at erosion control are centered in conservation districts known as catchment boards that direct erosion research and the application of control measures. Grange and Gibbs (1947) have described the types of erosion in North Island, and Gibbs and Raeside (1945) those of the high country in South Island.

Fertilization with Minor Elements

Fertilization is chiefly with phosphatic fertilizers to encourage maximum growth of legumes and thus produce enough nitrogen to stimulate grass growth. Potash is needed in some areas and most soils need rather heavy applications of lime. Superimposed on these needs in certain areas are minor element deficiencies. The use of cobalt has greatly expanded livestock production in the region around the Bay of Plenty and responses to minute applications of sodium molybdate are being reported from widely scattered trials in many parts of the dominion. Its effect on the growth of legumes is particularly striking.

Crop Improvement

Most of the agricultural plant species are exotics, although native species are important in the tussock grasslands. In spite of the great amount of testing of plant introductions and of improvement by breeding, far more remains to be done. Most improvement research has been directed at the problems of the improved pastures because the greatest accomplishments could be made in those areas. More recently the research on hill country problems of all types has been greatly expanded. Exotic species such as smooth brome, intermediate wheatgrass, and many others are being given new trials in areas where they had not been tried before, and certain ones doubtless will be found useful. Native species are being studied as well, in the hope of developing better varieties. The facilities for pasture plant breeding and for seed production and certification are available. Their application to hill country problems is now proceeding.

Conclusion

It has been impossible to touch on all phases of grassland management in New Zealand. That would require a review of the entire economy. This has been an attempt to emphasize the management and some of the problems of the hill country pastures, roughly comparable to the range lands in the United States but far more intensively utilized in the more productive areas. Discussion of the improved pastures has been intentionally omitted, but it must be recognized that they play an extremely important role in butterfat production and the fattening of stock. Far more study and research have been directed at their problems than at those of the hill country, but the hill pastures offer a great challenge and of recent years they are receiving more and more attention.

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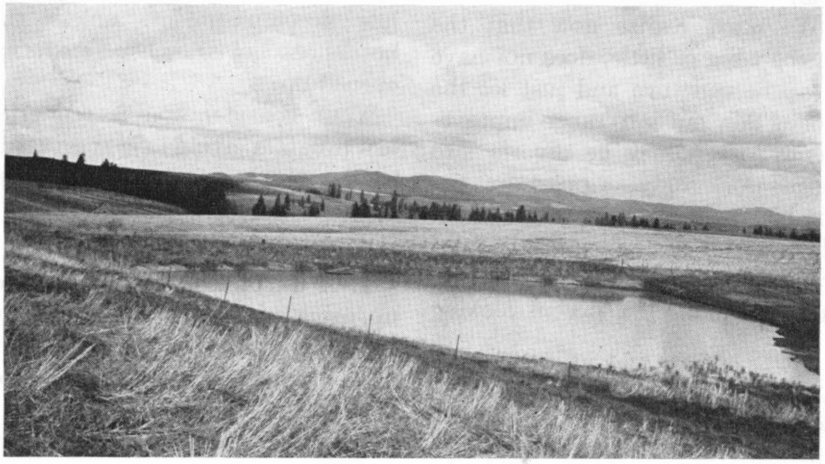

A stock pond on the J. O. Broyles farm in the Latah (Idaho) Soil Conservation District. Photograph by John L. Schwendiman, Pullman, Wash. First prize, Range Landscape, Photography Contest at Omaha, Nebraska annual meeting.

The Stockman's Need for Longtime Credit for Range Development[1]

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Western Ranching Services, Dalhart, Texas

TIME has run out on our present approach to conservation at the rancher level. We are facing a crisis in range development—a crisis in which the momentum of progress made in the past fifteen years is in danger of falling off into lethargy and indifference. One of the direct factors in creating this situation is the pitiful absence of adequate rancher credit for range development.

How we—as grass men supposedly skilled in establishment—have allowed this problem to sneak up on us with such force and apparent suddenness is a CLASSIC of shortsightedness. It is as though we had been rehearsing a play before a few for these many years, to finally face an opening night where the vast audience didn't have the price of admission!

Our programming, based on need, is of 50-year duration. Our proposals, based on an outmoded concept of demonstration financing, will take the rancher 500 years to accomplish. He has every tool at his command—except money. And our recommendations are not bankable!

We must realize now that the rancher, big or little, does not have a tap he can turn and just let the money flow out into range improvement. Any money he diverts into range work only cripples or ties up his normal operating credit. There is not one rancher in a hundred who can afford to do what we suggest and keep a decent looking balance sheet—unless he has that well-known Texas Hybrid Vigor obtained by crossing oil and whitefaces! And contrary to public opinion and present conditions, there are too few of them.

Why should the colleges and hundreds of range graduates be concerned with this problem? If the ranching industry could obtain sufficient credit to attack its range problems on the full-scale front that is needed—our range schools would scarcely be able to supply the demand for trained range men for private employ.

Only when government is compelled to compete with private channels for the employment of these young men can we consider that range management has become a full-fledged professional field.

Why should you be concerned with this problem? If you are a public employee, how long do you suppose your services will be needed if your efforts are insulated from the very people you are hired to help? Insulated by the incapacity of the rancher to apply a program. How can you continue to show visible accomplishment, unless this bottleneck of rancher credit is opened up?

Your consideration is requested of a program giving long-term credit to the rancher for range development.

It is proposed that:

1. A direct loan program be set up, using private investment money, to make available adequate funds needed by the rancher in range development.
2. Loans be made on a longtime basis—10, 15, 20 years—in which to repay at a low rate of interest.
3. The program is supported by government loan insurance.
4. The private funds for loans are channelled through and administered by the local banks.
5. Feasibility and specifications are controlled through existing range agencies.

Now briefly, let us examine the highlights of this proposal.

1. The rancher would be enabled to plan ahead his entire program of range development. His livestock and management program could then be adapted to give him a stable outlook toward an expanded and more economical production.
2. The attraction of private money into this type of program is believed to be the most important single item needed to break this bottleneck of pent-up activity. Any form of direct government subsidy or loan large enough to cover the suggested program would be impractical from the standpoint of administration by a government agency.
3. This type of program is practical largely because the rancher is the type of individual that he is. We have a range development program which is streamlined to the need, and as sound as any banker can expect a government-insured loan to be. There will be the usual individual failures, but not any more frequently than in any other capital risk investment.
4. Let's analyze by comparison the amount of increased progress we would obtain under this program: Remember the old feed and seed loans? Made more or less indiscriminately, they were about as risky a loan as can be imagined. Yet more than 80 percent of these loans were repaid. As a sound businessman how much better risk would you say the average rancher was?

Now, assuming that a range development loan *was* as risky as one

[1] *Paper presented at the Seventh Annual Meeting of the American Society of Range Management, Omaha, Nebraska, January 26–29, 1954.*

of these feed-seed loans, if the 254 million dollars of conservation payments made last year had been applied as loss insurance by the government against possible losses, 1⅓ BILLION dollars of conservation would have been the result. How puny it makes our present efforts appear!

5. Another advantage would be the invoking of the old adage: 'A practice which will not pay for itself is not good conservation.'

6. This loan program would not only be the means of releasing tremendous energy but would place the rancher in an important role in conservation. This is appropriate, because the individual initiative of the rancher has never failed in a job which was based on practical means and profitable benefits.

* * *

The growth of our nation demands that the West's potentials be developed and restored. If the rancher cannot provide himself with the financial means to accomplish this job on time and on a morally sound self-respecting basis, then at some future time there will likely arise a political "emergency" in which abrupt action with too little forethought will involve him in a program from which his own self-determination and initiative has been taken.

A vigorous course of action in the establishment of longtime private credit for ranchers should be undertaken in the interests of conservation of forage and soil resources.

Consumption of Minerals by Cattle on Southeastern Coastal Plain Forest Range

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WHEREVER low quality forage comprises the greater portion of animal diet, supplementary feeding of deficient nutrients becomes an important aspect in livestock management. Such is the case in longleaf-slash pine forests of the lower Coastal Plain or "flatwoods" of Georgia. The so-called native "wiregrass" forage within this region is composed mainly of pineland threeawn, curtiss dropseed, numerous bluestems, panicums and carpetgrass. These species produce an abundant source of feed but they are particularly low in the minerals, phosphorus and calcium. Much winter burning has been done to increase the phosphorus content of forage in the spring and calcium in the summer. However, even with the advantage of winter burning, the phosphorus content rarely exceeds 0.12 percent in the spring and declines to 0.06 percent by winter. Calcium reaches its highest concentration during mid-summer, when it may go up to 0.21 percent, but for most of the year calcium is below 0.16 percent. Thus, according to standards established by the National Research Council (1950), the forage rarely meets the calcium requirement and always falls below the phosphorus requirement for normal growth of young animals and reproduction of lactating cows.

Methods and possibilities of overcoming these apparent deficiencies in phosphorus and calcium have been a secondary part of various forest grazing studies conducted near Alapaha, Georgia, since 1942.[1]

Bone meal, alone and in a mixture with salt, was fed free choice to young growing animals on burned and unburned range from 1942 through 1949. Other groups of steers and breeding cows were supplied with a mixture of salt and bone meal from 1947 through 1952.

Free-Choice Consumption of Salt, Bone Meal and Mixture

Comparisons were available from 1942 through 1949 in the free use by cattle of salt, steamed bone meal and a mixture of the two on both burned and unburned ranges. Groups of yearling and 2-year-old steers and heifers involved in forage management studies were confined to individual ranges from March through January. Six groups occupied ranges which had been partially or completely burned during the winter; two groups were confined to unburned ranges. A 3-compartment mineral box was located in each range. In all the boxes, one compartment provided free access to salt, the second compartment provided steamed bone

[1] *Cooperative investigations by U. S. Forest Service, Bureaus of Animal Industry and Plant Industry, Soils and Agricultural Engineering of the U. S. Department of Agriculture and Georgia Coastal Plain Experiment Station.*

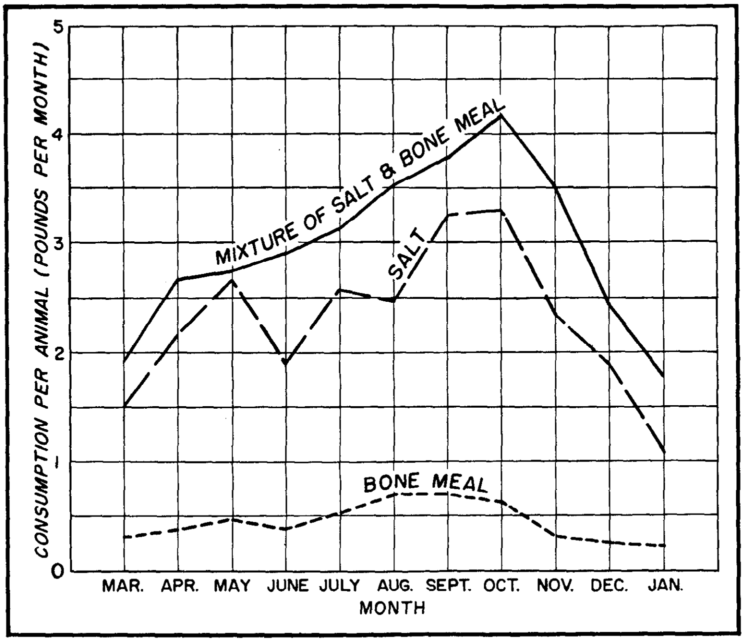

FIGURE 1. Cattle consumed greater amounts of bone meal when fed in mixtures with salt than in single choice. Mineral consumption fell off in October when supplemental feeding with peanut meal began.

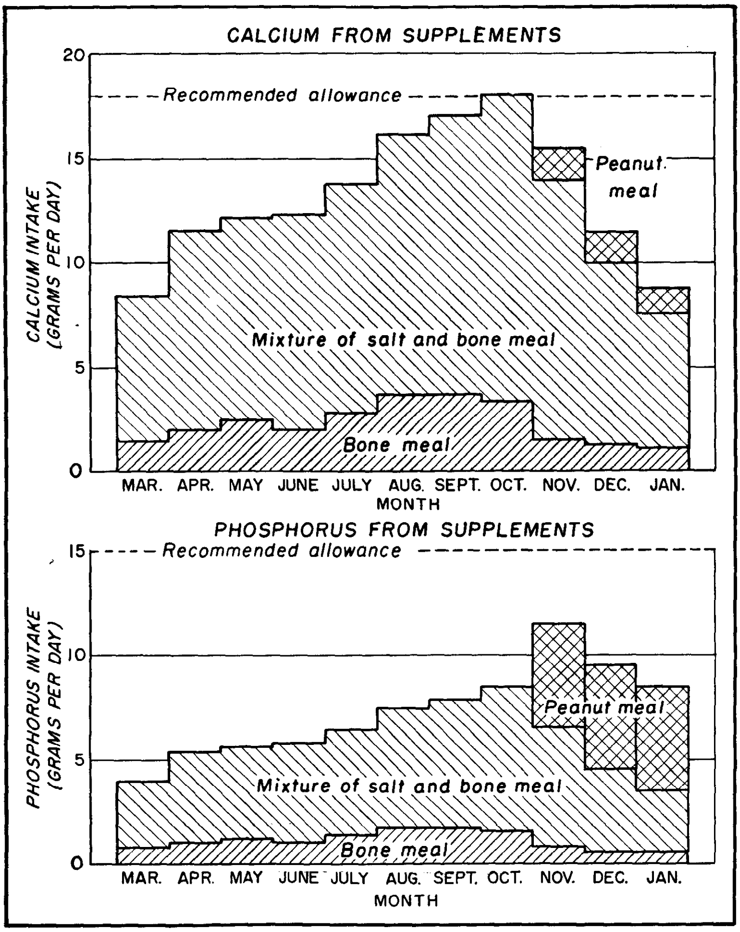

FIGURE 2. When cattle received peanut meal supplement, total calcium intake from supplements decreased (*upper graph*) and phosphorus intake increased (*lower graph*).

meal, and the third, a mixture of two parts steamed bone meal to one of salt by weight. The bone meal contained 7.1 percent crude protein, 32.6 percent calcium, and 15.2 percent phosphorus. Consumption of salt and minerals was checked every 28 days.

The trend was for lightest use of minerals in the spring and heavier use during the summer and early fall (Fig. 1). In other words, as the forage became more mature and phosphorus content declined, the consumption of salt and minerals became greater. Animals were reluctant to eat bone meal alone, as evidenced by the consumption of only 5 pounds per animal from March through January. They preferred the mixture of salt and bone meal. By means of this mixture, cattle consumption of bone meal was increased five times.

From mid-October through January, cattle were further supplemented at the rate of 2 pounds per head per day with peanut meal (43.5 percent crude protein, 0.16 percent calcium and 0.54 percent phosphorus). This decreased the craving for and consumption of salt, bone meal and mixture from the 3-compartment boxes. However, the peanut meal more than compensated for the decreased intake of phosphorus from bone meal, and the net effect was an increase in phosphorus consumption through the combined sources of bone meal, mixture and peanut meal (Fig. 2). Total calcium intake was slightly decreased as a result of the peanut-meal ration.

Large fluctuations occurred from year to year in the amounts of salt and minerals eaten. On the average, these young animals consumed a total of 36 pounds of salt and 26 pounds of bone meal (total from bone meal and mixture of salt and bone meal) from March through January. On a yearly basis, animals on burned range ate about the same total amount of minerals as animals on unburned range. On a seasonal basis, cattle on unburned range tended to eat more mineral mixture during the spring but less during the summer than cattle on burned range.

Consumption of a Mixture of Salt and Steamed Bone Meal by Breeding Cows and Steers

Having established the fact that cattle will eat more bone meal and salt when supplied in mixtures in comparison with single choice, additional and larger groups of breeding cows and steers were supplied with a mixture only. The average mineral consumption by seasons and under various supplemental feeding practices from 1947 through 1952 is presented in Table 1.

Mineral consumption during the feedlot period (February 1–March 15), when cows were calving, was fairly high. This was probably because of the low phosphorus content of the roughage fed (sugarcane) and the easy access to mineral boxes which encouraged more frequent use of minerals. After cows were turned on forest range in the spring and relatively good quality native forage was available, the rate of mineral intake dropped considerably. Consumption of bone meal mixture increased through the summer and reached the highest rate during the fall. When cows were further supplemented with cottonseed meal during the summer, the intake of mineral mixture was decreased, but the total intake of phosphorus from both sources was increased. Mineral requirements for these mature animals during late fall and winter, when about one-half were in the final three months of pregnancy, were high. Animals then consumed large amounts of the mixture of salt and bone meal in addition to cottonseed meal (1 pound per day) in order to meet their mineral requirements.

Table 1. Average daily consumption of a mixture of salt and bone meal

Period of Year	Cows Not Fed Protein Supplement on Range	Cows Fed Protein Supplement on Range*	1- and 2-Year-Old Steers
	Pounds	*Pounds*	*Pounds*
In feedlot			
Feb. 1–Mar. 15†	.166	.167	—
On range			
Mar. 16–Apr. 15	.126	.107	.123
Apr. 16–June 30	.155	.089	.188
July 1–Oct. 15	.236	.173	.195
Oct. 16–Jan. 31‡	.241	.209	.173
Average	.203	.159	.171
Total yearly consumption	74	58	62

* These cows were fed 2 pounds of 41-percent cottonseed meal per animal per day from April 16 to June 30 and 1 pound per day from July 1 to October 15.

† Cows fed 2 pounds of 41-percent cottonseed meal and 25–30 pounds of sugarcane per animal daily in feedlot.

‡ All animals fed 1 pound of 41-percent cottonseed meal per head per day.

Younger animals (average weight 600 pounds) showed the same tendency towards low consumption during the early spring and toward an increase through the summer. Consumption of the mineral mixture decreased in the fall when cottonseed meal was fed, but again the total intake of phosphorus was actually increased.

Mature cows ate about 12 pounds more of the salt and bone meal mixture per head than the younger steers and heifers under comparable treatment. The difference occurred largely in late fall and winter, when mineral consumption by cows continued to be high.

The amount of mineral mixture eaten showed a wide yearly and monthly variation. Extremes in herd averages ranged from 40 to 92 pounds per animal per year, and from none to 13 pounds per month. There was no apparent correlation between amount of minerals eaten and the number of calves within a herd. Also, variation could not be attributed to fluctuations in rainfall.

Discussion and Conclusion

Amount and chemical composition of cattle diet must be known to form a strictly reliable basis for determining whether or not mineral requirements of cattle are fulfilled. In these experiments forage intake was not measured, and chemical analyses were made from forage samples estimating cattle diet. Therefore, suppositions as to whether or not sufficient minerals were supplied are made with these reservations in mind.

When mineral sources such as steamed bone meal are fed alone, cattle do not eat enough to meet their requirement. By mixing steamed bone meal with salt, greater mineral consumption is induced and the average bone meal intake, as indicated in these tests, insures sufficient calcium for dry cows and one- or two-year-old steers or heifers throughout the year. Calcium may be deficient, however, for lactating cows the first 3 to 4 months after parturition, when calcium requirements are high and the forage is relatively low in this mineral. At such times animals may have to draw on body reserves. Based on standards set up the the National Research Council, phosphorus intake through mineral mixture and native forage is sufficient for dry cows, although it approaches the critical point for much of the year. Nursing cows require more phosphorus than they generally obtain from these combined sources. This deficiency can be largely or fully overcome by feeding other supplements, such as cottonseed meal at the rate of 1 or 2 pounds per animal daily.

LITERATURE CITED

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Effects of Grazing on the Soils and Forage of Mixed Prairie in Southwestern Saskatchewan

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Of an estimated 20 million acres of native grasslands in Saskatchewan, over 8 million acres consist of mixed grass prairie. Characteristics of mixed grass prairie that have been studied include yield, chemical composition, seasons of growth and reaction to grazing.

Research was initiated in 1950 to determine if heavy grazing causes chemical or structural changes in the soil, and consequent changes in the chemical composition of the vegetation of mixed grass prairie with primary emphasis on phosphorus. This report summarizes the observations made with respect to differences in stands, yields and chemical contents of ungrazed and overgrazed mixed grass prairie in southwestern Saskatchewan.

Literature Review

Clarke and Tisdale (1945) have shown the seasonal trends in chemical composition of five grasses of the short-grass prairie. They report that phosphorus contents range from 0.252 percent in plants collected in the leaf stage to 0.062 percent in the cured plants after winter exposure. They indicate that phosphorus content is deficient in the cured forage.

Stoddart (1941) found that changes in phosphorus content of browse plants resulted from changes in soil type.

Musser (1948) and Webb *et al.* (1948) found that changes in floristic composition of pastures occur with changes in the amount of available phosphorus. Cook and Harris (1950) found the availability of soil moisture to be more important than the available phosphorus in the soil in influencing the phosphorus content of plants. Godden (1926) and Daniel and Harper (1934) showed that with over 10 parts per million of soluble phosphorus in the soil there was a slight positive correlation between the total phosphorus in the grass and the soluble phosphorus in the soil; with less than ten parts per million of available phosphorus in the soil, there was a slight negative correlation.

Daubenmire and Colwell (1942), in studies of the Agropyron-Poa prairie of Eastern Washington, found a decrease in the amount of available phosphorus in the soil below one decimeter as a result of grazing. The amount of organic matter in the upper decimeter of soil increased.

In contrast, Tebbe *et al.* (1947), in studies conducted on shortgrass prairie grazed at three different rates, found small but consistent reductions in amount of organic matter in the surface soil under grazing.

Description of the Area

The mixed grass prairie area of Saskatchewan, the northern portion of the Northern Great Plains Region, lies west of the Missouri Coteau, which runs diagonally across the province from the southeast to approximately the center of the west boundary. It is characterized by an undulating to rolling topography interspersed with extensive flat, dry glacial lake beds.

Generally, the soils are derived from glacial material and range from sand to heavy clays. They have a shallow surface horizon that varies from grey-brown to dark brown in color. A calcium carbonate layer occurs at a depth of from 10 to 18 inches below the surface.

The climate is semi-arid. Average annual precipitation ranges from 13 to 16 inches with slightly over half occurring in the period from April to July inclusive. May–September evaporation is approximately 30 inches.

The vegetation of mixed grass prairie is dominated by blue grama grass (*Bouteloua gracilis*) and needle-and-thread (*Stipa comata*). Other grasses of importance are June grass (*Koeleria cristata*), western wheatgrass (*Agropyron smithii*), short-awned porcupine grass (*Stipa spartea* var. *curtiseta*) and northern wheatgrass (*Agropyron dasystachyum*).

Common broad-leaved plants include pasture sage (*Artemisia frigida*), puberulent androsace (*Androsace puberulenta*), moss phlox (*Phlox hoodii*) and broomweed (*Gutierrezia diversifolia*). Little clubmoss (*Selaginella densa*) is abundant.

Methods

During the summer of 1950, four mixed grass prairie sites were selected, each crossed with a fence line which separated grazed from ungrazed areas. Sites were located on similar soils, loams and silt loams. Site 2 was located on a level upland, Sites 1 and 3 on level parts of generally sloping areas; Site 4 was located on a low-lying area. At each site, exclosures one by two rods were erected on each side of the fence. Throughout this report these exclosures are referred to as the grazed and ungrazed treatments. The grazing histories of the grazed portions of the various sites indicate that Site 3 was the most heavily used, but has not, of late, been used in the spring. Information for Site 2 is limited. Site 1 was grazed for a long season at relatively light rates. Site 4 was grazed only slightly heavier than the accepted rate, but from early spring to late fall. The composition and percent basal area of species on each treatment were obtained by the point method of sampling as described and used by Clarke *et al.* (1942). Data obtained showed the ungrazed treatments to be representative of the vegetation of the mixed grass prairie in the region.

In late June, 1951, four plots (one-half by two yards) in each treatment were clipped. At this time needle-and-thread was in the late leaf stage. The forage harvested from each plot was divided into three groups consisting of needlegrasses, wheatgrasses and other forage, each bagged separately. Composite samples of the forage from adjacent plots in each treatment were analyzed by the Division of Chemistry, Science Service, Ottawa for protein, crude fiber, ether extract, nitrogen-free extract, total ash, calcium and phosphorus.

Soil samples consisted of a core sample of the surface 0 to 4 inches, and bulk samples from 6- to 12-inch and 12- to 24-inch depths. The 4- to 6-inch depth containing both A and B horizons was deleted. Soil analyses included volume weight, soil moisture, nitrogen, pH and organic matter. Carbonic-acid soluble phosphorus was determined by the method of McGeorge as used by Ensminger and Larson (1944).

Results

Vegetation

Grazing produced changes in the composition of the vegetation at all sites. However, few species reacted similarly on all sites. The dominants usually decreased with grazing, but needle-and-thread on Site 1 and blue grama on Site 3 showed increases in basal area. The wheatgrasses decreased on all but Site 4. Total grasses and sedges decreased with grazing on all sites except Site 3, at which the decrease was overshadowed by the large increase in blue grama grass. With the exception of Site 1, total broad-leaved species were more abundant on the grazed area. Of the principal broad-leaved species, pasture sage showed the most uniform trend, increasing in abundance on the grazed portion of three sites. Puberulent androsace usually decreased with grazing, while moss phlox varied in its response.

Forage yields by sites are presented in Table 1. Yields were lower for the grazed than the ungrazed treatments at all sites. The difference was particularly striking in needlegrasses in which the bulk of the reduction occurred. The reduction of yield in needlegrasses corresponds to changes which occurred in the cover.

Results of the protein and phosphorus analyses are summarized in Table 2. Higher percentage contents of protein and phosphorus were noted on grazed than on ungrazed treatments, although the differences in phosphorus content were not significant. It is of particular interest to note that protein contents of the wheatgrasses show smaller differences between grazed and ungrazed sites than needlegrasses and other forage. Chemical analyses of other nutrient constituents suggested that NFE and calcium were higher in grazed than in ungrazed treatments, while the reverse condition held for ether extract, crude fiber and total ash. Significant differences were not established between treatments for the other nutrient analyses.

Table 3 shows the average yield of protein and phosphorus in

Table 1. Average forage yields of four sites in mixed grass prairie, June, 1951

Class of Forage	Site 1		Site 2		Site 3		Site 4	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
	Lbs. per acre		*Lbs. per acre*		*Lbs. per acre*		*Lbs. per acre*	
Needlegrasses	211.3	377.7*	40.6	85.4*	210.2	491.9**	161.1	666.8**
Wheatgrasses	125.9	128.0	102.4	230.5**	6.4	24.5	168.6	82.2*
Other forage	146.2	170.8	167.5	149.4	407.6	510.0	106.7	211.3**
Total	483.4	676.5*	310.5	465.3**	624.2	1026.4*	436.4	960.3**

* Significant difference between grazed and ungrazed treatments at 5 percent level.

** Significant difference between grazed and ungrazed treatments at 1 percent level.

Table 2. Protein and phosphorus(P) content of forage from four sites in mixed grass prairie, June, 1951

Class of Forage	Condition	Site 1		Site 2		Site 3		Site 4	
		Protein	P	Protein	P	Protein	P	Protein	P
		%	%	%	%	%	%	%	%
Needlegrasses	Grazed	10.46*	0.15	13.06*	—	8.54	0.14	9.76	0.16
	Ungrazed	9.47	0.15	9.44	0.17	8.66	0.11	7.86	0.13
Wheatgrasses	Grazed	8.72	0.13	11.72	0.19	7.03	0.16	10.02*	0.16
	Ungrazed	7.68	0.11	8.88	0.16	8.01	0.15	8.22	0.15
Other forage	Grazed	11.24**	0.12	13.42**	0.17	9.90**	0.14	11.42**	0.16
	Ungrazed	9.90	0.14	9.52	0.16	8.84	0.14	8.88	0.11

* Significant difference between grazed and ungrazed treatments at 5 percent level.

** Significant difference between grazed and ungrazed treatments at 1 percent level.

Table 3. Average weight of protein and phosphorus in the forage of four sites in mixed grass prairie, June, 1951

Site	Protein		Phosphorus	
	Grazed	Un-grazed	Grazed	Un-grazed
	Lbs. per acre			
1	49.3	63.1	0.64	0.96
2	39.8	37.9	0.59	0.77
3	59.1	90.0	0.95	1.56
4	47.7	78.1	0.70	1.28

pounds per acre. Forage from grazed areas showed significantly lower amounts of phosphorus than that from ungrazed areas. Differences between sites were especially marked in the amounts of this element found in the wheatgrasses and in the other forage class. Differences between treatments were greatest in needlegrasses. In wheatgrasses and 'other forage', the grazed sites occasionally produced more phosphorus per acre in the forage than the ungrazed areas. The variations in gross amounts of crude protein produced per unit area are an expression of the varying yield of forage and the differences in percent of this constituent in the forage. It could be expected that, if the percent protein is increased in the grazed forage, the increase would be reflected in the gross production. The validity of this assumption is emphasized by the data obtained on Site 2. On this site, 465.3 pounds of ungrazed forage produced 37.9 pounds of protein, and 310.5 pounds of grazed forage produced 39.8 pounds of protein. Qualitative increases in protein in the forage are reflected in the gross protein produced.

Soils

Pertinent soil analyses are reported in Table 4. These indicate similarity in pH, moisture equivalent, and organic matter at Sites 1, 2 and 3. Soil textures at all sites were loams and silt loams. With the exception of the ungrazed treatment of Site 4, all treatments contained similar amounts of total nitrogen (0.23 to 0.26 percent). Site 4 had a slightly acid soil, but resembled the other sites in the remaining soil characteristics studied. Statistical analyses of the factors evaluated indicates that differences in pH, moisture equivalent and organic matter cannot be considered significant between sites or treatments. Differences in volume weight, available phosphorus and moisture content were significant between treatments. These results indicate that grazing tends to cause soil compaction and reduces soil moisture-holding capacity. The availability of phosphorus is less clearly established, but there is an indication that phosphorus is more available on grazed than on ungrazed sites within the 0- to 4-inch horizon. There was some association between availability of phosphorus and moisture content of the soils but the trend was not consistent.

Table 4. Soil characteristics from four sites, in mixed grass prairie, June, 1951

Treatment	pH	Moisture Equiv.	Organic Matter	Avail. P.	Volume Weight	Field Moisture
		Percent	*Percent*	*p.p.m.*		*Percent*
Site 1						
Grazed						
0–4″	6.5	17.2	3.7	24**	1.20	13.5
6–12″	7.7		2.1	3		14.2**
12–24″	8.1		1.1	3		10.9*
Ungrazed						
0–4″	6.8	17.5	3.6	16	1.19	15.6
6–12″	7.6		2.2	4		15.4
12–24″	8.1		0.9	4		12.2
Site 2						
Grazed						
0–4″	7.5	16.0	5.4	10**	1.17**	4.7*
6–12″	7.8		4.5	4		4.0**
12–24″	7.9		2.5	6		4.8*
Ungrazed						
0–4″	7.2	18.6	4.8	7	1.04	6.0
6–12″	7.8		3.0	7		6.4
12–24″	8.0		1.6	4		6.4
Site 3						
Grazed						
0–4″	6.9	21.5	4.9	22	1.18	17.1
6–12″	7.9		2.5	3		19.7
12–24″	7.8		0.9	2		16.3
Ungrazed						
0–4″	6.7	21.2	6.0	18	1.20	18.0
6–12″	7.9		2.7	2		17.7
12–24″	7.7		1.0	3		14.0
Site 4						
Grazed						
0–4″	6.2	20.6	4.6	14**	1.21**	15.2**
6–12″	6.5		1.9	4		14.6
12–24″	6.1		1.7	1**		16.9*
Ungrazed						
0–4″	5.7	19.5	7.9	27	1.02	27.8
6–12″	6.1		2.9	4		16.6
12–24″	6.4		1.9	3		14.4

* Significant difference between grazed and ungrazed treatments at 5 percent level.

** Significant difference between grazed and ungrazed treatments at 1 percent level.

Discussion and Conclusions

The four sites illustrate the variability in the reaction of mixed grass prairie to grazing. Specific reactions to grazing have been attributed to individual species of the mixed grass prairie. The reaction of individual species to grazing is a complex interaction, modified by differences in topography, exposure, moisture supply, surface and sub-surface drainage and soils. Site 4 differed considerably from the other three sites in the reaction of species to grazing.

Forage yields were lower on all sites under grazing. Yields from needlegrasses were reduced with grazing on all sites. On Sites 2 and 3, wheatgrasses were reduced with grazing, while on Site 1, grazing produced little change in the forage yields of these species. Evidently the less intense rate of grazing, to which Site 1 had been subjected, influenced the forage production of the dominant needle-and-thread, but had less effect on the production by wheatgrasses than the heavier rates at which Sites 2 and 3 were grazed. On Site 4, wheatgrass forage production was increased with grazing. Grazing markedly reduced the production from other forage species on Site 4.

Mixed grass prairie varied with site in its ability to produce forage when grazed. Reductions in total forage production occurred on all sites with grazing, but the reaction of the various species was not consistent.

Changes in chemical composition of the forage in the late leaf stage of the four sites showed general trends. Ether extract, crude fiber and ash were usually lower for all classes of forage on the grazed treatment, while protein, nitrogen-free extract, calcium and phosphorus tended to be higher.

The differences in protein between grazed and ungrazed treatments were most significant. The decrease in gross protein in the grazed forage was of a smaller order, percentagewise, than the decrease in total forage yield. This differential reduction in forage and in gross protein (Table 5) might be expected in the 'other forage' class due to variations in species composition on grazed and ungrazed treatments. If this were true in only the 'other forage' class, the increase in protein could be attributed to an increase in less palatable species. However, in both the needlegrasses and wheatgrasses, the percentage reduction in gross protein is less than that in forage production.

This finding is of significance in that it suggests that the protein content of ungrazed forage may not be the true measure of the protein value of that forage when grazed. In the past, measurements of ungrazed vegetation have been used to determine the ability of mixed prairie to support grazing animals. Although it is realized that protein is not the only nutritional factor, these data indicate that the use of nutritive content of ungrazed forage may lead to errors.

Examination of the soil conditions on the grazed and ungrazed treatments was primarily concerned with the influence of grazing on the available phosphorus.

Moisture characteristics of the site may influence the relation of availability of soil phosphorus to grazing as shown by the data from Site 4. In this site, with more favorable moisture conditions, phosphorus content of the soil was reduced under grazing. These data, although not conclusive, indicate that changes in available phosphorus of the soil apparently occur due to grazing, but may be modified by the moisture conditions of the site. Further study on this problem in the mixed prairie would entail a detailed appraisal of edaphic and vegetational types.

Table 5. Percentage differences in forage production and gross protein content of forage due to grazing on four sites in mixed grass prairie, June, 1951

Site	Forage Production	Gross Protein
1	−28.0	−22.0
2	−33.0	+5.4
3	−39.2	−34.2
4	−54.6	−38.9

Summary

The effects of heavy grazing on chemical and structural conditions in the soil and on the phosphorus and protein content of forage were evaluated in a study in the mixed prairie in southwestern Saskatchewan.

Forage analyses in the late leaf stage and soil analyses were conducted on grazed and ungrazed treatments on four sites. Forage constituents were separated into needlegrasses, wheatgrasses and other forage for chemical analyses. Soils were analysed for texture, volume weight, percent moisture, pH, moisture equivalent, organic matter content, total nitrogen and available phosphorus.

Forage analyses showed that ether extract, crude fiber and ash were higher and protein, nitrogen-free-extract, calcium and phosphorus were lower on the ungrazed treatments as compared to the grazed areas in all classes of forage. Differences in protein between grazed and ungrazed treatments were most significant.

Changes in the availability of phosphorus in the soils studied apparently occurred due to grazing but were influenced by soil moisture conditions. On sites of low moisture content, available phosphorus tended to increase under grazing. The single site with more favorable moisture conditions showed diminished available phosphorus under grazing.

The reactions to grazing of the vegetation of mixed grass prairie were modified by differences in site characteristics.

Acknowledgment

The author is indebted to Mr. J. B. Campbell, Officer-in-Charge, Pasture Division, Experimental Station, Swift Current, Saskatchewan, and Dr. E. W. Tisdale, Head, Range Management, School of Forestry, University of Idaho, for direction and guidance during the study and pertinent discussion of the manuscript.

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Economic Criteria for Determining Optimum Use of Summer Range by Sheep and Cattle[1]

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The primary purpose of this article is to outline an economic framework of analysis wherewith the most profitable combination of sheep and cattle on a given range can be determined (Hopkin, 1954). A recent issue of this Journal carried a most interesting article by C. Wayne Cook, (Cook, 1954), wherein he presented his estimates of grazing capacity of a given mountain range when grazed by both sheep and cattle with various numbers of each, and when each class was grazed alone. His calculations were based on estimates of the vegetational composition and estimates of the utilization by cattle and sheep. From these estimates the forage acre factor was computed for each class of livestock and the combined grazing capacity of the given range for several different combinations of sheep and cattle was estimated.

According to the basic assumptions of the forage acre factor and grazing capacity any one of the combinations of sheep and cattle suggested by Cook is equally desirable from the standpoint of forage production or "proper" carrying capacity. He does not specify which combination is preferred, but merely shows that a greater number of animal units can be grazed when both cattle and sheep are combined on the range than when each class is grazed separately. A secondary purpose of the article is to submit the very interesting data outlined by Cook to the analysis of the economic model in order to determine the adequacy of his suggested enterprise relationships.

The Economic Framework

Agricultural economists have been working for some time on the economic problem of selecting a most profitable crop or combination of crops from among the possible crop sequences. Out of this experience has come the logic and method of determining the optimum enterprise combination for a given set of resources (Heady, 1952, pp. 201–275). The economic principles of optimum enterprise combination apply as well to range resources as to any other kind of resources.

Consider the problem of determining the optimum combination of cattle and sheep on a given range site. Although there are some areas that are better adapted to one class of livestock than another, for the

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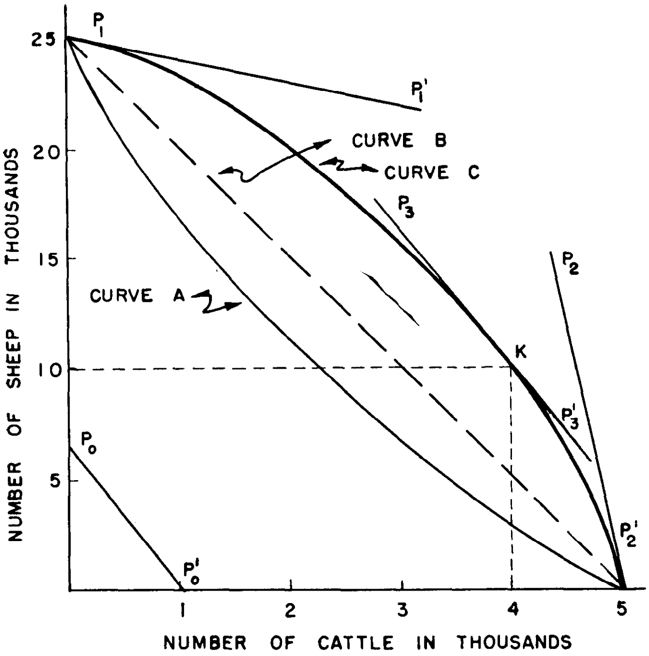

FIGURE 1. Hypothetical enterprise relationship between sheep and cattle.

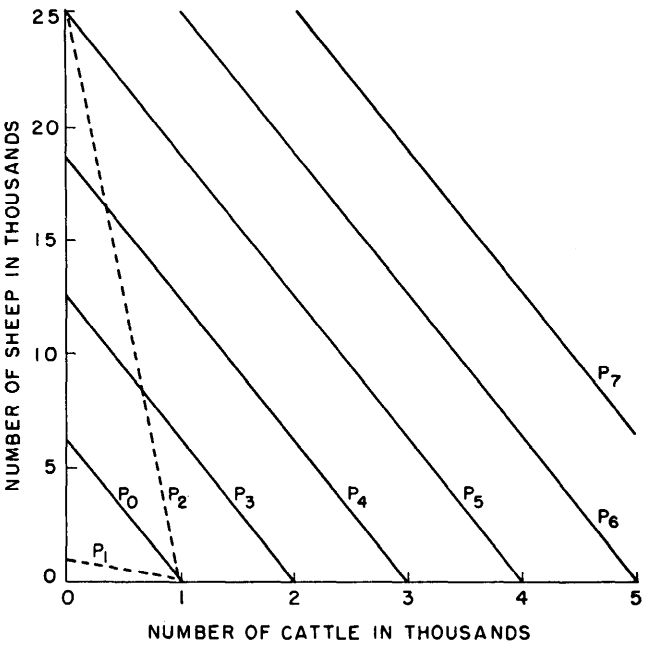

FIGURE 2. Iso-revenue lines for various price relationships of sheep and cattle.

most part, both classes can utilize the same range. The economic problem of determining the optimum combination to maximize long-time profits turns on two basic relationships that need to be known (or estimated with sufficient confidence to warrant a decision), viz., the physical relationship or marginal rate of transformation, and the price relationships reflecting the relative preferences of consumers.

The physical relationships

The first of these basic relationships (the marginal rate of transformation or product substitution), merely outlines the number of physical units of one class of livestock (sheep) that would have to be removed from the range in order to permit one unit of the other class (cattle) to be added to the range *and still leave the range in as good condition as it previously was.*

This physical relationship is illustrated graphically for a hypothetical situation in Figure 1, where three different types of physical relationships are shown together for comparison. Curve B (the straight line) shows a constant marginal rate of substitution. It is plotted by first showing the maximum number of cattle (with no sheep) that could be grazed on the range, based on sound range management. This is assumed to be 5,000 head, and is plotted as (5000, 0) on the grid coordinate. Next, determine the number of sheep (with no cattle) that can be grazed on this same range (again, without injury to the plant species). In Figure 1 this is assumed to be 25,000 head and is plotted (0, 25,000). If the rate of substitution between cattle and sheep on this range is constant we can represent such a relationship by drawing a straight line between the two plotted points. This produces Curve B, which is the locus of points showing the maximum number of sheep that can be grazed on this hypothetical range when any specified number (from 0 to 5,000) of cattle are being grazed. According to Curve B, the condition of the forage would be the same whether 1,000 head of cattle and 20,000 head of sheep, 3,000 cattle and 10,000 sheep, or 5,000 cattle and zero sheep were being grazed.

This is the kind of relationship that is implied in most range management research and recommendations when it is considered that one cow is equivalent to five sheep for all combinations on a given range. Cook (1954) very neatly points out the error of the assumption of constant marginal rates of product substitution.

Curve A shows a decreasing marginal rate of substitution. The curve is convex to the origin indicating that no combination of sheep and cattle would be as productive as would one class by itself. Where this relationship exists, the most profitable solution would always be where only one class of livestock was grazed. This type of relationship was implied in the early days of the range when the belief predominated that sheep and cattle could not use the same range. This kind of thinking still dominates the decisions of many ranchers, grazing associations and public land administrators, since more grazing land is allocated singly to either sheep or cattle than is grazed jointly by both.

A much more reasonable assumption is that an increasing marginal rate of transformation exists, for reasons that were emphasized by Cook (1954, p. 10).

> Many grasses on summer ranges are used only sparingly by sheep, especially late in the grazing season after they become stemmy, whereas, cattle eat most grasses rather readily during most of the grazing season. In addition cattle consume many forbs and shrubs with avidity but generally more complete use of these plants is made by sheep. Therefore, more effective use of summer range might be made by sheep and cattle grazing in combination.

This relationship is represented by Curve C of Figure 1, which we will want to examine in detail. (For the time being we will ignore the straight lines P_1P_1', P_2P_2', and P_3P_3', and focus on the physical relationship implied in Curve C). Again, we assume that when devoted entirely to cattle, a maximum of 5,000 head of cattle can be grazed year after year without damage to the range. Curve C shows that by removing just a few head of cattle, a substantial number of sheep can be added (the slope of the curve is very steep at the lower end) and still leave the range in the same condition as when grazed by 5,000 head of cattle. This occurs, of course, because the sheep are consuming the plant species that were under-utilized by the cattle. As more cattle are removed, however, relatively fewer sheep can be added, per unit of cattle removed, without injury to the range. (The traditional 1:5 ratio is reached when Curve C is parallel to Curve B). At the other extreme, the maximum number of sheep that can be grazed when zero cattle are grazed is 25,000 head. At this point several head of cattle could be added by removing just a few head of sheep (the slope of the curve is very flat), but as sufficient cattle are added to eat the coarse, dry feed, they come more into competition with the sheep. Note that the supplementary relationships (flat and steep parts of the curve) occur at the extremes, and that the slope of the curve becomes more constant toward the center. This will be important later on. The relationship of Curve C is logical based on (1) traditional range management principles (as indicated above by Cook) and, (2) the law of diminishing returns (variable proportions).

The curves of Figure 1 are, of course, hypothetical. They are the assumed physical relationships that might exist between two enterprises (cattle and sheep) in the use of a given quantity of resources (a hypothetical range with a fixed quantity of labor and capital), and are called iso-resource curves. Only an increasing marginal rate of substitution, where the curve is concave to the origin (Curve C) is logically consistent for ranges where both classes of livestock can graze.

It must be emphasized that the curves are production possibility lines. They describe only physical phenomenon and have their origin in the physical science of range management. They can be derived in two ways. First, they may be obtained from physical experiments where sufficient combinations of sheep and cattle are observed over time under controlled experiments designed for curvilinear regression analysis. Obviously, results from experiments of this nature are forthcoming only after several years. In the meantime, the relationships may be reasonably approximated by quantitative and qualitative judgments of competent range management technicians based on the preference index figures for each kind of livestock and on the range inventory and range condition. The same procedure used in estimating grazing capacity for one type of livestock (cattle) could be used in estimating grazing capacity for various combinations of sheep and cattle. The assumption that the livestock will graze over the entire range area without concentrating in local areas may be more nearly true for combinations of sheep and cattle than for one livestock species grazing alone. The actual shape of the curve will depend on the relative proportion of forage that is preferred by each class of livestock. The general shape of Curve C (Fig. 1) or Curve F (Fig. 3) will hold for all range units where both cattle and sheep can graze.

Irrespective of how the curve is estimated, it outlines the possible combinations that leave the range in the same condition, but it provides no criterion for selecting the preferred combination from among the possible combinations. Before a selection can be made we must have choice criteria that we can apply to our model.

Price Relationships

The choice criteria we will use in this case are the price relationships of the two commodities (sheep and cattle). These will be determined by means of iso-revenue lines. For example, if the market price of a steer (of the weight and quality we are assuming in the above hypothetical situation) is $187.50, then from selling 1,000 head we could derive $187,500. The number of head of sheep we would have to sell to obtain the same revenue depends on the price of the sheep. If the market price of sheep is $30 per head it would take 6,250 head to bring the same revenue as obtained from 1,000 head of cattle. When these two points are connected with a straight line (see line P_0 of Figure 2), this line becomes an iso-revenue line, with every point on it representing a combination of sheep and cattle which, when sold at the assumed market prices, will provide $187,500. The same reasoning can be applied to 2,000 head of cattle and it will be found that (at the assumed prices) 2,000 head of cattle or 12,500 head of sheep will each sell for $370,000. Line P_3, connecting these two points, represents all combinations of sheep and cattle that together will return $370,000. It is obvious that as long as the relative prices of sheep and cattle do not change all iso-revenue lines will be parallel, regardless of the amount of revenue each represents. It is equally obvious that one iso-revenue line that is further from the origin than another represents more revenue than does the latter. Thus P_7 represents more revenue than P_6. There can, of course, be a vast number of iso-revenue lines drawn, each representing a separate quantity of revenue. The slope of the iso-revenue line gives us the price ratio of the two commodities—the ratio at which cattle exchange for sheep in the market. In the case of P_0 (and lines parallel to it) the ratio is 1:6.25. Line P_1 (Fig. 2) reflects a very high price for sheep. Here the ratio is 1:1. Line P_2 reflects a very low price for sheep (price ratio = 1:25).

It should be realized that the iso-revenue line refers to gross revenue and not net revenue when market prices are used. If there are substantial differences in the costs of producing and marketing the two products these differences could be considered so as to determine a "net" price ratio or an iso-net-revenue line. For purposes here we will use the iso-revenue line for simplicity. The logic would be the same in each case.

The Theoretical Optimum

We are now in position to determine the theoretical optimum combination for this range. The iso-resource curve shows the combinations of sheep and cattle that are possible without injury to the range. The iso-revenue lines show the combinations of sheep and cattle that are of equal revenue. As we move further from the origin each iso-revenue line represents a higher revenue. The optimum combination along the production possibility (iso-resource) curve to where we are on the highest possible iso-revenue line. The solution will be, of course, when the iso-revenue line is tangent to the iso-resource curve.

Let us take an example. Assume the prices to be $187.50 per head for cattle and $30 per head for sheep. This is shown by line P_3P_3' of Figure 1 (which is drawn parallel to P_0P_0' so that it is tangent to Curve C). Now Curve C tells us how many sheep we can add by removing a specified number of cattle from the range (and vice versa). The slope of the iso-revenue line (the price ratio) tells us how many sheep it takes to be equal in value to cattle that are given up. In this case it takes 6.25 sheep to be equal in market value to one cattle unit. At the point where these two relationships are equal (the point of tangency—point K) profits will be a maximum. This is the optimum combination and is uniquely determined.

Under the relationships of Curve C, grazing only sheep on that range would be optimum only if the price ratio was at least as favorable for sheep as that shown by iso-revenue line P_1P_1', Figure 1, (one sheep equal in market value to one cattle unit—see line P_1, Fig. 2). Grazing only cattle would be optimum only if the price ratio was at least as favorable for cattle as shown by P_2P_2', Figure 1, (25 sheep equal in value to one cattle unit—see line P_2, Fig. 2).

Application of the Model

We will now use the above model in analyzing the data presented by Cook in order to: (1) check the suggested physical relationships for logical consistency, and (2) determine hypothetically optimum solutions for different assumed price ratios. The data were derived from grazing experiments where sheep and cattle were grazed separately on adjacent and comparable areas. The vegetational composition was determined for both ranges and the percent utilization of plant species was estimated separately for sheep and cattle. The forage factor for sheep and for cattle was thus estimated for each species. The aggregate forage factor for sheep and cattle was computed to be .2034 and .3728 respectively. Thus, with cattle alone more animal units (based on the customary 5 to 1 ratio) could be grazed than with sheep alone. "However, if the higher forage factor for either cattle or sheep is used for each plant species the total becomes .4339" (Cook, 1954, p. 11). Cook takes this figure to represent "the forage factor for common use" and estimates a total grazing capacity of 652 animal units for that combination where 422 animal units of cattle and 230 animal units of sheep are being grazed. (At that point the ratio of sheep to cattle is the same as the ratio of their respective forage factors, or 1.83.) The calculated grazing capacities for different combinations of sheep and cattle are listed in Table 1. The first two columns are taken directly from Table 2 of Cook's report. The marginal rate of substitution of cattle for sheep is merely the ratio of the decrease in sheep divided by the increase in cattle. It simply states that, according to these data, one animal unit of cattle can be added for each .177 animal units of sheep that are removed, and the range will still be in the same condition as when grazed only by sheep. Cook's data indicates that this

Table 1. Combinations of sheep and cattle (in animal units) on the same range and marginal rate of substitution of cattle for sheep. (Data based on Cook (1954))

Cattle	Sheep	Marginal Rate of Substitution of Cattle for Sheep
0	306	—
141	281	.177
281	255	.177
422	230	.177
468	153	1.674
514	77	1.674
560	0	1.674

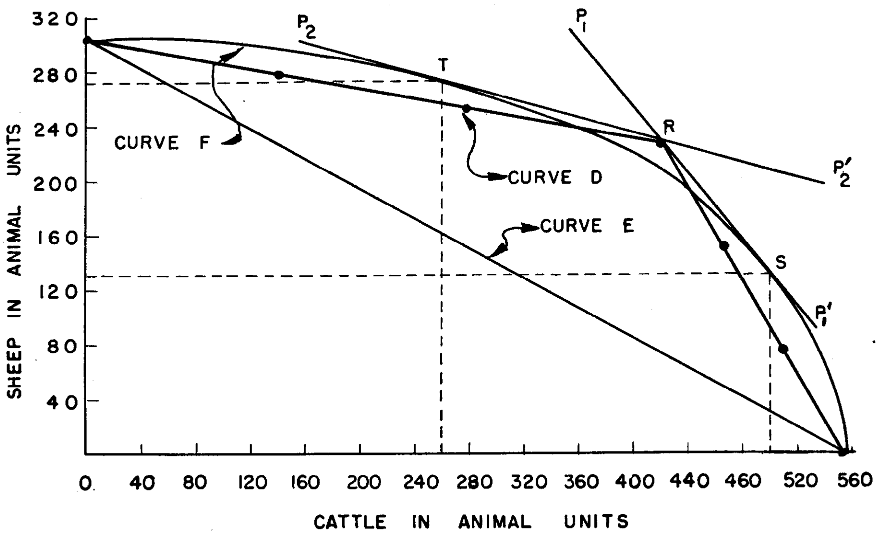

FIGURE 3. Combinations of sheep and cattle on 2,800 acres of range land in the Wasatch Mountains and optimum use for selected price relationships of sheep and cattle.

marginal rate of substitution is constant at .177 up to the point at which 422 animal units of cattle and 230 animal units of sheep are grazed. Beyond that point, however, an animal unit of cattle could be added only by reducing the number of sheep by 1.674 animal units.

Curve D of Figure 3 is obtained by plotting Cook's data (number of sheep and cattle in Table 1) on a coordinate system and connecting the seven points. Based on his interpretation of the forage factor Cook rightfully discredits the argument that sheep and cattle displace each other on the range at a constant rate. (Such a relationship would be shown by Curve E where the marginal rate of substitution is constant at 306/560 = .546). The hypothesis of Curve D is a distinct improvement over Curve E for it does show the marginal rates of substitution to be increasing, rather than constant. However, there is nothing in the logic of range management or economics that supports the hypothesis that the marginal rate of substitution of cattle for sheep remains constant at a low rate (.177) up to a certain point (point R, Fig. 3) and then suddenly increases to 1.674, remaining constant at the new level beyond that point. We must conclude that the shape of Curve D results from the fact that only one point (point R) was independently determined and the intermediate points were determined by linear interpolation.

Based on the reasons for common use mentioned by Cook, it is logical that when all, or most, of the livestock were cattle, a few sheep might do fairly well on those species that cattle do not utilize. At the other extreme, a few cattle might do well on those species for which sheep show little preference. As the numbers of the two classes of livestock become such that they compete directly for the important forage species, the marginal rate of substitution would not change so rapidly. Curve F is suggested as a more realistic picture of the substitutional relationship in question. (In the absence of detailed empirical observations Curve F might be only a rough approximation; it has been drawn free hand for illustrative purposes only.)

Although at first glance one may get the impression that the difference between Curve D and Curve F is so little as to be insignificant, a more careful analysis reveals otherwise. First consider the optimum combination under the assumed market situation as indicated by the iso-revenue line P_1P_1', Figure 3. (Here the price of cattle is high relative to the price of sheep, 1:1.2.) For Curve D the point of tangency with the iso-revenue line is at point R, indicating the optimum combination to be 422 animal units of cattle and 230 animal units of sheep. For Curve F the point of tangency is at point S (500 animal units of cattle and 132 animal units of sheep).

Next, consider the optimum combination under the market situation as indicated by the iso-revenue line P_2P_2' (cattle prices are low relative to sheep prices, 1:.275). For Curve D, the optimum solution has not moved from point R, while for Curve F the optimum solution now calls for only 250 animal units of cattle and 272 animal units of sheep (point T).

Some limitations of the model

The above model is limited, of course, by any substantial inaccuracies of the physical information that go into determining the functional relationship. This limitation is no greater for this model, however, than for any decision that is made relative to the grazing of any livestock on that range. The model assumes equal resource inputs not only of range lands but of labor and capital. This may not be true in some instances. Range sheep require closer supervision than do range cattle. Either they are under the direct watch of a sheepherder or they are placed within sheep-tight fences. There may be important economies of scale associated with the production of sheep or cattle. These factors can be considered in the analysis (although they have not been in the above simple model). They are no more an inherent weakness of this method than of any alternative analytical system. Should the differences in cost structure between the two enterprises be too complex to permit their consideration through the use of net revenue lines, then a more complex model would have to be used. The logic of the simple model would still direct our analysis by specifying the information needed for the analysis and by determining the statistical procedures to use in collecting and analyzing the data and in testing the hypotheses.

The problem of determining the effective price ratios for sheep and cattle has not been discussed because of space limitation. In this illustration only naive hypothetical prices have been used. It is obvious that more is involved here than a comparison of the market price of feeder steers and feeder lambs for a given season.

Some policy implications

To encourage adjustment to an optimum combination of domestic grazing, more information needs to be known about the use adaptability of the range. This, of course, is a very complex phenomenon which to discover and predict presents methodological and technical problems that challenge the plant scientist. In the meantime, decisions continue to be made that assume the relationship between two livestock enterprises grazing the same range to be linear—an assumption that seldom can be valid. However, the first need is to estimate the enterprise relationship for a given range area and then to pass this information on to the ranchers using that area. Before the adjustment could be made on public grazing land, the procedures of adjustment would have to be worked out by the administering agencies. Although the public land agencies now tend to compute the conversion ratio separately for each allotment (thus getting away from the conventional 1:5 ratio of cattle for sheep) they still consider the conversion ratio to be constant for all combinations (Curve B, Fig. 1, or Curve E, Fig. 3).

Consider the procedure for adjustment on a given public range where only cattle have been permitted previously. Assume that a detailed range study reveals the enterprise relationship between sheep and cattle to be as shown by Curve C (Fig. 1). The assumed price ratio between sheep and cattle is shown by the slope of the iso-revenue line P_3P_3', and the optimum combination (the goal for which both rancher and public land administrator should be striving) is represented by point K. It is thus estimated that by removing 1,000 head of cattle from the range 10,000 head of sheep can be added and still leave the range in the same condition as when previously grazed only by cattle. It then should be possible for the ranchers using this range to exchange permits by obtaining permit for ten sheep for each cattle unit given up—up to the point where the 1,000 head of cattle have been removed and 10,000 head of sheep have been added. If adjustments were to be permitted only on the 5:1 ratio normally used by the public agencies, it is unlikely that any adjustment would occur, since the price ratio is 6.25:1.

Summary

The optimum combination of sheep and cattle on a given range is obtained by equating two independent functions: (1) the physical enterprise relationship (the iso-resource curve) which shows the combinations of sheep and cattle that can be grazed on a given range without injury to the plant species, and (2) the price relationships (the iso-revenue line). From the standpoint of "proper" range stocking, every alternative along the iso-resource curve is equally acceptable. If the costs of producing a "unit of product" are not substantially different for the two enterprises, the iso-revenue line can be determined from market prices; otherwise additional considerations must be given.

The suggested analytical model was applied to some very interesting data presented by Cook in a noteworthy contribution to the science of range management (Cook, 1954). The discussion has been directed toward a refinement of the method in order that it might be amenable to economic analysis and thus useful in making decisions pertaining to the combination of sheep and cattle on a given range site. It is an example of the need for a blending of the efforts of the physical scientist and the economist in finding better solutions to range management problems.

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Some Interrelations of the Merriam Kangaroo Rat to Velvet Mesquite[1]

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The Merriam kangaroo rat (*Dipodomys merriami merriami*) is one of the important biotic factors disseminating seed of velvet mesquite (*Prosopis juliflora* var. *velutina*) on certain rangelands of southern Arizona. Mesquite, because it dominates and eliminates the more desirable perennial grasses, has been an unwanted invader of many rangelands during the past 50 years and this invasion is still underway. Merriam kangaroo rats increase in numbers as perennial grasses decrease, and, because of their seed-storing habits, contribute to the further spread of mesquite. This paper appraises the relative importance of this means of spread as compared to other possible agencies of mesquite dissemination.

Experimental Area

All experimental work was done on the Santa Rita Experimental Range located about 30 miles south of Tucson, Ariz., and maintained by the Forest Service. This experimental range has been invaded seriously by mesquite during the last 50 years, and inasmuch as it also supports a dense population of Merriam rats, offers an excellent opportunity to study the interrelations of the two species. Moreover, conditions found on the experimental range are believed to be representative of about 20 million acres of rangeland in Arizona, New Mexico and Texas.

Occupying elevations between 3,000 and 4,500 feet, the experimental range exhibits a wide variety of environmental conditions. Average annual rainfall varies from 12 to 20 inches. Average annual rainfall and other environmental influences which are related to elevation result in significant differences in the biota. The vegetational aspect varies from creosotebush at the lower elevations to typical oak woodland-grass at the higher altitudes. The number of plant and animal species living in this transition zone is large. Merriam kangaroo rats are the most abundant rodents, and at the intermediate elevations mesquite is the dominant shrubby plant.

Effect of Merriam Kangaroo Rats on Mesquite

The diet of Merriam kangaroo rats, as measured by pouch collections, averages about 6 percent mesquite beans, and during the period of seed maturation in July beans may exceed 27 percent of the rat diet (Reynolds and Glendening, 1949). All seed collected by kangaroo rats is not consumed. A portion of the seed is stored in the surface soil. Seed caches vary from ½ to 1½ inches in depth and contain 1 to 13 seeds which are in an ideal environment for germination and establishment (Reynolds, 1950*A*). Some seedlings survive in spite of drought or other mortality factors. On some areas, enough seedlings remain to produce potentially not less than 8 mesquiet trees per acre per year (Paulsen, 1950). Because some seedlings survive and produce mature trees, the seed-collecting and surface-caching habits of Merriam kangaroo rats have an important influence on mesquite propagation. Thus, the distance which the seed is moved from the parent tree by Merriam rats has an effect upon the rate of spread of mesquite.

Distance Seed Is Moved by Rats

Merriam kangaroo rats, in common with other small rodents, are known to live in certain spatial units (Blair, 1943). These "home ranges" are known definitely to be occupied during the time of breeding, which includes the period of mesquite seed maturation. In 1942 and 1946, 38 home ranges of kangaroo rats were determined by the live-trapping, marking, and recapturing technique advocated by Blair (1941). Average radius of a home range, considering all sexes and ages, varied from 58 to 80 feet. Hence, on the average, these animals are capable of moving seed to a maximum distance of 160 feet from the parent tree.

In 1950, movement of mesquite seed by the kangaroo rats was actually measured. All seed-eating rodents except Merriam kangaroo rats were removed by live-trapping from selected areas. Just prior to the summer rains, mesquite seed well mixed with sorghum seed was placed at central feeding stations. This mixture of seed was collected by Merriam rats, and some of it was buried in surface caches at variable distances from the central feeding stations. When the surface caches sprouted in response to summer rains, the mesquite seeds transported from the central feeding stations were identified by observing the "marker" sorghum seedlings.

A total of 29 sorghum seed

[1] *The help of Professors A. S. Leopold and F. A. Pitelka of the University of California, who criticized the manuscript, Professor J. F. Lance of the University of Arizona, who assisted in evaluating paleontological references, and H. S. Haskell, who did some of the field work, is gratefully acknowledged.*

[2] *Forest Service, U. S. Department of Agriculture, with headquarters at Colorado A & M College, Fort Collins, Colo.*

Table 1. Percentages of kangaroo rat burrows beneath various shrubs on a 7.5-acre plot in 1946

Shrubs		Burrow Systems	
Name	Number of plants	Percent available shrubs occupied	Percent total number burrows
Mescat acacia (*Acacia constricta*)	1	100	T
Shortleaf baccharis (*Baccharis brachyphylla*)	2	100	T
Velvet mesquite (*Prosopis juliflora* var. *velutina*)	98	99	70
Catclaw acacia (*Acacia greggii*)	33	76	18
Spiny hackberry (*Celtis pallida*)	8	50	3
Cholla and pricklypear (*Opuntia* spp.)	2	50	T
Wolfberry (*Lycium* spp.)	2	0	1
No shrubs	—	—	7

caches was discovered. Twenty-four percent of the caches contained 1 to 4 mesquite seeds. Average movement of marked mesquite seed was 47 feet although distances ranged from 2 to 105 feet. About 2 percent of the available mesquite seed was recovered in caches. By actual measurement, *Dipodomys venustus*, another species of kangaroo rat, is known to store seed in surface caches at distances as much as 168 feet from the den (Hawbecker, 1940).

Judging from observations of home range, Merriam kangaroo rats can be expected to move seed less than 200 feet from the borders of a mesquite stand. A tree matures sufficiently to produce seed in about 20 years (Glendening, 1952). Therefore, it would take over 500 years for mesquite to invade a distance of 1 mile. On the Santa Rita Experimental Range mesquite has moved several times this distance in less than 50 years, indicating that other factors contribute more to its spread than the rats.

Effect of Mesquite on Merriam Rats

Mesquite seems to provide a favorite location for kangaroo rat burrows (Table 1). On a 7.5-acre plot, mesquite was favored over any of the other shrubs present, except for shrubs which were too scarce for adequate sampling. Of the total number of burrows on the plot, 70 percent were under mesquite, and 99 percent of the mesquite shrubs were occupied. Presumably a mesquite or other shrub overstory offers easier digging and protection for burrows by preventing trampling by domestic livestock. Also, roots of the trees may discourage burrowing by badgers, coyotes and other digging predators.

Mesquite improves the habitat for the kangaroo rats by decreasing the abundance of perennial grass. Mesquite is known to compete with and to decrease the abundance of perennial grass (Parker and Martin, 1952). The numbers of kangaroo rats tend to increase as the density of perennial grass decreases. The mode of escape used by these rodents is probably a major factor contributing to this relation. Upon being frightened, they run a speedy zigzag course to their burrows. This type of retreat would be progressively hampered as perennial grass density increases (Reynolds, 1950).

Once mesquite becomes established on an area, the habitat improves rapidly for kangaroo rat habitation. The more mesquite, the less grass is available to hinder movement of rats. These rodents can then disseminate more seed to propagate mesquite at a faster rate. Once mesquite and Merriam kangaroo rats become established on the same site, a potent animal agency becomes available for further thickening of a mesquite stand.

Other factors in addition to mesquite increase could be responsible for reducing grass density. For example, perennial grass density fluctuates with changes in annual rainfall. In measurements made on the experimental range, density index changes from 3 to 15 percent have occurred in a period of 7 years as a result of annual rainfall differences (Reynolds, 1950*A*). Other factors being equal, these changes in

Table 2. Relation between Merriam kangaroo rat populations, numbers of mesquite trees and other conditions

Sampling Site	Rats per Acre	Mesquites per Acre		Habitat Evaluation for Rats	Other Conditions
		Over 6′	Total		
I	0	8	10	Poor	Dense annual grass. Coarse sandy loam soil.
II	0	245	294	Poor	Resting area for cattle. Rocky ridge.
III	1.8	48	132	Fair	Corner of cattle drift fence. Rocky soil.
IV	2.0	227	341	Fair	Top of ridge near cattle watering rim. Rocky soil.
V	2.0	12	12	Fair	Artificially cleared of trees, stumps intact. Good perennial grass cover.
VI	3.2	49	78	Good	Little perennial grass. Sandy loam soil.
VII	3.8	65	70	Good	Little perennial grass. Sandy loam soil.
VIII	4.0	34	42	Good	Little perennial grass. Sandy loam soil.
IX	4.2	102	126	Good	Little perennial grass. Sandy loam soil.
X	4.3	10	51	Good	Perennial grass cover depleted. Loam soil.

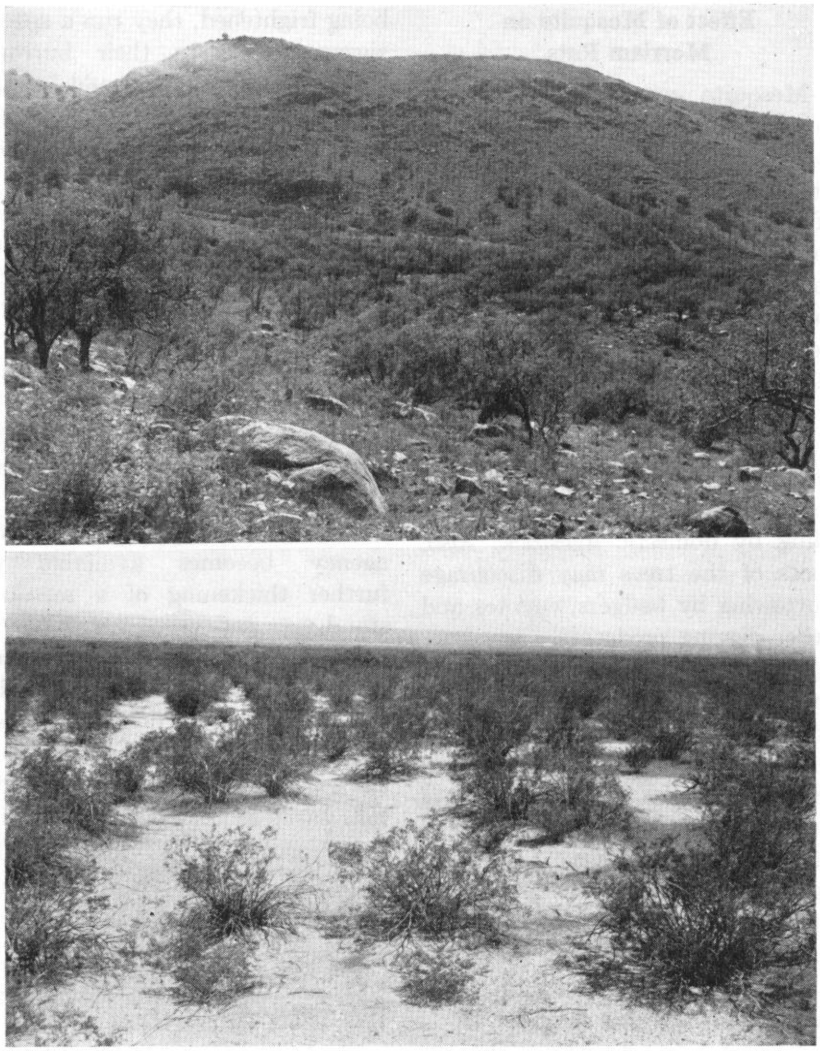

FIGURE 1. Lack of reciprocal dependency between velvet mesquite and Merriam kangaroo rats. *Upper.* Grassland which has been invaded by mesquite but where no rats are present mainly because of a shallow, rocky soil which is unfavorable for burrowing. *Lower.* A high population of rats exists in this creosotebush area, but the site is practically devoid of mesquite.

grass density would have a considerable effect upon rat populations and hence the dissemination of mesquite and other seeds. Heavy, continuous grazing also destroys perennial grass.

Interrelations of Mesquite and Rats

To determine the amount of interdependency of Merriam kangaroo rats and velvet mesquite, locations having different densities of trees were deliberately selected and sampled for animal populations. Rat populations were determined by a modification of the method of Dice (1938). Individual museum break-back traps were equally spaced along lines 450 feet in length and set for three consecutive nights. Border corrections were applied to allow for animal drift, and the results were expressed on a per acre basis. Mesquite numbers were determined by actual counts.

Mesquite-infested areas were found where no kangaroo rats were present. This indicates that other factors in addition to the rats are responsible for the spread of mesquite (Table 2). Rat populations were also discovered on creosotebush areas where there was no mesquite, which shows that rats are not dependent upon mesquite (Fig. 1). In fact, the distributional range of Merriam kangaroo rats has been noted to coincide closely with that of creosotebush (Monson & Kessler, 1940).

Of the factors noted in sampling, grass density and soil appear to be the major factors influencing the choice of a habitat by rats. Soils which are so rocky as to discourage digging, or are so sandy as to result in burrow caving, do not offer a good environment. Any persistent herbaceous vegetation which impedes escape appears to discourage kangaroo rats.

Other Biotic Agencies for Mesquite Seed Dispersal

If Merriam kangaroo rats were entirely responsible for the spread of mesquite, they could have moved mesquite seed to all mutually favorable sites in past geologic time. Paleontological records indicate that the genus *Dipodomys* (Wilson, 1937) and *Prosopis* (Axelrod, 1950) had developed in forms at least closely related to those of the present before early Pleistocene time which was some 1 to 5 million years ago.

Domestic livestock and several other species of native animals are probably as important as kangaroo rats in disseminating mesquite on the Santa Rita Experimental Range. Mesquite seeds pass through the digestive tract of domestic livestock in a viable condition, and many seedlings are produced in the dung. Feeding trials with mesquite seed showed that many seeds were potentially viable after passage through the alimentary tract, amounting to 27 percent for sheep (Glendening & Paulsen, 1950), and 45 percent for cattle (Fisher, 1947). In their normal grazing habits, cattle move distances of 2½ to more than 5 miles. Hence, cattle are perhaps a more important biotic factor for dissemination of mesquite seeds than kangaroo rats which move seeds less than 200 feet. Among the native animals known to be spreaders of mesquite seed are deer, peccary, cottontail rabbit, jackrabbit and coyote (Allred, 1949). All of these animals, even though they may not be as abundant as Merriam kangaroo rats, have much larger home ranges and thus potentially could spread seed much greater distances.

Conclusions

Ecological—Merriam kangaroo rats appear to be favored by mesquite invasion because of the resulting lowered density of perennial grass, but they are not dependent upon mesquite for production of a favorable habitat (Fig. 2). However, they may extend their range and increase their numbers because of mesquite spread. Cattle are a more important factor contributing to mesquite spread than are kangaroo rats. Cattle disseminate seed to greater distances. Also, cattle grazing pressure can be so heavy as to reduce perennial grass density. The habitat is then improved for mesquite seedling establishment, and becomes more favorable for the kangaroo rats. Once mesquite is established and the habitat is favorable for kangaroo rats, these rodents can, however, assist in effecting a rapid thickening of a mesquite stand. Once mesquite and rats exist on the same site, mesquite can be expected to increase rapidly until competition for space or some other factor limits populations. In this regard, wild range fires which are now mostly controlled are believed to have contributed considerably to mesquite suppression (Humphrey, 1949).

Economic—The Merriam kangaroo rat is not the primary, and is only one of several agencies for dispersal of mesquite seed. Mesquite, because of its effect in reducing grass density, is probably

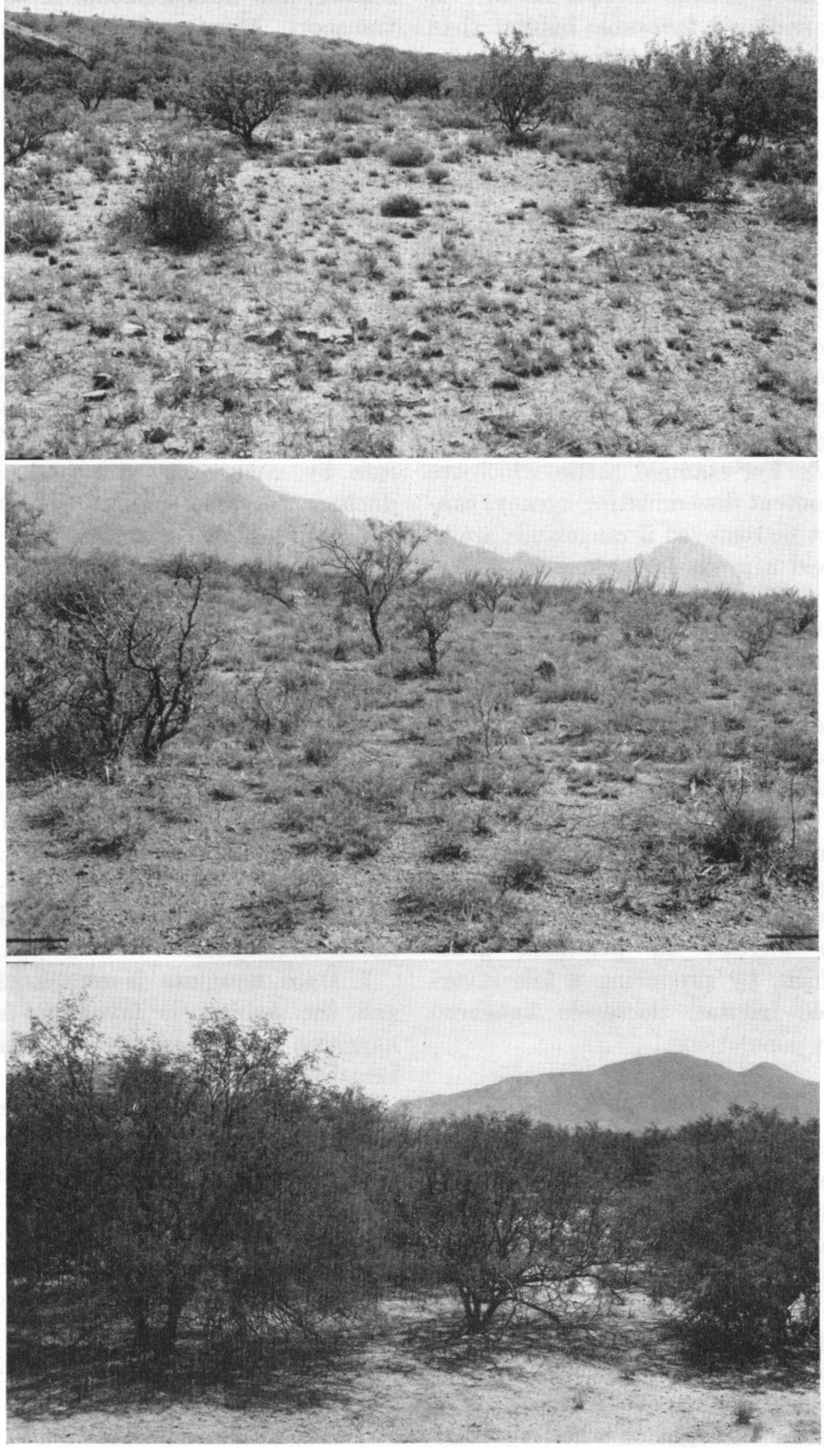

FIGURE 2. Interrelations of velvet mesquite, perennial grass, livestock grazing and Merriam kangaroo rats. *Upper*. Perennial grass density is being reduced as a result of mesquite invasion and heavy livestock grazing use. Rat population is moderate, but the environment is becoming increasingly favorable for rats. *Center*. Perennial grass virtually depleted as a result of heavy livestock grazing. Rat population is high. Increase of mesquite is being favored by rats. *Lower*. Site completely occupied by mesquite to the exclusion of perennial grass. Rat population is high but the site is fully occupied by mesquite and these animals are having little effect upon mesquite increase.

more beneficial to rats because of providing a favorable habitat than the rat is beneficial to the mesquite through seed dissemination.

Once the cycle: more mesquite→ less perennial grass→more rats→ more mesquite, is initiated because of the increase or suppression of modifying environmental factors, the rate of increase of mesquite is not likely to be slowed appreciably by removing kangaroo rats. Even though these rodents are removed from a mesquite-grass area, other agencies for dispersal are still available. For example, cattle, which are a potent disseminating agency, cannot be removed if rangelands are to yield a profit from grazing.

An approach which seems sounder than concentrating upon the disseminating agencies is that of preventing further invasion of mesquite by direct chemical or mechanical attack on the trees themselves. This destroys the source of seed and automatically eliminates the effect of disseminating agencies. Moreover, destruction of mesquite trees usually brings about an increase in perennial grass which, by producing a less favorable habitat, decreases kangaroo rat populations.

Summary

1. Some of the interrelations of velvet mesquite and Merriam kangaroo rats were investigated on the Santa Rita Experimental Range near Tucson, Arizona.

2. Velvet mesquite seeds are known to be buried in surface caches by kangaroo rats. These caches produce enough seedlings in spite of drought or other mortality factors to effect mesquite spread and increase.

3. By inference from home range studies, and measurements of seed transport, Merriam kangaroo rats were found to be capable of moving mesquite seed less than 200 feet on the average. On this basis and accounting for time required for mesquite trees to fruit, kangaroo rats could spread a mesquite border about 1 mile in about 500 years.

4. On a sample plot, 70 percent of the kangaroo rat burrows were located beneath mesquite trees and 99 percent of the trees were occupied by burrows. The trees further improve the habitat for rats by competing with and reducing perennial grass density which interferes with escape of rats from predators.

5. Mesquite and rats apparently have no dependency relation. Heavy populations of mesquite were found where there were no rats, and vice versa.

6. Cattle apparently are a more important biotic agency than kangaroo rats for mesquite seed dissemination. Among other biotic agencies of dispersal are deer, peccary, cottontail rabbit, jackrabbit and coyote.

7. Once mesquite is established and the habitat is favorable for kangaroo rats, these rodents may help to thicken the stand.

8. Once the cycle: more mesquite→less perennial grass→more rats→more mesquite, is initiated because of the effect of other dispersal agencies or the suppression of factors which may prevent the increase of mesquite, the rate of mesquite increase is not likely to be retarded appreciably by removing Merriam kangaroo rats.

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EFFECT OF TIME OF CUTTING ON YIELD AND BOTANICAL COMPOSITION OF PRAIRIE HAY IN SOUTHEASTERN NEBRASKA[1]

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More than three million acres of native prairie are harvested annually in Nebraska for hay. This crop is an important natural resource in the livestock industry in the State. Good management of a native meadow requires the adoption of practices that will give maximum feeding value per acre of hay consistent with the maintenance or improvement of the stand and vigor of the desirable plants.

The effects of five cutting treatments on the yield and botanical composition of a native upland meadow in eastern Gage County, Nebraska, were studied for an eight-year period, 1945–1952. The cutting treatments involved early (early July), midseason (early August), and late (mid-September) cutting each year and early and midseason cutting in alternate years during the six years, 1945–1950. In five of the six years, an aftermath crop was harvested in mid-September from the plots cut early that year. All the plots were cut in midsummer in 1951 and 1952 to determine the cumulative effects of the cutting treatments on yield and botanical composition.

[1] *Abstract of dissertation submitted in partial fulfillment of the requirements for the Ph.D. degree, A. & M. College of Texas, Range Management, College Station, Texas, 1953.*

Published with the approval of the Director as Paper No. 647, Journal Series, Nebraska Agricultural Experiment Station, Lincoln, Nebraska.

The average yields of hay from the midseason and late cuttings were 1.35 and 1.28 tons per acre, respectively, for the six-year period. The average yield from the early cutting was 0.93 tons per acre, but when this was combined with the aftermath crop harvested from the same plots, the total was 1.40 tons per acre. The combined yield of early cutting and aftermath from plots cut early in alternate years averaged 1.53 tons per acre. The midseason harvest from the same plots in the other years averaged 1.26 tons per acre.

The crude protein content of the three regular cuttings of hay decreased with the later dates of cutting each year. Variations in ether extract, crude fiber, nitrogen-free extract, calcium and phosphorus were not consistent. Generally, the chemical composition of the aftermath hay approximated that of the midseason-cut hay of the same year.

The results of feeding trials conducted during the first three years of the experiment have been reported in Nebraska Experiment Station Bulletin 403 (Baker *et al.*, 1951). The hays from the three dates of cutting were fed alone and with two levels of protein supplement as wintering rations for growing calves. In general, as the maturity of the grass increased, the amount of hay consumed by the calves decreased, a larger portion of the hay was refused, and the average daily gains of the calves decreased. These trends were evident whether the hay was fed with or without supplement. More pounds of gain per acre of hay were obtained from early-cut hay than from mid-season- or late-cut hays when fed alone or with about one-half pound of protein supplement per head daily. In every comparison, the late-cut hay produced fewer pounds of gain per acre of hay than either the early-cut or midseason-cut hays, regardless of whether protein supplement was fed.

Permanent belt transects 12 inches wide and 475 or more feet in length were used for determining the effects of the different cutting treatments on the native forbs. Many of the important broad-leaved species were reduced in vigor and abundance by early cutting. The total forb population in the transects decreased 19 percent under six years of early cutting as compared with increases of 49 and 87 percent under midseason and late cutting, respectively.

Psoralea floribunda, the most abundant and conspicuous forb in the meadow at the beginning of the study, appeared to be affected by the time of cutting more than any other species. A marked reduction in size of the plants was noted after only two years of early cutting. In 1951, the average weights per stem following six years of early, midseason and late cutting were 1.04, 2.72 and 2.90 grams, respectively. The populations in the permanent transects were approximately 70, 83 and 113 percent, respectively, of those present at the beginning of the experiment.

Other important forb species which were reduced in size and abundance by early cutting are: *Aster multiflorus*, *Helianthus rigidus* and *Gaura biennis*. The populations of *Amorpha canescens* in the transects remained relatively constant, but the average weight per stem was reduced 52 and 28 percent by early and midseason cutting, respectively, as compared with late cutting each year.

The average total density of the grasses, sedges and rushes in 24 permanent meter-square quadrats increased approximately 25 percent from 1946 to 1952. There were no significant changes in total density due to the cutting treatments. *Poa pratensis* increased markedly under all the cutting treatments. *Sporobolus heterolepsis* decreased 60, 34 and 19 percent under early, midseason and late cutting, respectively. Important increases in the density of *Andropogon scoparius* occurred under early and midseason cutting, and of *Bouteloua curtipendula* under early cutting.

Early cutting and the removal of an aftermath crop in mid-September reduced the vigor of the grasses the following spring as compared with midseason cutting. The average yield of hay in 1951 from the 10 plots which were cut twice in 1950 was 1.08 tons per acre as compared with 1.41 tons from the 10 plots which were cut once in midseason the preceding year. In 1952, following one year of uniform cutting, the average yields were 1.08 and 1.12 tons per acre, respectively.

Delaying the harvesting of the aftermath from mid-September to early October and to late October increased the yield of the grasses the following summer 18 and 38 percent, respectively.

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OU

A SIMPLE PULLER FOR SOIL TUBES[1]

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Sampling by use of a soil tube is often laborious because of the difficulties involved in removing the tube from certain soils after it has been driven below one or two feet in depth. Soils high in clay content prevent the tube from being removed easily; also, extremely dry soils will settle and pack about the enlarged portion of the cutting head thus wedging the tube in the hole.

An apparatus consisting of an automobile bumper jack, five feet of 2/0 passing link chain and a simply constructed jack platform has been used successfully for removing soil tubes from several types of soils (Fig. 1).

The jack platform is constructed from two by four lumber. A nine-inch length of 1½-inch angle iron is used to support the direct thrust of the bumper jack. The platform is 9 by 16 inches in size. The opening for the soil tube is wide enough to permit the pounder head of the tube to pass through easily.

In operation, the platform is placed over the tube after insertion in the soil and blocked beneath for levelling on uneven ground. The chain is wound around the tube four or five times to prevent slipping when pressure is applied. The ends of the chain are tied in a square knot and the bumper jack set up as shown in the photograph. When the jack has been raised to its maximum height and the tube is still stuck, the jack can be lowered and the chain will slide down the tube to the platform, ready to continue lifting. The jack and tube should be parallel for best results. The type of chain used with this apparatus is made of soft material which will not score the tube.

Figure 1. Soil tube puller in operation, showing the soil tube and arrangement of bumper jack, chain and platform. The black part of the platform is 1½-inch angle iron; the remainder is constructed of wood.

[1] *Contribution from Federal Aid in Wildlife Restoration Act, Project California W-31-R.*

BOOK REVIEWS

Edited by Hudson G. Reynolds, Rocky Mtn. For. & Range Exp. Sta., Box 951, Tucson, Arizona.

Principles of Farm Management. By J. Norman Efferson. *McGraw-Hill Book Co., Inc., New York. 431 pages. 1953. $6.00.*

This book is concerned chiefly with the management of a segment of the business of agriculture—the farm. It differs from the numerous other books on the subject in that the author treats of farming—any farm—as a business organization. He does not discuss in detail variations in types of farming between regions or areas which may account for differences in income. Therefore a reader will not find any great elaboration of a particular type of farming such as cotton, wheat, dairying or beef cattle production. This is a new and refreshing approach.

Professor Efferson never loses sight of his thesis that farming is a business and should be conducted by people who, although they may be schooled in the biological sciences, must be businessmen. He states, "Farming in the United States is essentially a business rather than a way of life." For many farmers, and particularly for ranchers, this would seem to be an extreme point of view. Some feel it can be both.

The author has sought to make the book an introduction to basic principles. As such he has done a remarkable job in steering clear of economic jargon. There is little on economic theory and it is confined to one chapter with a discussion of six economic principles of importance to specific farming problems. In clear and concise language Professor Efferson defines and applies to farm management the principles of diminishing returns, marginal return, substitution, comparative advantage and opportunity costs.

The rancher will be interested in the stress the author places on weather as a variable factor affecting the farm business. He points out that farming is a biological business and differs from industry which is mechanical. In extending this thesis, Efferson details the effect of weather on the biological processes in dictating income and the sometimes disastrous effects on the capital structure of the farm. It is forcefully pointed out in the book that farm management practices must be highly flexible to compete with the vagaries of the weather.

The author suggests in the preface that the book will find most usefulness as a first course for students of agriculture and will be of some application to farmers in developing farm management programs. An indication of its primary objective can be found in the questions and exercises following each chapter.—*H. R. Hochmuth*, Bureau of Land Management, Washington, D. C.

Breeding Better Livestock. By Victor A. Rice, Frederick N. Andrews, and Everett J. Warwick. *McGraw-Hill Book Co., Inc., New York. 465 pages. 1953. $6.50.*

The combined efforts of the Animal Husbandry professors of the Universities of Massachusetts, Purdue and Tennessee have resulted in a well-rounded and complete analysis of the what and how of breeding better livestock. From fundamental background material the book proceeds into complicated and deeper material of interest to the more finished breeder. The wealth of well illustrated material is divided into four sections: (1) Background for Animal Breeding, (2) Mechanisms of Production, (3) Mechanisms of Heredity, and (4) The Art of Breeding. Each section is complete in itself yet develops logically into the succeeding unit. In addition, teachers and students alike will find the "List of Visual Aids", which is in the form of an appendix, of real benefit.

In the reviewer's opinion the book is not as readable as the former works of Victor A. Rice which are "bibles" on my desk. This may easily be the result of combining the slightly different styles and approaches of the three authors. Western breeders may feel the book has wider application east of the Rockies and that some of the problems of the Intermountain region have been overlooked. Those breeders using some *Bos indicus* blood may find that some of the *Bos indicus-Bos taurus* differences, interactions and recombinations have been overlooked.

The authors have covered a very wide field in a constructive, helpful and quite complete way. This book will be a welcome and worthy addition to the library of every breeder from tyro to purebred breeding artist.—*E. S. Humphrey*, Mgr., Bard-Kirkland Ranch, Kirkland, Arizona.

Handbook of Plants of the Colorado Front Range. By William A. Weber. *University of Colorado Press, Boulder, Colorado. 238 pages. 1953. $5.00.*

This is a comprehensive key to the flora of the central portion of the Front Range of Colorado. The author identifies and describes over 1,300 species found in this area. The description of plant zones and references to these zones in identification are helpful. The illustrated floral parts and illustrated glossary are well prepared and essential to the use of the key. One of the more interesting and helpful contributions is the explanation of the source or meaning of the species names.

Dr. Weber has had wide experience in taxonomic botany both in the United States and Canada. His knowledge of the flora of the Front Range has been obtained from intensive field and herbarium study. The completeness of his treatment of the flora of the area amply illustrates his qualifications and ability in his chosen field.

The book is an excellent text for students of taxonomy or for well-trained technicians working with vegetation in the Front Range of Colorado. The layman, tourist or nature lover not trained in botany would find it difficult to use unless he was willing "to make a serious effort" to "learn to recognize the plants around him" as suggested by the author.—*W. M. Johnson*, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

The Clever Coyote. By Stanley P. Young and Hartley H. T. Jackson, *The Stackpole Co., Harrisburg, Pa. 411 pages. 1951. $6.50.*

The Clever Coyote is really two books. Part II, "Classification of the Races of the Coyote", by Hartley H. T. Jackson, is a thorough taxonomic treatment which includes descriptions, ranges and subspeciation. Part I, "Life Habits, Economic Status and Control" by Stanley P. Young, of greater interest to range men, begins with the spread, history and distribution of the coyote. The account of habits and characteristics helps in understanding how the coyote has survived and prospered in spite of extermination efforts. Another section discusses domestic livestock prey, food habits and rodent relationships. Finally, several control methods are discussed in detail, although modern chemical techniques are only briefly mentioned.

Predator control, in general, and coyote control, in particular, have long been controversial subjects. Extermination of the coyote is now seldom advocated but local control of problem animals is frequently an economic necessity. In this volume, Stanley P. Young combines his personal experience, which covers 33 years in government predator control work, and the selected work of other authors. He has succeeded in arousing the reader's interest in the coyote's adaptability, tenacity of life and ability to survive in spite of man's persecution. Author Young has not answered clearly, however, the basic questions of when and where control should be practiced and how much control of the coyote is economically sound.

To range men or anyone interested in wildlife, this book is recommended. The reader may find it necessary to read certain sections carefully. On some points his conclusions may differ from those of the author.

Every reader will recognize this volume as the result of years of experience by both authors and a welcome addition to the slowly growing list of monographs on North American wildlife.—*C. R. Hungerford*, Arizona Cooperative Wildlife Research Unit, University of Arizona, Tucson, Arizona.

Ernest Thompson Seton's America. Edited by Farida A. Wiley. Illustrated with drawings by Mr. Seton. *The Devin-Adair Company, New York. 413 pages. 1953. $5.00.*

To those familiar with Seton's work this volume will be an excellent refresher. To those who have resorted only to his classic *Lives of Game Animals*, as a reference, the book will picture in a splendid way the work and life of an able and versatile naturalist.

The editor has assembled not only samples of the best of Seton's work but also biographical material, the techniques he developed, his artistry and some fine bits of philosophy. Seton chose his profession early and proceeded to equip himself with tools of the trade. This included two full years of study of anatomy and art to enable him to portray pictorially his subjects and their activities. As a story teller he was a dynamic writer and lecturer. His drawings were not only vivid but noted particularly for the accuracy in which the form and pelage of animals were depicted and for the wholly lifelike portrayal of attitudes and action.

The work is timely in that it covers a profession that has largely disappeared. Seton laid no claim to science, spoke of scientists as the third person "they", chided them for attempting to inject unneeded science into the layman's approach to biology and used unscientific tricks such as bundling up years of observation of a species into a story of only a few moments in the life of a single wildling. It may be regretted that recent educational opportunities have drawn potential naturalists into more somber scientific fields and more regimented vocations bent on satisfying more than an interest in a biological field.

An introduction by the editor forms an excellent biography which is made increasingly intimate through notes by Mrs. Julia M. Seton on his life and work. There is a table of contents, a carefully prepared index and a list of sources of each of the stories. Reproduction is of high quality.

Seton fans may complain that the volume is all too brief and that the large print results in excluding much fine material. They may also feel that the number of sketches reproduced was all too few and unsatisfying. The book is highly recommended for anyone to whom wildlife is of interest, Young America included.—*F. P. Cronemiller*, Div. of Wildlife Mgt., U. S. Forest Service, San Francisco, Calif.

Photography Afield. By O. I. Sprungman. *The Telegraph Press, Harrisburg, Pa., 449 pages. 1951. $7.50.*

This interesting book contains a wealth of information and suggestions for the novice, the advanced amateur and even many so-called professionals. The field of outdoor photography is well covered in terms that anyone can understand.

The book appears to have a twofold purpose. One is to attract individuals who have yet to take their first picture. The other is to help a vast army of snapshot enthusiasts to gain greater enjoyment and satisfaction for their efforts, in view of the fact that perhaps not over 20 percent of the photos snapped by the novice are of a quality leading to any semblance of satisfaction.

The discussion of camera types, kinds of lenses, shutters, lens openings, films and various accessories with the advantages and limitations in each instance is invaluable to the beginner in making his selection of equipment and to the more proficient amateur who wishes to get the most from his present equipment. The section on composition is indeed timely for too often the camera enthusiast fails to realize that a really satisfying picture can be made with more attention to proper arrangement or viewpoint of subject matter.

The author's discussion of photos of fishing, hunting, animals, birds, big game, insects and nature in general includes countless suggestions for making pictures. Just enough of the darkroom procedure in connection with processing films and the making of prints or enlargements is given to show that the ultimate degree of enjoyment from picture-taking lies in being able to follow through to the finished product.

As with the rest of the book, the sections on flashlight color and movie photography are replete with ideas for making more satisfying pictures.

One can read between the lines that good pictures don't just happen but are usually the result of some planning, thought, effort and time. If we would all realize this we might reap more in the way of enjoyment out of our cameras.—*Matt Culley*, Prescott, Arizona.

Fresh Water from the Ocean. By Cecil B. Ellis. *The Ronald Press Co. New York. 217 pages. 1954. $5.00.*

This book, sponsored by the Conservation Foundation, is a thorough evaluation of a subject which has created considerable public interest in the last few years. The aim of the study was to determine whether fresh water could be extracted from the ocean on a significant scale at a reasonable price. The conclusion was reached that within the next 10 years such conversion should be within the financial possibilities of many large cities and industries in the United States which do not have access to river water. At present, the costs of conversion for irrigation purposes are prohibitive. The author concludes in this regard:

> For large irrigation projects it seems unlikely that fresh water from the ocean can ever be made economic by any extraction method suggested so far—unless most of the cost is borne by other installations and commerce attracted to the irrigated region. This is primarily because crops under irrigation require a quantity of water which is large in relation to the value of the ultimate product.

People without training in physics and chemistry will find much of the material difficult reading. However, technicians concerned with planning or evaluating water supply problems for cities, industry and education will benefit greatly from this book.—*H. G. Reynolds*, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

New Publications of Interest

Agricultural Policy: Farm Programs and National Welfare. By R. Schickele. *McGraw-Hill Co., N. Y. 453 pages. 1954. $6.50.*

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Thirteen Million Acres: The Santa Fe Railway and its Western Land Grant. By W. S. Greever. *Stanford Univ. Press, Stanford, Calif. 200 pages. 1954. $4.00.*

CURRENT LITERATURE

Edited by Arnold M. Schultz, School of Forestry, University of California, Berkeley, California

RANGE PLANTS

Forage value, chemical composition, ecology, physiology, systematics, genetics

Currie, B. W. Climatic trends on the Canadian prairies. *Agr. Inst. Rev. 9 (1): 21–23. Jan.–Feb. 1954.* (Univ. Saskatchewan, Sask.)

Dougall, H. W. Kikuyu grass: 1—Seasonal variation in composition of degenerate and productive pastures. *East African Agr. Jour. 19 (2): 74–80. Oct. 1953.* (Dept. Agr., Kenya)

Gaines, E. M., R. S. Campbell and J. J. Brasington. Forage production on longleaf pine lands of southern Alabama. *Ecology 35 (1): 59–62. Jan. 1954.* (So. Forest Expt. Sta., New Orleans, La.)

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Hutton, E. M. Production of allopolyploids in *Phalaris* by a modified colchicine technique. *Jour. Austral. Inst. Agr. Sci. 19 (4): 244–247. Dec. 1953.* (Div. Plant Industry, Canberra)

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Thakur, C. and H. L. Shands. Spring small grain agronomic response to plant clipping when seeded at two rates and fertilized at two levels of nitrogen. *Agron. Jour. 46 (1): 15–19. Jan. 1954.* (Univ. Wisconsin, Madison)

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Whitman, Warren C. Pyramid Park experimental area laboratory for rangeland research. *N. Dak. Bimo. Bull. 15 (2): 63–66. Nov.–Dec. 1953.* (N. Dak. Agr. Expt. Sta., Fargo)

RANGE AND PASTURE MANAGEMENT

Management plans, utilization, condition, maintenance

Hardison, W. A., J. T. Reid, C. M. Martin and P. G. Woolfolk. Degree of herbage selection by grazing cattle. *Jour. Dairy Sci. 37 (1): 89–102. Jan. 1954.* (Cornell Univ., Ithaca, N. Y.)

Kennedy, W. K. and C. M. Johnson. How to keep ladino clover. *What's New in Crops and Soils 6 (7): 20–22. Apr.–May 1954.* (Cornell Univ., Ithaca, N. Y.)

Whyte, R. O. Mediterranean grasslands and fodder research. *World Crops 6 (2): 59–61. Feb. 1954.* (Food and Agr. Organization, Rome, Italy)

RANGE IMPROVEMENT

Artificial revegetation, noxious plant control, mechanical improvements, fertilization

Anonymous. Better pastures with drill seeding and banded fertilizer. *Farm Mangt. 3 (4): 31–33. Apr. 1954.*

Bohmont, Dale W. 2,4-D is paying off on big sagebrush. *Farm Jour. pp. 34–35, 181. Apr. 1954.*

Clark, Wilson F. Controlling weeds and scums in small ponds. *Breeder-Stockman 15 (9): 10, 11, 96, 102. Feb. 1954.*

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Bailey, Reed W. and George W. Craddock. Contributions of western public lands to conservation. *Jour. Soil and Water Conserv. 9 (2): 59–64. Mar. 1954.* (Intermtn. Forest and Range Expt. Sta., Ogden, Utah)

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Chepil, W. S. Seasonal fluctuations in soil structure and erodibility of soil by wind. *Soil Sci. Soc. Amer. Proc. 18 (1): 13–16. Jan. 1954.* (Kans. Agr. Expt. Sta., Manhattan)

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RANGE LIVESTOCK MANAGEMENT

Production, feeding, pests and diseases, history

Anonymous. Does a break in growth hurt beef calves? *Agr. Res. 2 (9): 8–9.* Sept. 1953.

Clegg, M. T. and H. H. Cole. The action of stilbestrol on the growth response in ruminants. *Jour. Anim. Sci. 13 (1): 108–130. Jan. 1954.* (Univ. Calif., Davis)

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Rohlf, John. Big feedlot news ahead. *Farm Jour., Apr. 1954, p. 31, 176.*

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Bibliographies, methods, equipment

Castle, M. E. Grassland production and its management using the dairy cow. *Jour. Brit. Grassland Soc. 8 (3): 195–211. Sept. 1953.* (Univ. Liverpool Vet. Field Sta., Neston, Cheshire)

Huhtanen, C. N., R. K. Saunders and L. S. Gall. Fiber digestion using the miniature artificial rumen. *Jour. Dairy Sci. 37 (3): 328–335. Mar. 1954.* (Nat. Dairy Res. Lab., Oakdale, L. I., N. Y.)

Rowland, E. F., T. D. Fagan and Geo. A. Crabb, Jr. A slide rule for soil moisture determinations. *Agr. Engin. 35 (3): 163–164. Mar. 1954.* (BPISAE, East Lansing, Mich.)

Shaw, Byron T. Research and the cattleman's future. *Breeder-Stockman 15 (9): 7, 106, 108–114. Feb. 1954.*

Williams, C. B. The statistical outlook in relation to ecology. *Jour. Ecol. 42 (1): 1–12. Jan. 1954.* (Rothamsted Expt. Sta., Harpenden, Herts)

COMING EVENTS

July 11–14. Western Section, Amer. Soc. of Animal Production, Oregon State College, Corvallis, Ore.

July 21–22. Western Section, Canad. Soc. of Animal Production, Kamloops, Brit. Columbia

July 26–28. Western Farm Economics Association, Estes Park, Colo.

Sept. 5–9. Amer. Institute of Biological Sciences, Univ. of Florida, Gainesville, Fla.

Sept. 6–9. Amer. Forestry Association, Multnomah Hotel, Portland, Ore.

Oct. 17–20. Soc. of Amer. Foresters, Hotel Schroeder, Milwaukee, Wisc.

Nov. 8–12. Amer. Society of Agronomy & Soil Science Society of America, St. Paul Hotel, St. Paul, Minn.

Nov. 15–17. Soil Conservation Soc. of America, Hotel George Washington, Jacksonville, Fla.

Nov. 26–27. Amer. Soc. of Animal Production, Chicago, Ill.

Dec. 6–9. Natl. Wool Growers Association, Salt Lake City, Utah

Dec. 26–31. Amer. Assoc. Advancement of Science, Univ. of California, Berkeley, Calif.

Fresh Water from the Ocean. By Cecil B. Ellis. *The Ronald Press Co. New York. 217 pages. 1954. $5.00.*

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NEWS AND NOTES

Meetings and Conferences

International Meeting on Forest Grazing Held by FAO

The first international meeting to consider problems of livestock grazing in forest areas, sponsored by the Food and Agricultural Organization of the United Nations, was held in Rome, Italy from March 29 to April 3, 1954. The meeting, attended by nearly 50 foresters and agriculturalists from 26 countries, was planned by W. R. CHAPLINE, formerly Chief, Division of Range Research of the U. S. Forest Service, and now Chief, Forest Conservation Section of the Forestry Division of FAO. Chapline was assisted by CLARK E. HOLSCHER of the Pacific Northwest Forest and Range Experiment Station, who was loaned to FAO.

The meeting brought out that grazing is one of the principal uses of forest lands the world over, along with timber production and watershed protection, and that, in many cases, such multiple use is most desirable from a social and economic standpoint. A general policy on forest grazing was set forth which underdeveloped countries might follow in forest range management and improvement programs.

JOSEPH F. PECHANEC, Division of Range Research, Forest Service, was elected Chairman of the meeting; R. KOBLET of Switzerland and A. LATESSA of Italy were named Vice-Chairmen. Working committees prepared recommendations on: (1) forest grazing policy, (2) technical range management and (3) administration, research, surveys, education, training and extension.

British Conferences Stress Grassland Management

Two recent conferences held in Great Britain stressed grassland management and the improvement of production on grazing lands. The first, held in London, on November 17, 1953 by the Agriculture Group of the Society of Chemical Industry, featured discussions on the general management of grassland by WILLIAM DAVIES, Director, Grassland Research Station, Hurley and on eradication of weeds from grazing land and turf by W. G. TEMPLEMAN of Jeallots' Hill Research Station. Another conference at Chelmsford, held on January 14, 1954, dealt with various aspects of grazing management and the utilization of leys. The meeting was organized by the National Agricultural Advisory Service of the Ministry of Agriculture.

Natl. Assoc. of Soil Conservation Districts Meeting Held in New Orleans

At the annual meeting of the National Association of Soil Conservation Districts held in New Orleans, Louisiana in late February, the group called for a strong program of research in soil and water conservation by additional federal funds to be placed at the disposal of research agencies. Speakers at the meeting included Secretary of Agriculture E. T. BENSON; DONALD A. WILLIAMS, Administrator of the Soil Conservation Service; ORME LEWIS, Asst. Secretary in the Department of Interior; and WATERS DAVIS, JR. of League City, Texas, re-elected President for the coming year. NOLEN J. FUQUA of Duncan, Oklahoma was named National Vice President.

Field Day Held at San Joaquin Experimental Range

On April 17, 1954, foothill ranchers from the San Joaquin Valley met at the San Joaquin Experimental Range to review results of reseeding tests and other work conducted jointly by the California Forest and Range Experiment Station, the University of California Agricultural Experiment Station and the Agricultural Research Service. More than 200 species of annual and perennial plants from many parts of the world have been tested for local range reseeding. Adapted species, seeding recommendations and procedures for establishing stands were discussed by LISLE R. GREEN, Agricultural Research Service.

Also highlighted on the program was an examination of treated wooden fenceposts after 9 years in the ground. Methods and costs of such treatment were discussed by WOODBRIDGE METCALF, Extension Forester, and CHARLES A. GRAHAM, Superintendent of the Experimental Range.

Hopland Station Work Reviewed at Field Day

The Hopland Range Field Station of the University of California held its second annual field day on May 8, 1954. The progress of research was reviewed for chemical control of woody vegetation, seeding annual legumes on rangeland, range fertilization, sheep management and deer populations. California's Livestockman of the Year, W. HUGH BABER, addressed the group.

Bureau of Land Management Announces State Supervisors

New supervisors of the state offices of the Bureau of Land Management, with their respective headquarters are:

- ED PIERSON, Phoenix, Arizona
- LUTHER T. HOFFMAN, Sacramento, California
- MAX CAPLAN, Denver, Colorado
- J. RUSSELL PENNY, Boise, Idaho
- ROBERT D. NIELSON, Billings, Montana
- EDMUND R. GREENSLET, Reno, Nevada
- EASTBURN R. SMITH, Santa Fe, New Mexico
- GWYNNE H. SHARRER, Portland, Oregon
- WILLIAM N. ANDERSON, Salt Lake City, Utah
- JESSE M. HONEYWELL, Spokane, Washington
- RAYMOND R. BEST, Cheyenne, Wyoming

Grassland Newsletter to be Issued by Extension Service

The Federal Extension Service announced the publication of a quarterly *Grassland Newsletter* from material sent in from the states through the Office of Experiment Stations and the Extension Service. Supplemental material will be furnished by the Federal research staff at Beltsville. C. M. FERGUSON, Administrator of the Federal Extension Service, is chairman of the steering committee for the publication.

BLM Regional Offices Converted to Area Offices

The five Bureau of Land Management regional offices have been reduced to the following three Area Offices:

Area I—Portland, James F. Doyle, in charge

Area II—Salt Lake City, H. Byron Mock, in charge

Area III—Denver, Westel B. Wallace, in charge

Animal Diseases to be Studied at Plum Island Laboratory

Bids have been requested by the U. S. Department of Agriculture for the construction of laboratory facilities at Plum Island, New York, for the study of foot-and-mouth disease and other foreign diseases of animals that create a threat to the livestock industry. Plum Island is owned by the Department of Defense which has made the site available under an inter-agency agreement. Congress has appropriated $10 million for construction of the facilities, according to Dr. M. S. Shahan, Director of the Agricultural Research Service's Plum Island Animal Disease Laboratory.

Secretary Benson Plans to Declare Mexico Free of Foot-and-Mouth Disease

If present favorable conditions with respect to foot-and-mouth disease in Mexico continue and no more outbreaks occur, Secretary E. T. Benson will declare our neighboring Republic to be free of the disease as of December 31, 1954, and the U. S.-Mexican border opened to imports of livestock and livestock products. The eradication campaign of the Joint Mexican-U. S. Commission has been under the direction of Dr. Lauro Ortega, Mexican Subsecretary of Agriculture for Livestock, and Walter Thurston, co-director and special assistant to Secretary Benson. The Secretary's advisory committee, headed by Albert K. Mitchell of New Mexico, has devoted much effort to the eradication program.

Charles U. Duckworth, former head of the California Department of Agriculture, has been in the Philippines on a technical assistance program under the FOA to help in combatting recent outbreaks of the foot-and-mouth disease in carabao. Duckworth has earlier served in an advisory capacity on the Mexican outbreaks.

National Forests Consolidated

Consolidation of the following national forests has been announced by the U. S. Forest Service: Nanthahla and Pisgah in North Carolina; Crook, Gila, Coronado and Tonto in Arizona; Minidoka and Sawtooth in Idaho; Clark-Mark Twain and Shawnee in Missouri and Illinois; Harney and Black Hills in South Dakota and Wyoming; Cabinet with Lolo Kaniksu in Montana; Wallowa and Whitman in Oregon. One forest will be eliminated in California and in Colorado.

Alaskan Livestock Production Studied

The potentialities for range livestock production are being studied by the Bureau of Land Management in cooperation with Gov. Heintzleman of the Territory of Alaska, Messrs. Irwin and Anderson of the Agricultural Research Administration of Palmer, Alaska and others.

Conservation Week Sponsored by Colorado A. & M. College Group

Colorado A & M students, comprising a Conservation Council under the direction of Prof. J. V. K. Wagar and Chuck Terrell, Extension Conservationist, carried out a vigorous educational program in the celebration of Colorado Conservation Week, April 19–25, 1954. Conservation guides were sent to all individuals and organizations cooperating in the movement.

State Conservationists of SCS Announced

State and territorial Conservationists in charge of the program of the Soil Conservation Service in western states and territories as announced by D. A. Williams, Administrator, include:

Robert V. Boyle, Phoenix, Arizona

John S. Barnes, Oakland, California

Kenneth W. Chalmers, Denver, Colorado

Robert N. Irving, Boise, Idaho

Frank H. Mendell, Des Moines, Iowa

Fred J. Sykes, Salina, Kansas

Truman C. Anderson, Bozeman, Montana

H. G. Bobst, Lincoln, Nebraska

George Hardman, Reno, Nevada

Robert A. Young, Albuquerque, New Mexico

Lyness G. Lloyd, Bismarck, North Dakota

Ray Walker, Oklahoma City, Oklahoma

Harold E. Tower, Portland, Oregon

Ross D. Davies, Huron, South Dakota

Henry N. Smith, Temple, Texas

J. A. Libby, Salt Lake City, Utah

Paul C. McGrew, Spokane, Washington

B. H. Hopkins, Casper, Wyoming

Charles W. Wilson, Palmer, Alaska

John H. Christ, Honolulu, Hawaii

Summer Sessions at Jackson Hole Research Station

The Jackson Hole Biological Research Station, administered by the University of Wyoming under agreement with the New York Zoological Society is available for use by research workers until September 10, 1954. Range Society members on the Advisory Council for the Research Station include Reed W. Fautin, Director of Wildlife Conservation and Management, John F. Reed, Associate Professor of Botany, and Alan A. Beetle, Associate Professor of Agronomy, all of the University of Wyoming.

"Grass—The Elko Way" Movie Produced by Nevada Soil Conservation Districts

"Grass—The Elko Way" is the title of a color motion picture narrated by Hollywood actor and Elko County ranch owner James Stewart and produced by the Northeast Elko Soil Conservation District and the Nevada Association of Soil Conservation Districts. Filmed last summer in the two million acre district, the picture relates how the rancher-supervisors of this area have initiated a widespread program of grass reseeding, restoration and improvement.

The district supervisors pioneered in getting land owners and state and federal agricultural and land management agencies to work on a common program for improvement on private and public lands.

Cooperating with the district and the state association in the production of the film were the Nevada Cattlemen's Association, Nevada State Soil Conservation Committee, Nevada State Departments of Fish and Game and Agriculture, U. S. Fish and Wildlife Service, Bureau of Land Management, Soil Conservation Service, Forest Service, and Agricultural Stabilization and Conservation Service.

GRAHAM HOLLISTER, rancher of Genoa, Nevada was chairman of the Nevada Association committee and EYER BOIES, of the Northeast Elko Supervisors arranged for the filming, according to HARVEY S. HALE of Rogerson, Idaho, Chairman of the District.

Halogeton Control Reviewed at Salt Lake City

A joint meeting of Halogeton Control and Research Workers was held March 18–19, 1954 in Salt Lake City, Utah. The meeting was held to summarize work completed by action agencies and research organizations on the Halogeton control problem and to formulate plans for 1955 fiscal year. The group included representatives from all states having an infestation problem: Bureau of Land Management, Agricultural Research Service, Bureau of Reclamation, Utah State Agricultural College, University of Idaho, University of Nevada, Bureau of Animal Industry and State Land Commission of Idaho.

RANGE MEN ABROAD

The Foreign Operations Administration conducted a 3-week training course in Jordan on range management techniques, including waterspreading, May 3–21, 1954. Officials and technicians from eight Near East countries reviewed the waterspreading handbook developed by FOA, estimating watershed runoff characteristics, learning topographic mapping, designing waterspreading systems and studying the use of heavy machinery and hand labor in construction.

U. S. technicians conducting the training course and advising individual countries on range management practices and waterspreading were: JOSEPH F. PECHANEC—Forest Service; O. S. AAMODT and ALVIN D. AYERS,—Agricultural Research Service; FLOYD D. LARSON, TOM I. DUDLEY and NORMAN FRENCH—Bureau of Land Management.

EARL D. SANDVIG recently returned from a special mission to Chile to study range conditions and make recommendations to the Chilean government. He has accepted the position of assistant regional forester in charge of personnel management for the Pacific Northwest region of the Forest Service. Sandvig was formerly chief of range and wildlife management for this region.

THOMAS I. DUDLEY, formerly with the BLM in Miles City, Montana, left in April on a two-year technical assistance assignment to Amman, Jordan, under the FOA. Dudley will replace NORMAN FRENCH, who is returning to the Bureau of Land Management in the U. S. Dudley will be Chief of the Cooperative Department for Range and Forest Resource Development and responsible for projects in waterspreading, soil conservation, forestry, underground water development, range improvements and range reseeding.

PALMER SCHIELE, agricultural engineer for the BLM at Albuquerque, New Mexico, has arrived in Israel on a two-year assignment under the Point IV program. Palmer will work with the Israeli Government in initiating range waterspreading and other soil and water conservation measures on rangelands.

KEITH J. FINLEY, agricultural engineer in the Albuquerque, New Mexico office of the Bureau of Land Management is in Amman, Jordan on a two-year assignment to serve as head engineer for waterspreading projects in the Cooperative Department of Range and Forest Resource Development with the U. S. Operations mission to Amman.

IN THE FIELD

ALBERT K. MITCHELL, rancher of Albert, New Mexico, is a member of President Eisenhower's National Agricultural Advisory Commission which is reviewing the agricultural problems of small farmers. The commission recently endorsed the 1955 budget requests for agricultural research and education as proposed by the Department of Agriculture.

WELDON O. SHEPHERD, formerly in charge of Range Management Research at the Southeastern Forest Experiment Station at Asheville, North Carolina, has transferred to Washington as assistant in the division of Range Management Research in the Forest Service.

E. J. WOOLFOLK, formerly in charge of range management research work at the Northern Rocky Mountain Forest and Range Experiment Station at Missoula, Montana, has transferred to the Southeastern Forest Experiment Station at Asheville, North Carolina in charge of range management research.

CLARENCE E. KINGERY, formerly Conservation Specialist with the Soil Conservation Service at Fort Worth, Texas, is Range Conservationist for the western two-thirds of Oklahoma with headquarters in the Oklahoma State Office.

Recent appointments and transfers in the Soil Conservation Service include:

- ALAN H. ANDERSON, Soil Conservationist, Coleman, Texas
- R. Y. BAILEY, Research Liaison Representative, Auburn, Alabama
- JOHN A. BARTRUFF, Assistant State Conservationist, Laramie, Wyoming
- ROBERT L. BROWN, Assistant State Conservationist, Portland, Oregon
- DONALD H. FULTON, Soil Conservationist, Elko, Nevada
- THOMAS P. HELSETH, Assistant State Conservationist, Boise, Idaho
- PETER N. JENSEN, Range Conservationist, Dodge City, Kansas
- JESSE J. NEWLUN, Soil Scientist, Yakima, Washington
- R. M. MILHOLLIN, Range Conservationist, Stephenville, Texas

RUDY J. PEDERSON, Soil Scientist, San Angelo, Texas

PAUL M. SCHEFFER, Washington-Field Biologist, Oakland, California

L. E. SHERBURNE, Soil Conservationist, Soda Springs, Idaho

FRANCIS A. SMITH, Soil Conservationist, Pinedale, Wyoming

JAMES E. SMITH, JR., Plant Material Specialist, San Antonio, Texas

RALPH S. E. SMITH, Soil Scientist, Watford City, North Dakota

JULIEN J. TURNER, Conservation Engineer, Phoenix, Arizona

VIRGIL L. WEISER, formerly with the SCS at Dickinson, North Dakota, is employed by the North Dakota Agricultural Extension Service.

EAMOR C. NORD, who recently completed residence requirements for the Ph.D. in range management at Texas A. & M. College, is now with the California Forest and Range Experiment Station working on the new Game Browse Project with A. L. HORMAY.

W. E. MARTIN, Extension Soils Specialist of the University of California, is heading large-scale range fertilizer trials in seven California counties in 1954 in cooperation with fertilizer companies, local stockmen and county farm advisors.

CLARK TERELL of the University of Idaho is the new Superintendent of the Knoll Creek Field Station, Nevada Agricultural Experiment Station at Contact, Nevada.

In Memoriam

Members of the Society extend their sympathy to Bob Campbell, former Editor of the Journal, at the death of his wife, Imogene Foltz Campbell, on April 21, 1954. Mrs. Campbell died of cancer following a year's illness.

Mrs. Bob Campbell was active with Bob on the detailed editorial work of getting out the Journal for the period 1950 to 1952. She helped Bob immensely in this work, especially during the last year when the press of other duties occupied his time. Mrs. Campbell attended several of the meetings of the Society and her presence will be missed by many.

David A. Savage, (1901–1954)

Range management and the Range Society lost one of its most active supporters and workers in the death of DAVID A. SAVAGE, former president of the American Society of Range Management, on April 3, 1954. Savage, 53, was found dead at his home from self-inflicted gunshot wounds. At the time of his death, "Dave" was the Superintendent of the U. S. Southern Great Plains Field Station at Woodward, Oklahoma.

Savage was born at Laurel, Montana on August 12, 1901. After graduation from Montana State College in 1924 he took a position as Junior Agronomist with the Bureau of Plant Industry until 1927. He was a member of the experiment station staff at Montana State College in 1928 and of the Fort Hays Experiment Station until 1937 when he became associated with the Division of Forage Crops and Diseases work at the Southern Great Plains Field Station. Savage became Senior Agronomist and Superintendent of the station in 1948.

Dave left a well marked trail behind him of major accomplishments in the field of rangeland improvement. He developed methods for reseeding abandoned farm and crop land which have been applied on well over a million acres in the Southern Great Plains. Savage was also instrumental in developing brush control practices for range improvement that have been used on nearly three million acres of sagebrush-infested ranges. Through his efforts, information was given to the public on many additional phases of livestock husbandry and range improvement which greatly helped to increase the standard of living of the stockmen of that region.

D. A. SAVAGE

In 1946 Savage was detailed to Alaska by the U. S. Department of Agriculture to investigate the potentialities of that area for range livestock. He was a member of a technical assistance mission group to Uraguay and in November, 1952 he was assigned as a range management specialist on an FAO mission to Mexico. This assignment was conducted at the request of stockmen and the government of Mexico to advise and assist in the development, planning and executing of a program for increasing the productivity of the grazing lands of that country. Savage resumed his position as Superintendent of the Southern Great Plains Field Station in November, 1953.

Dave was a charter member of the American Society of Range Management and served as President in 1950. He was active in the affairs of the Society and aided greatly in its early development.

ARIZONA

LYNN HENRY, Secretary of the Arizona Section, reports that the section now has 232 members, of which 112 are ranchers. The Arizona Section has consistently had a high proportion of ranchers in its membership and the group is to be commended for maintaining this active interest. This section ranked first in 1953 in getting the largest number of new members. Keep up the good work!

CALIFORNIA

MILTON D. MILLER, Extension Service, Orland, was appointed by the Executive Committee to serve as Secretary-Treasurer of the California Section. JAMES I. MALLORY, of the University School of Forestry, was appointed as custodian of the archives of the Section.

Tentative plans of the California Section call for a July tour into the Modoc and Shasta national forests, including the Pit Soil Conservation Pilot District.

Bay Area Chapter

On January 11, 1954, the Chapter met at the University of California School of Forestry for an interesting and enlightening presentation and discussion of range fertility and fertilization. W. E. MARTIN, Extension Soils Specialist, stimulated thought and discussion by relating brush and weed invasions to a low soil fertility level. AMRAM KADISH, range management student, described his study of range fertilization effects. HAL MILLER of the Soil Conservation Service told the group about large scale demonstrations of range fertilization in California. JAY BENTLEY of the California Forest and Range Experiment Station gave Chapter members information on weight gains by cattle on pastures where annual legumes have been stimulated by sulphur fertilization. Professor A. W. SAMPSON introduced the speakers and led the discussion.

The February meeting was devoted to the topic "*Use of Chemicals in Control of Undesirable Range Plants*, under the chairmanship of H. F. HEADY. Speakers and topics included: ARTHUR SEELEY, Legal requirements; ARNOLD M. SCHULTZ, Brush seedlings; DONALD R. CORNELIUS, Weeds on mountain meadows; D. IRVING GROVER, Weeds on annual ranges; BRYAN C. SANDLIN, Coyote brush.

On March 8, the Chapter met to discuss grazing management systems in California. GEORGE C. WOOD, San Ramon Valley rancher, spoke about ranching with both sheep and cattle. JAMES I. MALLORY of the U. C. School of Forestry described some of the sheep grazing practices on the University's Hopland Range Field Station. WALTER H. JOHNSON, Alameda County Farm Advisor, discussed cattle grazing on Alameda County range lands. M. W. TALBOT, Associate Director of the California Forest and Range Experiment Station, talked about a grazing management system for the perennial bunchgrass ranges of Northeastern California. CHET WING of the California Woolgrowers Association was chairman of the meeting.

On April 12, the final meeting of the series was held. M. L. UPCHURCH of the Agricultural Research Service was chairman of a panel discussing leases, rentals and permits for grazing land. G. A. CAMERON of the Pacific Gas and Electric Company described the grazing leases of that organization and D. W. COX of the Forest Service Region 5 talked about the history and present status of permits for grazing national forest land. ED ROWLAND, Bureau of Land Management, and FRANK DUTRA, Contra Costa County rancher, were unable to participate in the program.

The Bay Area Chapter has been in existence for somewhat over a year and Chairman BILL HARTMANN, Secretary JAY BENTLEY and Program Chairmen D. R. CORNELIUS and H. H. BISWELL have done a very satisfactory job of providing opportunities for range people to discuss common problems and topics of mutual interest. H. H. BISWELL was elected Chairman of the Bay Area Chapter for the next year. JAMES I. MALLORY, of the University School of Forestry, was elected Secretary.—*James I. Mallory.*

Section Meeting Calendar

July 6 South Dakota, field day, Black Hills

July 23–24 Wyoming, field day, Big Horn National Forest

Aug. 10 South Dakota, ranch tour, Allen Smith Ranch, Kadota

Aug. 31 South Dakota, ranch tour, Harding County

COLORADO

On February 20, a joint meeting of the Colorado Section, the Rocky Mountain Section of the Society of American Foresters and members of Region 4 Wildlife Management Society was held at Colorado A. & M. College, Fort Collins. This meeting was held in conjunction with the Forestry Days program on the campus. The grass board contest held at the Denver stock show was discussed. It is hoped that this contest may be extended to other sections and that a national exhibition of the grass boards be conducted in collaboration with the Denver Stock Show next January or at our National Meeting. RODNEY TUCKER and CHUCK TERWILLIGER of the Grass Board Committee gave the report of the contest for last year at Denver.

The principal address at the meeting was given by DAVE SAVAGE of the Southern Great Plains Field Station on the topic *Problems and Possibilities of Natural Resource Development in Parts of the Western Hemisphere*. Savage discussed natural resource problems as observed on his recent missions to Alaska, Uraguay and Mexico. Directors FRED KENNEDY and GEORGE WEAVER reported on the annual meeting.

ERNEST MCCRARY reported on the Conservation Week program, sponsored by the Colorado A and M College Conservation Council.—*C. S. Fonte.*

IDAHO

Officers of the Idaho Section elected at the March meeting include:

Chairman: JAMES P. BLAISDELL, U. S. Sheep Experiment Sta., Dubois

Vice-Chairman: PETER W. TAYLOR, Soil Conservation Service, Shelley
Secretary-Treasurer: WALTER MUEGGLER, U. S. Sheep Experiment Sta., Dubois
Council: VIRGIL STARR, Bur. of Land Management, Idaho Falls; and ROBERT L. CASEBEER, U. S. Fish and Wildlife Service, Boise.

NEVADA

Newly-elected officers of the Section are as follows:
Chairman: JOHN M. FENLEY, Box 590, Las Vegas
Vice-Chairman: WILLIAM N. WHITE, Bur. of Land Management, Reno
Secretary-Treasurer: LOUIS D. HATCH, U. S. Fish and Wildlife Service, Box 432, Las Vegas
Council: NED A. SMITH, Box 332, Winnemucca; LAWRENCE SETTELMEYER, Gardnerville; JOSEPH H. ROBERTSON, Department of Range Management, University of Nevada, Reno

SOUTH DAKOTA

The fifth annual meeting of the South Dakota Section was held in Rapid City, February 5–6 with more than 80 persons attending. The get-acquainted session with movies and dutch lunch was a high point of the meeting. Speakers and topics on the first day's session included: LESTER M. BERNER, Some aspects of watershed management in the Black Hills; CARL LARSEN, Range condition surveys as a basis for grazing preferences; GENE TERRILL, Irrigated pastures in South Dakota; WENDELL BEVER, Deer range management in the Black Hills; LES ALBEE, Renovation of crested wheatgrass with alfalfa. HARLAND MEANS led a discussion on range management problems.

A panel on *Profit Margins in Range Livestock Production* was led by IKE CHASE of the Black Hills Forest Advisory Council. Panel members and topics were: DON DAVIS, Management of native ranges for maximum sustained production; U. J. NORGAARD, Establishment of tame pastures and hay crops; CHET SMITH, Maintenance of fertility for maximum hay production; TOM STRACHAN, Harvesting hay for highest quality; HENRY HOLZMAN, Feeding for most economical gains; and JAMES K. LEWIS, Research for increased efficiency of livestock production in South Dakota.

The program committee has planned a series of seven field tours during 1954. The first of these tours was held on April 19 on the Wolff winter sheep range southeast of Scenic in Shannon County. The group inspected the winter range and lambing operations and saw a colored movie of Mr. Wolff's year-round program.—*Les Albee.*

TEXAS

The annual meeting of the Texas Section was held on January 13 at College Station. The group of 74 members and guests was led on a field tour of experimental and demonstration work in range management and brush control on the Department of Range and Forestry Experimental Area and on outlying ranches. Discussion leaders included: A. H. WALKER, retiring Chairman; VERNON A. YOUNG; ROBERT R. RHODES; WAYNE G. MCCULLY; FRANK W. GOULD; GERALD W. THOMAS; and W. J. WALDRIP. A plant utilization contest was held at the Frank Seale Ranch at which LAMAR LESSER of Smiley placed first among the ranchers present and C. A. RECHENTHIN won first place in the technician group.

ROGER Q. LANDERS, JR. of Menard, senior student at Texas A. & M. College, was given the yearly Section award for Outstanding Range Student in 1953. The plaque for the range management department having the outstanding student was presented to W. G. MCCULLY representing Texas A. & M. College. OMER E. SPERRY presided as toastmaster at the annual banquet which featured an address by C. "DUTCH" HOHN, rancher. Dutch related, as only he can, experiences with conservation in Texas and on his 26½ acre ranch.

Plans for the Texas Section include five meetings to be held at various locations in the state. The first of these programs was held in Abilene on May 10.—*C. A. Rechenthin.*

WYOMING

The Wyoming Section collaborated with the Colorado-Wyoming Academy of Science in a panel discussion of range management at the University of Wyoming, April 30, 1954. Papers presented on the program included: The so-called primitive grasses, ALAN A. BEETLE, Univ. of Wyoming; A Montana grassland relict area, JOHN STURM, grad. student, Univ. of Wyoming; Some temperature relationships of Big Horn Mountain soils, MORTON MAY, grad. student, Univ. of Wyoming; The effect of chemical sagebrush control upon the use of sagebrush-grass type range land, DALE BOHMONT, Univ. of Wyoming; Effects of seed treatments upon the germination of certain browse species in Colorado, RAYMOND J. BOYD, grad. student, Colorado A. & M. College; Control of grass diseases by fungicidal seed treatment, JOHN EHRENREICH, Colorado A. & M. College.

The next meeting of the Wyoming Section will be July 23 and 24, 1954 in a program jointly sponsored with the Bighorn National Forest Permittees Association, the U. S. Forest Service, and the Wyoming Agricultural Experiment Station. The program will include observations of field experiments in the Bighorn National Forest on sagebrush spraying, range pitting, infiltration studies, range survey and rates of grazing for sheep and cattle. Society members wishing to attend can receive further information from the secretary. —*Alan A. Beetle.*

You help to keep down expenses if you pay your membership fee for 1955 before January 1st.

AMERICAN SOCIETY OF RANGE MANAGEMENT

National Committees for 1954

Program
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Hudson G. Reynolds
James A. B. McArthur
Robert E. Williams
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C. Wayne Cook, *Chairman*
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M. L. Upchurch
A. L. Baker
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Technical Planning
Ben O. Osborn, *Chairman*
Donald W. Hedrick
Arthur D. Smith
Donald N. Hyder
E. J. Woolfolk
E. J. Dyksterhuis, *Counselor*

National Advertising (Temporary)
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W. R. Hanson
Harold B. LeSueur
Wilkie Collins, Jr.
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Rodney Pringle
H. Keary DeBeck
Mont H. Saunderson, *Counselor*

Washington Affairs
A. C. Hull, Jr., *Chairman*
Grover F. Brown
Ernest Palmer
George E. Weaver, *Counselor*

Annual Meeting Place: Convention City, 1956
Don Davis, *Chairman*
Merle D. Varner
Laurence E. Riordan
George E. Weaver, *Counselor*

Civil Service
R. K. Pierson, *Chairman*
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Charles R. Joy
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George Britton
Tom Honneycutt
Allenby L. White
Harold F. Heady, *Counselor*

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Grant A. Harris, *Chairman*
Wesley Keller
Walter B. Rumsey
Myrvin E. Noble
A. P. Atkins, *Counselor*

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Edward G. Grest, *Chairman*
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Evan L. Flory
Vernon A. Young, *Counselor*

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Dean L. Higgins
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F. G. Renner, *Chairman*
Daniel A. Fulton
Harold F. Heady
Joseph F. Pechanec
W. T. White

Sale of Display Space
W. T. White

Cooperation with Youth Organizatio
Karl G. Parker, *Chairman*
R. H. Tucker
Charles Terwilliger
Alfred H. Walker
E. R. Jackman
A. P. Atkins, *Counselor*

NEW LIFE MEMBERS ADDED IN 19

B. W. ALLRED, Soil Conservation Ser ice, Washington, D. C.

A. P. ATKINS, Box 470, Guymo Oklahoma

ROBERT S. CAMPBELL, Southern Fore Expt. Sta., New Orleans, La.

W. R. CHAPLINE, F. A. O., V' Terme Caracalla, Rome, Italy

W. A. DONAHOE, White Sulph Springs, Montana

CHARLES A. GRAHAM, San Joaqu Experimental Range, O'Neals, Cali

LISLE R. GREEN, San Joaquin Exper mental Range, O'Neals, Calif.

AUGUST L. HORMAY, California Forest Range Expt. Sta., Berkeley, Calif.

I. D. MALDONADO, Dr., Valenci Venezuela

JOSEPH F. PECHANEC, U. S. Fore Service, Washington, D. C.

ANNUAL MEETINGS

The Eighth Annual Meeting of the American Society of Range Management will be held in San Jose, California, January 25–28, 1955. MAURICE S. BECKLEY, Agricultural Extension Service, 201 Post Office Bldg., San Jose, California is Chairman of the Local Arrangements Committee.

The summer meeting of the Board of Directors will be held July 26, 1954 at the Shirley-Savoy Hotel in Denver, Colorado.

METHODS AND TECHNIQUES IN RANGE RESEARCH

A tentative outline of the proposed handbook on Methods and Techniques in Range Research as submitted to the Board of Directors at the Seventh Annual Meeting of the American Society of Range Management, Omaha, Nebraska, January 29, 1954 by the Research Methods Committee consisting of C. WAYNE COOK, *Chairman*, HAROLD H. BISWELL, D. A. SAVAGE, M. L. UPCHURCH *and* A. L. BAKER.

1. Introduction
- A. The field of range management and the development of research work
- B. Problem analysis and selection of research problems
- C. Range problems compared to other fields of research
  - 1. Dual nature, i.e., effect of livestock on range and effect of range on livestock
  - 2. Weather variability, annual and perennial vegetation, soil and plant heterogeneity
  - 3. High animal variability on fixed grazing environment due to state of maturity, sex and temperament
    - a. need for maximum uniformity in animal composition between groups and between years where pastures are variable factor
- D. Need for standardization
- E. Appraising the problem and planning the project
  - 1. Need for preliminary survey
    - a. climatic conditions
    - b. soil types—best use of land—previous treatment
    - c. type of livestock best adapted to program
- F. Teamwork with others in associated fields

2. Methods of Studying Vegetation
- A. Sampling technique
  - 1. Quadrats (photograph, pantograph, chart, etc.)
  - 2. Point analysis
  - 3. Line intercept
- B. Measuring the quantity of vegetation
  - 1. Frequency-list
  - 2. Basal area
  - 3. Foliage density
  - 4. Numbers
  - 5. Weight and estimates
  - 6. Clipping
- C. Measuring the quality of vegetation
  - 1. Animal gains or cow days
  - 2. Chemical composition
    - a. selecting the sample
    - b. analyses to be made
  - 3. Digestibility
  - 4. Indexes to nutritive values
  - 5. Application of nutritional data to range practices

3. Methods of Inventorying Vegetation
- A. Reconnaissance survey method
- B. Square foot density survey method
- C. Range condition and trend method
- D. Key areas, key species

4. Assessment and Control of Ecological Factors
- A. Climatic factors
- B. Edaphic factors
  - 1. Soil heterogeneity and its measurement
    - a. Soil moisture, soil compaction, soil temperatures, soil fertility, erosion and aeration
- C. Biotic factors
  - 1. Management
  - 2. Succession
  - 3. Competition
  - 4. Fire
- D. Physiographic factors

5. Studying Root Habits and Development
- A. Value of knowledge of root reactions
- B. Root reserve analyses
- C. Trench washing method
- D. Trench tracing method
- E. Steel cylinder method
- F. Soil block washing method

6. Forage Utilization
- A. Palatability and preference
  - 1. Movable cage method
  - 2. Stomach analyses
  - 3. Feeding minutes
  - 4. Exclosures
- B. Degree of use
  - 1. Ocular estimate by plot
  - 2. Ocular estimate by average of plants
  - 3. Weight measurements
  - 4. Height measurements
  - 5. Stem count
  - 6. Twig length measurements
  - 7. Photographic method

7. Livestock for Grazing Trials
- A. Species best adapted to general environment—cattle or sheep, or common use by both species
- B. Class of livestock
  - 1. Breeding animals (cows or ewes)
  - 2. Non-breeding animals (steers or wethers)
  - 3. Relative merit of different species; classes within species from standpoint of economic problems, environmental adaptation and forage utilization

8. General Livestock Procedure and Management
- A. Experimental design
  - 1. Number head per lot or replicate for optimum accuracy
  - 2. Methods of selection and allotment to secure uniformity between groups
  - 3. Method of orderly replacement—in cases where continuous yearlong trials are indicated with breeding stock
  - 4. Weighing procedure—number of initial, intermediate and final weighings—time of weighing—order, etc.
  - 5. Body scores and measurements techniques for evaluating animal differences
  - 6. Seasonal variation in number of animals on experimental pastures to compensate for variation in forage production and to secure uniform utilization
  - 7. Methods of securing optimum and uniform grazing pressure over entire experimental area
  - 8. Effective controls on all common livestock parasites, infectious diseases, etc., in order to reduce animal error to a minimum level
  - 9. Discussion of suitable equipment for weighing and handling livestock as a means of reducing error due to handling

and thus aid in the accumulation of accurate information

B. Measuring effect of grazing procedure on livestock
   1. Gain in weight per animal unit or animal gain per grazing unit
   2. Change in animal condition as reflected by body scores
   3. Percentage increase (calf or lamb crop)
   4. Type and percentage of forage removal as related to animal gains or losses in weight, percentage calf crop, etc.
   5. Blood chemistry to determine relative mineral levels under varying systems of grazing
   6. Long-time effect on growth and reproduction (breeding stock only) of different methods of grazing

9. Experimental Grazing

A. Management studies
   1. Yearlong grazing—continuous, etc.
   3. Deferred—rotation grazing
   3. Grazing intensity
   4. Range readiness
   5. Distribution of water and mineral supplements

B. The pastures
   1. Number, size, shape, water, etc.
   2. Supplemental feeds during studies
   3. Adjusting for various degrees of utilization

10. Statistical Estimates by Sampling With Special Reference to Range Management

A. The sample
   1. Estimates of the number of samples required
   2. Area, shape and nature of sampling unit
   3. Testing the efficiency of sampling

B. Random sampling

C. Importance of replication

D. Choice of the error for testing in analysis of variance

E. Fiducial inferences and statements

F. Stratified sampling

G. Systematic sampling

H. Regression, covariance and correlation

I. Chi-square

J. Group comparisons

11. Experimental Designs (*Illustrations for use and analyses of data and its application to range research*)

A. Completely randomized designs

B. Randomized blocks

C. Latin squares

D. Simple factorial experiments

E. Split-plot experiments

F. Incomplete blocks

G. Lattice designs

H. Lattice squares

I. Single plot versus multiple plot technique

12. Economics of Range Research

A. Measuring range production output

B. Application of theory of production economics to range problems

C. Evaluating economic problems of conservation

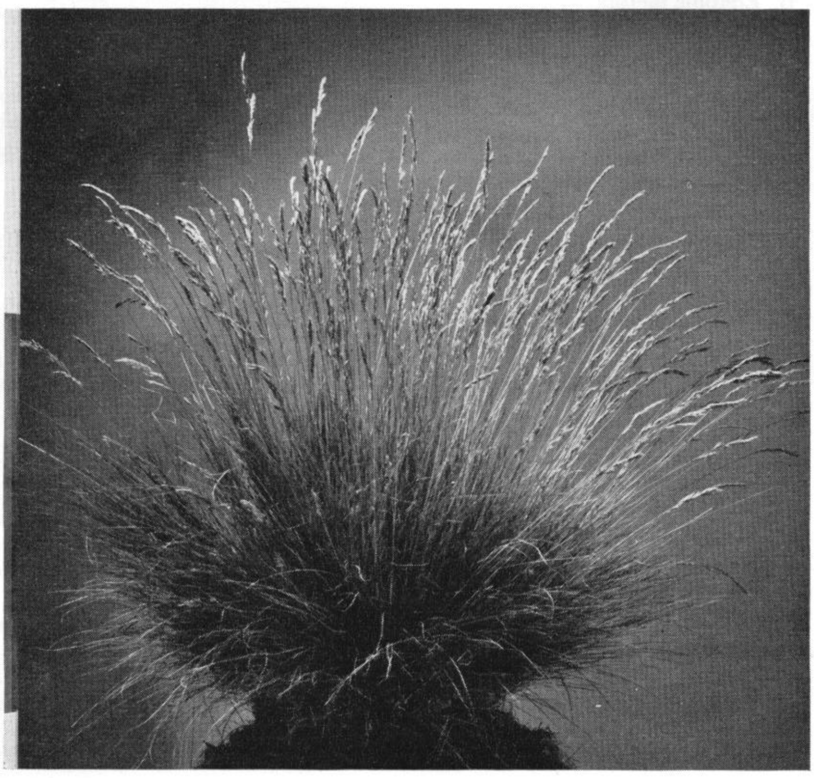
D. Evaluating economic problems arising from tenure, etc.

13. Studies of Specific Problems in Range Management (*To be included if believed desirable but appears too large a project and an unlimited one. Such illustrations could be presented in Chapter 11.*)

Examples might be:

A. Range seeding
   1. Designs
   2. Rates and spacings
   3. Competition
   4. Rodent effects

B. Brush and weed control
   1. Designs
   2. Sprays
   3. Burning
   4. Mechanical
   5. Biological controls



Sheep fescue, *Festuca ovina*. A selection from a plant introduced from Kenya, Turkey. Photograph by John L. Schwendiman, Pullman, Wash. First prize, Portrait of Individual Plant, Photography Contest at Omaha, Nebraska annual meeting.

Information for Authors

The JOURNAL OF RANGE MANAGEMENT is the official publication of the American Society of Range Management. Articles on range and pasture management by non-members may be published in the JOURNAL with the approval of the Editorial Board. All manuscripts and correspondence concerning them should be addressed to the Editor:

Robert A. Darrow, Department of Range and Forestry, Agricultural and Mechanical College of Texas, College Station, Texas.

Articles concerning technical and practical problems of range and pasture management my be submitted for publication. Review papers on selected subjects may be published on invitation or acceptance by the Editorial Board. Articles of not more than 500 to 700 words describing the results of research, experimental equipment or techniques may be included in the Technical Notes Section. Articles describing a single plant species useful for range or pasture seeding of primarily local interest may be accepted for publication as: (a) a technical article if based on research data and comparisons with other species, or (b) a technical note if based on observational results without specific research data. A limited number of articles may be published concerning the establishment, maintenance and grazing management of improved pastures used as an adjunct to ranges in range livestock operations.

Papers should be based on new and adequate information. The introduction should state clearly and concisely the purpose of the report and its relation to other work in the same field. Unsupported hypotheses and rambling discussion should be avoided. Organization of the manuscript may vary to fit the content but the text should point out the application of the results to the range management problem considered. The paper should end with a brief summary of the outstanding points and their practical application.

All papers will be critically reviewed by the Editorial Board, or other subject-matter specialists designated by the Editor. Papers returned to the authors for revision should be revised and returned promptly. Papers not suitable for the JOURNAL will be returned to the authors with an explanatory statement.

Preparation of Manuscript

1. Manuscripts must be typewritten, double-spaced with ample margins, on good-quality white paper, size 8½ x 11 or 8 x 10½ inches. Use one side only of the paper and number all pages. Submit the original or ribbon copy.
2. The title of the manuscript and name, position, and complete address of the author should be typed on a separate page.
3. When plants or wild animals are first mentioned in the text, both common and scientific names should be included. Further reference should be to the common name only.
4. Tables should be as few and as simple as is feasible for presentation of essential data. They should be typed, double-spaced, on separate sheets of regular size paper. Each table should carry its own separately numbered set of footnotes, if any are needed.
5. Illustrations are desirable but the number should be kept to a minimum consistent with conciseness and clarity of presentation. Photographs should be printed on glossy paper and should be sent unmounted in separate envelopes or mounted on thin cardboard. Graphs should be prepared on white or blue-lined cross-section paper with neat lettering of a size suitable for reduction in printing. All figure titles should be typed, double-spaced, on a separate sheet. Photographs and graphs should be numbered on the back for identification.
6. Footnotes in the text should be used very sparingly and numbered consecutively throughout the article. All footnotes should be typed, double-spaced, on a separate sheet.
7. Literature citations should be listed in alphabetical order and referred to in the text by author and date, i.e., Jones (1949), or (Jones, 1949). Citations may be referred to by number when the number of citations is too great to permit convenient use of the above form. Lists of literature cited should be typed, double-spaced, in the style of the following examples:

    PECHANEC, JOSEPH F. AND GEORGE STEWART. 1949. Grazing spring-fall sheep ranges of southern Idaho. U. S. Dept. Agr. Circ. 808. 34 pp.

    SPERRY, OMER E. 1949. Control of bitterweed on Texas ranges. Jour. Range Mangt. 2: 122–127.
8. For further suggestions on arrangement and typing of manuscripts, see "Samples of Typing for Manuscripts—Journal of Range Management," a copy of which may be secured from the Editor upon request.
9. In general, papers should not exceed 6 printed pages including illustrations. Illustrations and tabular material together are limited to 20 percent of the total number of pages. At cost to the author, this length and space may be greater. Charges for extra material depend upon composition and approximate \$12.50 per page for text and \$1.00 per column-inch for tables and figures.
10. When galley proof is received by the author, it should be carefully corrected and mailed immediately to the Editor. Orders for reprints should accompany the corrected proof. Reprints cost the author about \$1.40 per page per 100 copies without covers. Covers are \$4.00 per 100.