Journal of

The Trail Boss

American Society of Range Management

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

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

The JOURNAL OF RANGE MANAGEMENT, published bi-monthly, is the official organ of the American Society of Range Management. The Journal aims to publish something of interest to the entire membership in each issue. The Society, however, assumes no responsibility for the statements and opinions expressed by authors and contributors.

Subscriptions. Correspondence concerning subscriptions, purchase price of single copies and back issues and related business should be addressed to the Executive Secretary, P. O. Box 5041, Portland, Oregon 97213. Subscriptions are accepted on a calendar year basis only. Subscription price is $10.00 per year in the U. S. and insular possessions, Canada and Mexico; $10.50 in other places. Checks should be made payable to the American Society of Range Management. Subscribers outside the United States are requested to remit by International Money Order or by draft on a New York bank.

Address Change. Notice of change of address should be received by the Executive Secretary prior to the first day of the month of Journal issue. Lost copies, owing to change of address, cannot be supplied unless adequate notice has been given.

Missing Journals. Claims for missing copies of the Journal should be sent to the Executive Secretary within 90 days of publication date. Such claims will be allowed only if the Society or the printing company is at fault.

Membership Dues. Dues for regular members are $10.00 per year in the United States, Canada and Mexico, $10.50 elsewhere. Student memberships are $5.00 per year. Life Memberships are $300. Dues include a subscription to the Journal. Remittance must be in U. S. funds.

Post Office Entry. Second-class postage paid at Portland, Oregon, and at additional offices.

Manuscripts. Address manuscripts and correspondence concerning them to the Editor, Journal of Range Management. Instructions to authors appear in the March Journal. Copies are available in the Editor's office.

Reprints. Reprints of papers in the Journal are obtainable only from the authors or their institutions.

News And Notes. Announcements about meetings, personnel changes and other items of interest to Society members should be sent directly to the Editor.

Printers. The Nebraska Farmer Company, 1420 P Street, Lincoln, Nebraska 68501.

IN THIS ISSUE

Cover Photo—More Beef from Wiregrass-Pine Ranges

See story by Ralph H. Hughes under Management Notes
Page 41

Journal of
RANGE MANAGEMENT

Volume 19, Number 1
January, 1966

Cooperation And Planning — Keys To Development And Integration Of Public And Private Rangelands

DILLARD H. GATES
Range Management Specialist, Oregon State University, Corvallis

Highlight

Complex land ownership patterns in the West intensify problems of range resource management. In addition, demands for use of public rangelands are increasing. The livestock industry, public land managers, and other resource users must cooperate and share responsibilities for integration and development of all rangelands, public and private.

Grazing land management in the West is made more complex by land ownership patterns. Federal, state, and private land may be contiguous or intermingled. A ranch operation may be based upon integrated use of several ownerships. A ranch unit made up of multiple ownerships may well create a dilemma for either rancher or public land manager. Land owners and public land administrators may sometimes have different views or points of emphasis in regard to resource management. Full development and wise use of the range resource can become a reality only if all range users assume their proportionate share of responsibility and work together to effect "good resource use." In actuality, those classed as "other range users" make up the majority of rangeland users. This group consists of sportsmen, recreationists, rock-hounds, hikers, etc.

Everyone involved in management and use of the range resource must understand the complementary nature of intermingled public and private land; neither can be used nor developed to its potential without coordination of development and utilization of the other.

The role of the livestock industry in the economy of the West and the nation (Gates, 1964) should be well recognized, especially by the urban public. Many private lands now on tax roles would be of little value without their use in conjunction with public lands. These lands may also enhance the value of public rangelands, which by themselves may contribute little to the economy. Competition for use of all lands is increasing with public demand (Stoddart, 1965). Competition increases interdependency of public and private lands. These pertinent facts must be made clear to sportsmen and recreation-minded public lest they influence or force range management decisions out of perspective.

Demands of the public and the tone of the times have set the stage for a program of cooperation. The range resource consists of millions of acres of public and private land. A large majority of western rangelands are not producing at or near their potential level. Reasons for this are legend and need not be expanded here. The present situation and future demands need to be examined critically and a course charted to reach desired goals. Much thought has been given to range improvement, development, and management. Many range improvement projects now exist on both public and private land. The problem now is to insure integration of these improvements for maximum mutual benefit to both public and private interests and to plan wisely for future improvements.

Need for Cooperation, New Concepts, Planning, Research

One of the primary problems facing range users is the need for an intensified program of integrated improvement, development, and management on interdependent public and private rangelands. Everyone involved in use of rangelands must realize the need for a developmental program and be willing to cooperate to bring it about. Such a program may mean breaking tradition and taking a new look at some policies. It may mean some flexibility of programs where little now exists. It will require broad thinking, and perhaps most difficult of all, it will take acceptance of new ideas. Sometimes it is difficult to admit that what we have been doing for 40 years is not necessarily the best way. Both public and private interests must think seriously about those lands that lie beyond their own boundaries. Everyone must realize that decisions made for any piece of land have implications far beyond its borders.

The "unit management" concept must become a basic part of the thinking of all rangeland managers. "Unit management" implies that all lands utilized by a single rancher, grazing association, or game herd to provide a year-around feed source make up a single management unit. These lands are not always contiguous, but may be separated by many miles and thousands of feet in elevation. The fact remains, they are still a part of the management unit and each contributes to the whole. No real alterations in management should be made without full realization of their effects on the entire management unit. This being the case, collective planning involving all interested range users appears mandatory.

Other public land-management agencies could take note from the U.S. Soil Conservation Service in their insistence on rancher participation in planning. In this case, participation would need to be expanded to include concerned recreation, sporting, and other interests. A lot of subsequent cooperation and understanding can be obtained by working jointly, from the day a plan is conceived, through its development and activation.

Programs that get public and private developments out of balance would be minimized by joint planning. It appears less than prudent to develop public rangelands far beyond present production capacity of private base property. It would appear more logical to encourage a program of balanced improvement on both public and private lands and plan together for their full development. More progress could be made in resource development with smaller expenditures of funds. New improvements would not be executed until plans were fully developed for their management and use. Development of the entire resource would be encouraged and sound management would become a part of the development and improvement, not just an afterthought.

Immediate effectiveness of a planning group will, in a large measure, be determined by the kind and amount of information available concerning the resource. Little real planning, from a resource standpoint, can be accomplished unless there is a sound basis on which to plan. A reliable inventory of the resource, based on ecological considerations becomes a basic need. Such an inventory should provide a "timeless base" on which to build soundly and wisely.

Research has a critically important obligation to provide the basic ecological knowledge and inventory methodology to meet the needs of intensive resource management. The Forest Service allotment analysis procedures, the Soil Conservation Service range site and condition methods, and the Bureau of Indian Affairs vegetation and soil surveys, represent steps in the right direction. The Bureau of Land Management has tested some of these and other ideas for use on their lands and are continuing actively to support research on inventory methods development. Experiment stations and universities need to take off from where we now stand and: (1) Develop the knowledge of range ecology that is needed, (2) help develop feasible methods for obtaining accurate ecological inventories of the range, and (3) train a larger reservoir of people in the use and application of this knowledge in intensive management.

Obviously, in view of increasing demands, too little effort is being expended on wild-land research. It seems paradoxical that while demands on these lands are increasing and large sums of money are being appropriated and spent on their development, relatively little money and effort is being spent on research, the thing most needed to lead the way in wise development of these lands.

The real factors and philosophies contributing to this apparent decline in research effort on wild-lands are difficult to assess. However, there are questions that should be considered. Has the present basic research binge contributed to this decline? Have we failed to demonstrate, to those who hold research purse strings, that the outdoors is as complex as any test tube? Why is it so difficult to see that many questions about this great and valuable resource will only be answered by scientists working in the field and on the ground? Whatever the reason(s), it appears that requisition budgets in research agencies involved in wild-land management are, in fact, decreasing. Many research administrators appear hard pressed to keep a research organization together—let alone provide them with a budget adequate to do the job for which they were hired.

If the research job necessary to lead the way for the development and management of rangelands is to be accomplished, all interested persons, ranchers, public land managers, and other users alike have a responsibility to make these facts known to administrators and politicians. In addition, they must demand that steps be taken to correct the present situation. Sound land management must be based on the needs of the resource and the people, not on political expediency.

What Can be Done Now

Despite the urgent need of suitable resource inventory techniques, it would be foolhardy to delay range development programs until suitable inventories are completed. Considerable information is now on hand. A beginning should be made with what is available. Most important, all interested people must get together and work together. The habits of cooperation and constructive thinking must be developed. With cooperation as a fundamental groundwork, planning and carrying out improvements in development of range and related resources will come more easily as more technical information is made available. Interagency cooperative programs now in existence must be expanded and strengthened.

Financial agencies or institutions must be made aware and kept informed of resource development needs. A worthwhile program of integrated land management will require considerable capital, both public and private. Some lending agencies may need to revise their views on mid and long-term loans for range improvements. Loaning agencies, using livestock as primary collateral, may be inadvertantly contributing to range deterioration brought about by overstocking. This situation may improve as more range and livestock trained men are employed by financial institutions.

Full advantage must be taken of already existing Farm Home Administration and Agricultural Stabilization Conservation Service programs. Programs now exist where farmers or ranchers can, through pooling agreements, borrow money through the Farm Home Administration, and receive assistance through Agricultural Stabilization Conservation Service for range improvements on group or association lands. Programs have also been considered where Farm Home Administration funds could be used to improve Federal rangelands.

All possible financial avenues, especially for private capital, need to be explored. Financial agencies have the responsibility to investigate needs of people they serve, understand the resource, and develop programs tailored to fit these needs.

The livestock industry and individual ranchers have come a long way in recent years. The hard-headed, hard-nosed individuals that put together a spread the hard way, asked little help and gave none are now the rare breed. Gone are those who believed that what belonged to the government, belonged to the first to get it, especially if it were he. Most in the livestock industry see and accept change. Demands on lands have put their "good ole days" far behind. The livestock man once in the majority is now in the minority, forced by the times to accept change, and cooperate with some with whom he used to quarrel. Stockmen must realize they hurt only themselves in refusing to objectively consider improved range management. Ranchers must recognize and meet their obligations to the resource. They need to complement improvement of public lands by keeping their own holdings commensurate, by willingly modernizing their range and pasture management, and improving their total feed utilization.

Ranchers have a responsibility to see the relationship of their lands to public lands. They must realize that all lands now being grazed by livestock are not well suited to livestock use, that changes are in order. They must recognize that grazing use is only one use, that some lands must serve additional uses to meet demands of an increasing population.

The livestock industry has a responsibility to give constructive criticism to all land use programs. It must not condemn for the sake of differing. It must stand ready to cooperate in rangeland management programs that stand to do the most good for the most people, in the long run. The place of the livestock industry on public ranges in the West may be largely determined by action of the industry itself (Stoddart, 1965).

State Game Commissions also have responsibilities in the development of range and related resources. They are single custodians of the greatest number of animals utilizing rangelands. Generally, these animals have no "base property", but depend on both public and private ranges for sustenance. Game managers, too, must be resource managers. They must realize, and more effectively publicize, the fact that game numbers must be kept in balance with the forage resource. They must stand ready to take necessary steps to accomplish that end. Game numbers are generally increasing. Demands for game are increasing. Range improvements and developments may significantly affect game populations. It is imperative that game managers take an active and constructive part in planning for integrated resource development.

Sportsmen also have an opportunity to contribute to development and management of western rangelands. They should continue to provide constructive criticism. Their opinions should be considered. However, groups or individuals with little real understanding of biological concepts of wildlife and range management should not overrule professionally trained biologists.

Federal agencies should inculcate into their thinking the need for integrated resource management. Staff at all levels must come to realize the interdependence of each land segment, public and private, upon the development and wise use of all. They must realize that even though their authority stops at a given boundary, their responsibilities do not.

A major responsibility of land managing agencies is to seek counsel from and cooperate with local people in development and management of the resource.

Agency personnel and range users must work together to cooperatively develop plans aimed at solution of problems that are mutually agreed to be important and solvable.

State universities have a responsibility to help in the development of cooperation among interested range users. They have an opportunity for training both individuals and agencies in cooperating and functioning effectively as a group. They must also contribute technical information on which to base sound management plans. In these times, it is practically impossible for the professional man in the field to keep pace with new information pertinent to his work. Universities and agencies should cooperate in development of short courses, workshops, and other training aids for up-dating and retraining professional men now in the field.

Universities through their Extension programs have a history of working with people in development of both human and natural resources. They must continue their educational programs at a high level of technical competency. Their services should be available to provide maximum contribution to the programs.

Conclusions

Many problems face everyone in the field of resource management. These problems are important to the public agencies, the rancher, the recreationist, the range manager, and all other resource users. All of these people must take a broader view of problems involved and expand their thinking. Universities and other research organizations must take a more active part in acquiring and dispersing information concerning development and improvement of range and related resources.

A program of integrated resource management is needed—badly needed—if rangelands are to be developed wisely. For a program to be successful, land management agencies must work with the people on the ground. Some policies and procedures may need to be critically revised before such a program is possible. Unless there is full cooperation and support of all user groups, any program involving them will, in the long run, result in only partial success or even in complete failure.

Summary

1. Demands are increasing for use of range and related resources.
2. Most of these lands are capable of producing far in excess of present production.
3. For maximum benefit, both public and private land must be developed under the "unit management" concept to provide an efficient year-around feed supply for grazing animals, consistent with other demands on the land.
4. Public and private rangelands must be considered an integrated resource and managed for maximum benefit.
5. Management decisions made for a given piece of land have implications far beyond its boundaries.
6. Cooperation and support of all interested users is basic to program success.
7. Land managing agencies, state universities, the livestock industry, and others have definite responsibilities and opportunities in program development.
8. Research is needed to lead the way in resource development.
9. Allocations of research funds need to be changed to better meet current needs.
10. Concepts discussed do not usurp rights of any agency or individual, but recognize needs and stress cooperation in their accomplishments.
11. Interagency cooperation in decision making processes needs to be intensified.
12. The program discussed may be a break from traditional land management and development patterns. Breaks from traditions are often essential for progress.

LITERATURE CITED

GATES, DILLARD H. 1964. Good range managers recognize opportunities, responsibilities. Oregon Farmer, Oct. 1 p. 5.

STODDART, L. A. 1965. What hope for grazing on the public lands. J. Range Manage. 18: 109-112.

Longevity of Crested Wheatgrass in the Sagebrush-grass Type in Southern Idaho[1]

A. C. HULL, JR., and G. J. KLOMP

Range Scientists, Crops Research Division, Agricultural Research Service, U.S.D.A., Logan, Utah, and Twin Falls, Idaho.

Highlight

Crested wheatgrass has proved to be well adapted on most sites in the sagebrush zone in southern Idaho. Continued high production as indicated in more than thirty-years records show crested wheatgrass will maintain itself and even spread despite such adverse factors as heavy use, extremes of temperature and moisture, and disease.

Experimental range seedings in southern Idaho commenced on many national forest lands during 1909 and 1910[2]. It was not until the early 1930's when seed of crested wheatgrass became available that sagebrush lands were considered feasible for seeding. Crested wheatgrass, as then used, was a complex of species (Swallen and Rogler, 1950). Most of the early seed was crested wheatgrass *(Agropyron desertorum* (Fisch.) Schult.) with some fairway wheatgrass *(Agropyron cristatum* (L.) Gaertn.). In this discussion the early seeded stands will be referred to as crested wheatgrass.

The first known range seedings with crested wheatgrass in the sagebrush type in southern Idaho were in 1932 on the Herman Winters farm near American Falls and at the U. S. Sheep Experiment Station[3] near Dubois. The Idaho Extension Service made seed available for trial plots at several locations in the spring of 1934 (Wood, 1936). Crested wheatgrass was the most widely used species in early seedings in the sagebrush type. Later other species were seeded. The performance of some of these species is included in this discussion for comparison with crested wheatgrass.

The early seeded areas are representative of the better sagebrush lands in southern Idaho. Seed was scarce, and ranchers and technicians were cautioned to seed shallow on a well-prepared seedbed on the better lands, usually dry-farm areas. Because good planting practices were followed and the species was adapted, most of the seedings were successful. Many of these 30-year old seedings are still productive. This paper evaluates these seedings and indicates their durability and productivity.

Methods and Results

All of the early crested wheatgrass seedings which could be located were examined from 1941 to 1944 and again in 1963. Some, such as at the U. S. Sheep Experiment Station, have been observed every year. This report evaluates establishment and productivity of the older seeded stands for which records are available.

Locations of seeded areas are shown in Fig. 1. Site characteristics are shown in Table 1 and long-time air-dry yields of some areas in Table 2. Herbage yields were usually taken by clipping current growth 0.5 inch above the ground on several 4.8 or 9.6 ft^2 samples. Some yields were obtained by a combination of clipping and estimating.

The seedings are treated in two groups: (1) areas shown in Table 2, for which comparative long-time records are available; (2) areas for which only a few yields are available. Seedings are described in the discussion and in the tables, starting with those in the eastern part of the State and progressing westward. All U. S. Sheep Experiment Station seedings are described together.

U. S. Sheep Experiment Station. — This station is 6 miles northeast of Dubois, Idaho. In about 1917 several areas were cleared of native sagebrush-grass vegetation and seeded to sunflowers and sorghum, with poor success. The lands were not cultivated after about 1923. Following abandonment, there was a reinvasion of scattered plants of the original brush species, mainly threetip *(Artemisia tripartita* Rydb.) with some big sagebrush *(A. tridentata* Nutt.). In addition to brush, the seeded areas supported some squirreltail *(Sitanion hystrix* (Nutt.) J. G. Smith)

---

[1] *Cooperative investigations of Crops Research Division, Agricultural Research Service, USDA, and the Idaho and Utah Agricultural Experiment Stations at Moscow, Idaho, and Logan, Utah. Utah Agric. Expt. Sta. Journal Paper 458.*

Most of the early seedings in the sagebrush-grass type were made by ranchers; the Intermountain Forest and Range Experiment Station, U. S. Forest Service (experimental range and seeding phases now Crops Research Division, Agricultural Research Service); Rural Resettlement Administration (land areas now administered by U. S. Forest Service and Bureau of Land Management); Bureau of Animal Industry (now Agricultural Research Service); Soil Conservation Service; Bureau of Land Management; and the University of Idaho. Thanks are extended to personnel of the cooperating agencies, to all who supplied information on seeded areas, and to those who made helpful comments on this paper.

[2] *Unpublished reports and file data.*

[3] *The U. S. Sheep Experiment Station is maintained by the Animal Husbandry Research Division of Agricultural Research Service, USDA, in cooperation with the Intermountain Forest and Range Experiment Station, Forest Service, USDA, and with the Agricultural Experiment Station of the University of Idaho.*

and a fair cover of annual weeds, mainly Russian thistle (*Salsola kali* var. *tenuifolia* Tausch) and mustards. Seed of crested wheatgrass was drilled with no seedbed preparation in 1932, 33 and 34. Because of the drought years and the slow establishment of stands, it was assumed that all seedings were failures. With better moisture in 1936, the seedings began to show and there were full stands of grass on all seeded areas.

Half of a 3-acre area was drilled in the early spring of 1932 and half in 1933. The seeded area has been grazed light to heavy each year. To date there is little sagebrush invasion. In 1963, one of the most favorable years on record, this 31-year-old stand produced 2,384 lb/acre of herbage (Table 2). As seed was produced, some of it was blown over the snow from the original stand toward a snow fence 120 feet south of the seeding. The entire area between the snow fence and the seeding now supports a good stand of volunteer crested wheatgrass.

In 1933, a 5-acre area was seeded. In 1941, part of the seeded area was fenced to test early and late spring grazing. At the initiation of this study, the area was mowed and raked to remove brush and old grass. Each year from 1941 to 1952 the area produced 120 sheep days/-acre of early spring and late fall grazing. Although there is considerable reinvasion of threetip sagebrush, the grass is still productive and produced 2,016 lb/-acre of air-dry grass in 1963, the best yield on record (Fig. 2). Crested wheatgrass has gradually spread into poor native range and forms a full stand for 100 to 400 feet on all sides of the seeding.

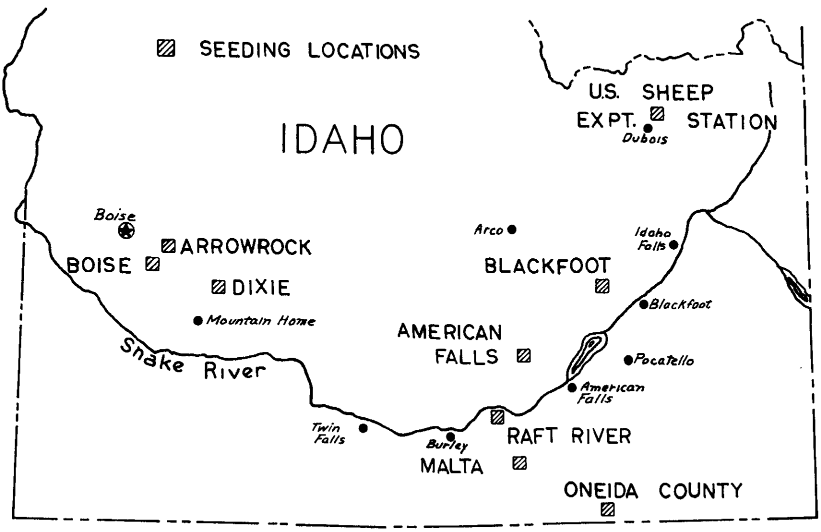


Fig. 1. Location of nine early seedings in southern Idaho is shown by the squares.

Table 1. Location, site characteristics, and seeding method for early Idaho seedings.

Location and years seeded	Elevation Feet	Precipitation Inches	Soil Characteristics	Seeding Method
U. S. Sheep Expt. Station 1932, 33, 34, 46	5500	11	Silt loam 12 to 36" deep	Drilled ¾" deep, 6" rows, 15 lb/A[a]
Blackfoot 1933-39, 46	4600	8	Silt loam	Broadcast and harrowed 10 lb/A[b]
Oneida County 1936 to present	4600 to 5800	9 to 14	Silt loam Some sandy loam	Mostly drilled ¾" deep, 12" rows, 6 lbs/A. Some in alternate strips
Malta 1943	4800	11	Silt loam	Drilled 1" deep, 12" rows, 6 lb/A
Raft River 1944	4300	10	Silt loam	Drilled 1" deep, 12" rows, 7 lb/A
Boise 1943	3500	11	Silt loam	Drilled ¾" deep, 12" rows, 7 lb/A
Arrowrock 1936	4600	18	Coarse sandy loam	Broadcast and raked, 15 lb/A
American Falls 1932	4800	9	Silt loam	Drilled ¾" deep, 6" rows, 8 lb/A
Dixie 1934	4500	16	Sandy loam	Drilled ¾" deep, 12" rows, 5 lb/A

[a] 1946 seeding was at 6 lb/acre in 12" rows.
[b] 1946 seeding was at 6 lb/acre, ¾" deep in 12" rows.

Table 2. Area, year seeded, and air-dry crested wheatgrass[a] herbage yield in lb/acre for several locations in southern Idaho and U. S. Sheep Experiment Station.

Year of Yield	U. S. Sheep Station 1932	U. S. Sheep Station 1933	Blackfoot 1934	Oneida Co.[a] 1937	Malta 1943	Raft River 1944	Boise 1943	Arrowrock 1936
1940	—	—	—	943	—	—	—	1603
1941	—	729	—	1533	—	—	—	2207
1942	1200	665	—	751	—	—	—	2427
1945	—	—	—	—	1274	—	—	1537
1946	—	—	—	—	1785	785	—	1090
1947	1190	785	—	770	1267	1298	1146	2468
1948	780	685	—	585	840	936	1005	1726
1949	763	800	—	1476	820	818	796	1385
1950	1283	675	—	950	700	—	1455	1772
1951	1220	555	—	1150	990	—	—	—
1952	1406	560	—	1100	941	—	788	—
1955	1573	1005	638	996	700	592	674	1095
1956	—	856	1280	928	860	504	—	—
1957	—	—	1630	1020	1160	1180	—	—
1958	—	—	1600	920	1280	1787	—	—
1959	—	—	670	975	820	1120	—	—
1960	—	—	660	310	700	450	—	—
1961	—	—	835	356	640	650	—	1200
1962	1398	1316	1740	1590	1790	1740	440	1019
1963	2384	2016	2750	1426	2173	2265	1008	1377
1964	1677	1268	1602	1279	1746	1405	735	1524
Average	1357	916	1341	1003	1138	1109	894	1602

[a] Yield plots at Oneida County are mostly fairway wheatgrass.

Fig. 2. Crested wheatgrass, seeded in 1933 at the U. S. Sheep Experiment Station at Dubois, has been grazed moderately to heavily for 30 years. Seed from seeded plants, carried by wind and livestock, produced a good stand in the unseeded area beyond the fence. In 1963 the seeded area produced 2,016 lb/acre of grass air-dry weight.

Several areas were seeded in the spring of 1934. One of the areas has been heavily grazed each year by horses and sheep. In 1942 this area was mowed to remove invading threetip sagebrush, and in September 1952, it was burned. Burning completely killed the brush with no apparent damage to the grass. The area is now almost brush-free and the grass forms a full stand. Grass has spread to rocky areas and surrounding native range where it was not originally seeded. Yields have been taken on this area in lb/acre during 5 years:

1942	514
1956	896
1962	1,890
1963	2,320
1964	1,792

In 1946 an area of depleted native range was plowed to kill threetip sagebrush and the grass understory. Twelve species were drilled with 8 replications of each to be used for a grazing study. After 18 years, six species are doing well and some have spread to several times their original plot area (Table 3). Species that have spread most are fairway and pubescent *(A. trichophorum* (Link) Richt.) wheatgrasses. Crested and intermediate *(A. intermedium* (Host) Beauv.) wheatgrasses have spread, but not as far as the first named species. Siberian wheatgrass *(A. sibiricum* (Willd.) Beauv.) and Russian wildrye *(Elymus junceus* Fisch.) have spread erratically. The following six species were also seeded, but stands became progressively poorer under sheep grazing and competition with other species: thickspike *(Agropyron dasystachyum* (Hook.) Scribn.); tall *(A. elongatum* (Host) Beauv.); western *(A. smithii* Rydb.); and bluebunch *(A. spicatum* (Pursh) Scribn. and Smith) wheatgrasses; big bluegrass *(Poa ampla* Merr.); and alfalfa *(Medicago sativa* L.).

Blackfoot.—In 1933 Howard Hartman seeded crested wheatgrass on a dry sagebrush site 14 miles northwest of Blackfoot. Seedings were continued for several years on areas supporting big sagebrush of medium size and a sparse understory of native grass. Most areas were plowed, fallowed and seed was broadcast. Stands established slowly. The seeded areas were closely grazed by sheep until

1954 (Fig. 3). Since then they have been grazed moderately by cattle. Heavy rabbit concentrations have been present on these seedings. The oldest seeding is still productive with a good stand of vigorous plants (Table 2) and with only a slight amount of sagebrush reinvasion on any of the seedings. The grass has spread to rocky areas and sagebrush range where it was not originally seeded. Part of the 1933 seeding was flooded during spring run-off in 1962 and 1963. The flooded area produced 3,558 lb/acre of herbage in 1962 and 3,940 lb in 1963.

In 1946 several species were drilled in experimental plots on recently abandoned land. Yields of Russian wildrye and crested and fairway wheatgrasses are shown in Table 4.

Other species which produced seedling stands, and either failed to establish well or declined to very poor stands, were as follows: tall, intermediate, western, pubescent, and beardless (*Agropyron inerme* (Scribn. and Smith) Rydb.) wheatgrasses; Indian ricegrass (*Oryzopsis hymenoides* (R. & S.) Richter); Nevada bluegrass (*Poa nevadensis* Vasey ex Scribn.); and mountain rye (*Secale montanum* Guss.).

Oneida County.—In 1936 the Rural Resettlement Administration began drilling the first of 57,000 acres of crested and fairway wheatgrasses on the land utilization project in Curlew and Black Pine Valleys in Oneida County. Early seedings were made in fallow, wheat stubble, or in annual weeds such as Russian thistle and mustards. In later seedings the big sagebrush and perennial plants were plowed out of abandoned wheatland or depleted rangeland before drilling to grass.

The Bureau of Land Management now administers the public land in Black Pine Valley, while the Forest Service administers the public land in the Curlew Valley as the Curlew National Grassland. On the Grassland, use is rotated so that fields may be used any time from May to February for seasonal grazing by cattle (Fig. 4). Stands of crested and fairway wheatgrasses which have

Table 3. Yield for six species (air-dry herbage lb/acre) and the area now occupied by each species in the grazing study at the U. S. Sheep Experiment Station. Average of 8 replications.

Species	Area[a]	Years 1950	1952	1953	1954	1955	1962	1963	Average
Crested wheatgrass	169	672	718	1318	975	1056	1299	2238	1268
Fairway wheatgrass	438	579	708	1194	952	942	1060	1738	1099
Siberian wheatgrass	131	579	692	1232	913	1009	1096	1513	1076
Intermediate wheatgrass	155	586	790	1314	919	898	1198	2037	1192
Pubescent wheatgrass	210	493	796	1378	1160	869	1287	2038	1254
Russian wildrye	112	542	578	902	574	705	668	1794	870
Average	203	575	714	1223	915	913	934	1893	

[a] Percent spread and area covered in 1963 as compared to the original plot area of 100 percent as seeded in 1946.

Table 4. Yields (air-dry herbage lb/acre) of grasses seeded in 1946.

Year of yield	Crested wheatgr.	Fairway wheatgr.	Russian wildrye
1955	949	737	1089
1956	876	770	1220
1957	1480	1080	2150
1958	1280	960	1937
1959	970	550	1410
1960	560	340	975
1961	750	610	1695
1962	1179	1541	1778
1963	2320	2180	2340
1964	1502	1352	1574
Average	1187	1012	1617

Fig. 3. This area northwest of Blackfoot was seeded in 1933 and heavily grazed by sheep and rabbits until 1954. *Left*—This 1946 photograph is typical of the grazing during the first 13 years of the life of the stand. *Right*—In 1963, possibly the year of the highest production, this stand produced 2,750 lb/acre.

Fig. 4. Crested wheatgrass seeding began on this large, abandoned land area in Curlew Valley in the fall of 1936. The area has now been grazed for 28 years and a good stand of grass remains. Photographed December 1963.

been grazed for over 20 years still are vigorous with no signs of deterioration. Pastures are grazed at approximately 3 acres per animal unit month.

With good range management the sagebrush reinvades slowly in this area. Some areas need spraying with 2,4-D or mowing with brush cutters every 10 to 20 years to hold down the sagebrush.

A grain stubble area was drilled experimentally in 1937 to fairway and crested wheatgrasses with 9 other species. The area was not grazed until 1946 when it was used as a bull pasture and heavily grazed until 1959. Since 1960 it has been moderately grazed by horses. Where species other than fairway and crested wheatgrasses were seeded and failed, big sagebrush soon occupied the plot areas. Sagebrush invasion has been slow where there was a good initial stand of the two wheatgrasses. The 28-year-old wheatgrass stand is still vigorous (Table 2). It has spread into fence rows and unseeded areas and now forms a good understory to the sagebrush on plots where other seeded species failed.

Malta.—East of Malta near Sublette a large area of depleted big sagebrush was burned and seeded by drilling crested wheatgrass in 1943. Sampling commenced in 1945 when the stand was two years old. The plants are vigorous and the stand produced its highest yield, 2,173 lb/acre in 1963, a favorable year (Table 2).

Raft River.—On the Raft River flat, 15 miles east of Rupert, large seedings of crested wheatgrass and smaller seedings of several species were made on depleted sagebrush range in 1944. The area was protected for about four years. Since then it has been grazed moderately. Crested wheatgrass has been the best species (Tables 2 and 5). It yields well and is spreading into areas which were missed in drilling and where other species failed. Seeded species which did not maintain good stands are: bluebunch, intermediate, tall, and thickspike wheatgrasses; big, Nevada, and bulbous (*Poa bulbosa* L.) bluegrasses; mountain rye; alfalfa; and sicklepod milkvetch (*Astragalus falcatus* Lam.). Some big sagebrush is invading the crested wheatgrass areas.

Arrowrock. — Crested wheatgrass was seeded 5 miles southeast of the Arrowrock Dam and about 20 miles southeast of Boise in 1936. The seeding was on a dry 10% south slope. It established slowly but there is now a vigorous 28-year-old stand of wheatgrass (Table 2). In this area intermediate and pubescent wheatgrasses were first seeded in 1941. Consistent annual yields have not been taken on these grasses, but they are spreading more rapidly and yielded more than crested wheatgrass in 1963 and 1964.

Boise.—Twenty-four miles southeast of Boise, near Regina, some sagebrush and cheatgrass (*Bromus tectorum* L.) areas were plowed and drilled to several species in 1943. The stands have been lightly to moderately grazed. Crested wheatgrass plants are vigorous and keep out the cheatgrass and other invaders (Table 2). Spreading by seed has been much slower in southwestern than in eastern Idaho.

Table 5. Yield of 7 species (air-dry herbage lb/acre) at Raft River, Seeded in 1944.

Year	Crested wheatgr.	Fairway wheatgr.	Siberian wheatgr.	Pubescent wheatgr.	Beardless wheatgr.	Russian wildrye	Ave.
1946	785	—	—	—	—	—	785
1947	1298	1002	—	—	—	—	1150
1948	936	402	—	296	251	172	411
1949	818	734	—	560	882	856	770
1955	592	546	610	549	—	673	594
1956	504	402	427	502	920	709	577
1957	1180	930	1280	825	1310	1000	1087
1958	1787	1075	1472	865	1430	1252	1313
1959	1120	840	1240	630	1200	1135	1027
1960	450	375	550	455	570	535	489
1961	650	445	580	435	760	717	596
1962	1740	1666	1952	1326	1538	1721	1657
1963	2265	1905	1650	1560	1150	1055	1598
1964	1405	1222	1098	1478	1254	1219	1280
Average	1109	888	1086	790	1024	920	

American Falls.—In 1932 Herman Winter seeded crested wheatgrass on a small area of fallow wheat land located in the moderately dry sagebrush zone 15 miles northwest of American Falls. Most of the seeded area was later plowed, but on the remainder there is a good 33-year-old stand. The grass spread from the original seeding and forms a good volunteer stand on unseeded, rocky areas and waste places.

Dixie.—On the Weaver ranch on Long Tom Creek near Dixie, a small area of big sagebrush was grubbed, and crested wheatgrass was drilled on a good seedbed in the fall of 1934. The stand, protected during the first few years, has since been moderately to heavily grazed. There is still a good stand of crested wheatgrass, but sagebrush has invaded most of the seeding. Where sagebrush has not invaded, this stand produced 1,539 lb/acre of air-dry herbage in 1963 and 1,725 lb in 1964. In this area crested wheatgrass yields are equalled by several fields of intermediate wheatgrass seeded in the early 50's.

Discussion

Crested wheatgrass is native over wide areas in Russia, Siberia, Mongolia and other countries. It withstands heavy grazing, is resistant to heat, drought, cold, and little damaged by disease (Konstantinov, 1923). Rogler (1960 a,b) states that crested wheatgrass is the most successful of all grasses introduced on the northern Great Plains in the United States. It has wide adaptation, long life, drought and cold resistance, relative freedom from disease, good productivity and palatability, persistence under abuse, good competitive ability, excellent seed production, ease of establishment, and sufficient seedling vigor to volunteer successfully. No other exotic or native grass has so many desirable characteristics. It also has been found to be well adpated in the prairie region of Canada (Knowles, 1956).

Crested wheatgrass was the earliest successful species seeded in the sagebrush-grass type in southern Idaho. It has continued to be the best-adapted seeded species (Hull and Holmgren, 1964). Fairway wheatgrass has also proved to be well adapted. Siberian wheatgrass undoubtedly has the same characteristics. Other species should be adapted to some sagebrush sites, but they need further testing to determine their specific adaptability.

Age of stands, precipitation, and grass yields.—Under favorable growing conditions in Russia, crested wheatgrass reaches its greatest productivity in the second to fourth growing season (Konstantinov 1923). In the sagebrush-bunchgrass type near Burns, Oregon, crested wheatgrass attained maximum productivity during the second growing season, and declined with increased age to the fifth growing season (Hyder and Sneva, 1963). Barnes and Nelson (1950) in Wyoming found that this decline in production came after the third year. Bleak and Plummer (1954) found that crested wheatgrass in the sagebrush type in central Utah declined in yield after 7 years as the result of old age or decadence.

Westover and Rogler (1947) and Rogler[4] observed that a 1915 seeding of crested wheatgrass at Mandan, North Dakota, returned its second highest hay yield of 3,400 lb/acre during its forty-second year of production. The highest yield was 3,550 lb/acre in 1916; and the lowest was 146 lb during the severe drought of 1936. The average for 30 consecutive years was 1,675 lb. The plants from this 1915 planting are still growing vigorously at the end of 50 years.

In southern Idaho there is a tendency for crested wheatgrass to reach its highest productivity 2 to 5 years after seeding and then decrease to the level of its long-time productivity (Hull and Holmgren, 1964). Because of the extremes in annual precipitation on arid lands in southern Idaho, however, the highest yields have usually been more closely associated with favorable rainfall than with the age of the stand. In southeastern Idaho the highest yields were in 1962 or 1963, either during or following the high rainfall of 1962. Southwestern Idaho has fewer yield records, but those available indicate that grass production was highest during the 1940's when precipitation was also high.

Climatic extremes.—In southern Idaho there is a wide variation in temperatures and in annual precipitation. The highest temperature for the crested wheatgrass area was 110 F in 1955 near the Boise seeding. The lowest temperature was −40 F recorded in 1962 near the Raft River seeding. The Raft River and the Herman Winter seedings each withstood a range of 142°—Raft River from 101 to minus 41 and Herman Winter from 104 to minus 38. There have been many temperature readings above 100 and below minus 30.

The Malta seeding withstood the lowest recorded annual precipitation for the area when only 5.49 inches fell in 1954. There were several locations where the precipitation in one or more years dropped to less than 6 inches. In no instance did these climatic extremes result in loss of the seeded stand.

Sagebrush reinvasion.—When crested wheatgrass or other adapted grasses are seeded in the sagebrush-grass type, reinvasion by sagebrush can be expected. This is especially true when sagebrush seed is available during the year of establishment and while seeded plants are small and unable to suppress the brush. With proper grazing, sagebrush reinvasion has been of minor importance in most seeded areas. Where sagebrush does reinvade, it must be controlled be-

[4] *Personal correspondence.*

fore it reduces the productivity of the grass. This can be done with herbicides, burning, beating, or dragging.

Summary and Conclusions

The first crested wheatgrass seedings in the sagebrush type in southern Idaho were made during 1932, 1933, and 1934.

An examination of the 20 to 30-year-old stands of crested wheatgrass in southern Idaho and surrounding areas shows it to be well adpated on all but the driest sagebrush lands. This grass has not died out when moderately used within the range of its adaptation. In many locations, even though heavily used and eaten to the ground level year after year, and though the vigor is low, crested wheatgrass still forms a good stand and produces seedheads when given a chance. It withstands heavy grazing and is resistant to heat, drought, cold, fire, and disease. Other species also appear to be adapted on some sagebrush lands.

Throughout this area in southern Idaho when plots seeded to crested wheatgrass were compared to those seeded to native grasses, crested wheatgrass seems to withstand drought, cold, and disease just as well. It is more resistant to fire and severe grazing, and spreads better.

LITERATURE CITED

BLEAK, A. T., AND PLUMMER, A. PERRY. 1954. Grazing crested wheatgrass by sheep. J. Range Manage. 7: 63-68.

HULL, A. C. JR., AND HOLMGREN, RALPH. 1964. Seeding southern Idaho rangelands. U. S. Forest Service Res. Paper INT-10, 32 p.

HYDER, D. N., AND SNEVA, FORREST A. 1963. Studies of six grasses seeded on sagebrush-bunchgrass range; yield, palatability, carbohydrate accumulation, developmental morphology. Oregon Agr. Exp. Sta. Tech. Bull. 71. 21 p.

KNOWLES, R. P. 1956. Crested wheatgrass. Canada Dep. of Agr. Bull. Pub. 986. 13 p.

KONSTANTINOV, P. N. 1923. The geographical distribution of *Agropyron cristatum* and *A. desertorum* and the environment to which it is adapted. Moscow, New Land, 68 p. (Trans. from Russian by T. K. Pavlychenko).

ROGLER, G. A. 1960 a. Growing crested wheatgrass. U. S. Dep. Agr. Leafl. 469, 8 p.

ROGLER, G. A. 1960 b. Crested wheatgrass—history, adaptation and importance. Western Grass Breeder's Work Planning Conf., June 24-25, 1960. Univ, of Sask., Saskatoon, Sask. 16 p.

SWALLEN, J. R., AND ROGLER, G. A. 1950. The status of crested wheatgrass. Agron. J. 42: 571.

WESTOVER, H. L., AND ROGLER, G. A. 1947. Crested wheatgrass. U. S. Dep. of Agr. Leafl. 104, 8 p.

WOOD, C. M. 1936. Crested wheatgrass in Idaho. Idaho State Chamber of Commerce. 5 p.

Vegetation-Soils And Vegetation-Grazing Relations From Frequency Data[1]

D. N. HYDER, R. E. BEMENT, E. E. REMMENGA, and C. TERWILLIGER, JR.

Research Agronomist and Research Range Conservationist, Crops Research Division, Agricultural Research Service, U. S. D. A., and Experiment Station Statistician, and Associate Range Conservationist, Colorado Agricultural Experiment Station, Fort Collins, Colorado.

Highlight

An upland vegetational continuum and three bottomland associations are interpreted from frequency data, but intra-site heterogeneity masks vegetation-grazing relations. Summer-long grazing at different intensities for 23 years has not affected the frequency percentages of species to a great extent.

[1] *A contribution from the Central Plains Experimental Range, Crops Research Division, Agricultural Research Service, U.S.D.A., and Colorado Agricultural Experiment Station, Colorado State University, Fort Collins. Published with the approval of the Director of the Colorado Agricultural Experiment Station as Scientific Series Paper No. 993.*

Frequency data are a blend of species density and dispersion characteristics. Therefore, they should be useful for the study of vegetation-soils and vegetation-grazing relations. To test this assumption, frequency sampling was undertaken at the Central Plains Experimental Range near Nunn, Colorado, where grazing has been controlled at various intensities since 1939, and where a recent soil survey provides a basis for sample stratification by soils. This paper reports vegetation-soils and vegetation-grazing relations on blue-grama range, and compares the results with previous classifications of range sites and range conditions.

Methods

Frequency Sampling Techniques.—Frequency sampling techniques for Short Grass Plains were developed in a previous study (Hyder et al. 1965). Each sample is restricted to a macroplot 100 by 75 ft., and includes 250 quadrat placements allocated 25 in each of 10 transects. The term "stand" refers to the vegetation encountered in any macroplot.

The sampling frame includes a nested pair of quadrats mounted on a handle. A large quadrat of 16 by 16 inches includes a 2 by 2-inch quadrat in one corner. At each quadrat placement an observer names the species in each quadrat size and an assistant accumulates the observations and records species frequencies for each transect. The term "frequency" refers to the percentage of quadrats in which a species occurs. Our sampling required about 4 man-hours per macroplot.

Sixty-seven stands were sampled in 1962 and 1963. Two or more macroplots were located on each phase of the soil series found in range units grazed lightly, moderately, and heavily, and in ungrazed exclosures. Macroplot locations were paired on opposite sides of fences, where possible, to obtain unbiased differences attributable to grazing intensity.

Soils and Grazing Intensities.—The soil series encountered in sampling were Vona sandy loam; Greeley sandy loam, Ascalon sandy loam; Renohill loam and fine sandy loam; Midway-Renohill complex, Havre loam and very fine sandy loam; Fort Collins loam; unnamed undifferentiated loam and clay loam; Nunn clay loam; and unnamed saline-alkali loam and clay loam.

The range pastures sampled were grazed by yearling Hereford cattle from May 1 to November 1 annually since 1939. Stocking rates were adjusted to obtain light, moderate, or heavy grazing. Each pasture included a 1 to 2-acre livestock exclosure. Vegetation and livestock measurements in the first 15 years were reported by Klipple and Costello (1960).

Vegetation-Soils Relations. — The correlations between individual species frequencies and scored values of soil texture, subsoil, permeability, substratum permeability, soil depth, topographic exposure, and slope were calculated. The soil characteristics that were significantly correlated with the frequencies of individual species were used, along with topographic position, to stratify the soil series into interpretive soil groups. This stratification of soils was made independent of species composition and stand characteristics. Subsequently, the frequency percentages of species were compiled by interpretive soil groups to evaluate vegetation-soils relations. The term "community" refers to the combination of stands in an interpretive soil group.

The vegetation is shown to be coordinated with the interpretive soil groups by coefficients of community similarity (Oosting, 1956, p. 77). These coefficients were calculated from the mean frequency percentages of all (123) species. Otherwise, the data base includes 46 species whose mean frequency percentages equal or exceed 5% in at least one stand. Thirty species had mean frequencies of 5% or more in at least one interpretive soil group. Five-percent confidence limits of mean frequency percentages were used to evaluate sampling precision within stands and heterogeneity among stands within communities.

The combination and segregation of species among communities is derived from interspecific correlations (Goodall, 1953) among 46 species independent of the interpretive soil groups. Significant correlations were obtained among 16 perennial species. Combinations and segregations among them are portrayed by the positive and negative coefficients. Therefore, these 16 species are arranged into community indicator groups called "unions".

Stands from all grazing intensities were included in the analyses of vegetation-soils relations. Since some soil series were not found in all exclosures and pastures, the grazing intensities are not equally balanced among soil-series groups. Thus, community differences among soil-series groups can be slightly confounded with differences due to grazing intensities.

Vegetation-Grazing Relations.—The frequency percentages of 46 species in each soil-series group were correlated with grazing intensities. The grazing intensities none, light, moderate, and heavy were scored 1, 2, 3, and 4, respectively, for these calculations. Positive correlation coefficients indicate increaser responses of species, and negative coefficients indicate decreaser reponses (Dyksterhuis, 1949).

Species nomenclature follows that of Harrington (1954). Common names are used in the text and tabulations. The botanical and common names of species mentioned are listed in Table 5.

Results

Interpretive Soil Groups.—Individual species frequencies are more uniformly related to soil texture and subsoil permeability than to the other soil characteristics considered. Therefore, the scored values of soil texture and subsoil permeability are added together for each soil series encountered and used as an index for assigning the soil series to interpretive soil groups. Upland soils are classified into four interpretive soil groups, and ordinated according to decreasing value of the texture-permeability index (Table 1). Bottomland soils are classified into three interpretive soil groups; but this classification is partly independent of the texture-permeability index. All bottomland soils can be flooded by high-intensity summer storms. The unnamed saline-alkali series is classified separately from other bottomland soils because of its salt content and high water table.

Vegetation-Soils Relations. — Coefficients of community similarity, computed from the frequency percentages of 123 species assembled by interpretive soil groups, portray vegetation-soils

Table 1. Interpretive soil groups.

Interpretive soil groups	Topographic position	Texture-permeability index[1]	Soil Series	Number of macroplots sampled
1	Upland	9	Vona sandy loam	17
2	"	8	Greeley sandy loam	7
3	"	7	Ascalon sandy loam	14
4	"	6	Renohill loam and fine sandy loam	
			Midway-Renohill complex	9
5	Bottomland	6	Havre loam	
			Fort Collins loam	8
6	"	4-5	Unnamed clay loam	
			Nunn clay loam	6
7	"	5	Unnamed saline-alkali	6

[1]The texture-permeability index is the sum of soil-texture and subsoil-permeability scores.

relations (Table 2). The progressive decrease in similarity between the community of Interpretive Soil Group 1 and those of Interpretive Soil Groups 2, 3, and 4 suggests an upland vegetational continuum co-ordinated with soil texture and permeability (Curtis, 1955). Interpretive Soil Groups 6 and 7 produce plant communities that are very different from those on other soils. However, the "Overflow" conditions of Interpretive Soil Group 5 produce a community that is surprisingly similar to that of the upland Interpretive Soil Group 1.

Table 2. Coefficients of community similarity among interpretive soil groups.

Soil groups	Upland 1	2	3	4	Bottom land 5	6	7
Upland							
1							
2	.77						
3	.67	.79					
4	.64	.75	.84				
Bottom land							
5	.71	.65	.62	.64			
6	.35	.30	.35	.41	.41		
7	.40	.43	.41	.41	.40	.38	

The mean frequency percentages of 30 species are given by interpretive soil groups in Table 3. Most of these species, being unequally distributed among the communities, indicate competitive or adaptive vegetation-soils relations. We computed 5% confidence limits for the frequency percentages in Table 3. The confidence limits computed from the variances among transects within stands generally equal ±2 to 3%. Therefore, sampling precision is very good. The confidence limits computed from the variances among stands within communities average ±13%, and are greater on bottomland than upland soils. The great variance among stands indicates excessive heterogeneity in species frequencies on each soil. Such heterogeneity can result from grazing effects, random variations, species substitutions, soil heterogeneity (as found in Utah by Stewart and Keller, 1936), or variations in other site characteristics.

Species Unions. — Significant interspecific correlation coefficients were obtained among 16 perennial species. Forty-six species were included in the calculations. These 16 species are ordinated, according to positive and negative coefficients, into 5 unions (Table 4). Within each union the species generally are positively associated, but between unions the species generally are negatively associated or unrelated. Western wheatgrass and fourwing saltbush are the primary exceptions. These two species are treated as a separate union even though they are positively correlated with one or more species in Unions II, III, and especially V. In general, the species in each union are loosely associated. Union V is the most coherent, and Union II is the least coherent.

The frequency percentages of these 16 species, summed within

Table 3. Mean frequency percentages of thirty species by interpretive soil groups.

Species[1]	Interpretive soil groups 1	2	3	4	5	6	7
Perennial grasses and sedges:							
Blue grama[2]	71	75	75	72	76	18	33
Three-awn	27	15	16	6	1	1	3
Western wheatgrass	26	8	6	10	33	52	70
Broad-leafed sedge	13	16	40	29	22	63	4
Needle-and-thread	9	6	1	1	1	1	3
Sand dropseed	7	4	4	2	1	0	3
Buffalo grass	3	7	7	36	10	80	3
Saltgrass	0	0	0	0	5	0	81
Alkali sacaton	0	0	0	0	0	0	36
Shrubs and cactus:							
Plains pricklypear	26	32	35	43	22	2	4
Buckwheat	11	23	4	3	1	0	3
Fourwing saltbush	4	1	1	0	7	1	6
Fringed sage	3	1	7	1	1	2	1
Winterfat	1	1	0	0	9	0	0
Perennial forbs:							
Scarlet globemallow	29	32	41	43	39	9	12
Plains bahia	12	1	1	4	4	3	2
Scarlet gaura	2	6	2	4	2	1	3
Rush skeletonplant	1	5	1	1	3	0	4
Silky sophora	1	1	1	1	7	6	0
Two-grooved loco	1	1	1	0	0	7	0
Povertyweed	0	0	0	1	1	38	11
Talinum	0	0	0	0	0	1	13
Annuals:							
Sixweeks fescue	9	31	65	53	2	11	40
Tansyleaf aster	6	9	3	7	1	0	2
Prairie pepperweed	4	7	4	3	1	1	6
Wooly indianwheat	2	10	22	26	1	3	12
Gilia	2	4	6	2	0	1	1
Slimleaf goosefoot	1	1	1	1	2	1	5
Cryptantha	1	3	4	1	1	0	5
Skeletonleaf bur-sage	0	0	0	0	0	12	0

[1] This list includes the species that appear at a mean frequency of 5% or more in at least one interpretive soil group.

[2] Blue grama frequencies are from a 2-inch quadrat, and all other species frequencies are from a 16-inch quadrat.

Table 4. Species unions derived from interspecific correlation coefficients.

Union	Species symbol[2]	Blue	Pric	Glob	Need	Thre	Sand	Bahi	Buck	Buff	Pove	Sedg	West	Four	Salt	Alka	Tali
		Inter-specific correlation coefficients[1] (r) among species															
I	Blue	1.00															
	Pric	.55	1.00														
	Glob	.42	.31	1.00													
II	Need				1.00												
	Thre				.48	1.00											
	Sand				.37	.37	1.00										
	Bahi					.52		1.00									
	Buck				.38	.35	.51		1.00								
III	Buff	-.54	-.26			-.27			-.27	1.00							
	Pove	-.68	-.39	-.36						.53	1.00						
	Sedg				-.25					.41		1.00					
IV	West	-.67	-.37	-.31				.40			.44		1.00				
	Four							.37			.25		.44	1.00			
V	Salt	-.43	-.42	-.29								-.29	.45		1.00		
	Alka	-.38	-.32	-.30							.28		.40	.40	.77	1.00	
	Tali	-.29	-.27										.28		.66	.65	1.00

[1] With n-2 = 65 degrees of freedom an r of 0.25 is significantly greater than zero at 5%, and an r of 0.32 is significant at 1%. Non-significant coefficients are omitted.

[2] Blue = Blue grama
Pric = Plains pricklypear
Glob = Scarlet globemallow
Need = Needle-and-thread
Thre = Three-awn
Sand = Sand dropseed
Bahi = Plains bahia
Buck = Buckwheat
Buff = Buffalo grass
Pove = Povertyweed
Sedg = Broad-leafed sedge
West = Western wheatgrass
Four = Fourwing saltbush
Salt = Saltgrass
Alka = Alkali sacaton
Tali = Talinum

each union, were assembled by interpretive soil groups (Figure 1). Union I is dominant in Interpretive Soil Groups 1 through 5; Union III is dominant in Soil Group 6; and Union V is dominant in Soil Group 7.

Upland soils produce a vegetational continuum in which Unions I and III increase and Unions II and IV decrease as the soil becomes less permeable. Needle-and-thread and other grasses in Unions II and IV give Interpretive Soil Group 1 a midgrass aspect even though blue grama is dominant. Hanson (1955) described communities in which needle-and-thread is dominant, but his communities were found on areas that receive more precipitation than our Interpretive Soil Group 1. Mid-grasses and shrubs decrease with decreasing soil permeability, but short grasses, plains pricklypear, and scarlet globemallow increase. Blue grama is dominant on all of these upland soils. Buffalo grass is dominant on upland soils less permeable than those of Interpretive Soil Group 4, and on similar soils that receive less precipitation. Thus, the upland continuum portrayed in Figure 1 and Table 2 is part of a broader continuum encountered in the vicinity of this experimental range.

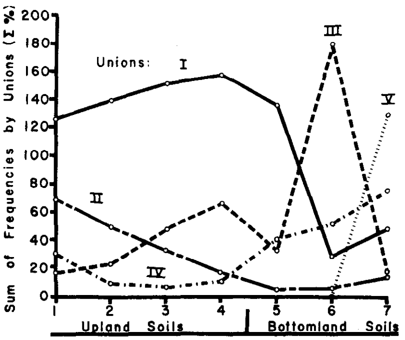


Fig. 1. The distribution of species unions among interpretive soil groups.

The vegetation on the saline-alkali soils is unique, presumably because of the salt content and high water table. The loamy soils of Interpretive Soil Group 5 support a highly productive community with an aspect of fourwing saltbush and western wheatgrass. Western wheatgrass, fourwing saltbush, and blue grama are replaced by buffalo grass as soil permeability and flooding frequency decrease. When isolated from flood waters, Interpretive Soil Group 5 produces a community like that of Interpretive Soil Group 4, except for the low occurrence of plains pricklypear.

Vegetation-Grazing Relations.—None of the species were correlated with grazing intensities at the 10% confidence level. Therefore, the frequency percentages of species arranged by grazing intensities are omitted. Three species were correlated with grazing intensities at the 20% level. Needle-and-thread, with a correlation coefficient (r) of −0.68, is a decreaser on the sandy loams of Interpretive Soil Groups 1 and 2. Western wheatgrass, with an r of −0.89, is a decreaser on the loamy soils of Soil Group 5. Scarlet globemallow, with an r of 0.84, is an increaser on the saline-alkali soils of Soil Group 7. Other species, varying in both degree and kind of response among soils, show

Table 5. Common and botanical names of species mentioned in text and tables.

Common name	Botanical name
Perennial grasses and sedges	
Western wheatgrass	*Agropyron smithii* Rydb.
Three-awn	*Aristida longiseta* Steud.
Blue grama	*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.
Buffalo grass	*Buchloe dactyloides* (Nutt.) Engelm.
Broad-leafed sedge	*Carex heliophila* Mack.
Saltgrass	*Distichlis stricta* (Torr.) Rydb.
Alkali sacaton	*Sporobolus airoides* (Torr.) Torr.
Sand dropseed	*Sporobolus cryptandrus* (Torr.) A. Gray
Needle-and-thread	*Stipa comata* Trin. & Rupr.
Shrubs and cactus	
Fringed sage	*Artemisia frigida* Willd.
Fourwing saltbush	*Atriplex canescens* (Pursh) Nutt.
Buckwheat	*Eriogonum effusum* Nutt.
Winterfat	*Eurotia lanata* (Pursh) Moq.
Plains pricklypear	*Opuntia polyacantha* Haw.
Perennial forbs	
Two-grooved loco	*Astragalus bisulcatus* (Hook.) Gray
Plains bahia	*Bahia oppositifolia* (Nutt.) DC.
Scarlet gaura	*Gaura coccinea* Nutt. ex Pursh
Povertyweed	*Iva axillaris* Pursh
Rush skeletonplant	*Lygodesmia juncea* (Pursh) D. Don.
Silky sophora	*Sophora sericea* Nutt.
Scarlet globemallow	*Sphaeralcea coccinea* (Pursh) Rydb.
Talinum	*Talinum parviflorum* Nutt. ex Torr. & Gray
Annuals	
Tansyleaf aster	*Aster tanacetifolius* H.B.K.
Slimleaf goosefoot	*Chenopodium leptophyllum* Nutt. ex S. Wats.
Cryptantha	*Cryptantha minima* Rydb.
Sixweeks fescue	*Festuca octoflora* Walt.
Skeletonleaf bur-sage	*Franseria discolor* Nutt.
Gilia	*Gilia laxiflora* (Coult.) Osterh.
Prairie pepperweed	*Lepidium densiflorum* Schrad.
Wooly indianwheat	*Plantago purshii* Roem. and Schult.

very weak responses to grazing intensity. We find insufficient foundation for range-condition classification on these range areas, because summer-long grazing at different intensities for 23 years has not affected species composition to a great extent on any soil.

Discussion

Classifications by SCS Personnel. — Soil-Conservation-Service personnel completed range-site and range-condition mapping on the Central Plains Experimental Range just one year prior to our sampling. Our interpretive soil groups are approximately equivalent to the range sites delineated. "Sandy Plains" includes all the macroplots in Interpretive Soil Group 1 and a few of those in Interpretive Soil Groups 2 and 3. "Loamy Plains" includes most of the macroplots in Interpretive Soil Groups 2, 3, and 4. "Overflow" includes some of the macroplots in Interpretive Soil Group 5, and the remainder, located where flood waters have been intercepted since 1950, are classified as "Brule Loam." "Clayey Swale" includes all macroplots in Interpretive Soil Group 6, and "Salt Meadow" includes those in Interpretive Soil Group 7.

All of the pastures included in our sampling were rated as fair or good (mostly good) range condition. The great variation in vegetation due to site differences, and the small variation due to range condition, was observed and interpreted as such by Soil-Conservation-Service personnel.

Range Site versus Range Condition. — Present concepts of range sites and range-condition classes are distinctly different. A range site is intended to be a natural subdivision in which the vegetation, being the product of special site conditions, includes species that, in fact, identify the site. A range-condition class is intended to be a successional subdivision (to be more exact, a secondary-successional subdivision) within a range site that can be manipulated to some more-advanced or some less-advanced state by the adjustment of grazing. A range-condition class is recognized by the array of (increaser and decreaser) species plus other characteristics of vegetation and soil. Modern range management is built upon the ecological foundation provided by these two concepts.

For the range areas included in the frequency sampling, Klipple and Costello (1960) described four range-condition classes and three grades of condition in each class. However, they did not separate soil-related from grazing-related vegetational differences. We sampled essentially the same extent of vegetational differences (and in the same areas) as sampled previously by Klipple and Costello (1960). Most of the vegetational differences in our data were soil related; therefore, they would be incorrectly classified under the term "range-condition classes." The blue-grama/buffalo-grass/pricklypear community of Interpretive Soil Group 4 can not be manipulated to equality with the "flood plain" of Interpretive Soil Group 5, or even with the short-grass/mid-grass community of Interpretive Soil Group 1. Site definition and delineation must precede range-condition classification, because range condition is interpreted as an indication of grazing severity.

But what is a range site in the upland vegetational continuum? Site differences on the bottomland soils are reasonably natural and discrete. However, sharp vegetational demarcations do not occur on the upland soils. We classified four interpretive soil groups on upland soils where the Soil Conservation Service classifies two range sites. For mapping purposes, three upland range sites probably would be more appropriate than either two or four. Whatever may be the division into sites, the standards for mapping are more arbitrary than natural. Any division that can be mapped with facility will contain considerable inherent variability that might subsequently be classified erroneously into classes of range condition. Although the concepts of range sites and range-condition classes are distinctly different, the phenomena upon which they are determined are partially inseparable in the field. Variations in range condition can alter the delineation of range sites. And heterogeneity within range sites can complicate range-condition classification.

Adequacy of Frequency Data. —Stable characteristics of vegetation are most useful in vegetation classification. For this reason, a complete species list is needed for each stand sampled. In addition, the characteristics of density, dispersion, and basal area are stable enough to be valuable criteria. Yield and cover often are too ephemeral to be useful in vegetation classification, but become important in subsequent studies. Frequency provides a relatively complete species list and measures the pooled effect of two reasonably stable characteristics — density and dispersion. Consequently, we theorized that frequency data should be valuable in the study of vegetation-soils and vegetation-grazing relations on the Short Grass Plains. Regarding the adequacy of frequency data, we conclude (1) that vegetation-soils relations have been clarified very well, (2) that summer-long (May 1 to November 1) grazing at different intensities for 23 years has not affected species frequencies to a great extent, (3) that the frequency percentages of species are stable enough to permit the study of vegetation-soils relations at all of these grazing intensities, and (4) that the most important effect of heavy grazing has been a reduction in herbage yields (Klipple and Bement, 1961).

Since the value of the frequency method depends on the sampling problem as well as the study objective, frequency data can be more or less valuable in other vegetation types and kinds of studies. Frequency, like density, rates individual plants equally regardless of size. Where density is a valuable criterion, frequency also can be valuable.

Grazing intensities introduce differences in species frequencies more slowly than in herbage yields. But reduced productivity can be recovered rather quickly with lighter grazing (Klipple and Bement, 1961) unless there have been significant changes in the density and dispersion of species. Therefore, the characteristics sampled by frequency are important in both site and condition classification on the Short Grass Plains.

Data processing limitations have restricted the use of frequency data in range investigations, but this is not an obligate disadvantage of the method. In the development of frequency sampling techniques for Short Grass Plains, we utilized the advantages of two statistical forms —the binomial and the normal distributions. A binomial classification of presence or absence permits maximum objectivity, accuracy, and speed in data collection. And the accumulation of data according to the requirements of sub-sampling theory permits the use of normal-theory statistics in data processing. The advantages gained in this way justify the careful development of frequency sampling techniques.

Summary

Frequency sampling was undertaken at the Central Plains Experimental Range in Colorado to test the assumption that the characteristics of species density and dispersion, as measured by frequency, are useful for the study of vegetation-soils and vegetation-grazing relations on the Short Grass Plains. Sampling techniques were developed and reported previously.

We conclude that (1) vegetation-soils relations have been clarified, (2) that summer-long (May 1 to November 1) grazing at different intensities for 23 years has not affected species frequencies to a great extent, (3) that the frequency percentages of species are stable enough to permit the study of vegetation-soils relations at all of these grazing intensities, and (4) that the most important effect of heavy grazing has been a reduction in herbage yields.

The results obtained are compared with previous classifications of range sites and range conditions, and the problem of classifying sites and conditions in a vegetational continuum is discussed.

LITERATURE CITED

COSTELLO, DAVID F., AND GEORGE T. TURNER. 1944. Judging condition and utilization of short-grass ranges on the Central Great Plains. U.S.D.A. Farmers' Bull. No. 1949: 1-21.

CURTIS, J. T. 1955. A prairie continuum in Wisconsin. Ecology 36: 558-566.

DYKSTERHUIS, E. J. 1949. Condition and management of range land based on quantitative ecology. J. Range Manage. 2:104-115.

GOODALL, D. W. 1953. Objective methods for classification of vegetation. I. The use of positive interspecific correlation. Austral. J. Bot. 1:39-63.

HANSON, HERBERT C. 1955. Characteristics of the *Stipa comata-Bouteloua gracilis-Bouteloua curtipendula* association of northern Colorado. Ecology 36:269-280.

HARRINGTON, H. D. 1954. Manual of the plants of Colorado. Sage Books, Denver. 666 p.

HYDER, D. N., R. E. BEMENT, E. E. REMMENGA, AND C. TERWILLIGER, JR. 1965. Frequency sampling of blue grama range. J. Range Manage. 18:90-93.

KLIPPLE, G. E., AND DAVID F. COSTELLO. 1960. Vegetation and cattle responses to different intensities of grazing on short-grass ranges on the Central Great Plains. U. S. Dep. Agr. Tech. Bull. No. 1216: 1-82.

KLIPPLE, G. E., AND R. E. BEMENT. 1961. Light grazing—is it economically feasible as a range-improvement practice. J. Range Manage. 14:57-62.

OOSTING, HENRY J. 1956. The study of plant communities. W. H. Freeman and Co., San Francisco. 440 p.

STEWART, GEORGE, AND WESLEY KELLER. 1936. A correlation method for ecology as exemplified by studies of native desert vegetation. Ecology 17: 500-514.

Vegetation And Soils Of Alkali Sagebrush And Adjacent Big Sagebrush Ranges In North Park, Colorado

D. R. ROBERTSON, J. L. NIELSEN and N. H. BARE[1]

Range Conservationist and Soil Scientists, respectively, Soil Conservation Service, U.S.D.A., Glenwood Springs, Colorado

Highlight

Alkali sagebrush ranges were found to have a shallow, root restricting claypan soil. In contrast, the adjacent big sagebrush plant community occurred on loamy soils where roots penetrated freely. This direct relationship between range sites and soils shows how soil surveys can be used to determine range sites.

In North Park, Colorado an unusual sagebrush plant community stands out in sharp contrast with other kinds of sagebrush rangelands. While the boundaries of other plant communities change gradually, the boundary of this plant community is sharp and distinct. A low growing sagebrush species sets aside this plant community from all others. The species is alkali sagebrush *(Artemisia longiloba* (Osterhout) Beetle) as identified by Beetle (1960). The local name for this species is "chicken sage."

Many have questioned why solid stands of this plant occur in blocks of a few acres to several hundred acres to the exclusion of other sagebrush species—then abruptly change on a sharp line to big sagebrush *(Artemisia tridentata* Nutt.).

This paper describes the vegetation and soils occurring on this range site, and compares both to the vegetation and soils on adjacent range sites having a cover of big sagebrush.

Beetle described alkali sagebrush as a dwarf, dark gray-green shrub which "stands strikingly alone in two respects; first its extremely early maturity which normally prevents crossing with any other species in the section, and secondly, its adaptation to tight-to-heavy soils derived from highly alkaline shales." He showed its distribution on "poorly drained or tight and highly alkaline soils from 6,000 to 8,000 feet elevation, in the vicinity of the foothills of the ranges forming the Continental Divide from southwestern Montana, through Wyoming to northwestern Colorado, and at scattered localities westward in northern Utah and Nevada and southern Idaho and Oregon." Passey and Hughie (1962) differed with the placing of alkali sagebrush on "poorly drained or tight and highly alkaline soils." Soils on which this species dominated, they found, were slightly alkaline to slightly acid in reaction.

Thatcher (1959) and others have shown that big sagebrush evidently requires at least moderately deep soils in order to dominate a plant community and avoids shallow soils. Thatcher found that the depth of soil to which big sagebrush (where dominant) could freely penetrate was at least 15 inches on 17 sites studied, and there were only two sites where the effective soil depth was less than 36 inches.

Study Area and Methods

North Park and North Park Soil Conservation District cover a high mountain valley which drains the headwaters of the North Platte River. It is a park about 40 miles long and 30 miles wide surrounded by mountains. The precipitation at Walden near the center of the park is 9.47 inches, the frost-free period is 46 days, and the mean annual temperature is 37.1 F. The elevation at Walden is 8,132 feet. The precipitation increases markedly toward the mountains so that the average annual precipitation nine miles east, where much of this data was gathered, is estimated to be 15 inches at an elevation of 8,400 feet. Low rounded hills of the Coalmont and Pierre shale formation are the loca-

[1] *Now Soil Scientist, Forest Service, USDA, Salt Lake City, Utah.*

tion of this site in the North Park soil survey area. Sandstone beds near the top of these formations form minor hogbacks. This feature creates a banding effect as seen from the air (Rocky Mountain Association of Geologists-1957). Soils derived from Coalmont and Pierre shales support a plant cover dominated by alkali sagebrush. Soils derived from the sandstone hogbacks support a higher producing plant cover dominated by big sagebrush. These bands are often no more than 150 feet wide with abrupt vegetation and soil boundaries (Fig. 1). The alkali sagebrush-dominated range site is called "Claypan," and the adjacent big sagebrush site is called "Mountain Loam."

Eight study areas were selected in the Claypan range site, and for comparison, 5 study areas were selected in the adjacent Mountain Loam range site. Soil pits were dug and profiles described for each of the 13 areas. Soil samples were taken and laboratory analyses were obtained from 7 of the study areas. Profiles of the other 6 soils were described and analyzed by field methods. Plant composition and production were determined for each location (Fig. 2).

Range study plots, 9.6 ft^2 in size, were located in the vicinity of the soil pits. Current year's growth of each species was clipped to ground level, placed in separate sacks, air dried, and weighed in grams. Current year's growth of shrubs was removed and weighed in grams. The productivity of each plot was expressed in lb/acre of air dry herbage.

Soil profiles were described and sampled in the manner outlined in the Soil Survey Manual (1951). Laboratory determinations included pH, both paste and 1-5 dilution, total soluble salt content, gravimetric salts, organic matter, lime, particle size distribution, saturation moisture, cation exchange capacity, exchangeable sodium percentage, and exchangeable potassium percentage. In addition to the laboratory analyses and usual field tests, kind and amount of root material were determined visually for each horizon. Density and size of cracks between aggregates were also observed.

Results

A summary of composition by weight of major species, total yield, and crown cover density for the Claypan and Mountain Loam range sites is shown in Table 1. A summary of important soil characteristics of the two range sites is shown in Table 2.

Each profile of the Claypan soils had two definite soil zones. The upper zone consisted of granular, friable soil that allowed easy circulation of air, water, and root growth of all kinds. The second zone consisted

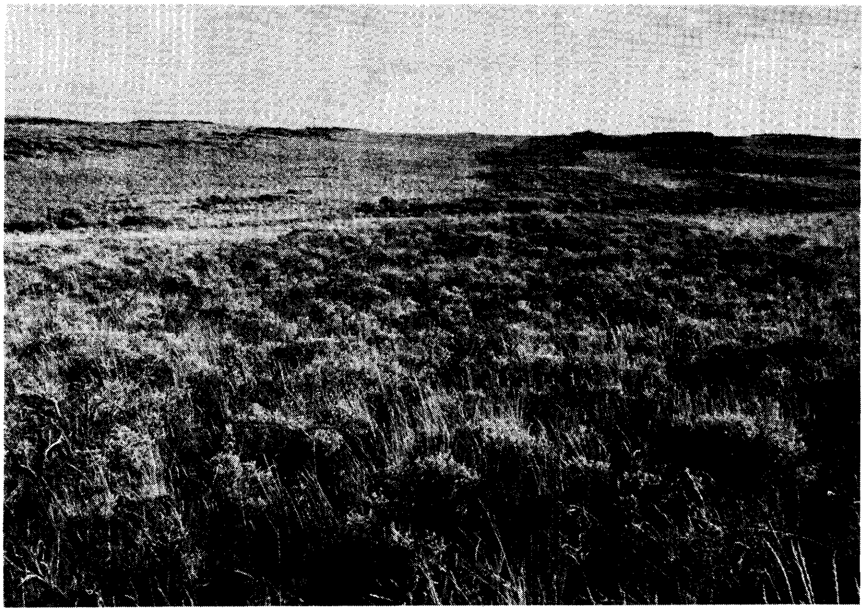


Fig. 1. Mountain Loam range site, foreground, and Claypan range site, center rear.

Fig. 2. Soil Conservation Service technicians making vegetative and soils studies of the Claypan range site in conjunction with the North Park Standard Soil Survey, Jackson County, Colorado.

Table 1. Summary of percent composition by weight for major species, total annual yield in lb/acre airdry, and crown cover density in percent for the Claypan and Mountain Loam range sites.

Species	Composition Claypan	Composition Mountain Loam
Alkali sagebrush *(Artemisia longiloba* (Osterhout) Beetle)	36	—
Big sagebrush *(Artemisia tridentata* Nutt.)	—	54
Bearded bluebunch wheatgrass *(Agropyron spicatum)*	10	—
Streambank wheatgrass *(Agropyron riparium)*	5	—
Thickspike wheatgrass *(Agropyron dasystachyum)*	—	2
Idaho fescue *(Festuca idahoensis)*	—	26
Pine needlegrass *(Stipa pinetorum)*	8	3
Prairie junegrass *(Koeleria cristata)*	6	—
Muttongrass *(Poa fendleriana)*	3	—
Nevada bluegrass *(Poa nevadensis)*	—	2
Sandberg bluegrass *(Poa secunda)*	4	—
Bottlebrush squirreltail *(Sitanion hystrix)*	—	2
Hoods phlox *(Phlox hoodii)*	11	—
Vasey rabbitbrush *(Chrysothamnus vaseyi)*	11	—
Total annual yield—all species	510	974
Crown cover density	20	35

Table 2. Summary of important soil characteristics of the Claypan and Mountain Loam range sites.

Claypan Soils	Thickness	Texture	Structure	Organic Matter %	pH	Exch. Sodium Percent
Non-restrictive Zone	Less than 10 inches except one of 16 inches	Sandy loam to clay	Granular	1.5 to 2.6	6.2 to 7.1	Negligible
Re-restrictive Zone	8 to 29 inches	Sandy clay loam to clay	Angular blocky	0.6 to 1.5	6.7 to 8.1	1.9 to 8.0
Mountain Loam Soils						
Topsoil	5 to 7 inches	Sandy loam to loam	Granular	4.0 to 5.3	6.0 to 6.1	Negligible
Subsoil	30 to 36 inches	Sandy clay loam to clay loam	Sub-angular blocky	Less than 1.0	6.2 to 6.5	Negligible

of dense, tight layers with moderate angular blocky structure which severely restricted the circulation of air and water and the penetration of all but the finest roots. The two zones are identified in this discussion as (1) nonrestrictive and (2) restrictive. No similar zone separations were observed in the Mountain Loam soils.

In the Claypan soils, the grade of structure development in the restrictive zone was moderate to strong. An angular blocky structure was always present. The larger roots of shrub species were observed to make right-angle turns upon contacting the restrictive zone. This suggests the existence of a rapid-swelling, slow-shrinking clay fraction in the restrictive zone. These observations would indicate that the clay fraction of the restrictive zone has two principal properties which limit the penetration of roots: (1) The aggregates swell rapidly upon wetting and all voids are closed before roots can extend through the restrictive layers. (2) When the soil dries and very small shrinkage cracks occur, there is insufficient available moisture for root growth. Larger roots penetrating any structure voids may be sheared off by the sharp edges of the aggregates during the swelling process. A rather low-producing plant community of alkali sagebrush and other shallow rooted, drouth-adapted shrubs, grasses, and forbs are able to survive under these soil conditions (Fig. 3).

The Mountain Loam soils had upper horizons that consisted of granular, friable soil that allowed easy circulation of air, water, and root growth of all kinds.

The subsoil consisted of moderate subangular blocky structure that allowed normal penetration of both large and small roots, and free circulation of air and water.

Big sagebrush and associated deep-rooted plants grow on the loamy soils, whereas shallow rooted drouth-adapted alkali sagebrush and associated plants occupy the Claypan soils. (Table 1).

This study points out the direct relationship between range sites and kinds of soil. By determining kinds of soil that are included in a range site and establishing soil mapping legends for the rangeland, the boundaries of soil mapping units can be used to determine the boundaries of range sites. The range sites and soils in the North Park soil survey area have been correlated in this manner, and this is being done throughout the United States as part of the National Cooperative Soil Survey.

Fig. 3. Cattle grazing the Claypan range site, Jackson County, Colorado.

Summary

In North Park, Colorado, the alkali sagebrush plant community stands out in sharp contrast from adjacent sagebrush range. Its abrupt boundary makes it an excellent site on which to study range site and soil correlation.

In preparing the legend for the North Park Standard Soil Survey, the soil and vegetation of this site were compared with the adjacent big sagebrush dominated range site.

A marked difference occurs in plant composition, total annual plant yield, and soil characteristics between the Claypan (alkali sagebrush) and the Mountain Loam (big sagebrush) range sites. These differences were consistent throughout the area studied.

The Claypan range site is the result of a shallow, restrictive soil zone which prohibits the penetration of all but the finest roots. The alkali sagebrush plant community, being drouth-adapted, can survive under this condition. On the other hand, this soil characteristic precludes the survival of big sagebrush and associated species. The big sagebrush community occurs only on moderately deep to deep, loamy soils where deep root penetration is possible.

After range sites and soils are correlated, it is possible to determine range sites from the soil survey. This is being done throughout the United States today by the National Cooperative Soil Survey.

LITERATURE CITED

BEETLE, A. A. 1960. A study of sagebrush. Univ. of Wyoming Agr. Exp. Sta. Bull. 368. 83 p.

PASSEY, H. B., AND V. K. HUGHIE. 1962. Sagebrush on Relict Ranges in the Snake River Plains and Northern Great Basin. J. Range Manage. 15:274-278.

ROCKY MOUNTAIN ASSOCIATION OF GEOLOGISTS. 1957. Guidebook to the Geology of North and Middle Park Basins, Colorado. 152 p.

SOIL SURVEY STAFF. 1951. Soil Survey Manual. U. S. Dep. Agr. Handbook No. 18. 503 p.

THATCHER, A. P. 1959. Distribution of sagebrush as related to site differences in Albany County, Wyoming. J. Range Manage. 12:55-61.

Fertilization and Management Implications on California Annual-Plant Range

C. EUGENE CONRAD, E. J. WOOLFOLK,[1] and DON A. DUNCAN

Range Conservationists, Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Berkeley, California

Highlight

The results from the first three years of a study at the San Joaquin Experimental Range on the effect of sulfur and sulfur-plus-nitrogen on management of annual-plant range are reported. Fertilizer increased production, especially in herbage yield and grazing capacity. Some effects these results may have on the costs of grazing cattle, especially in the green-forage season, are discussed.

Herbage yield on many annual-plant ranges in California has been increased by fertilizing with sulfur or sulfur-plus-nitrogen. The increase from use of sulfur has been as much as 200%; sulfur-plus-nitrogen could bring even greater increases. When herbage yield is increased, grazing capacity generally increases. Wagnon et al. (1958) found that daily gains in steers also increased on sulfur-fertilized ranges.

Sulfur deficiency has been found in more than half the counties in California. And nitrogen deficiency is assumed to be at least as widespread (Martin, 1958). But as researchers and ranchers have become more experienced in using fertilizers, they have found that gains have brought more problems along with more returns.

---

[1] *Presently Project Manager, Estacion Experimental Agropecuria, Casille de Correo No. 6, Concepcion del Uruguay, Argentina.*

Increased returns are mainly from the greater number of livestock that can be grazed. To graze the maximum number of animals, a rancher must know in advance how much herbage will be produced. He must consider land values before deciding whether to fertilize; he must also consider his ability to predict weather, and decide how often to fertilize. It is possible that buying or renting more land may be less expensive than buying and applying fertilizer.

Some information on managing and integrating fertilized and unfertilized annual-plant range is now available from a study started in 1959 at the San Joaquin Experimental Range, near O'Neals in the central Sierra Nevada foothills of California. The Experimental Range is maintained by the Pacific Southwest Forest and Range Experiment Station of the Forest Service, U. S. D. A. This paper reports results from the first 3-year fertilization cycle, completed in 1962. Some preliminary results were reported by Woolfolk and Duncan (1962).

Fig. 1. Yearling steers grazing green annual-plant herbage on unfertilized range at the San Joaquin Experimental Range.

The Study

The study design includes twelve separate range units at the Experimental Range. Hereford yearling calves—heifers the first year and steers the second and third years—were used in the study (Fig. 1). Fertilizer was applied in the fall of 1958 on the range units that were to be grazed in the dry-forage season, and in the fall of 1959 on the range units to be grazed in the green-forage season. Four range units were fertilized with gypsum to furnish 60 lb/acre of sulfur. Four others were fertilized with a mixture of ammonium sulfate and ammonium nitrate to furnish 60 lb of sulfur plus 80 lb/acre of nitrogen. The remaining four units were left unfertilized.

The cattle started grazing on dry summer feed, wintered on adjacent unfertilized range, and finished on green feed the next spring. Half the range units were stocked to capacity in June or July to obtain moderate use of the herbage by the end of the dry-forage season, in October or November. The other range units were similarly stocked during the green-forage season, usually the first part of February through early June. In this report, these two forage seasons will be referred to as the dry and green seasons, and the range units grazed during each as dry- and green-season units, repectively.[2]

Precipitation at the San Joaquin Experimental Range from 1934 through 1962 averaged about 19 inches per year, almost all rain. About ¾ of the total fell during the period from December through March (Fig. 2). Only the 1961-62 rainfall was average or better compared with the 29-year average (Fig. 3).

Past experience has shown that most plant growth occurs when mean daily temperature is above 50F. Average daily temperature in March generally is above 50F, but in 1961 and 1962, it was not until April that the average daily temperature rose above 50.

[2] *For statistical analysis the study was set up as a split plot with two blocks. The main plot effects were between forage seasons because of the crossover grazing program described by Woolfolk and Duncan (1962). The sub-plot effects were due to fertilizer treatments.*

Vegetation Results

Even though rainfall was below the long-term average except in the 1961-62 weather year, herbage production exceeded the 1,650 lb/acre long-term average in both 1960 and 1962. In general, if rainfall is below average, total herbage yield is expected to be below average. This was generally true of herbage yield, except in 1960 when it was 13% above average even though rainfall was 18% below average. Apparently spring rainfall in 1960, along with slightly warmer-than-average March temperatures, made up for the over-all lack of rainfall. In 1962 yield was 11% above average; rainfall was 9% above average.

Response of total herbage production to sulfur fertilizer was not remarkable at any time. First-year increase was less than 200 lb/acre in both the dry-season units in 1959 and the green-season units in 1960 (Table 1). Response in the second and third years after application was greater than in the first year, but still was lower than that reported by

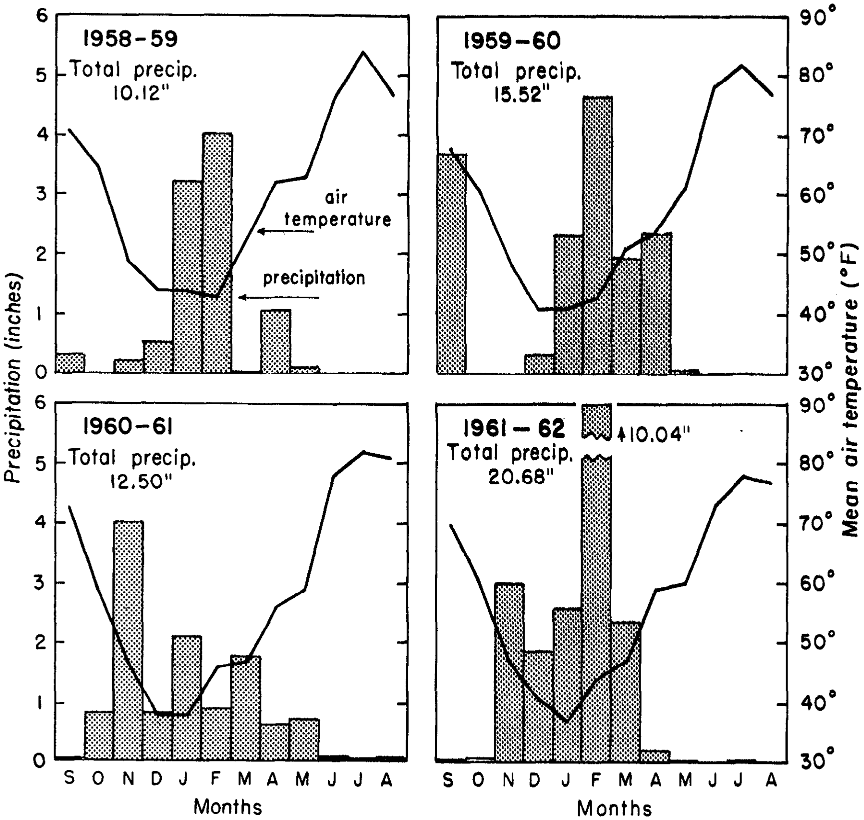


Fig. 2. Monthly rainfall and mean air temperature, September through August, at the San Joaquin Experimental Range, 1958-62.

Table 1. Yield of annual-plant herbage, in lb/acre air-dry, San Joaquin Experimental Range (1959-62).

Year	Fertilizer (dry-season units) None	Sulfur	Sulfur+ nitrogen	Fertilizer (green-season units) None	Sulfur	Sulfur+ nitrogen
1959	692	884ns	2,513**	——	——	——
1960	1,662	2,066*	3,485**	2,074	2,179ns	4,906**
1961	1,307	1,529ns	2,020**	1,477	1,859ns	2,235**
1962	——	——	——	1,829	2,345*	2,712**

Table 2. Percent weight composition of annual-plant herbage at the San Joaquin Experimental Range (1959-62).[1]

Plants	1959 None	1959 S	1959 S+N	1960 None	1960 S	1960 S+N	1961 None	1961 S	1961 S+N	1962 None	1962 S	1962 S+N
	Fertilizer[2]											
Grasses[3]	58	71	71	26	35	45	35	42	59	58	54	64
Forbs:												
Filaree	39	26	27	63	58	49	55	47	38	22	21	23
Clover	1	1	1	1	1	(4)	2	7	2	8	12	7
Other	1	2	1	10	7	6	7	4	1	12	12	6

[1] Except for 1959 and 1962 these data were calculated from the combined herbage production on units grazed in the dry- and green-forage seasons. The 1959 composition was calculated from the units grazed in the dry season and the 1962 composition from the units grazed in the green season.

[2] S=sulfur fertilizer, S+N=sulfur-plus-nitrogen fertilizer.

[3] Grasses include all true grass species plus small amounts of grasslike species.

[4] Less than 0.5 percent.

Bentley et al. (1958). Increase per year averaged about 270 lb on the dry-season units and 300 lb on the green-season units.

What is most striking about the units fertilized with sulfur-plus-nitrogen is the comparatively high yield in each year, including 1959. A less obvious but important comparison was the effect of dry weather on the carryover of sulfur-plus-nitrogen fertilizer. On the dry-season units fertilized with sulfur-plus-nitrogen, yield was 1,820 lb/acre higher than on the unfertilized units in both of the first two years. On green-season units, herbage yield was 2,830 lb/acre more than on unfertilized units in 1960, but only 760 lb more in 1961. The third-year increase was about 700 lb/acre on the dry-season units and about 900 lb on the green-season units. The average increase from sulfur-plus-nitrogen for three years was about 1,400 and 1,500 lb/acre on the dry-season and green-season units, respectively.

Botanical composition was changed drastically in 1960 by poor rainfall distribution the preceding fall and winter. In 1959 herbage composition was roughly 58% grass and 40% filaree (*Erodium* spp.) on the unfertilized units (Table 2). This is a fair balance of grass and filaree. In 1960 the balance was

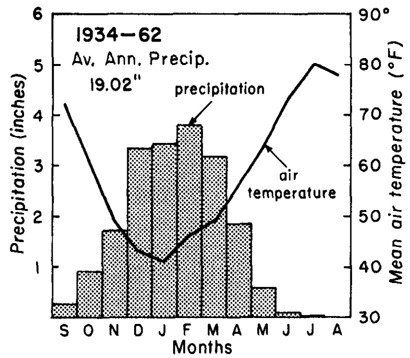


Fig. 3. Average monthly rainfall, 29 years (1934-62), and mean air temperature, 28 years (1935-62), September through August, at the San Joaquin Experimental Range.

upset—26% grass and more than 60% filaree. Reppert and Duncan (1960) have suggested that a fall drought, which lasted for more than three months in 1959 and followed an early storm that produced 3.75 inches of rain (Fig. 1), probably caused these unusual composition percentages. Finally, in 1962 there was a favorable balance of 58% grass and 22% filaree. Fertilizer apparently decreased the effect of the long fall drought in 1959. Even in 1960, grass made up 35 and 45% of the weight on the units fertilized with sulfur and sulfur-plus-nitrogen.

Clover response to sulfur did not begin to approach the proportions reported by Bentley et al. (1958) and Green et al. (1958) until 1961. This lack of response was apparently the result of low rainfall or poor rainfall distribution or both.

Table 3. Animal-days grazing per acre by yearling cattle at the San Joaquin Experimental Range (1959-62).

Year	Fertilizer (dry-season units) None	Sulfur	Sulfur+ Nitrogen	Fertilizer (green-season units) None	Sulfur	Sulfur+ Nitrogen
1959	7.8	8.5^{ns}	28.1**	—	—	—
1960	19.7	31.7^{ns}	57.3**	20.4	40.5*	69.3[1]**
1961	29.6	41.8^{ns}	52.3*	24.8[1]	43.4*	52.2[1]*
1962	—	—	—	23.1	40.2^{ns}	45.8*

[1] Adjustments in unit boundaries and correction of measurement errors changed these statistics since first published (Woolfolk and Duncan, (1962), but did not affect prevailing trends or resulting comparisons.

Grazing Seasons and Grazing Use

The animals started grazing on dry-season units when most of the plants were dry. They were not moved to the wintering unit until herbage use was satisfactory or the herbage was severely leached by fall rains. During the winter some new plant growth was available along with leached old growth and supplemental feed. The animals were put into the green-season units when plant growth became sufficient to produce gain without supplemental feed. The starting dates of green-season grazing varied between treatments and between years, depending on fertilizer and weather.

In each year of the study, more days of grazing were provided by fertilized range than by unfertilized range (Table 3). The amount of grazing use furnished by dry- and green-season units depended on the amount of herbage that cattle could use without overgrazing. By using extra animals, we attempted to obtain equal use on all units by the end of the respective grazing seasons. We counted the number of steer-days—heifer-days in 1959-60—and calculated the actual animal-days use per acre. For the dry and green seasons combined, an average of 21 days/acre of grazing per year was provided from the unfertilized range, 34 days from the sulfur-fertilized range, and 50 days from the sulfur-plus-nitrogen-fertilized range. To check the equality of use, we estimated the amount of residue remaining in each unit after grazing was completed. The differences between units were small in any single year.

Grazing use can be a valuable criterion for evaluating the effect of a change in a range operation. It is especially sensitive to the amount of feed available. In the annual-plant range type, differences in the amount of feed resulting from some treatment can be more important than differences in quality of feed, especially in the green season. Most of the herbaceous species are high quality for at least part of the growing period.

The amount of grazing produced in 1959 was lower than we hoped for, but the fertilizer applied in 1958 was not lost. The response in 1960, and again in 1961, demonstrated that the effects of sulfur or sulfur-plus-nitrogen extend beyond one year. The sulfur-fertilized units grazed during the dry season produced from one additional day/acre in 1959 to 12 additional days in 1960 and in 1961. The sulfur-plus-nitrogen-fertilized units produced 20 more days grazing per acre than the unfertilized units in 1959; 38 more days in 1960; and 23 more days in 1961.

The extremely dry 1958-59 season was reflected in days of grazing in 1959 and in herbage yield. The most encouraging result that year was the grazing produced by the sulfur-plus-nitrogen-fertilized units. Less than 8 days grazing per acre were produced on the unfertilized units and only 8.5 days on the sulfur-fertilized units. The 28 days grazing per acre from the sulfur-plus-nitrogen-fertilized units were nearly 4 times that from the unfertilized units; still, the 28 days were only about what we normally would expect from an unfertilized range.

The grazing produced by the unfertilized green-season units did not vary among years nearly as much as did the grazing produced by the unfertilized dry-season units (Table 3). Weather is the basic reason for less difference among the green seasons. A single dry year accounted for the extreme variation among the dry seasons: 22 days/acre between the best and poorest. There were no outstandingly dry or wet years among the three green seasons; consequently, less than 4.5 days/acre difference separated the best from the poorest green season.

The same reasoning applies to the variation in the amount of grazing produced on the sulfur-fertilized units. The difference was 33 days grazing per acre between the best and the poorest dry season, but only 3.5 days difference for the same comparison among green seasons. The sulfur-plus-nitrogen-fertilized green-season units produced 69 days/acre in 1960; 52 days in 1961; and 46 days in 1962. This is the way we expected sulfur-plus-nitrogen fertilizer to affect grazing capacity.

Part of the increased grazing capacity on the sulfur-plus-nitrogen-fertilized units resulted from earlier range readiness. In both 1960 and 1961 animals were turned in 25 days earlier than on the other units. Increased early grazing capacity could be one of the most valuable aspects of sulfur-plus-nitrogen-fertilized range. The range was ready for grazing when the herbaceous plants developed enough to feed the animals adequately. Even at these early dates, February and January in 1960 and 1961, little trampling damage resulted because most of the soils dry rapidly.

Cattle Performance

So far in this study, total gain per animal has averaged from more than 400 lb in the first year to about 260 lb in the third year. The cattle used the first year (1959-60) were heifers whose average starting weight was 464 lb/animal. The average starting weights of the steers were 414 lb in 1960 and 409 lb in 1961. The heifers also started out as older animals than the steers did, and they stayed on the range two to three weeks longer. These are three of the reasons the animals gained considerably more during the first year than in either of the other two years. The quality of the herbage for feed, discussed below, was another reason for better gains the first year.

At the beginning of each study year in June or July, the animals were grouped so the groups would differ only slightly in average weight. The range of weights in each group was also kept as small as possible. Each group was then assigned to a unit. In 1959 the average starting weight of the heifers in the unfertilized units was 462 lb; in the sulfur-fertilized units, 463 lb; and in the sulfur-plus-nitrogen-fertilized units, 467 lb. In 1960 the average starting weight of the steers was nearly 414 lb in each of the units. In 1961 the average starting weight of the steers was 410, 410, and 406 lb/animal on the unfertilized, sulfur-, and sulfur-plus-nitrogen-fertilized units, respectively.

Table 4 shows the difference among animal weight gains. Much of the difference among dry-season units in each year is probably a response to the botanical composition (Table 2) and nutritive quality of the herbage rather than to total yield. As the relative amount of grass and clover increases and forbs other than clover decrease, the cattle weight gain in the dry season should increase. Data from this study seem to support this hypothesis. Except for clover, forbs tend to become brittle and lose their leaves and seed in the first or second month of the dry season. During the same period, grasses also become dry, lose much of their seed, and nutritive quality, but tend to stay pliable and keep their leaves. Clover seems to stay green later than either grasses or other forbs.

Table 4. Average live-weight gain, in lb/animal, for yearling cattle by forage season, San Joaquin Experimental Range (1959-62).

Year and fertilizer[1]	Forage seasons Dry	Winter	Green	Total
1959-60				
None	65	116	189	370
Sulfur	83	134	171	388
S+N	136	116	210	462
1960-61				
None	-2	98	214	310
Sulfur	-9	110	205	306
S+N	2	101	220	323
1961-62				
None	33	65	154	252
Sulfur	42	67	159	268
S+N	56	62	149	267
Averages				
None	32	93	186	311
Sulfur	39	104	178	321
S+N	65	93	193	351

[1] S+N = Sulfur-plus-nitrogen fertilizer.

Live-weight gain per animal in 1959-60 was materially higher on the sulfur-plus-nitrogen-fertilized units than on the other units. The difference in gain on the dry-season units was greatest —more than 70 lb/animal higher than on the unfertilized units. The difference in gain on the green-season units is important, but may be misleading. The green season in each of the first two years was 25 days longer on the sulfur-plus-nitrogen-fertilized units than on the other units. The daily gain on the sulfur-plus-nitrogen-fertilized green-season units was actually lower than on the other units in 1960 and also in 1961. Otherwise the cattle performed equally well on all of the green-season units.

During the wintering period the cattle in this study gained considerably in total weight, but daily gain was below a pound. The first herd gained about 0.7 lb/day, the second 0.8 lb, and the third 0.4 lb/day. To maintain these winter gains, a cottonseed meal-salt mixture was fed free choice each winter. Depending on the weather and the amount of green forage available, the amount of meal eaten varied. Generally the cattle ate from 1.1 to 1.6 lb/day per head.

Implications

The obvious conclusion from this study is that sulfur-plus-nitrogen fertilizer caused herbage and cattle production to increase. Sulfur alone also caused some increase but by a much smaller amount. Additional production, however large, implies new problems in range management. Some of these implications may be considered within the scope of this paper.

We have placed major emphasis on animal-days of grazing produced by the range units. Granted, there were some differences in average gain per year per animal among the units.

Live-weight gain was greatest on range units fertilized with sulfur-plus-nitrogen and was particularly noticeable on the dry-season units. In one year, the cattle on such units gained more than 100 lb during the dry season. Fertilizing range with sulfur-plus-nitrogen cannot be justified solely by this amount of gain for one out of three years. Apparently the cost of fertilizing with sulfur-plus-nitrogen for dry-season use must be justified by the need to provide for a source of additional or emergency forage. An example of this kind of need occurred as a result of the 1958-59 drought. A fair-sized herd could have been maintained by a relatively small amount of fertilized range. Fertilizing for dry-season use may have more advantages that are not yet apparent. The period covered here, only three years, is questionable as being representative — considering the weather. Also, these results apply only where application of fertilizer is once every three years at the rate we used.

The greatest differences among fertilizer treatments occurred in the green-season units. Consequently the rest of this discussion will deal mainly with the green seasons. Even these differences mostly affected grazing capacity rather than animal gain. There should be little difference in animal gain, provided an adequate amount of forage is available at all times during the green season.

The seemingly obvious conclusion is that sulfur-plus-nitrogen fertilizer gives the best results because grazing capacity is highest where this fertilizer is used. But the relationship between the cost of fertilizing and the amount of additional grazing obtained may modify or even change the conclusion. Certainly some consideration of costs is needed to strengthen the usefulness of the information.

We do not intend to make an economic analysis of the data presented. But we can show how our costs may affect a fertilizer program. As stated earlier only two rates of fertilizer were applied, 0 and 60 lb of sulfur or 60 lb of sulfur plus 80 lb of nitrogen. The rates were based on the results of earlier work done at the San Joaquin Experimental Range (Green and Bentley, 1954; McKell et. al., 1960).

Recognizing these limitations, we used the information from the studies to evaluate the cost of grazing on these particular range treatments. The information, consisting of averages from the data presented earlier, was as follows:

1. Average length of the green season in days:
   Unfertilized units 96
   Sulfur-fertilized units 96
   Sulfur-plus-nitrogen-fertilized units 113
2. Average grazing capacity of the green-season units in days/acre:
   Unfertilized units 22.8
   Sulfur-fertilized units 41.4
   Sulfur-plus-nitrogen-fertilized units 55.5
3. Cost of the fertilizer program per acre/year including 6% interest charge discounted yearly:
   Sulfur-fertilized units $1.16
   Sulfur-plus-nitrogen-fertilized units $4.72

The cost of the animals has been left out since the study was limited to the grazing problem. An additional set of costs, which we will call "range costs", are missing: investments in rangeland, equipment, upkeep, and improvements, plus labor, taxes, and interest on these investments. The study and the analysis of the data were not designed to evaluate such costs, but our analysis did show that they may determine the kind of fertilizer program to be followed.

According to our data, if range costs were $5.86/acre/year, the cost of grazing per animal would be about equal ($21.54) for either a 96-day season on the sulfur-fertilized units or a 113-day season on the sulfur-plus-nitrogen-fertilized units. At the same time, the costs on the unfertilized units would be much higher ($29.94). Range costs lower than $5.86 would tip the scales in favor of sulfur-fertilized range. Higher range costs would favor sulfur-plus-nitrogen.

Several factors account for the lower cost of grazing per animal with a particular kind of fertilizer at a given evaluation of range costs. Probably the greatest contributing factor is the increased grazing capacity on the fertilized range units. A second factor is earlier range readiness on range units fertilized with sulfur-plus-nitrogen. As the cost of maintaining the livestock during the wintering period goes up, early range readiness becomes increasingly more valuable. Finally, as the costs of a resource such as rangeland and of labor increase, the relative cost of a fertilizer decreases. Thus when land and labor are high enough, the cost per animal will be least on the nitrogen-plus-sulfur-fertilized units. At one extreme it could be more economical to buy or lease more land than to fertilize. At the other extreme, great expense for fertilizer may be justified to get the highest possible production per unit of resource.

Summary

In a grazing study at the San Joaquin Experimental Range, 60 lb of sulfur, 60 lb of sulfur plus 80 lb of nitrogen, or 0 lb of fertilizer were applied on annual-plant range. Both herbage production and cattle live-weight gain increased as a result. The

study, begun in mid-1959, included two years of severe drought and poor rainfall distribution.

The greatest effect of using fertilizer was to increase grazing capacity. Little important difference in daily gain was noted except in the first year of dry-season grazing. The number of animal-days of grazing in the dry season was increased by 45% on the sulfur-fertilized units, and by 141% on sulfur-plus-nitrogen-fertilized range units. On the same kind of range grazed in the green season, the increase was 82% on sulfur-fertilized units and 145% on sulfur-plus-nitrogen-fertilized units. Also the green season began an average of 17 days earlier on the sulfur-plus-nitrogen-fertilized range.

We considered the additional grazing capacity produced on fertilized range a useful way of evaluating a fertilizer program. Even considering the longer green season and greater grazing capacity, the cost of grazing per animal for the sulfur-plus-nitrogen-fertilized range was higher than for sulfur alone so long as the cost of the rangeland, equipment, labor, etc. was below $5.86 /acre/year. This includes consideration of the cost of maintaining the animal on winter range plus supplement during the 17 days when the green season had started on the sulfur-plus-nitrogen-fertilized units.

LITERATURE CITED

BENTLEY, J. R., L. R. GREEN, AND K. A. WAGNON. 1958. Herbage production and grazing capacity on annual-plant range pastures fertilized with sulfur. J. Range Manage. 11:133-140.

GREEN, L. R., AND J. R. BENTLEY. 1954. A report on some costs and returns from applying sulfur fertilizers on rangeland. Northrup King, Westland Pasture J. 5(2):1.

GREEN, L. R., K. A. WAGNON, AND J. R. BENTLEY. 1958. Diet and grazing habits of steers on foothill range fertilized with sulfur. J. Range Manage. 11:221-227.

MCKELL, CYRUS M., CHARLES A. GRAHAM, AND ALMA M. WILSON. 1960. Benefits of fertilizing annual range in a dry year. U. S. Forest Serv., Pacific Southwest Forest and Range Exper. Sta. Res. Note 172, 9 p.

MARTIN, W. E. 1958. Sulfur deficiency widespread in California soils. Calif. Agr. 12(11):10-12.

REPPERT, JACK AND DON DUNCAN. 1960. Range annuals endure record fall drought. West. Livestock J., October, p. 23.

WAGNON, K. A., J. R. BENTLEY, AND L. R. GREEN. 1958. Steer gains on annual-plant range pastures fertilized with sulfur. J. Range Manage. 11:177-182.

WOOLFOLK, E. J., AND D. A. DUNCAN. 1962. Fertilizers increase range production. J. Range Manage. 15:42-45.

Interval of Observation of Grazing Habits of Range Beef Cows

A. B. NELSON,[1] AND R. D. FURR[2]

Associate Professor and Graduate Assistant, Department of Animal Science, Oklahoma State University, Stillwater.

Highlight

Reasonably accurate estimates of activities of longer duration, such as grazing and ruminating, can be obtained by observations at intervals of 15 or even 30 min. Observations at 15 min or longer intervals failed to give reliable estimates of such activities as walking, sleeping, nursing calves, defecation, urination and drinking.

[1] *Present address: Professor of Animal Science, New Mexico State University, University Park, New Mexico.*

[2] *Present address: Livestock Specialist, Agricultural Extension Service, University of Hawaii, Honolulu, Hawaii.*

It is important to know animal grazing behavior in pasture experiments. A large quantity of accurate data may be obtained from continuous observation, but the procedure is laborious. A larger number of animals may be observed with less labor by lengthening the interval between observations. Hughes and Reid (1951), Tayler (1953) and Harker et al. (1954) concluded that observing activities of grazing cattle at 4-min intervals yielded satisfactory results. Sheppard et al. (1957) recorded observations of grazing habits at 30-min to 1-hr intervals, but did not make any observations at night. Hull et al. (1960) compared 15-, 30-, and 60-min observation intervals with continuous observation using four steers in 0.4 acre of irrigated pasture. Among those reporting grazing habits of range beef cattle observed continuously are Dwyer (1961) and Wagnon (1963). This study reports the frequency of observations necessary for an accurate estimate of the activity of range beef cows in a 24-hr period.

Methods

Five 24-hr grazing behavior studies (continuous observation) were conducted with grade Hereford cattle grazing in excellent condition native grass pastures approximately 100 acres in size, eight miles northwest of Stillwater, Oklahoma. The dominant grass species were little and big bluestem *(Andropogon scoparius* and *A. gerardi)*, indiangrass *(Sorghastrum nutans)* and switchgrass *(Panicum virgatum)*. The topography was gently rolling with some small hills, however, none was steep enough to hinder the natural travel of the cows.

The number of cows observed per study varied from 7 to 11; in three of the studies the cows were suckling calves. The first study began on August 18, 1959, at 10 AM and ended 24 hr later. All other studies started at 5:30 AM. One group of spring-calving cows was observed in one pasture on August 25, 1959, and again on September 25, 1959. A second group was fall-calving cows observed in another pasture on August

18, 1959, September 11, 1959, and July 2, 1960. The activities recorded were grazing, standing ruminating, standing idle, lying ruminating, lying idle, walking, suckling calves and sleeping. Walking included only actual time spent in walking directly from one place to another and did not include time devoted to travel accompanying grazing. Cows were considered to be sleeping when they turned their head to one side and rested it against their body or on the ground with their eyes closed. A record was also made of the distance traveled, and the number of times cattle drank, defecated and urinated. Distance traveled was measured from routes traced on aerial photographs. Results of continuous observations over a 24-hr period were compared with those recorded at 15-, 30-, and 60-min intervals over the same period. At these time intervals the total time spent in a given behavior was calculated on the assumption that the animal remained in a particular pattern from the time of one observation to the next.

Different colored paints or combinations thereof were used to identify individual cattle. Marking the cattle across the back, across the forehead and across the tailhead and pinbone region facilitated identification of individuals from any angle of observation. Small reflective glass beads were dusted on the wet paint as an aid to identification during nighttime.

Observations were made by at least three persons. Usually two persons observed the animals, generally with the aid of field glasses, while the third person recorded the information. Observers were generally at a distance of about 75 and 50 yards from the cattle during the daytime and nighttime, respectively. A pickup truck, to which the cattle were accustomed, was used to follow them in the pasture. At night it was usually necessary for the observers to use a handlamp or spotlight to determine certain activities such as ruminating and sleeping. Disturbance resulting from the use of light appeared to be negligible.

Results and Discussion

A summary of the activities of the cows determined from observations made at the four different time intervals in each of the five studies is given in Table 1. The variation in relation to size of the mean for activities recorded during continuous observations indicate that, within any individual study, grazing time varied the least.

For most activities the standard deviation increased as the time interval between observation increased. As might be expected, the activities of shortest duration were usually the most variable. For example, the time associated with walking was quite different in two of the studies (August 18 and September 11) when the observation intervals were 15 min instead of continuous; also, the standard deviation was usually markedly increased. When the interval of observation was increased to 60 min, no time whatsoever was recorded for walking on August 24 and September 11. It seems that for a reliable estimate of walking and perhaps other activities of short duration, the observation interval must be less than 15 min.

The larger standard deviation in all studies for any activity at the 60-min interval of observation as compared with continuous observation does not appear to be associated with the difference in mean time associated with that activity. Illustrative of this is a comparison of grazing time at the different intervals of observation on September 11. The average time spent grazing was 673, 686, 693, and 671 min for continuous, 15-, 30-, and 60-min intervals of observation, respectively. However, the standard deviation was more than

Table 1. Activities of range beef cows for a 24-hr. period as determined at different intervals.

Date					Ruminating				Idle			
and	Grazing		Walking		Standing		Lying		Standing		Lying	
Interval	Min	SD[a]	Min	SD	Min	SD	Min	SD	Min	SD	Min	SD
July 2, 1960 (10 cows)												
Contin.	536	35.8	26	8.8	133	58.1	443	67.4	192	34.3	110	25.3
15 min.	523	45.0	21	14.5	134	63.8	452	61.8	207	44.0	103	30.4
30 min.	482	60.9	21	20.2	147	72.7	453	47.9	225	45.3	111	56.7
60 min.	456	120.9	24	31.0	162	89.7	396	106.6	270	76.2	132	108.8
August 18, 1959 (11 cows)												
Contin.	586	35.8	47	7.6	188	48.1	364	52.2	170	36.7	85	32.2
15 min.	573	37.8	19	9.7	187	47.6	361	48.1	207	47.3	93	36.0
30 min.	619	36.2	3	9.1	177	60.7	368	52.1	175	42.0	98	42.6
60 min.	638	72.4	6	18.1	169	88.3	382	48.5	169	79.9	76	66.2
August 25, 1959 (10 cows)												
Contin.	576	23.7	34	3.6	280	55.8	242	44.0	204	31.8	104	50.4
15 min.	582	30.7	28	14.9	300	36.8	228	56.0	195	55.2	107	50.2
30 min.	612	42.9	33	9.5	297	53.8	228	69.6	168	53.3	102	51.4
60 min.	660	56.6	0		258	89.7	246	77.2	169	73.8	108	62.0
September 11, 1959 (11 cows)												
Contin.	673	34.3	9	6.3	131	44.5	413	63.3	81	26.3	133	44.2
15 min.	686	37.4	1	4.5	120	39.7	420	64.3	87	29.1	126	49.4
30 min.	693	41.3	3	9.1	120	40.2	403	64.8	90	46.5	131	54.1
60 min.	671	75.0	0		153	62.1	393	77.6	76	54.3	147	67.7
September 25, 1959 (7 cows)												
Contin.	634	55.3	15	9.8	106	60.7	373	70.5	134	34.9	178	47.3
15 min.	647	57.7	13	18.2	105	60.0	367	61.1	124	28.3	184	49.5
30 min.	651	68.7	9	14.7	99	66.4	377	71.1	116	20.7	188	61.8
60 min.	634	90.7	17	29.3	60	69.3	343	108.0	129	64.1	257	75.2
Average (Weighted) Activities Five Dates of Observation												
Contin.	600	60.4	27	15.8	171	80.1	368	90.8	156	56.1	118	48.8
15 min.	601	71.0	16	15.4	173	85.5	366	96.3	166	65.3	118	51.0
30 min.	611	86.3	14	17.4	171	89.4	366	96.4	156	64.2	122	58.9
60 min.	612	114.9	9	21.2	166	97.4	354	98.9	163	78.5	136	93.1

[a] Standard deviation

double for 60-min interval as compared with continuous observation. Usually, variation increased most when the interval of observation was increased from 30 to 60 min, e.g., on September 11 the standard deviation was 41.3 at the 30-min interval vs. 75.0 at the 60-min interval.

Harker et al. (1954) found that the error introduced by observing grazing habits at 4-min intervals rather than continuously was inversely proportional to the time spent in each activity. Hull et al. (1960), who compared 15-, 30- and 60-min intervals with continuous observation on the behavior of four steers over a 24-hr period in 0.4 acre of irrigated pasture, reported wide individual variation in animal behavior patterns.

In general, for activities of longer duration (grazing and ruminating) the variation and mean were not altered greatly up to but not including 60-min intervals of observation. Times spent in each of these two activities during each hour on July 2 when observed at the different time intervals are illustrated graphically in Fig. 1. No time was recorded for either activity because 6:30 and 7:30 AM at the 60-min interval of observation even though an average of 24 min was noted for grazing time at the 30-min interval of observation. Standing idle was the main activity other than grazing during this particular hour. Another example of considerable variation is during the time from 8:30 to 9:30 P.M. when 36 min of grazing and 6 min of ruminating were recorded for the 60-min observation interval vs. 18 min of grazing and 30 min of ruminating for the 30 min interval.

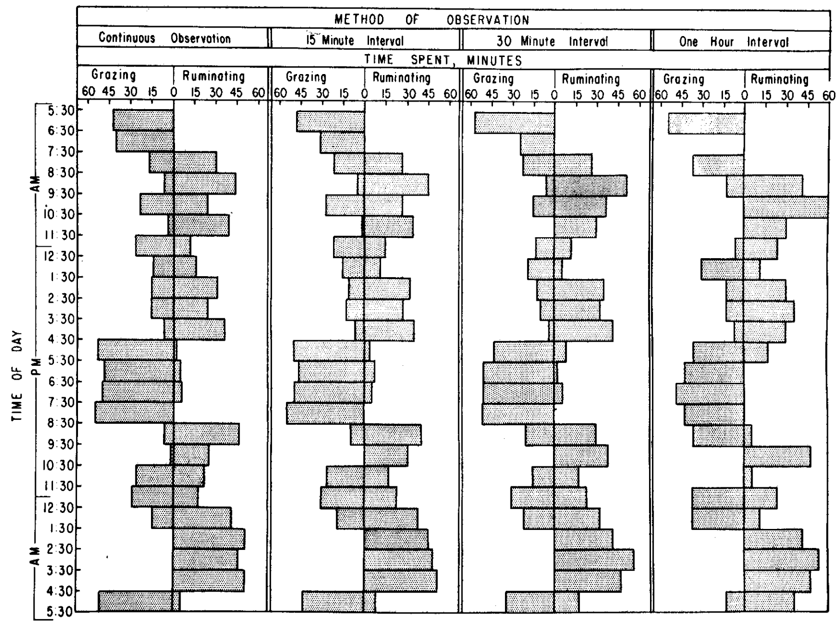


Fig. 1. Grazing and ruminating times of range beef cows when observed continuously and at 15-, 30-, and 60-minute intervals, July 2, 1960.

These studies indicate that the accuracy desired by the experimenter will tend to dictate the most desirable observation interval. It appears that reasonably accurate estimates of the activities of longer duration can be obtained by observations at intervals of 15 or even 30 min. This is in agreement with the results of Hull et al. (1960) who observed steers on irrigated pasture. The primary purpose of the longer interval would be to allow the experimenter to observe more animals.

Summaries of the miscellaneous activities from a record of continuous observation are given in tables 2 and 3. In order to determine accurately these activities they must be recorded at intervals of less than 15 min.

Table 2. Miscellaneous activities of beef cows on the range in a 24-hour period.

	July 2, 1960		August 18, 1959		August 25, 1959		September 11, 1959		September 25, 1959	
Activity	Avg	SD[a]	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Avg. distance traveled, mi.										
Day	1.92	—	2.81	—	2.26	—	1.64	—	1.52	—
Night	0.23	—	0.92	—	0.65	—	0.36	—	0.65	—
Total	2.15	—	3.73	—	2.91	—	2.00	—	2.17	—
Time walking, min	26.0	8.8	47.0	7.6	34.0	3.6	9.0	6.3	15.0	9.8
Time sleeping, min[b]	30.6	16.1	—	—	—	—	26.6	13.4	27.0	15.9
No. of drinks of water[c]	2.0	—	—	—	2.0	—	1.4	—	—	—
No. of defecations	7.8	1.7	8.0	3.9	2.1	1.6	6.4	3.2	3.6	1.4
No. of urinations	1.5	1.1	5.0	3.8	1.5	0.8	2.4	1.4	1.6	0.8

a Standard deviation.
b No record kept on August 18 and 25.
c No record kept on August 18. Cattle did not drink on September 25 which was relatively cool with a very heavy dew.

Table 3. Observations of calves with their dams on the range.[a]

Date of Study	Age of calves mo.	Nursing periods No	SD[b]	Total time spent nursing Min	SD
July 2, 1960	8	2.4	1.6	18.1	14.6
August 25, 1959	6	3.2	1.2	23.7	8.8
September 25, 1959	7	3.6	1.0	27.3	12.9

[a] In 24-hour period.
[b] Standard deviation.

Therefore, values for the different intervals of observation are not given.

Summary

Five 24-hr. grazing behavior studies (continuous observation) were conducted with grade Hereford cows grazing native range pastures. The number of cows varied from 7 to 11; in three of the studies the cows were suckling calves.

Results of continuous observation were compared with those obtained from observations at 15-, 30-, and 60-min intervals. Reasonably accurate estimates of the two major activities, grazing and ruminating, were obtained in each study from observations at 15- and 30-min intervals. Estimates of these activities obtained from observations at 60-min intervals were quite variable. Observations at 15-min intervals failed to give reliable estimates of such activities as walking, sleeping, nursing calves, defecation, urination and drinking.

LITERATURE CITED

DWYER, DON D. 1961. Activities and grazing preferences of cows with calves in northern Osage County, Oklahoma. Okla. Agr. Exp. Sta. Bull. B-588. 61 p.

HARKER, K. W., J. I. TAYLOR, AND D. H. L. ROLLINSON. 1954. Studies on the habits of Zebu cattle. I. Preliminary observations on grazing habits. J. Agr. Sci. 44: 193-198.

HUGHES, G. P., AND D. REID. 1951. Studies on the behavior of cattle and sheep in relation to the utilization of grass. J. Agr. Sci. 41: 350-366.

HULL, J. L., G. P. LOFGREEN, AND J. H. MEYER. 1960. Continuous versus intermittent observations in behavior studies with grazing cattle. J. Anim. Sci. 19: 1204-1207.

SHEPPARD, A. H., R. E. BLASER, AND C. M. KINCAID. 1957. The grazing habits of beef cattle on pasture. J. Anim. Sci. 16: 681-687.

TAYLER, J. C. 1953. The grazing behavior of bullocks under two methods of management. Brit. J. Anim. Behav. 1: 72-77.

WAGNON, K. A. 1963. Behavior of beef cows on a California range. Calif. Agr. Exp. Sta. Bull. 799. 58 p.

Range Improvement As Related To Net Productivity, Energy Flow, And Foliage Configuration[1]

WILLIAM A. WILLIAMS
Professor of Agronomy, University of California, Davis

Highlight

To maximize the conversion of the solar energy received by range vegetation into forms effectively used by domestic animals is an important objective of range managers. In annual-type California range improved by legume introduction and sulfur fertilization, the efficiency of the conversion of annual solar energy income over a three-year period averaged 0.09% by the vegetation and 0.004% by the stockers consuming the fed-off portion of the vegetation. Further study of the manner of display of the photosynthetic surfaces in range vegetation communities to incoming radiant energy will make it possible to identify foliage configurations that will maximize solar energy capture.

Productivity is the rate of generating or transforming a resource per unit time, and it is an attribute of many nonecological systems as well as all ecological systems (ecosystems). Productivity in the ecological context is the time rate of transforming radiant energy from the sun to chemical energy stored by photosynthetic organisms with the resulting generation of organic matter.

[1] *Adapted from a paper presented as part of a symposium on "Range Ecosystems", November 12, 1964, to the annual meeting of the California Section, American Society of Range Management, Ukiah California.*

From the relatively few long-term records of solar energy receipts that are available, we know that large amounts of energy are received at the earth's surface and that the amounts vary seasonally and from place to place. A primary management objective of ranchers is to maximize the conversion of this energy by range plants; although other qualities of the resulting organic matter, e.g., protein, mineral, or vitamin level, may attain importance in some range situations.

Records of productivity in range ecosystems are few and fragmentary. Nevertheless, it is useful to attempt to compile such information in an example to contrast energy input-output relations under various levels of resource management. In the example given below some components were not evaluated, and for those, estimates were derived from the observations of others working with related vegetation and consumer types.

Site Description and Productivity Analysis

The study area under consideration is located 30 miles due west of Modesto, California, on the periphery of the San Joaquin Valley at an elevation of 250 ft. The site is on a mature alluvial terrace, and the soil type is Snelling sandy loam. The land has been farmed to dry land winter cereals for grain and hay, but more recently has been used solely for grazing. In the unimproved state the vegetation is largely the annual type with filaree, *Erodium botrys*, and annual species of grass predominating. The climate is the Mediterranean type (Köppen's Csa) with annual precipitation of approximately 16 inches occurring mainly in the winter, with the summer essentially rainless; temperatures are mild in winter and warm to hot in summer (Kesseli, 1942).

In a 7-acre portion of a much larger grazing unit, various experimental treatments involving the introduction of numerous forage species and application of fertilizers were carried out over a 10-year period. In brief these trials demonstrated that marked increases in productivity result from the introduction of a winter annual legume, rose clover *(Trifolium hirtum)* and periodic application of sulfur fertilizer (Love and Sumner, 1952; Williams et al., 1957).

Over a period of three successive years the standing crop of vegetation above ground was measured on replicated plots which had received an initial treatment of gypsum containing 90 lb/acre of sulfur and a seeding of 10 lb/acre of rose clover.[2] The mean annual production of the organic matter sampled at the bloom stage was 2180 lb/acre (Table 1), and this value is used as the base point for the analysis.

In the simplified situation depicted in Fig. 1, two trophic or food levels are highlighted: the producers which comprise the vegetation community and the primary consumers or herbivores, cattle. The next trophic level is man, but his consumption involves export of the livestock products, and hence, is not included in the diagram. Various other consumers were observed, e.g., insects, birds, pocket gophers, and jackrabbits. Their activities were not assessed, but seemed to have little influence during the three years considered in this analysis and are not included in the quantitative aspects of the discussion. Other consumers undoubtedly present, but not discussed here, were the predators and parasites of the livestock and the soil inhabiting decomposers.

Since the vegetation was harvested with a walking sicklebar mower, it is estimated that a stubble amounting to 10% of the above ground portion remained after sampling. Hence the above ground standing crop was 2180/0.9 = 2420 lb/acre. Roots are estimated at 17% of the total biomass based on recent measurements of rose clover and filaree by Ozanne et al. (1965), and thus total plant

Table 1. Effect of range improvement techniques on harvestable forage, legume content of forage, and efficiency of solar energy conversion (SEC) by range vegetation.

	Unimproved		Sulfur fertilization		Rose clover seeding		Rose clover + sulfur	
	Harvest lb/a.	Legume %	Harvest lb/a.	Legume %	Harvest lb/a.	Legume %	Harvest lb/a.	Legume %
1st y.	1080	0	1120	0	1970	29	3080	64
2nd y.	680	0	730	0	1540	38	2270	53
3rd y.	410[1]	0	440[1]	0	940	42	1200	53
Mean	720		760		1480		2180[2]	
SEC. %	0.03		0.03		0.06		0.09	

[1] Rose clover had invaded the unseeded plots by the third year, and these two estimates are extrapolated from quadrats clipped from nearby sites.
[2] Base value for which energy flow example was calculated.

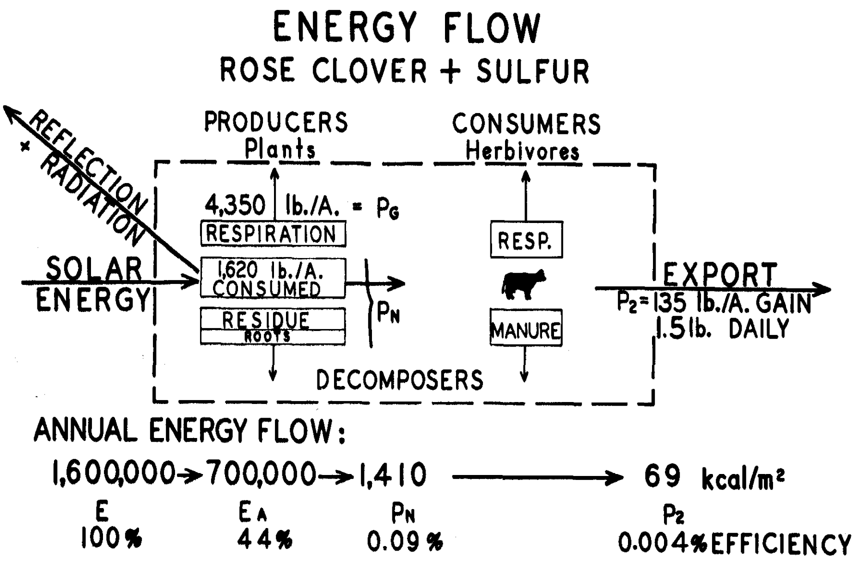


Fig. 1. Productivity, energy flow, and efficiency of solar energy conversion in a range ecosystem modified by introduction of rose clover and application of sulfur fertilizer.

[2] *The cooperation of W. N. Helphenstine, California Agricultural Extension Service and R. J. Arkley, Soil Morphologist, University of California, Berkeley, in the conduct of this trial is gratefully acknowledged.*

biomass was 2420/0.83 = 2920 lb/acre. If respiration accounted for 33% of gross productivity (Thomas and Hill, 1949), then gross productivity (P_G) amounted to 2920/0.67 = 4350 lb/acre annually. Since net productivity is gross productivity less respiration loss, the net productivity (P_N) was 2920 lb/acre annually.

Some considerations disregarded in the above analysis that may have led to underestimation of productivity are (1) ignoring the possible growth stimulating effects of moderate grazing, (2) not accounting for organic matter contained in plants succumbing prior to sampling, and (3) disregarding the differences in the time that different species reach their peak standing crop (Wiegert and Evans, 1964).

The kind of animals commonly used as primary consumers on this site are steers purchased in the autumn to utilize the winter and spring green forage produced by the annual-type range. If these stockers on the average consume two-thirds of the aboveground standing crop, their consumption amounts to 2420 x 0.67 = 1620 lb/acre. This might be expected to produce an average of 1 lb liveweight gain per 12 lb range forage consumed at a gain level of 1.5 lb per head per day (Lofgreen, 1964; Martin et al., 1958) for a total of 135 lb/acre liveweight gain per year (P_2). This equates to 135/1.5 = 90 grazing days per acre. Each steer may be expected to excrete about 6 lb total solids in liquid and solid manures per day (Anderson, 1957) for a total of 6 x 112 = 672 lb/acre. Losses of energy will occur at the herbivore level due to the respiration involved in the animal's metabolic activities as well as in the export of carcass weight increments to market.

Energy Flow

It was estimated by extrapolation from the nearest weather stations recording solar radiation, that the annual sum of solar energy (E) received at the study site is about 1,600,000 kilocalories per square meter of land surface. Of this total 44% or 700,000 kcal is within the spectrum of wavelengths which plants can use for photosynthesis (E_A). The further partitioning of the energy by the activities of plants has been discussed recently (Loomis and Williams, 1963). In the example presented here, the plant community averaged a conversion of (2920 x 0.112) g/m² x 4.3 kcal/g = 1410 kcal/m² as the annual net productivity (P_N) averaged for the three year period. Golley's (1961) mean caloric content for green herbs of 4.3 kcal/g of organic matter is used here. The efficiency of solar energy conversion at the producer trophic level then is 1410/1,600,000 = 0.09%.

At the herbivore level in the food chain, the consumption of the plant material described above results in animal gain equivalent in energy to (135 x 2080 kcal/lb) / 4050m²/acre = 69 kcal/m² annually (Lofgreen and Otagaki, 1960). Thus, the secondary productivity (P_2) associated with the consumer or herbivore trophic level has a net efficiency of 69/1,600,000 = 0.004% relative to the available solar energy income.

It is apparent that as the energy from the sun passes down the food chain, the amounts conserved and transmitted to each successive trophic level diminishes markedly. The energy flow is unidirectional, and losses in the form of heat and chemical degradation are irretrievable (Odum, 1963).

The three years comprising the time sample in this study comprise what might be labeled "good" to "poor" in respect to range production. It is of interest that this type of range is subject to violent year-to-year swings in the efficiency of solar energy conversion (Table 1). The annual total of incoming energy is quite stable, however.

Nutrient Relations

Other important considerations are the imports, exports, and cycling of essential nutritional elements. The "cycling" aspect of nutrient exchange is in contrast to the "one-way" degradation of energy in the ecosystem. This account will not go into detail on the cycling of nutrients, but will point out the effect of the alleviation of certain nutritional deficiencies in the soil on the productivity of this range site.

Nitrogen is the primary limiting nutrient on the site. This was corrected in part by the introduction of an adapted legume capable of symbiotic nitrogen-fixation, rose clover (Tables 1 and 2). The addition of sulfur fertilizer alone to the resident plant community was ineffective, because of the precedence of the nitrogen deficiency. However, in the presence of nitrogen-fixing organisms, correction of the sulfur deficiency further enhanced nitrogen-fixation and productivity. The nitrogen-fixing ability of sulfur-fertilized rose clover may be calculated approximately to be 44 − 6 (content of control) = 38 lb/acre nitrogen per annum. Phosphorus was not

Table 2. Effect of range improvement techniques on the nutrient content and annual nutrient removal in forages.

Nutrients in harvested vegetation[1]	Unit	Unimpr.	Sulfur fert.	Rose clover seeding	Rose clover + sulfur
Nitrogen	%	0.9	1.0	1.5	1.9
	lb/acre/year	6	8	22	44
Sulfur	%	0.10	0.14	0.09	0.15
	lb/acre/year	0.7	1.1	1.3	4.0
Phosphorus	%	0.32	0.32	0.27	0.23
	lb/acre/year	2.4	2.6	4.0	5.0

[1] These data are annual means of data from 3 years based on samples drawn from vegetation harvested with sicklebar mower and described further in Table 1.

a limiting factor as may be seen from the phosphorus percentages of the plant tops. They are above the critical level of 0.18% phosphorus for bloom-stage rose clover, and the existence of adequate soil phosphorus has been verified by other work at the site in which phosphorus fertilization was a variable (author's unpublished data).

A major effect of these modifications was to improve the efficiency of solar energy conversion by the producers from 0.03% in the unimproved state to 0.09% for the sulfur-fertilized rose clover treatment (Table 1).

Increasing Productivity By Ecosystem Modification

Odum has called ecosystem modification "ecosystem surgery" to emphasize the frequent drastic consequence for good or ill which may occur. Some modifications of range ecosystems which have had generally favorable effects when knowledgeably used are (1) forage species introduction; (2) the lowering of nutritional barriers; (3) weed and poison plant control; (4) pest control; and (5) grazing management. The first two are illustrated in the above example.

Are there other ways of improving the abysmally low solar-energy conversion efficiencies? Another obvious way is to make use of the peak solar energy income of the summer when our annual-type range is senescent because of protracted drought. By improving the moisture factor through the use of irrigated alfalfa, for example, productivity could be enhanced up to ten times. However, this takes us pretty far from range management.

Yet there is at least one more enticing approach within the range realm. Can we make the light trapping mechanism of our range plant communities more effective? There are certain bits of evidence that suggest a positive answer, and I would like to conclude my paper by a consideration of this thesis.

It has been demonstrated with certain forage species that maximum productivity occurs when there are optimum (or critical) amounts of leaf area relative to land area (leaf area index of Watson, 1958). The existence of these optima is nicely accounted for by Takeda (1961) in a diagram based on photosynthesis and respiration measurements in communities of *Oryza sativa* (Fig. 2). As the amount of leaf

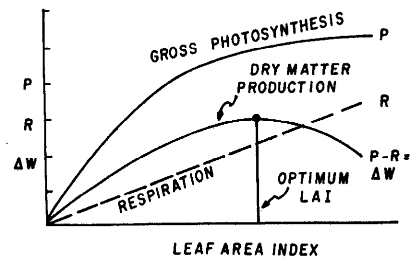


Fig. 2. Relationship between leaf area and dry matter production ($\Delta W =$ net productivity) after Takeda (1961).

area is increased, the rate of gross photosynthesis (and gross productivity) increases rapidly at first, but when the amount of leaf exceeds that necessary for essentially complete light interception, photosynthesis approaches a ceiling value. Respiration is more nearly a linear function of leaf area, i.e., increases proportionately with increasing leaf area. Therefore, dry matter production ($\triangle W =$ net productivity) may attain an optimum value, and then decline with further increases in leaf area due to increased shading of the leaves in the lower portion of the canopy. The optimum leaf area index has been shown to vary seasonally with the amount of solar energy received. Black (1963) has constructed a series of curves based on work with communities of subterranean clover *(Trifolium subterraneum)* which show that the optimum amount of leaf area increases with increasing levels of light intensity (Fig. 3). Moreover, productivity is increased up to the maximum sunlight available in South Australia. Benedict (1941) has observed increased productivity of *Agropyron cristatum, A. smithii,* and *Bouteloua gracilis* also up to the maximum sunlight available at Cheyenne, Wyoming where intensities up to 14,000 ft-c have been measured.

Brougham (1958) has demonstrated that the optimum leaf area varies markedly between the two major families of forage species. The optimum leaf area indices for two representative species obtained under comparable light conditions are white clover *(Trifolium repens)* 3.5 and perennial ryegrass *(Lolium perenne)* 7.1. Measurements of the leaf angles and leaf area in horizontal strata in a young pasture containing these two species as dominants show that they also differ markedly in the manner in which their leaf area is displayed (Warren Wilson, 1959). In white clover the leaves are almost horizontal near the top of the canopy, whereas the leaves of perennial ryegrass are nearly vertical (Fig. 4). Moreover, the leaf area distribution curves indicate that a greater proportion of the leaves in white clover are in the upper part of the profile than in perennial ryegrass. Let us attempt to relate this infor-

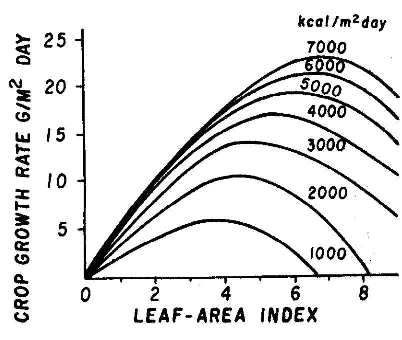


Fig. 3. Relationship of leaf area and crop growth rate (net productivity) at several mean daily solar radiation levels after Black (1963).

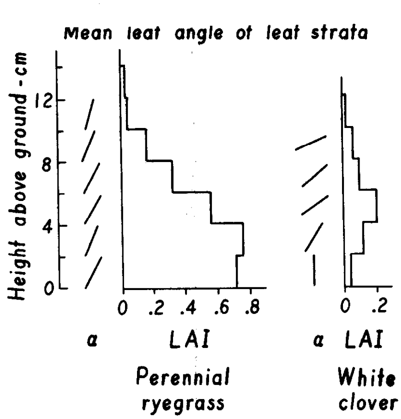


Fig. 4. Foliage angle (*a*) and leaf area index within horizontal strata 2 cm. deep as measured with the inclined point quadrat by Warren Wilson (1959).

mation to the light intercepting ability in two species of closely analogous leaf display characteristics, subterranean clover and Wimmera ryegrass *(Lolium rigidum)*, studied by Stern and Donald (1962). Species dominance was varied in communities of the two species by various levels of nitrogen fertilization. In the clover-dominant, no-nitrogen communities, light intensity fell off much more rapidly as the canopy was penetrated than in the ryegrass-dominant, high-nitrogen communities (Fig. 5). Looking at it from another point of view, we may predicate that in the ryegrass dominant community a more uniform distribution of light interception was attained in the vertical profile of leaf area, and that this is the type of relationship which accounts for the greater optimum leaf area index found by Brougham (1958) for perennial ryegrass than for white clover.

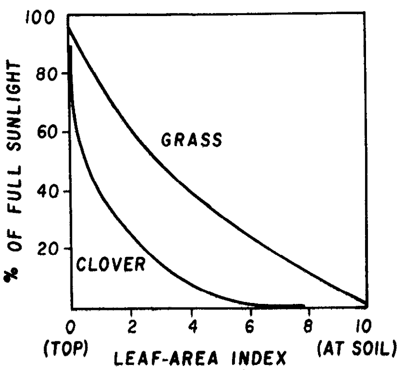


Fig. 5. Relationship of leaf area and light intensity in a clovery sward and a grassy sward after Stern and Donald (1962).

This leads us to a postulation based on data drawn from several workers widely separated geographically, yet through which a consistent thread may be detected. The inference is that plant communities with foliage configurations which allow relatively uniform light interception over the vertical distribution of leaf area, are more efficient in the utilization of solar energy and are likely to have greater net productivities than those with a concentration of horizontally disposed leaves. There is considerable circumstantial evidence in support of this thesis, but now we need the results of a series of integrated studies on all aspects of leaf arrangement that influence competition for light. In a recent review of plant competition Donald (1963) made the very appropriate statement: "Leaf layer density, the dispersion of the leaves, the leaf angle, and the vertical distribution are all aspects of leaf arrangement lending themselves to worthwhile, though difficult, study. Undoubtedly we must also add such leaf features as the reflectivity of the leaf surface, affecting both the back reflection to the sky and the complex reflection patterns within the crop . . . the whole field is wide open for profitable study."

Thus the next breakthrough in our quest for increasing the productivity in range ecosystems may be in ascertaining in detailed, quantitative terms the ideal architectural arrangements of foliage in the multitude of range vegetation types. Then the important task will be learning the necessary techniques for their achievement.

LITERATURE CITED

ANDERSON, M. S. 1957. Farm Manure. U.S.D.A. Yearbook of Agriculture, p. 229-237.

BENEDICT, H. M. 1941. Growth of some range grasses in reduced light intensities at Cheyenne, Wyoming. Bot. Gaz. 102:582-589.

BLACK, J. N. 1963. The interrelationship of solar radiation and leaf area index in determining the rate of dry matter production of swards of subterranean clover *(Trifolium subterraneum L.)*. Aust. J. Agr. Res. 14:20-38.

BROUGHAM, R. W. 1958. Interception of light by the foliage of pure and mixed stands of pasture plants. Aust. J. Agr. Res. 9:39-52.

DONALD, C. M. 1963. Competition among crop and pasture plants. Adv. Agron. 15:1-118.

GOLLEY, E. B. 1961. Energy values of ecological materials. Ecol. 42:581-584.

KESSELI, J. E. 1942. The climates of California according to the Köppen classification. Geogr. Rev. 32:476-480.

LOFGREEN, G. P. 1964. Net energy requirements of growing-finishing beef cattle. Univ. Calif. Animal Husbandry Dept. Mimeo. 2 p.

LOFGREEN, G. P., AND K. K. OTAGAKI. 1960. The net energy of blackstrap molasses for fattening steers as determined by a comparative slaughter-technique. J. An. Sci. 19:392-403.

LOOMIS, R. S., AND W. A. WILLIAMS. 1962. Maximum crop productivity: an estimate. Crop Sci. 3:67-72.

LOVE, R. M., AND D. C. SUMNER. 1952. Rose clover, a new winter legume. Calif. Agr. Exp. Sta. Circ. 407.

MARTIN, W. E., L. J. BERRY, AND W. A. WILLIAMS. 1958. Range fertilization in a dry year. Univ. of Calif. Agr. Ext. Serv. Mimeo. 39 p.

ODUM, E. P. 1963. Ecology. 2 ed. Holt, Rinehart, Winston. New York.

OZANNE, P. G., C. J. ASHER, AND D. J. KIRTON. 1965. Root distribution in a deep sand and its relationship to potassium absorption by pasture plants. Aust. J. Agr. Res. 16:785-800.

STERN, W. R., AND C. M. DONALD. 1962. Light relationships in grass-clover swards. Aust. J. Agr. Res. 13:599-614.

TAKEDA, T. 1961. Studies on the photosynthesis and production of dry matter in the community of rice plants. Jap. J. Bot. 17:403-437.

THOMAS, M. D., AND G. R. HILL. 1949. Photosynthesis under field conditions. *In* J. Franck and W. E. Loomis, ed. Photosynthesis in Plants. Iowa State Coll. Press, Ames.

WARREN WILSON, J. 1959. Analysis of the distribution of foliage area in grassland. *In* J. D. Ivins, ed. The Measurement of Grassland Productivity. Butterworths, London, p. 51-61.

WATSON, D. J. 1958. The dependence of net assimilation rate on leaf area index. Ann. Bot. N.S. 22:37-55.

WIEGERT, R. G., AND F. C. EVANS. 1964. Primary Production and the disappearance of dead vegetation on an old field in southeastern Michigan. Ecology 45:49-63.

WILLIAMS, W. A., R. M. LOVE, AND L. J. BERRY. 1957. Production of range clovers. Calif. Agr. Exp. Sta. Circ. 458.

Twig Diameter-Length-Weight Relations Of Bitterbrush[1]

JOSEPH V. BASILE and SELAR S. HUTCHINGS

Associate Plant Ecologist and Principal Plant Ecologist, Intermountain Forest and Range Experiment Station, Forest Service, U.S.D.A., Bozeman, Montana, and Ogden, Utah, respectively.

Highlight

Relations between bitterbrush twig diameters and their lengths and weights are sufficiently consistent to enable wildlife technicians to estimate browse utilization solely from postbrowsing measurements of the diameters and lengths or weights of the remaining portion of twigs.

Wildlife technicians often determine browse utilization by measuring length of selected current year's twigs before and after browsing. The difference in lengths represents utilization, usually expressed in percent. Knowledge of the relations between twig diameters and their lengths and weights may provide a means of estimating utilization solely from postbrowsing measurements, and may also permit expressing utilization in terms of either length or weight of twigs.

Two hypotheses were proposed for testing: (1) both lengths and weights are highly correlated with twig diameters; and (2) a single regression equation may yield reliable estimates of twig lengths or weights for a given species. If these hypotheses are valid, measurement of twig diameter after browsing provides an index of twig length and weight before browsing; then, from a measurement of either length or weight of the remaining portion of the twig, percent utilization can be computed.

We chose bitterbrush (*Purshia tridentata* (Pursh) D.C.) as the species to use in testing these hypotheses because this shrub is relished by most species of big game and livestock, it is widespread in occurrence, and it is important in the winter diet of deer in our area. Bitterbrush utilization is the criterion most often used by game managers in southern Idaho to indicate whether deer populations are in balance with their forage supplies.

Our sampling was confined to two contiguous sites in a stand of mature bitterbrush 18 miles east of Boise, Idaho. Site 1 faced generally northeast on a slope of approximately 40%. Site 2 was on a southeast-facing alluvial fan of about 5 to 20% slope. Soils on both sites have been derived from granitic rocks. Precipitation averages 15 inches per year. Elevation is approximately 3,100 feet.

Methods

During plant dormancy we sampled current-year twigs from 20 mature shrubs on each site. Sampling was confined to unbranched, unbrowsed terminal and lateral twigs at least 1 inch long.

Each shrub was sampled by quarters—upper north, lower north, upper south, and lower south. Twelve twigs were selected from each quarter by visually dividing the quarter into three equal portions and choosing four twigs from each portion. Twig selection was subjective in that a wide range of twig sizes was sought in each portion of the shrub.

Twigs were removed from the shrubs, tagged, and taken to the laboratory for measurement. Lengths were measured to the nearest 0.1 inch, including the terminal buds. Diameters were measured with a dial gage (Fig. 1) to the nearest 0.001 inch at a point 0.5 inch from the twig base. If a bud occurred at this point, it was removed to facilitate measurement; if node swelling occurred, the twig diameter was measured immediately above or below the swelling, whichever was nearer the 0.5-inch mark. Cross sections of most twigs were somewhat elliptical; hence, an average of the minimum

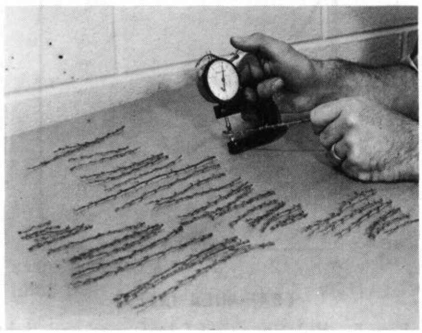


Fig. 1. Dial gage used to measure diameter of bitterbrush twigs.

---

[1] *Tests herein reported were part of a cooperative study by the Intermountain Forest and Range Experiment Station and the Idaho Fish and Game Department through Federal Aid to Wildlife Restoration Project W-111-R.*

and maximum diameters was used for all computations. Twigs were oven-dried at 70 C for 24 hours and then individually weighed to the nearest 0.01 g.

Twig measurements from all shrubs were appropriately grouped to yield one regression equation for each quarter for each site and for both sites combined. Coefficients were computed for the regressions of: length on diameter, weight on diameter, weight on length, and weight on diameter + length.

Results

Results obtained in this study are unusual in that most differences in regression coefficients were statistically significant but were too small to have practical importance. This high precision reflects the intensive sampling; 12 twigs from each quarter of 20 shrubs provided a sample of 960 twigs for each site.

Regression coefficients were similar for the two upper quarters of the shrubs and also for the two lower quarters. Because of these similarities, data for quarters were combined to compare twigs on the upper versus lower halves and the north versus south halves.

From a practical viewpoint the coefficients for the north and south halves were similar, two "significant" differences notwithstanding (Table 1). However, some differences between vertical segments of shrubs were great enough to be important; twigs on the lower halves were longer and more slender than those on the upper halves. Although such differences might dictate stratification of sampling, they do not rule out the possibility of a single prediction equation. From this viewpoint, the differences between sites appear to be more critical, especially for length and diameter (Table 1). This is discussed later.

The above considerations led to analyses combining data from all shrub segments to obtain a more generalized prediction formula and to evaluate the influence of site on twig conformation (Table 2).

Length-Diameter and Weight-Diameter Relations.—Regressions on diameter accounted for approximately 50% and 80% of the variation in length and weight respectively. Fiducial limits (P.05) for estimating length and weight from the diameter of a randomly selected individual twig were within approximately 50% and 55% of their respective means. However, fiducial limits for a stratified random sample of 30 twigs (Fig. 2 and 3) indicate that the mean length and mean weight probably can be estimated within approximately 10% of their respective actual means. The variation in twig weight (0.04 to 1.14 g) was about twice the variation in twig length (1.0 to 12.8 inches); coefficients of variation were 39 and 62% respectively. Although weight varied more than length it was more closely related to diameter, with the net effect that the residual errors around the regression lines were about equal for weight and length. Therefore, mean twig weight and mean twig length can be estimated with approximately the same precision with equal sized samples.

Differences between length-di-

Table 2. Regression and correlation coefficients for length (L), weight (W), and diameter (D) of bitterbrush twigs based on combined samples of all portions of plants.

Attributes Y	X_1	X_2	Site	Regr. coef.	Cor. coef.[1]
L	D	—	1	103.90 **	0.74
			2	79.86	.72
			1+2	89.83	.72
W	D	—	1	6.99 *	.88
			2	7.42	.90
			1+2	7.27	.89
W	L	—	1	.05 **	.89
			2	.06	.85
			1+2	.06	.86
W	D	L	1	b_1 3.87; b_2 .03 **	.95
			2	b_1 4.87; b_2 .03	.95
			1+2	b_1 4.57; b_2 .03	.95

* Differences between regression coefficients on sites 1 and 2 significant at the 5% probability level.

** Differences between regression coefficients on sites 1 and 2 significant at the 1% probability level.

[1] All correlation coefficients are significant at the 1% probability level.

Table 1. Regression coefficients for length-weight-diameter relations of bitterbrush twigs.

Relation	Site	Shrub Segments Upper	vs.	Lower	North	vs.	South
Length-diameter	1	95.65	**	126.59	104.08	n. s.	103.67
		**		**	**		**
	2	78.06	**	104.88	80.82	n. s.	78.98
Weight-diameter	1	6.85	**	7.54	7.05	n. s.	6.92
		**		n. s.	**		n. s.
	2	7.83	n. s.	7.46	7.67	*	7.18
Weight-length	1	0.06	**	0.05	0.05	n. s.	0.05
		**		**	**		**
	2	0.07	**	0.05	0.07	*	0.06

* Differences between shrub segments or between sites significant at the 5% probability level.

** Differences between shrub segments or between sites significant at the 1% probability level.

n. s. Differences not significant at the 5% probability level.

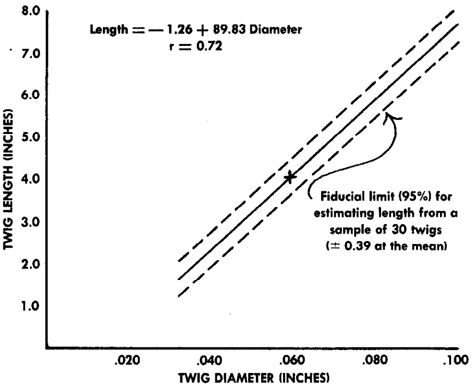


Fig. 2. Relation of twig length to twig diameter on bitterbrush.

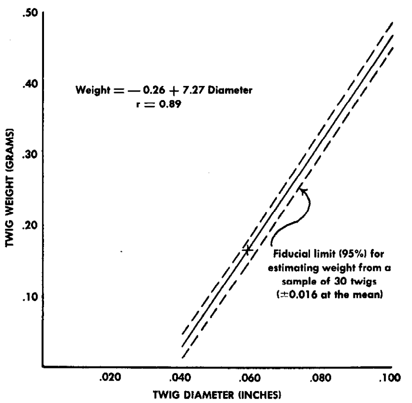


Fig. 3. Relation of twig weight to twig diameter on bitterbrush shrubs.

ameter relations for north and south halves of shrubs were not significant (P.05) on either site, but differences between upper and lower halves were highly significant (P.01) on both sites (Table 1). Twigs of a given diameter usually were slightly longer on the lower halves of shrubs. The relation of length to diameter also differed between sites. Regression coefficients for each canopy segment and for entire shrubs on site 1 differed significantly (P.01) from their counterparts on site 2.

Unlike length-diameter relations, weight-diameter relations sometimes differed with either the radial or the vertical positions of twigs on the shrubs (Table 1). Whereas the vertical position affected the weight-diameter relation on site 1, the radial position affected it on site 2. Twigs of a given diameter were slightly heavier on the lower than on the upper portions on site 1, and slightly heavier on the north than on the south portions on site 2.

Regression coefficients for entire shrubs differed significantly (P.05) between sites (Table 2). Thus the relations between weight and diameter differed between sites as well as between twig positions. However, these between-site and within-site differences, though statistically significant, have no practical significance because the regression lines and coefficients are extremely close (Fig. 4 and Table 1). The use of a stratified sample and of the prediction equation for entire shrubs would practically cancel these small differences.

Weight-Length Relations.—Approximately three-fourths of the variation in twig weights were accounted for by regression with length. The regression equation for weight-length relations for both sites combined was Weight $= -0.063 + 0.057$ Length, and the correlation, $r = .86$. Mean weight may be estimated within approximately 11% of the actual mean with samples of 30 twigs. For this size of sample, fiducial limits (P.05) were $\pm$ 0.019 gram (rounded to 3 places) both at the mean length and at a 3.0-inch departure from mean length. Fiducial limits for a weight estimate from the length of an individual twig were $\pm$ 0.10, or about $\pm$ 62% of the mean.

Weight-length relations were also affected by twig position (Table 1). On both sites, twigs of a given length were heavier on the upper part of the shrub than twigs of the same length on the lower half. The regression coefficient for the north halves of shrubs was not significantly different from that for the south halves on site 1, but a difference (P.05) did occur on site 2, where twigs were heavier on the north than on the south side.

Highly significant differences (P.01) between sites also occurred among regression coefficients of the entire shrub canopies. Thus weight-length relations differed between sites as well as with positions of twigs within sites. However, as with weight-diameter relations, these statistically significant differences have little practical importance except perhaps at the very extremes of twig diameters.

Weight-Diameter-Length Relations.—The multiple regression

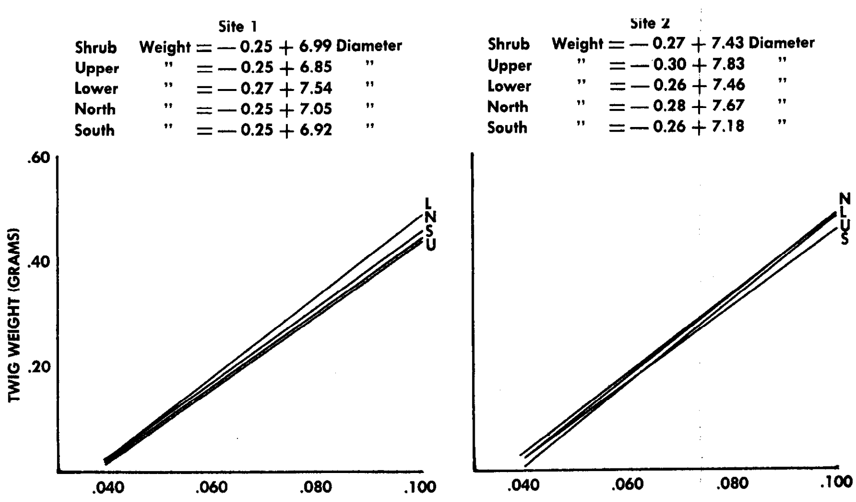


Fig. 4. Relation of twig weight to twig diameter on bitterbrush shrubs as affected by site and by twig position.

of weight on diameter plus length of bitterbrush twigs accounts for 90% of the variation in twig weight. The regression formula for both sites combined was Weight = -0.22 + 4.56 Diameter + .0301 Length. This relation is primarily of academic interest because length of twigs cannot be measured in postbrowsing samples if the twigs are grazed. Hence the relationship cannot be used to estimate twig utilization. However, it can be used to estimate twig production from measurements of twig diameter and length on areas where clipping is undesirable.

On both sites, tests between the multiple regression equations for the four portions of the shrub revealed significant differences due to twig position. Between-site differences were highly significant (P.01). Although the differences were statistically significant they were not great enough to have practical importance. Prediction values of weight obtained from the regression equations are extremely close for twigs within the range of diameters and lengths encountered in the study. A sample of 100 twigs should give reliable estimates of twig weight.

Discussion

The relations of weight to length and to diameter + length provide a basis for developing a method for estimating twig production on areas where clipping is undesirable. However, a concomitant estimate of twig numbers per shrub or per unit area would be needed before these relations would have much practical value.

The length-diameter and weight-diameter relations offer a promising method for estimating bitterbrush use on both a length and weight basis solely from postbrowsing measurements. A measurement of twig diameter after browsing provides an estimate of total length and of total weight before browsing. The length of the portion of twig remaining after browsing can be measured and the percentage utilization can be computed as follows:

$$P = 100 \left(\frac{T - R}{T}\right)$$

where P is the percentage utilization by length, T the total length of twig computed by regression, and R the length of the remaining portion.

To estimate utilization by weight, the portion of twig remaining after browsing can be clipped and weighed and utilization computed by substituting weight for length in the above formula.

Important within-site and between-site differences in regression of either length or weight with diameter would not handicap estimates of utilization. Where these differences are due to twig position on the shrub, sampling each canopy segment at equal intensity would permit use of the prediction equation for entire shrubs. This procedure eliminates the need for tallying data by canopy segments and for use of more than one prediction equation.

Similarly, significant between-site differences need not be as forbidding as they may seem. Estimates of utilization are usually confined to the same few key areas year after year. Unless length-diameter and weight-diameter relations differ significantly from year to year—a variable not tested—a prediction equation need be computed only once for a given key area.

Future savings should more than compensate for the cost of determining the equation. Estimating utilization solely from postbrowsing measurements eliminates the costs of transportation and manpower required for making prebrowsing measurements, the need for tagging twigs for subsequent identification, and the possibility of missing data resulting from lost tags and from lost or undecipherable prebrowsing records.

The proposed method has not been field-tested. However, the accuracy with which means may be estimated from small samples (30 twigs) lends considerable confidence that the method is practical. The same concepts embodied in this method should be applicable to other browse species and to other areas.

Summary

We measured 12 twigs from each quarter segment of 20 bitterbrush shrubs on each of 2 sites. Coefficients were computed for regressions of length on diameter, weight on diameter, weight on length, and weight on diameter + length. Data were grouped to evaluate differences in regression attributable to site and to position of twigs on the shrubs.

Twig weight was highly correlated with length (r = .86) and with diameter + length (r = .95). Both of these relations were affected by twig position on the shrub and by sites, but the differences were too small to have practical importance. Both relations provide a basis for developing a method for estimating twig production on areas where clipping is undesirable.

The length-diameter and weight-diameter relations offer considerable promise for estimating utilization on both a length and weight basis solely from postbrowsing measurements. A diameter measurement after browsing provides an index of total twig length and weight before browsing. The remaining portion of the twig can be clipped and weighed and its length measured and the percentage of utilization can be easily computed.

The highly precise sampling rendered small differences between shrub segments statis-

tically significant, but these differences were too small to have practical importance. A stratified sample would permit use of a single prediction equation based on the entire shrub. Mean length and mean weight may be estimated within 10% of the actual mean with a stratified random sample of 30 twigs.

A separate prediction equation may be necessary for each site. However, unless length-diameter and weight-diameter relations vary with year—a variable not tested—a prediction equation need be developed only once for a site.

TECHNICAL NOTES

Pot Test of Nutritive Status of Two High Elevation Soils in Wyoming

DIXIE R. SMITH
Plant Ecologist, Rocky Mountain Forest and Range Experiment Station[1], Forest Service, U.S.D.A., Laramie, Wyoming.

Highlight

Pot tests of two high altitude soils showed them to be deficient in available phosphorus. Protection from grazing for 20 years did not increase their productive capability as measured in this study.

The soils at timberline and above in the Rocky Mountains are a complex mosaic which have received little attention from the soil scientist. Superimposed on the soil mantle is an equally complex vegetation which varies greatly in its floristic composition and productivity. This variation in vegetation is difficult to interpret without more knowledge of the nutritive status of the soil, and how this status is affected by grazing.

The purpose of the study reported here was to investigate (1) the effects of grazing on the growth potential of two high altitude soils and (2) the nutrient status of these two soils.

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

Methods

Two long-established exclosures were available for study areas on the Medicine Bow Range of south-central Wyoming. Both were located on soils developed on glacial till. The Headquarters Park exclosure, established in 1940, was located on sheep range at an elevation of 10,200 feet. The Libby Flat exclosure, also located on sheep range, was established in 1939. It is at an elevation of 10,600 feet.

At each exclosure, adjacent and comparable sites subject to grazing were selected for study. A sample of about 40 lb of soil was removed from the upper 10 inches of the soil mantle at three randomly located points, both inside and outside each exclosure. Each of the twelve soil samples was thoroughly mixed, and passed through a ½-inch mesh to remove the larger stones. These samples were then used in the studies.

Cultivated oats *(Avena sativa* L.) was used as a test species. The tests were made in 6-inch pots containing 1,600 g of air-dry soil. All pots were lined with plastic bags to prevent contamination. Soils were irrigated with distilled water when necessary to prevent wilting of the plants being grown. Water in excess of field capacity was collected in plastic containers and returned to the pot from which it was drained.

The first trial compared growth of the test species on the soil samples without the addition of any nutrients. Three subsamples of each of the original soil samples were placed in a random pattern on the greenhouse bench. In the analysis of variance, a mixed model was assumed in which sites within study areas was a fixed effect.

In the second trial the 6 samples at each study area were composited. Then each soil was treated as follows: check, nitrogen, phosphorus, potassium, and micronutrients.

Nitrogen was supplied in the form of ammonium nitrate at the rate of 200 lb N/acre; phosphorus as monobasic calcium phosphate at 200 lb P_2O_5/acre; and potassium as potassium sulfate at 200 lb K_2O/acre. These pure salts were mixed with the soil prior to planting the test species. In establishing these rates, it was assumed that an acre of soil to a depth of 6 inches weighed 2 million lb.

Micronutrients were supplied by adding 1 ml of a stock solution to each liter of distilled water used to irrigate the relevant treatments. This stock solution, described by Bonner and Galston (1952), was prepared by adding the following materials to 1 liter of distilled water:

Material	*Grams*
H_3BO_3	0.60
$MnCl_2 \cdot 4H_2O$	0.40
$ZnSO_4 \cdot 7H_2O$	0.05
$CuSO_4 \cdot 5H_2O$	0.05
$H_2MoO_4 \cdot 4H_2O$	0.02
$MgSO_4$	0.50
$FeSO_4 \cdot 7H_2O$	0.01
$CaSO_4 \cdot 2H_2O$	0.20

The ten treatments were arranged in a randomized complete block with 5 replications. In the analysis of variance a fixed model was assumed.

In both trials, probabilities of 95% were assumed to be adequate protection, and interpretations of data are based on that assumption.

Soils.—The soil from Headquarters Park was a sandy loam; soil from Libby Flats was a loam. Analyses of the composite samples by the University of Wyoming showed the following:

	Hdq. Park	Libby Flats
pH (paste)	5.9	5.0
Organic matter %	3.9	6.0
Cation exchange cap. meq./100 g.	17.8	20.2
K_2O, lb/acre	197	108
P_2O_5 lb/acre	32	25
Calcium	Trace	Trace
Magnesium	Trace	Trace

Results

In the first trial, study areas and sites within study areas were significant sources of variation in shoot yield. The shoot yield of oats growing in soils from Libby Flat averaged 4.06 g/pot compared to only 1.27 g/pot from Headquarters Park soil. Yields from soils inside the exclosure at Headquarters Park were no different from those outside the exclosure (Fig. 1). Libby Flat soils outside the exclosure were the most productive. Average yield from soils inside the Libby Flat exclosures was 3.12 g/pot compared to 4.99 g from the soils outside the exclosure.

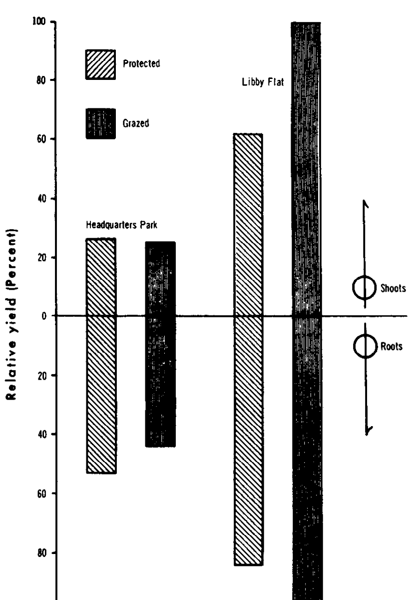


Fig. 1. Relative yields of oats growing in soils from inside and outside the exclosures at Headquarters Park and Libby Flat.

The average yield of roots was also greater on soil from Libby Flat than on soils from Headquarters Park—2.45 and 1.29 g/pot respectively. Soils from inside and outside the exclosure were equally productive of roots at each study area.

The total weight of shoots plus roots varied in the same pattern as shoot yield. Study areas and sites within study areas were significant sources of variation. Average yield on Libby Flat soil was 6.50 g/pot, compared with 2.62 g/pot on Headquarters Park soil.

Since soil moisture was not a limiting factor in this study, the differences in productivity between Libby Flat and Headquarters Park and between grazed and protected areas at Libby Flat may be assumed to reflect nutritional status.

In the second trial, significant sources of variation were identical for the three yield criteria. Since the interaction amendments x soils was not significant, the results may be discussed in terms of the average effect of amendments and the average effects of soils.

The addition of nitrogen, potassium, or micronutrients had no effect on shoot, root, or shoot plus root yield. The addition of phosphorus to the soils, however, increased roots about 100% and shoots 60% (Fig. 2).

The response of the test species to additional phosphorus suggests that phosphorus is deficient. This is somewhat contradictory to the results obtained by Scott and Billings (1964). In a similar greenhouse study of soils from the same general area, they found responses to nitrogen and Hoagland's solution, but not to phosphorus alone. The response to Hoagland's solution was greater than to nitrogen alone, however, which indicates some other element, perhaps phosphorus, became limiting when nitrogen was supplied. In a series of nitrogen fertilizer trials in the alpine tundra of this general study area in 1960, Billings found no significant increase in shoot production due to fertilization.

The results of the second trial suggest there was less available phosphorus in the protected soil than in the unprotected soil, but McGinnies and Retzer (1948) associate fertility with good range condition.

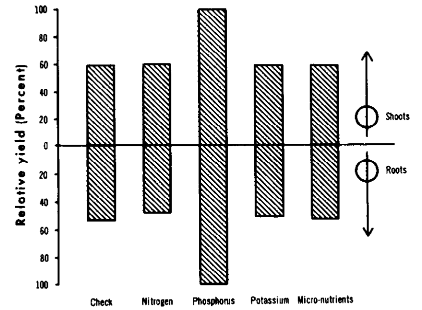


Fig. 2. Relative yields of oats in relation to treatment. The data are presented as averages of the two soil types, since the effect of treatment was independent of soil type.

Soil from inside the exclosure apparently had too low a concentration of phosphorus in the soil solution, or the rate of renewal from the solid-phase phosphorus was too low. Of the two alternatives, the latter seems to be the more probable, since with rapid plant growth the phosphorus in solution may be renewed several times a day (Olsen and Fried, 1957).

The mechanisms governing the phosphorus renewal rate are many and complex, but one is tempted to speculate about the role of pocket gophers. Their summer mounds and winter cores are abundant in the exclosure. Their activities continually expose fresh soil surfaces. These fresh surfaces contain the metal ions which react with phosphorus to lower the availability of phosphorus (Olsen and Fried, 1957).

Studies of the type reported here reveal specific information about the nutrient status of soils. Nevertheless, the total environment cannot be evaluated in pot studies in the greenhouse (Eckert and Bleak, 1960). Among other things, the temperature conditions are maintained near optimum, and the soil is modified considerably from its natural state. The hypotheses developed in greenhouse studies must ultimately be tested in the alpine environment thru carefully designed fertilizer trials.

Summary

The nutrient status of two soils on high-altitude ranges in Wyoming was determined in the greenhouse, with domestic oats as the test spe-

cies. The two soils responded similarly to the addition of nutrients. Nitrogen, potassium, and micronutrients resulted in no increase in the yield of shoots, roots, or shoots plus roots. The addition of phosphorus, however, resulted in about a 100% increase in root yield and 60% increase in shoot yield.

The effect of 20 years of protection from grazing varied between soils. Soils from the Headquarters Park area were equally productive inside and outside the exclosure. Productivity at Libby Flat, as measured in this study, was lower under protection.

LITERATURE CITED

Bonner, J., and A. W. Galston. 1952. Principles of Plant Physiology. W. H. Freeman and Co., San Francisco. 499 p.

Eckert, R. E., and A. T. Bleak. 1960. The nutrient status of four mountain rangeland soils in western Nevada and eastern California. J. Range Manage. 13: 184-188.

McGinnies, W. G., and J. L. Retzer. 1948. How range grass grows. In *Grass*, Yearbook of Agriculture, 1948. U. S. Government Printing Office, Washington, D. C. p. 203-205.

Olsen, S. R., and M. Fried. 1957. Soil phosphorus and fertility. In *Soil*, Yearbook of Agriculture, 1957. U. S. Government Printing Office, Washington, D. C. p. 94-100.

Scott, D. and W. D. Billings. 1964. Effects of environmental factors on standing crop and productivity of an alpine tundra. Ecol. Monog. 34: 243-270.

An Improved Vegetation Sampling Quadrat

JOHN F. THILENIUS

Associate Plant Ecologist, Rocky Mountain Forest and Range Experiment Station,[1] *South Dakota School of Mines Campus, Rapid City, South Dakota.*

---

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

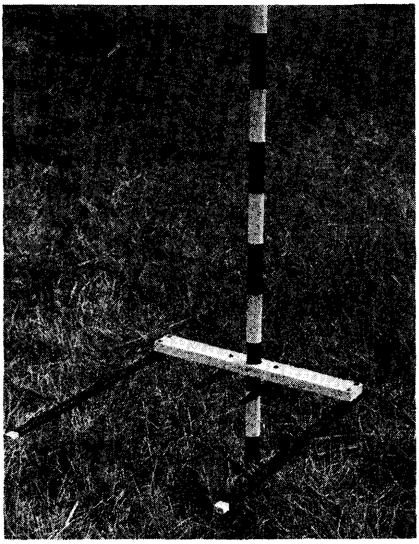


Fig. 1. **Quadrat frame assembled on staff.** The staff is marked in decimeters. The large quadrat is 0.2 m^2 in area, the smaller is 1.0 dm^2.

Measurements of rangeland vegetation requiring a larger number of small plots can be made faster and more easily if an open-end quadrat frame mounted on a short staff (Fig. 1) is used in place of the usual closed frame or plot outlined by chaining pins. An open-end frame can be positioned with minimal disturbance and rearrangement of herbaceous vegetation, and can also be placed under shrubs and around small trees. The ends of the arms provide two points for ocular alignment, so it is not difficult to determine whether a plant is within the quadrat when it occurs at the open end of the frame. A straightedge may be placed across the open end if greater precision is desired, but usually this is not necessary.

The frame can be moved up or down on the staff to fit the vegetation being sampled. A height of 2.5 dm works well on most rangelands. For carrying convenience, the frame can be removed from the staff and the arms folded to prevent breakage (Fig. 2).

The staff allows the operator to move the frame without having to bend over and pick it up. This decreases sampling time and reduces fatigue. If marked in suitable intervals, the staff can also be used to show scale in photographs.

The frame can be adapted for nested plots (Fig. 1), and used as a "complementary quadrat" in frequency sampling with plot size adjusted to species abundance. Frequencies of the most abundant species are recorded with the small quadrat while less abundant species are sampled with the larger quadrat (Hyder et al. 1965). Or the smaller interior quadrat can include a given percentage of the area of the larger (e.g., 5%), and be used as an aid in estimating foliage cover.

Quadrat size and shape may be varied. Square frames up to 6 dm on a side are balanced by a 1.5-dm spike on the staff. Larger frames will require a longer spike to prevent tipping. With rectangular plots, the sliding crosspiece should have the greater dimension.

Materials for constructing a frame and staff can be purchased for less than $2.00.

LITERATURE CITED

Hyder, D. N., R. E. Bement, E. E. Remmenga, and C. Terwilliger Jr., 1965. Frequency sampling of Blue Grama Range. J. Range Manage. 18: 90-94.

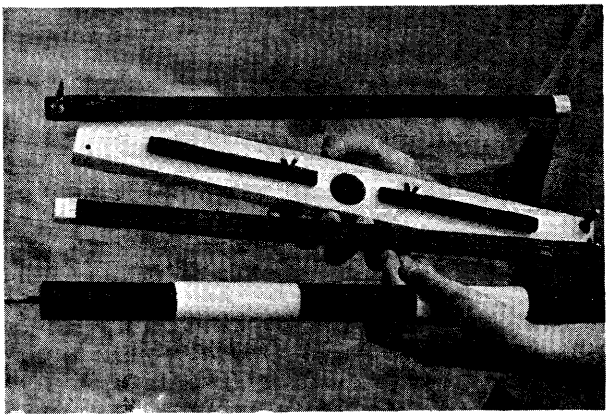


Fig. 2. Frame folded for transport.

Better Management Means More Beef from Wiregrass-Pine Ranges

RALPH H. HUGHES
Range Scientist, Southeastern Forest Exper. Sta., U.S.D.A., Tifton, Georgia.

Cattle in this month's cover photo typify a prevailing trend toward better management and increased beef production on southern forest ranges. These cows on wiregrass range with a balanced feed program produced calves averaging 427 lb at 8 months of age. Calf crops averaged 76% over a 6-year period and annual beef production per cow was 325 lb. Animals grazed the native range from March 15 to October 15 and during the rest of the year grazed meadow aftermath or were fed high quality Coastal Bermuda hay.

The cows were one of several herds at Alapaha, Georgia, in a study conducted by Coastal Plain Experiment Station and USDA researchers. Beef yields from various combinations of native and improved pasture were compared. Other herds had improved pasture during the spring and summer, range in the spring and pasture in the summer, or range plus limited pasture (0.6-acre/cow) in the spring and summer. These management systems also gave good results. Calf production per cow varied from the 325 lb mentioned earlier to 376 lb for cows on improved pasture in the spring and summer.

A key to increased beef production is better year-round management. Major factors considered in the development of Alapaha management systems are outlined in the following paragraphs.

Where controlled winter burning is compatible with good timber management and other land management practices, burned range is a cheap source of much valuable feed in a cow-calf livestock operation. Controlled burning of the native range improves grazing by increasing the quality and quantity of forage on burned areas. Forage becomes available about a month earlier and cattle gains are much greater than on unburned range.

Optimum burned acreage assigned a cow and calf varies from 6 to 10 acres—the exact acreage depending upon overstory of trees, competition from undesirable shrubs such as gallberry and saw-palmetto, and grass production. Feed supplements for cows on burned range may be limited to the fall-winter period with good results.

When the summer cattle diet combines native forage with a limited amount of improved pasture, range requirement per cow and calf may be reduced by one-third to one-half. The optimum ratio of pasture to range approximates 1:10, or as an example, 0.6 acre of improved pasture and 6 acres of burned range. The improved pasture can be on firebreaks.

Best calf gains on range or pasture, or a combination of the two, are had by July 1, and drop off rather sharply by September 15 or October 1. An obvious solution would be to wean the calves by September 15.

Some Brahman blood is helpful in range cattle production. Cows with 50% Brahman blood produced about 8% more calves and 16.5% heavier weaned weights than grade Herefords.

Ample feed during the fall and winter is essential for a good range cattle production program. Most of the spring-summer range treatments and cattle practices gave satisfactory calving percentages and weaned weights when winter feeding was adequate.

For further details see Georgia Agriculture Experiment Station Bulletin N.S. 129, "Beef Cattle Management Practices for Wiregrass-pine Ranges of Georgia," by Byron L. Southwell and Ralph H. Hughes, March, 1965. 26 p.

Sagebrush Control—Costs, Results, and Benefits[1] to the Rancher

S. Wesley Hyatt
Rancher, Hyattsville, Wyoming

I am of the third generation of Hyatts to live in the Paintrock Valley of the Big Horn Basin in Wyoming. Our ranching operation is a sheep and cattle combination.

The ranch lands consist mainly of hay meadows, which produce enough hay and pasture to feed the cattle for 6 months and the sheep 2 months each year. Also, enough grain is produced for our own use. The grazing lands are 4 different types; we have private lands, state lease lands, Bureau of Land Management permits, and Big Horn National Forest permits.

The majority of these lands is covered with sagebrush. In the higher elevations the big sagebrush grows vigorously; black sagebrush and small sagebrush or sageworts grow in the lower elevations. For years ranchers have known that sagebrush robbed their soil of moisture, choked out the grasses, curtailing their grazing capacity. In previous years, many acres of sagebrush land had been burned in hopes of eradicating the brush. In our area, this means of control was of no value, and the sagebrush returned thicker than before. Previous to spraying, roto beating was tried. This method was too slow and costly in our area.

During the late 1940's and early 1950's we were doing all we could to get the most from our range, developing the small out-of-the-way springs, putting in cross fences to keep the stock on the lower ranges, also hauling water in trucks to the area of feed and no water. Not helping matters any was the dry cycle we were going through. It seemed the rains never came at the right time.

In 1952, the University of Wyoming, with cooperation from the Big Horn National Forest officials and Big Horn National Forest Permittees Association, the first aerial spraying of sagebrush with chemicals was done. The results from these experimental plots were tremendous. This demonstrated that it was possible to spray sagebrush at a reasonable cost with 200 to 400% increase in grass production.

Our first spraying was done in the year 1954. We sprayed 1,000 acres of private lands, using 2 lb/acre Butyl-Ester 2-4-D and 1⅔ gallons diesel oil. The results from this spraying were rewarding, and our ranching operations placed money needed for sagebrush spraying at the top of the budget for range improvement.

Since 1954 we have sprayed a total of 12,000 acres of sagebrush land. This acreage is in comparison to a total of approximately 55,000 acres of grazing land. The spraying has been done on private lands, state leased lands, BLM lands, and U.S. Forest Service lands. All the spraying on government lands has been done with full cooperation of government personnel. The BLM has shared ⅓ of the spraying costs on 2,400 acres and ½ the cost on 1,000 acres. We have sprayed 3,200 acres on Forest Service lands and this cost has been ours alone. The cost of spraying these lands has averaged $3.00/acre.

The spraying has been done with three types of aircraft, the small fixed-wing plane, the large fixed-wing plane, and the helicopter. My personal preference is the helicopter, with the small fixed-wing plane at the bottom of the list. Use of flagmen is a must, and they must thoroughly understand their job.

We have obtained good results on big sagebrush using the Butyl-Ester formula mentioned above. When spraying sagebrush in the lower elevations we obtain better results using 2 lb. low volatile 2-4-D mixed with 1.5 gal. diesel oil and adding 1 pint of a good wetting agent in 200 gal. mixture. The use of a wetting agent has increased the sagebrush kill 10 to 20%.

Our results have varied considerably in percent of sagebrush control. On some areas we have had almost 100% results and on some of the poorer projects only 40%. This variation has been due largely to inexperience. Good results can be obtained when spraying is done with the sagebrush in the most vigorous growing stage, adequate soil moisture, competent flagmen, proper chemical mix, and a good pilot. All the variables involved must be at a maximum before near 100% results will be obtained.

The University of Wyoming had conclusive information showing increased forage production in areas where spraying had been done on big sagebrush in the higher elevations. Much of our grazing lands were at lower elevations, the sagebrush not so large and vigorous and, in some places, the lands were infested with black sagebrush. Plots were established and researchers from the Agronomy Department of the University took charge of gathering and compiling the information. The original survey made in 1956, showed we had a 52% ground cover of sagebrush and 28% ground cover of grass. Forage production was 343 lb./acre of air-dried forage. This land was sprayed and records kept for 6 years. At the end of the 6-year period, ground cover of sagebrush was reduced to 13%, most of this being dead sagebrush stocks, and a 70% ground cover of grass which produced 1143 lb./acre of air-dried forage. A check plot in the higher elevations showed a much higher increased yield. In the year 1962, we clipped 3,046 lb./acre of air-dried forage. Throughout the 6-year period of keeping forage production records, the percent increase between the sprayed and unsprayed areas has remained constant.

Along with sagebrush spraying, there has been an increase in water flow from our springs. These springs were not checked for flow before spraying, and the only proof is a visual one. In a couple of cases, springs were dry and had been for 30 years. These springs are again producing water. Further proof of more moisture made available to the soil can be obtained from Harold Alley

[1] *Paper presented at the 18th Annual Meeting, American Society of Range Management, Las Vegas, Nevada, February 9 to 12, 1965.*

Sagebrush range on Hyatt ranch in Big Horn Basin, Wyoming. *Left*, before control; *right*, after control.

of the University of Wyoming. He checked the snow and water measurements on sprayed and unsprayed sagebrush acres in two locations over a 6-year period. In the Hyattville area the depth of snow averaged 8.2 inches where unsprayed and 16.6 inches where sprayed. Resulting water averaged 2.3 inches where unsprayed and 4.9 inches where the sagebrush had been sprayed, or over 113% increase.

We now have increased grass production and increased water from springs. In order to better utilize our range, we began a program distributing water by means of plastic pipe. We now have 95,800 feet of plastic pipe laid on top of the ground, with tanks at various intervals. These tanks are kept full by means of float valves. These two factors have greatly increased the proper utilization of our grazing lands.

The control of noxious weeds is a must on grazing lands if a rancher wishes to maintain valuable grass land. Canadian thistle is the big threat to our grazing lands and hay meadows in the Paintrock Valley. Other noxious weeds of less importance are: perennial sow thistle, whitetop, quackgrass, and field bindweed. There are areas that have little grazing value because Canadian thistle has taken over. We live in a county which has a weed district, and the noxious weed problem is at a minimum compared to neighboring counties. On our ranch, and grazing lands attached to the ranch, all noxious weeds are controlled by us. We became aware of this problem 15 years ago and started controlling our weeds. It is not easy to carry a hand sprayer while walking for miles in the canyons, accessible only by foot or horseback and to spray noxious weeds. Also many hours are spent in the open country treating patches. But it is rewarding, come the end of a growing season, to know that you have kept the weeds in check and a minimum of grassland is infested.

A new chemical, Tordon 22K[2], is now available, and experimental work by the University of Wyoming looks very good. Because we have had a diligent spraying program, complete control of our noxious weeds seems very near at this time, leaving valuable grazing and meadow lands in a high productive state.

What are our benefits from this range improvement program? Selling feeder lambs and calves is the main source of income of our ranching operation. The weight records show an increase of 10 lb./lamb and 16 lb./calf yearly for a period after 1957, as compared to the years prior to 1957. Additional gross income has been a sizable amount when 2,000 lambs and 675 calves are sold each year.

The sagebrush spraying cost and plastic pipe cost have been completely absorbed with this additional income. Also, some net profit has been realized. A greater profit will be realized in the future with a higher carrying capacity of these ranges. These range lands are once more becoming sodded with grass, resulting in more pounds of forage available per acre. With the exception of one grazing unit, we have been able to maintain our basic A.U.M.'s. This has been done during a time when range reductions were being made. These range cuts were made by means of reducing either the number of livestock grazed or grazing the permitted number of livestock for a shorter grazing season. We received a 40% reduction on one grazing unit which had a Class I demand of 984 A.U.M.'s. This reduction was made effective in 1955.

In the year 1957 the sagebrush infested lands were sprayed. Cross fences and water development was done in the following two years. In 1960 we received a 25% increase, in 1961 another 10% increase, and the balance of the range reduction was restored in 1962. This has been a benefit in grazing 100 head of cattle for four months each season—a direct result from sagebrush spraying and water distribution.

---

[2]*Trademark for Dow Chemical Co. (4-amino-3,5,6, trichloropicolinic acid).*

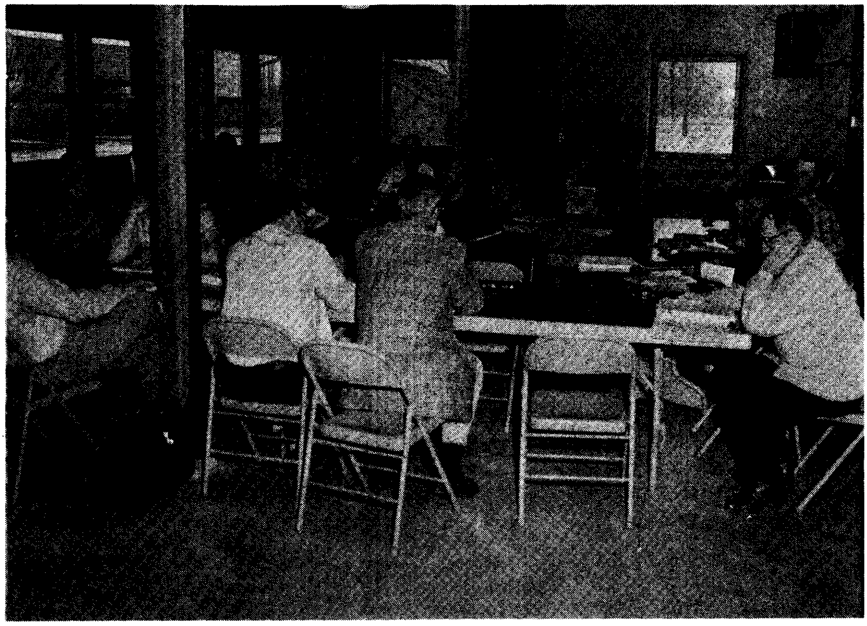
RANGE RENEWAL—A locally directed effort at Resource Development[1]

DON COOPS

Rancher and Board Member, Surprise Valley Soil Conservation District, Cedarville, California

Highlight

Range Renewal is a program in which interested individuals and groups of the community and public agencies plan and work together to accomplish resource conservation and development more rapidly. It involves direct Congressional appropriations to involved departments. Each group or agency must participate and be in a position to finance its part in the coordinated planning and development work agreed upon by all.



Advisory group developing Range Renewal program in northeastern California.

Over the years we have all seen many attempts by many interests to carry out resource development and management programs in the intermingled public and privately-owned lands of the West. These programs have had to deal with many varied ownerships and jurisdictions and a multitude of interests. Too often, however they accomplished only limited objectives, because the program was responsible only to a limited interest group.

The truly successful programs all had one common denominator—the active interest and support of the local people.

In our western states where the Federal Government actually owns some 50 to 80% of the land area and privately owned parcels are intermingled in somewhat of a hodgepodge pattern, it is no doubt hard for some to imagine that there are many local people and that there are local interests. With the multitude of Federal agencies, bureaus, and boards and the involved state and county departments and commissions it is easy to see how these public servants many times are the only ones to emerge from the confusion with a program.

We believe that we, in our small area of the western range country, are laying the foundation for a realistic and practical development program. It is called "Range Renewal", and is defined as an accelerated, community-inspired and directed, range and related resource-development program that includes all interests, and is centered around direct Congressional appropriations to the Federal agencies involved. State and local agencies also participate by their programming on a project basis.

I believe that the failure of many programs has often been due to lack of consideration of the local people's wishes and further that the local people have not made their wishes known in a solid plan. One of the problems that prevents a total interest program where agencies of both the Department of Agriculture and the Department of the Interior are involved, is the lack of a coordinating mechanism between the two departments.

There have been examples of local leadership strikingly demonstrated and the results of what real efforts by local people can produce. In the West, probably the most significant was the creation of the "pilot" soil conservation districts and their making of the word "coordination" into something practical and realistic. The Northeast Elko Soil Conservation District of Nevada is probably the best example of what local people can actually do when the inspiration, enthusiasm, and need are present. Coordination of plans and actions in a project that is prodded along with determined local people has produced results beyond the expectations of all. And on the results side of the picture we see, in addition to more grass, better wildlife and recreation and more income for the local people, and a new and better working relationship has emerged that includes understanding the other fellas' or agency's point of view.

In looking for a local group to sponsor or carry on a coordinated program it becomes important that this group must represent the involved area without selfish interest. We think that a soil and water conservation district made up of representatives of the local people and dedicated to the preservation of our soil and water resources for the generations to follow is that group, and presents an image all across our land that is essential for good public relations. Dedicated and unselfish people make up these soil and water conservation district boards for there is nothing there for those not unselfish and dedicated. In district-wide planning and in a coordinated approach, reservations in the minds of those participating soon disappear and results follow. The skeptics are those who will not or have not tried working cooperatively with SCDs.

"Range Renewal" or as some suggest Range and Resource Renewal, is a program where the community

[1] *Paper delivered at 18th Annual Meeting, American Society of Range Management, Las Vegas, Nevada, February 9 to 12, 1965.*

interests and all others including the agencies, plan and work together to accomplish resource conservation and development faster than at the present rate, and adds only one thought to the coordinated district approach. That is, direct Congressional appropriations to involved departments, bureaus and agencies of the Federal Government to insure participation by them in the project without interference with or robbing from already existing programs and priorities. Each interest must participate and be in a position to finance its part in the coordinated planning and development work decided on by all.

In our Surprise Valley area of northeastern California and the adjacent northwestern range area of Nevada, each and every interest involved in our two-state, two-district, 85% Federally-owned area is represented on the advisory group that assists the Vya & Surprise Valley SCD boards in carrying forward this total program. We think that we are succeeding in breaking up many age-old departmental and agency conflicts, jealousies, and antiquated operating procedures that have hindered progress for years. We are beginning to understand each other and certainly now have a better program than ever existed before. We know we are bucking the status quo and we have run up against an occasional individual who can see no reason for not following a route already in existence under one department or another. Without exception these people are only thinking of their own programs without recognizing that a district-wide resource renewal project involves many interests under both Agriculture and Interior, which must be coordinated if results are to be obtained.

I so far have not specifically mentioned wildlife and recreation, a most important part of Range Renewal plan. We think that these interests should receive particular consideration. It is our thinking that the public in general only really becomes interested in those things that affect them personally. And thru these two parts of a coordinated program *almost all* are potentially involved. People everywhere understand conservation and development of wildlife and recreation. In our area as in many others, projected figures show the tremendous increases in use by recreationists of all kinds that we must expect, for they and the increasing hunters and fishermen will be coming, and soon. Federal objectives are also in this same direction. We are now in the process of setting up a special game management area in our district to actually manage the development and harvest of big game. Water development for fishing, recreation and irrigation, access thru private property, and road development are all important parts of the project.

We think this approach to resource conservation and development in areas of intermingled public and private land is the answer. If this is true, more districts with similar problems will develop projects not identical but alike in that the same principles of coordination will be used. There has been considerable interest throughout the west where district and agency people have discussed "Range Renewal". The need certainly exists for a coordinating group that all interests can work thru and which adequately represents the local people. Soil and water conservation districts can do this job.

In the months ahead we will be carrying this Range and Resource Renewal concept to Congress in the attempt to get the special funds for the agencies involved in the project. We also are prepared to seek and include the counsel of all interests in the project area. And—as the private land owners, and one of the public lands users, I am confident that the rancher will contribute his share.

BOOK REVIEWS

The Compleat Rancher. By Russell H. Bennett. *T. S. Denison and Company, Inc. Minneapolis, Minnesota. 250 p. 1965. $4.95.*

This book is intended primarily for the man who wants a ranch of his own and seeks information on how to acquire and operate one.

Mr. Bennett has objectively presented modern ranching methods in such a manner that the essential lore of the trade and the sequence of its jobs can be learned by the beginner. His writing is based on his own experiences during 32 years of cattle ranching on the eastern slopes of the Rocky Mountains in southern Alberta, Canada.

The author is well versed on the techniques of range and ranch management. He relates, in an easy-to-read manner, the season to season and job to job pattern of a cattle ranch operation.

The first two chapters discuss basic items to consider in looking for a ranch and various ways that one can serve an apprenticeship prior to purchasing and operating a ranch.

The kind of livestock, type of operation, the ranch homestead and fencing and haying are covered in Chapters III through VI.

"Horse talk" and mention of various types of ranch recreation are interspersed throughout the book, although there is a separate chapter for each.

I especially enjoyed reading the chapter entitled "Grass." The highly technical subject was covered in a most readable manner. Incidentally, in giving references as to where a rancher can obtain assistance in botanical knowledge, Bennett comments, "There is in existence a very live association of ranchers and professional government men known as the American Society of Range Management. I have found their publications and their organized range tours interesting and informative."

The chapter entitled "Ranch Economics" brings into discussion such important items as size of economic units, complexity of ranch jobs, calf weights and calf crop percentages in relation to net profit, land values, economic effects of livestock diseases and the importance of having a good feed, forage, and livestock balance.

Throughout the book Mr. Bennett stresses the fact that ranching is a way of living as a family. In conjunction with practical knowledge, he has included the anecdotes, humor, recreation, and inner attitudes of cow country people. Though his thoughts tend to wander at times, this perhaps makes the reading less formal and more in form with the pattern of the hours and days on a western cattle ranch.

The book is a well written methodical discussion of facts and principles of a ranch operation. To the man who is interested in starting out in a ranching enterprise, this book will be of great value.—*Robert L. Ross,* U. S. Soil Conservation Service, Bozeman, Montana.

The Natural Geography of Plants. By H. A. Gleason and A. Cronquist. *Columbia University Press. 420 p. 1964. $10.00.*

Drs. Gleason and Cronquist have combined their complementary talents to produce a book of illustrated essays on plant ecology. As such, not only are they outstanding examples of the "green pen" but their black and white photographs are full-page, rich, and enjoyable.

For a book of such depth it is unusual to find that it is without supporting references. This, however, emphasizes the essay, editorial, and general reading nature of the book. The research worker can come here for ideas and inspiration but must look elsewhere for referenced research or data. Only in support of chapter 14 are twelve maps for eastern forest trees used.

The presentation is such that anyone, at any level, can enjoy the reading. While reading, graduate students may find themselves tying together those floating bits of information that formerly seemed irrelevant. Part floristics, part plant geography, but all plant ecology, from individual species to floristic provinces, this is a book well worth the few dollars it costs.—*A. A. Beetle,* University of Wyoming, Laramie.

A Selected Guide To The Literature On The Flowering Plants Of Mexico. By Ida Kaplan Langman. *Univ. of Pennsylvania Press. Philadelphia, Pa. 1015 p. 1964. $25.00.*

Students of the Mexican flora now have a new tool. After consulting nearly 50 libraries in the United States and a greater number in Mexico, as well as 359 bibliographies (see pages 25 to 32) Ida Langman has organized her own compilation of authors (pages 65 to 820). Mr. anonymous takes over through pages 820 to 856. Finally an index of plant names in smaller print occupies pages 859 to 1015. Here, should you need it, is a good guide to the literature on Mexican flowering plants, beginning with the days of the discovery and conquest of Mexico by the Spaniards, in the early sixteenth century.—*A. A. Beetle,* Univ. of Wyoming, Laramie.

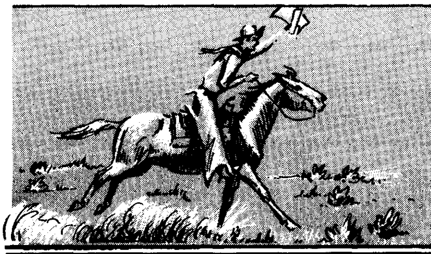
NEW PUBLICATIONS

CONSUMERS ALL—The Yearbook of Agriculture for 1965. Al Stefferud's preface states: "This book tells us—consumers all—many things about buying, using, or making food, clothing, household furnishings, and equipment; managing money; caring for yards, gardens, and houses; bettering communities; using leisure time; and staying healthy." Chapters are grouped under Houses, Furnishings, Equipment, Finances, Safeguards, Plants, Outdoors, Activities, Clothing, and Food. Available free on request from your Congressman as long as his supply lasts; otherwise, it costs $2.75 from The Superintendent of Documents, Washington, D. C. 20402.

CRY CALIFORNIA—We have received Vol. I, No. I of a new quarterly periodical. It is published by California Tomorrow, a non-profit educational organization dedicated to bringing to the public a greater awareness of the problems to maintain a beautiful and productive California, including orderly development of cities, preservation of agriculture, clean air and clean water. Dues are $9.00 per year: California Tomorrow, Forum Bldg., Sacramento, Calif. 95814.

INDEX TO BIOLOGICAL ARTICLES IN AMERICAN SCIENTIST, Publication of The Society of The Sigma Xi—Prepared by Paul C. Lemon and Cynthia McCochrane, published by State University of New York at Albany, 1965.

GLOSSARY OF PASTURE AND FODDER TERMS—in English, French, and Spanish; approved by the Seventh Meeting of the FAO Working Party on Mediterranean Pasture and Fodder Development in 1963. Objective was to include definitions and translations of terms likely to be encountered in practical work with pastures and fodder. 123 p., including index and list of Latin names of plants referred to in text. Mimeo. 1965. For further information, write to Dr. Roald A. Peterson, Chief, Pasture and Fodder Crops Branch, Food and Agriculture Organization of the United Nations, Viale delle Termi di Caracalla, Rome, Italy.



NEWS AND NOTES

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

Meat Animal Research Center—is being established by USDA near Clay Center, Nebraska for a concentrated attack on problems facing cattle, sheep, and hog industries. The 1966 Agricultural Appropriations Act carries a half-million dollars to finance preparation of plans for research facilities and development of land resources.

Scientific Meetings—AAAS met in Berkeley, California December 27-30, 1965. A special feature was the program on Ground Level Climatology, cosponsored by AAAS, SAF, and Ecological Society. Dr. Harold F. Heady presided at all-day session on Ecological Aspects of Ground Level Climatology in Relation to Plants.

AIBS will meet at University of Maryland August 14-19, 1966.

Paul B. Sears—was awarded the title of Eminent Ecologist at the 1965 meeting of Ecological Society during AIBS meetings at University of Illinois. Dr. Sears retired as chairman of conservation program at Yale University in 1960.

Southern Regional Forest Environment Research Committee — was formally organized at Hope, Arkansas, during a recent meeting of representatives from nine southern land-grant universities. Elected as officers were Earl J. Hodgkins of Auburn University, Chairman; T. H. Silker of Oklahoma State University, Vice-Chairman; and W. Frank Miller of Mississippi State University, Secretary.

The new organization is designed to provide an effective means of communication among researchers in forest environment at the southern land-grant universities. Membership is open to all personnel engaged in forest environment research—including foresters, plant ecologists, soil scientists, geologists, and others.

Forest Experiment Stations Consolidated — Central States, Lake States, and Northeastern Forest Experiment Stations are to be consolidated. Central States research programs, including range and wildlife habitat research, in Iowa, Missouri, Indiana, Illinois will be administered from the St. Paul office. Those in Ohio and Kentucky will be administered from Upper Darby, Pa.

Housefly Resistance to Insecticides —Resistance to insecticides varies with different fly species, areas, and materials used, according to October, 1965 issue of California Agriculture. G. P. Georghiou et al. report that flies have been able to survive and eventually build up resistant populations despite any insecticide used to date. Resistance to new compounds appears to develop even more rapidly where flies are already resistant to an earlier-used compound. Well-known fly-control methods including good manure management and general farm sanitation remain essential as a means of reducing the need for frequent insecticide applications and thus delaying development of resistance.

R. D. Lloyd is new assistant director in charge of forest economics, marketing utilization, and recreation research at Rocky Mountain Forest and Range Experiment Station in Fort Collins, Colorado. Dr. Lloyd's appointment completes the staff of assistant directors established under the station's organization change July 1 in which five assistant directors assumed the responsibilities formerly held by eight division chiefs.

Duane transferred from the Bureau of Land Management, U. S. Department of the Interior, in Washington, D. C., where he served since 1961 as Range Economist; Chief, Branch of Range Studies. Previously, he had been agricultural economist with the Economic Research Service in USDA, stationed at the University of Nevada, Reno.

Dr. Lloyd earned his B. S. degree in forestry from the University of Idaho at Moscow, and his Ph.D. from Utah State University at Logan with a major in range management and a minor in economics. He is a member of American Society of Range Management, American Farm Economics Association. He is a member of the Editorial Board of the Journal of Range Management.

Marion E. Everhart in November, 1965, assumed the position of Regional Appraiser of Region III, Bureau of Reclamation, U.S. Department of the Interior, with headquarters at Boulder City, Nevada. He will supervise the appraising of lands being acquired by the Bureau of Reclamation for public use purposes. Typical appraisals involve rangeland, desert, tame pasture, cropland, and urban uses. Lands are acquired for such purposes as electrical transmission lines, aqueducts, pumping plants, tunnel easements, channelization of rivers, diversion dikes, reservoirs and irrigation.

Marion is a charter member of the American Society of Range Management and was formerly Area Range Conservationist with the Soil Conservation Service in Texas. He served as president of the Texas Section of ASRM in 1960.

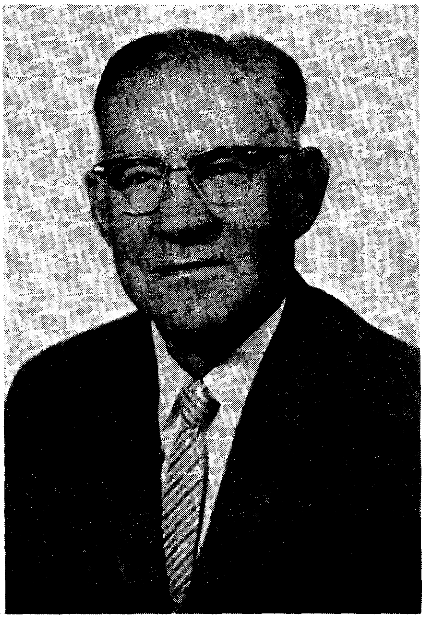
A. Perry Plummer of Ephraim, Utah, range scientist with the Intermountain Forest and Range Experiment Station, received a Certificate of Merit and an award of $1,000 for outstanding performance in cooperative wildlife habitat research. The award was presented by Station Director Joseph F. Pechanec at the auditorium of the Utah Department of Fish and Game in Salt Lake City. Perry's research has been cooperative with the Utah Department of Fish and Game and has been directed toward improvement of wildlife habitat in Utah and neighboring states.

Plummer's research on methods for improving winter range for deer has established a firm basis for a far-reaching research program in browse improvement. It will have major importance for Utah and adjacent states. Plummer's projects have shown exciting possibilities for greatly improving native shrubs for use by deer and other wildlife through selection and breeding of superior varieties that are more palatable, produce more food, or resist diseases and insects.

Director Harold S. Crane of the Utah Department of Fish and Game reported completion of 43 projects in improving 64,000 acres of game range under Plummer's guidance. Nearly half this area belongs to the Department; the remainder was federally owned land improved through cooperation with the Bureau of Land Management and the Forest Service. In all these projects, with a total investment of $736,000, there was not a single failure.

Orval E. Winkler, range conservationist in the Division of Range Management, Intermountain Region of Forest Service, USDA, Ogden, Utah, retired on September 20, 1965.

Director J. F. Pechanec (left) of Intermountain Forest and Range Expt. Sta. hands range scientist A. Perry Plumber (right) a check for $1,000 in recognition of unusually successful cooperative research and application of results with Utah Department of Fish and Game.



He and his wife departed for Buenos Aires, Argentina, where he is assigned as range and watershed consultant with FAO. Orval was with FAO on a similar assignment in Rome during 1959 and 1960. Upon his return from Rome he planned and directed the range rehabilitation program of the Forest Service Intermountain Region. Orval is a Charter Member of ASRM and was Chairman of the Utah Section in 1958.

J. S. McCorkle has retired from the U. S. Soil Conservation Service in Albuquerque, New Mexico. He now is employed by International Engineers and is working in Panama, making surveys and evaluations of grazing land in connection with the Panama government's Agrarian Reform Program.

Orville Andrew Beath—a member of the Faculty of the College of Agriculture of the University of Wyoming for forty years died on August 28, 1965.

Beath was born November 9, 1884 on a farm near Verona, Wisconsin. He majored in Chemistry at the University of Wisconsin receiving his BS degree in 1908. He taught science at Wauwatosa High School at Milwaukee until 1910. Then he was assistant chemist for the U. S. Forest Products Laboratory, and earned the M.A. degree at U. of Wisconsin in 1912. He taught Chemistry at the University of Kansas until he became Assistant Research Chemist at the University of Wyoming in 1914. With the exception of the years 1921 and 1922 when he did post-graduate work in Plant Chemistry at the University of Wisconsin as a Fritzsche Fellow and Research Assistant, Mr. Beath served the State of Wyoming and its University. In 1922 Professor Beath was named Research Chemist and Head of the newly formed Department of Research Chemistry. He served with distinction in this position until his retirement in 1955, at which time he was named Professor Emeritus of Agricultural Research Chemistry.

Professor Beath directed investigations of problems of the Wyoming Livestock Industry from a chemical viewpoint for forty years. His work included research, both in the laboratory and on the range, of native forage plants, stock waters and feeds.

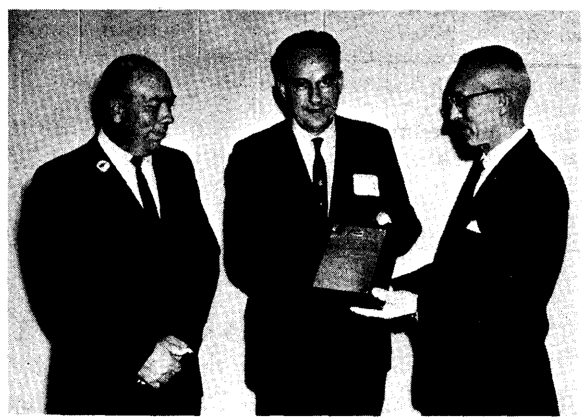
He won international fame for the classical work, directed by him, which uncovered the problem of selenium poisoning in livestock and humans. He was the first to point out the significant geological occurrences and plant relationships of this element. One of his papers on this subject appeared in Journal of Range Management 16:261-265, 1963. He was a pioneer in demonstrating that certain plants accumulate selenium and discovered that some plants actually have an obligate requirement for selenium. Professor Beath's work resulted in some 56 papers, bulletins and articles. He was coauthor of a book on selenium with Dr. Sam Trelease of Columbia University in 1949. He published a booklet on "The Selenium Story in Wyoming" in 1962, and was co-author with Dr. Irene Rosenfeld of a completely new book "Selenium, Geobotany, Biochemistry, Toxicity and Nutrition" published by Academic Press in 1964.

WITH THE SECTIONS

Clarence Kingery, SCS range conservationist, teaching 4-H and FFA boys and leaders how to judge a range site to determine degree of use, kind of site, and range condition, Cheyenne, Oklahoma.

Neal Stidham, SCS range conservationist, teaching range judging to 4-H and FFA boys at Range Youth Camp, Cheyenne, Okla., August, 1965.

Clarence E. Bunch, Extension range specialist, teaching plant identification to 4-H and FFA boys at Range Youth Camp, Cheyenne, Okla.



Left to right: John Sautter, chairman of Nebraska Section Awards Committee; L. F. Bredemeier receiving award; and D. E. Hutchinson, making the award.

KANSAS OKLAHOMA

One photo of the Range Youth Camp for 4-H and FFA boys and leaders at Cheyenne, Oklahoma, in August, 1965, was published in the November, 1965 Journal, page 355. But a new set of photos was submitted by Clarence Bunch, showing the boys on the range. They were too good to pass up.

NATIONAL CAPITAL

The September Newsletter reports two interesting meetings of the Section in 1965. Section membership is reported at 130.

NEBRASKA

Despite bad weather, 134 contestants competed for awards and honors at the 1965 state range judging contest at O'Neill in September. There were six 4-H teams and 20 FFA teams. Three Atkinson High School teams won first three places in FFA division; Broken Bow and Burwell Highs won fourth and fifth. In 4-H division, winners were Grattan Hustlers of Holt County, a Cherry County team, the Sandhill Highlanders of Brown County, Golden Rule Club of Sheridan County, and Four Corners Club of KBR District, in that order. Section President Jim Peters awarded ribbons; also plaques furnished by Nebraska Association of SWCD were awarded by Jim Cook.

The 1966 State Range Judging Contest will be held September 17 at North Platte.

Lorenz F. Bredemeier was honored at O'Neill on September 17, 1965 as the recipient of the "Nebraska Range Management Award." He was cited by the Nebraska Section ASRM. The award was presented by D. E. Hutchinson, State Soil Conservationist from Lincoln, Nebraska; and Walter Fick, Rancher near Inman, at the Section's annual banquet. Bredemeier was cited for "outstanding work in the development and use of Nebraska range resources". He received a wood plaque with the "Trailboss" embossed on a brass plate.

Bredemeier began working for the U.S. Soil Conservation Service in 1938 at Centerville, Iowa. When the first Soil and Water Conservation District was organized in the Nebraska Sandhill range area, he transferred to O'Neill in 1944, to develop a comprehensive range conservation program. His work took him to Cherry County in 1948 and in 1951 he was appointed the first State Range Conservationist for Nebraska in the Soil Conservation Service, stationed at North Platte. Lorenz pioneered in developing cost-return information with ranchers to show methods of planning ranching operations to obtain more net return with less cattle, less winter-feeding of hay, less labor, and therefore, conserving the range.

A native of Pawnee County, where he was reared on a livestock operating unit, Bredemeier obtained B. S. and M. S. degrees from the University of Nebraska.

PACIFIC NORTHWEST

Seventeenth Annual Meeting of the Section was held November 15-16 at Oregon State University. Theme was "Forward Look in Range Management". Featured speaker was Congressman Al Ullman on Nov., 15. Remainder of program was in four sections: "Extending our Horizons in Range Research and Development", "Place of the University in Development of Range and Related Resources", "New Concepts in Range Rehabilitation", and "Integration of Uses". Moderators, in order, were Al McLean, Bill Anderson, Henry Gerber, and Don Niven.

Range Management Short Course on "Essential Ingredients of a Grazing System" will be held at Oregon State University February 21-25, 1966.

Section meetings in 1966 will be at Vale, Oregon June 1-2, and in Spokane, Washington November 28-29.

SOUTH DAKOTA

Annual Section Meeting was held at Wall, November 22-23, 1965. Duane Moxon was program chairman; session chairmen were Gordon I. Powers and Charles Schumacher; theme was "Range Management in the Future."

The range booth at the State Fair attracted considerable interest. It was set up by Tom Strachan, John Holt, and Bob Koerner.

SOUTHERN

The Section's annual meeting was held at the modern headquarters building of the Florida Cattlemen's Association in Kissimmee, Florida on Oct. 12-13. An excellent program consisting of eleven papers was presented on the theme of the meeting, RANGE MANAGEMENT, ITS PAST, PRESENT AND FUTURE. A field trip was held the second morning to the Large Animal Diagnostic Lab. and to Henry Partin's Heart Bar Ranch.

TEXAS

Fifteenth Annual Section Meeting was held at Del Rio, December 3-4, 1965. Session chairmen were Dr. Judd Morrow, C. A. Rechenthin, and Howard B. Passey. Programs dealt with ecology and grass development, economics, research, and ranch management.

Thad Box, John Hunter, and Tom Copeland arranged a stimulating and informative Ranch Management Conference at Texas Tech, October 1, 1965. Some 156 people attended. Topics included drylot feeding of beef cows, performance testing, and influence of feeding and nutrition on range animal production.

SOCIETY BUSINESS

President's Annual Report to the Membership

C. H. Wasser
President, American Society of Range Management

My past year's association with the Society's business has been a challenging and rewarding experience. My thanks to you for this privilege and to all who have supported me and the Society's cause, especially to the many who have gladly assumed the numerous assignments and functions requested of you. Special mention is due Executive Secretary Clouston and Editor Campbell whose conscientious attention to business, often serving beyond the call of duty, saw us through the year "in the black" and kept our communication lines open and our profession respectable.

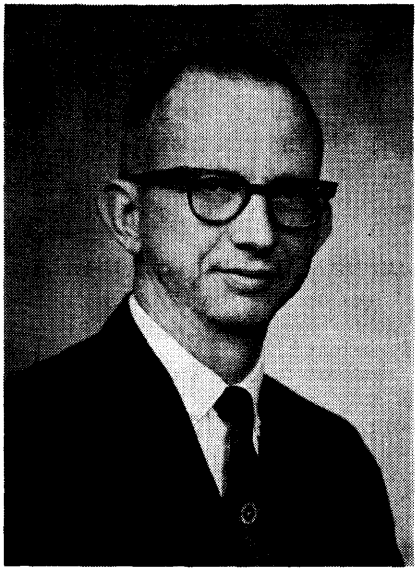
Credits for any achievements, other than those associated with the Executive Secretary and Editor's offices, are due to the volunteer services of our membership. These significant achievements are chronicled in committee and subcommittee reports to which you are referred for greater detail. Brief reviews are abstracted here, and a more complete account of the Annual Meeting in New Orleans will appear in the May issue of the Journal.

Membership made modest gains (approaching two hundred, December 1, 1965) a somewhat disappointing yet significant achievement during the first year of the currently higher dues rate. The President of one section, by careful review of the qualifications for and need for Society affiliation, convinced over 20 persons of the mutual advantages of membership. This same philosophy deserves adoption by Society members and not just membership committee members in all sections. We have a solid and useful organization and need to share it with others with the proper respect for mutually beneficial opportunities and services.

The creation of an ASRM Trust ranks as one of the more significant forward-looking steps your Society has taken in recent years. Our house is in order to accept funds to undertake significant research, publications, and education including national scholarship awards that the members, committees, and Soc-ciety patrons see fit to finance. Now that we have a tax-free instrument for such undertakings it becomes our challenge to make use of it personally and collectively to accomplish high priority projects which we have postponed.

This occasion marks the nineteenth anniversary of our organization. During the year frequent requests for opinions, or joint efforts with other scientific organizations suggest that the professional stature of our Society is growing and that we are gaining a respectable degree of maturity, perhaps more than commensurate with our age. Greater and more consistent representation with our sister societies and associations continues to be a challenge to us professionally in national and state meetings and especially from the service standpoint, in local meetings.

While we are becoming known among professional and natural resource organizations, our recognition in the international field needs attention. For whatever recognition we do have we are indebted to W. R. Chapline, our unpaid but nearly full-time chairman of the International Relations Committee. He has persevered until a reduced Journal subscription rate was recently approved for foreign members. His concern and constructive influence can be observed in almost all of our involvements in



C. H. Wasser, ASRM President for 1965.

foreign programs from emphases of U.S. AID missions to programs and participants for international grassland congresses.

Improvements in the Journal give us considerable pride. There continues to be room for further improvement. A Journal Review Committee has been helpful by soliciting suggestions to make the organ better serve your wishes. Not all of these will prove feasible, but I feel certain that further improvements are possible and will be forthcoming.

Editor Campbell has said that his policy is to publish something of interest to each member in each issue. He has further pleaded that if the Journal articles do not interest you or serve your need to please write the desired kinds of articles yourself, even if a technical person needs to be drafted to polish the manuscript to get it past the editorial review committee. My views are that the same philosophy applies to the Society. If you are genuinely interested in ranges and pastures and their improvement and the Society isn't meeting your needs, get in and become active and make the Society better accomplish what you think it should. How else are we to improve?

Continued efforts have been made to improve the standards of our profession. New recommended standards have been called to the attention of agencies and U. S. Civil Service. Currently standards for range classifications are being reviewed by Civil Service. We hope to see improvements soon before further damage results to the profession and resource from continued employment of sub-standard personnel.

Our Public Relations Committee has drafted a new bill of necessities to guide us in the correction of our apparent deficiencies. This matter deserves every officer's and section's undivided attention and fullest support and cooperation.

Our Range Education Committee reports trials being conducted with new youth handbooks that involve projects. They have tailored a Range Youth Fact Forum program to be given a trial at our next summer meeting if interest and funds warrant. A national scholarship program has been planned and is ready to be implemented whenever funds permit. A plan has been developed for distributing career brochures by either Sections or schools within the Section. Educators are reviewing biological science materials for a new curriculum textbook.

Finally, as a result of suggestions first made by our Executive Secretary, a Planning Committee chaired by Bill Hurst is in the final stages of drafting a blueprint which will merge a full-time executive secretary with a part-time technical editor and provide both with essential secretarial and clerical assistance at a centrally located Society headquarter's office. We are a year away from such a shift but we all need to be apprised of this most significant of all improvements that should incorporate a new public relations image and greater service to our membership and which should insure that our Society is truly professional and responsive to the membership's needs.

Thank you again for the privilege of serving our mutual interests during the past year. There are sufficient unattained goals that our new officers should be challenged to greater achievements and should find a full measure of satisfaction in striving to attain their new goals.

BYLAWS OF THE AMERICAN SOCIETY OF RANGE MANAGEMENT

as amended and corrected to December 31, 1965

ARTICLE I. Membership

SECTION 1. 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.

SECTION 2. The Society has three classes of membership: Regular; Student; and Life. Student membership is restricted to students actually attending school, who are required to maintain an address in care of a school department or professor. Any regular member may obtain Life membership by payment of the Life membership fee.

SECTION 3. Application for membership may be made at any time, but membership will begin only at the start of the calendar year. The application for Regular or Student membership should be accompanied by payment of one year's dues and a statement by the applicant signifying the January when membership should begin. The Board of Directors has the right to approve or reject applications, and if the application is rejected, dues will be refunded to the applicant.

SECTION 4. Annual dues for Regular or Student members shall be payable in advance to the Executive Secretary of the Society on January 1 of the current year.

SECTION 5. Members whose dues are in arrears on the 15th day of April will be declared delinquent and shall be immediately dropped from the roll of membership.

SECTION 6. A former member dropped for non-payment of dues will be eligible for reinstatement (1) upon payment of dues in arrears at the time he was dropped, or (2) by approval of the Board of Directors and payment of the current year's dues.

ARTICLE II. Officers and Directors

SECTION 1. The officers of the Society shall be a President and a President Elect.

SECTION 2. The Society shall have a governing body which shall be known as the Board of Directors and which shall consist of the elected officers, the immediate past President and six elective members, each of whom shall be a member of the Society in good standing.

SECTION 3. The term of office of the President, and President Elect shall be one year. The immediate past President shall serve as a member of the Board of Directors for one year. The terms for the six elected Directors shall be for three years. Terms of office shall begin at the close of the regular annual meeting after their election.

SECTION 4. The President, President Elect, and Directors shall not be eligible for reelection to the same office until at least one year has elapsed after the end of their respective terms.

SECTION 5. Vacancies in any unexpired term of office shall be filled among the Society members by a majority vote of the Board of Directors.

ARTICLE III. Nomination and Election of Officers and Directors

SECTION 1. The President Elect, and Board of Directors, other than the immediate past President, shall be elected by letter ballot which shall be sent to all members by the Executive Secretary. The President Elect shall succeed to the Presidency.

SECTION 2. The Executive Secretary shall be a paid employee of the Society appointed by the President in accordance with directions of the Board of Directors as to the duration of appointment, rate of pay, and time devoted to Society business.

SECTION 3. A nominating committee shall be appointed by the President not later than March 1 of each year. It shall be the duty of the nominating committee: (1) to receive nominating petitions from the membership at large as provided in Section 3, (2) to prepare a list of candidates who are qualified for the elective offices, including the elective memberships on the Board of Directors; this list of candidates shall include all nominations duly presented to the committee by petition as herein provided; this list shall include at least two candidates for each elective office, including each elected Director position, but may include others than those received by petition; such list of candidates shall be furnished to the Executive Secretary not later than September 1. Members of the Nominating Committee shall not be eligible for nomination to national office during the year in which they serve on the Nominating Committee, except when nominated by petition.

SECTION 4. Nominations by petition shall be subject to the following conditions: (1) each petition shall name but one candidate for each office; (2) all candidates nominated by petition must be eligible to hold elective office; (3) the petition shall bear the signatures of at least 25 voting members of the Society who at the time of signing such petition are eligible to vote by having paid their current dues; (4) petitions must be in the hands of the nominating committee by June 1.

SECTION 5. As soon after receipt of the final ballot from the Nominating Committee as possible, and not later than October 1, the Executive Secretary shall send to all members in good standing a typed or printed ballot containing a list of all candidates presented by the Nominating Committee or duly nominated by petition. An envelope shall be provided in which the ballot shall be sent to the chairman of the Elections Committee.

SECTION 6. An elections committee shall be appointed by the President not later than April 1st of each year, to receive and count the ballots. All ballots received by the chairman of the Elections Committee on or before November 30 shall be counted and the results reported to the President by December 15. The two candidates receiving the highest number of votes for Board of Directors shall be declared elected to the Board of Directors. Should a candidate receive votes sufficient to elect him to each of two or more offices, he shall be declared elected only to the office of the higher or highest rank to which nominated and for the purpose of such determination it shall be deemed that the offices from highest to lowest rank are in the following order: President, President Elect, and member of Board of Directors.

ARTICLE IV. Management of the Society

SECTION 1. The Society shall be governed by the Board of Directors.

SECTION 2. The Board of Directors shall meet immediately after the close of the annual meeting of the Society, at such other times as the Board of Directors may select and at the call of the President. Six members of the Board of Directors shall constitute a quorum. In case of lack of a quorum for a Board of Directors meeting, the Board members present are authorized to appoint not more than two members of the Society in good standing to serve for the meeting only.

SECTION 3. The Board of Directors shall direct the investment and care of funds of the Society; act upon applications for the establishment of Local Sections; take measures to advance the interests of the Society; disseminate technical knowledge by publications, meetings, and other media and generally direct its business.

SECTION 4. The President shall have general supervision of the affairs of the Society. He shall appoint necessary committees, preside at meetings of the Society and of the Board of Directors and shall deliver an address at the annual meeting.

SECTION 5. Standing Committees shall be accountable to the Board of Directors under the general supervision of the President.

SECTION 6. The President Elect shall, in the absence of the President, preside at meetings and discharge his duties.

SECTION 7. The Executive Secretary shall be accountable to the Board of Directors under the general supervision of the President. The Executive Secretary will be expected to attend all meetings of the Society and of the Board of Directors. He shall outline and duly record the business and proceedings thereof; maintain a suitable membership file and shall report the names of new members, delinquencies, and other changes in Society membership rolls at quarterly intervals to the President; make all necessary reports required by law; conduct the correspondence of the Society and keep full records of same; collect all dues and receive and deposit all monies in the name of the Society and shall pay all bills within his authorized budget. He shall make a report which shall be presented at the annual meeting of the Society and perform all other duties which may from time to time be assigned to him by the Board of Directors. The final fiscal report of the Executive Secretary shall be published. He shall be bonded in a suitable amount as decided by the Board of Directors and at the Society's expense. His account shall be audited by the Board of Directors before presentation of his annual report.

SECTION 8. Immediately after assuming office, the President and Executive Secretary will prepare a budget for the curent business year for submission to and approval by the Board of Directors.

SECTION 9. The business of the Society shall be conducted on a calendar year basis.

ARTICLE V. Meetings

SECTION 1. An annual meeting of the Society for the presentation and discussion of professional papers and for professional intercourse shall be held annually at such time and place as the Board of Directors may determine. Notice of such meetings, including the tentative program, shall be announced to the membership by the Executive Secretary at least sixty days in advance of the meeting.

SECTION 2. Business meetings and other meetings may be called at intervals by the Board of Directors. Upon written request of not less than fifty members, which request will state the purpose of the meeting, the Board of Directors shall call a special meeting of the Society. The call for such a meeting shall be issued not less than thirty days in advance and shall state the purpose thereof, and no other business shall be transacted at such meeting.

SECTION 3. The members in attendance at a regularly called meeting shall have the authority to transact the business of the Society.

SECTION 4. Regular business meetings of the Society shall be held in connection with the annual meeting.

SECTION 5. A program committee for the next annual meeting shall be appointed by the President immediately following the annual meeting to be responsible for the formulation of a program for the approval of the Board of Directors. Any member desiring to present a paper at a meeting shall so notify the program committee chairman.

ARTICLE VI. Local Sections

SECTION 1. Local Sections, composed of Society members, may be established in any locality, and such organization shall become effective as soon as its proposed Constitution and Bylaws shall have been submitted to and approved by the Board of Directors.

SECTION 2. An application for the establishment of a Local Section must be signed by at least fifteen members.

SECTION 3. Local Sections, in their speech, writing, and action, shall conform to the principles, policies, and objectives of the Society, as set forth in its Articles of Incorporation and/or Bylaws or as approved in policy statements by the Board of Directors or the membership of the Society.

SECTION 4. The functions of Local Sections shall be the encouragement of members to prepare and discuss papers, to confer and to suggest as to matters of Society policy, to study local range and pasture conservation and management problems, to cooperate with other local sections and other local organizations in matters of common interest, and to bring about closer personal acquaintance and a spirit of cooperation on matters relating to the objectives of the Society.

SECTION 5. Each Local Section shall elect a President, and Vice President or a President-elect who shall succeed to the Presidency, and may elect such other officers and provide for such committees as it finds desirable.

SECTION 6. Each member of the Society shall belong to the Section covering the area in which he resides, except where he specifies otherwise, and the Executive Secretary shall remit the appropriate portion of the annual dues of each member to the officers of the Section in which the member belongs. Any member of the Society may attend the meetings of any Local Section but may vote only in the Local Section to which he belongs.

SECTION 7. Each Local Section may hold such meetings and engage in such activities as it desires, and is encouraged to suggest needed action on the part of the Society. The Secretary of each Local Section shall report the proceedings of that section to the Executive Secretary of the Society.

SECTION 8. Society dues shall be paid directly to the Executive Secretary. If a Local Section receives any annual dues for the Society it shall transmit the entire amount to the Executive Secretary without any deduction therefrom for local expenses.

SECTION 9. The Board of Directors will examine and resolve any conflicts that may arise between Local Sections.

SECTION 10. The Board of Directors may rescind the authorization of any Section and terminate its existence.

ARTICLE VII. Publications

SECTION 1. The publications and papers of the Society shall be issued in such a manner as the Board of Directors may direct.

SECTION 2. The publications of the Society shall consist of a Journal of Range Management and such other publications as the Board of Directors may direct.

SECTION 3. The Society shall not be responsible for statements or opinions advanced in papers or discussions at meetings of the Society, or printed in its publications.

ARTICLE VIII. Amendments

SECTION 1. Proposed amendments to the Bylaws shall be submitted to all members. The Bylaws may be amended by a two-thirds affirmative vote of the members voting.

SECTION 2. Amendments may be proposed at any business meeting of the Society, providing they are submitted in writing, and bear the written endorsement of at least twenty-five members. Amendments may also be proposed by the Board of Directors in regular meetings. Such proposed amendments shall not be voted upon at that meeting but shall be open to discussion and modification, and to a vote as to whether, in its original or modified form, it shall be mailed to the Society members for action.

SECTION 3. A ballot shall be sent with the proposed amendment and the voting shall be by methods outlined for voting for officers, closing at noon of the twentieth day preceding the next announced business meeting of the Society. The presiding officer at the meeting of the Society following the close of voting shall announce the result, and if the amendment is adopted, it shall thereupon take effect.

ARTICLE IX. Section Chapters

SECTION 1. A chapter of any Section may be authorized by the officers or Council of the Section upon written petition of ten or more members of the Section resident in an area where a strong local organization may be effected. The boundaries of a Chapter shall be established by the Section on recommendations from the members concerned.

SECTION 2. Chapters shall hold at least one meeting each year to retain their authorization. Open meetings are specifically authorized.

SECTION 3. The officers of each Chapter shall include a Chairman, a Vice-Chairman, and a Secretary-Treasurer, who shall be voting members of the Society, serving concurrently with the officers of the Section, and elected by the members of the Chapter. The term of office for officers of college and university Chapters, may be on a school year basis. A current list of the officers and the members of each chapter shall be filed with the Secretary of the Section and with the Executive Secretary of the Society.

SECTION 4. A Section is authorized to appropriate funds from its treasury for the conduct of Chapter business.

SECTION 5. Actions or recommendations of a Chapter on Society matters will be transmitted to the President of the Society with recommendations of the Section. The Section shall have the right to rescind the authorization of any Chapter and to terminate its existence.

ARTICLE X. Policy

SECTION 1. The Board of Directors shall have the authority to initiate, formulate, and otherwise take action on basic Society policy regarding issues or matters which pertain to the provisions of Article II of the Articles of Incorporation.

SECTION 2. Sections, and Chapters through their parent Sections, may initiate and help develop proposed Society policy statements or propose changes in Society policy. Such proposals will be forwarded to the Board of Directors for action.

SECTION 3. The Board of Directors may refer proposed statements of Society policy to the general membership for ballot vote, or after appropriate review may take direct action on policy proposals. In accordance with Article X (1) and (6), the Board of Directors shall make the final decision, based upon results of the referendum, as to whether any issue of Society policy is sufficiently acceptable to the membership to justify a policy statement. Policy statements established by Board action may be changed by subsequent Board action; those established by referendum shall stand until removed by referendum.

SECTION 4. A Section or Chapter shall have the authority to formulate policies relating to matters within the area of its jurisdiction provided that such local policies shall conform to the objectives and purposes of the Society as expressed by Article II of the Articles of Incorporation, and to policy statements of the Society, and in Article VI, Section 3 of the By-Laws. Such policy statements shall be filed in the office of the Executive Secretary and are subject to review and final approval by the Board of Directors.

SECTION 5. Society policies approved by the Board of Directors, or by referendum, shall be published in the *Journal of Range Management*. The results of referenda held to obtain an expression by the membership on existing or proposed policy statements shall also be published in the *Journal*.

SECTION 6. In any matter of policy formulated by the Society, Sections, or Chapters, the following guides shall be followed:

a. Formulation of policy should be deliberate matter because of the diversity of groups within the Society, the breadth of its objectives, and the way in which it is organized. Impetuous and hastily conceived policy statements can be disastrously divisive and reflect unfavorably on the Society.

b. Policy statements should relate to principal rather than specifics or procedures. Thus formulated they would be more flexible, more enduring and more in keeping with the objectives of the Society.

c. The manner in which policy statements are made will need to be governed by prudence, foresight, and a sense of realism.

d. The Society can speak only for the profession of range management and not for the objectives and interests of any of the diverse groups represented within the Society.

e. On issues where the Society, Section, or Chapter is divided significantly in opinion, even though the issue is approved by majority vote, it would be unwise to express a position forcibly.

f. There are many kinds of issues on which it would be imprudent for the Society, Sections, or Chapters to issue policy statements or to express an opinion.

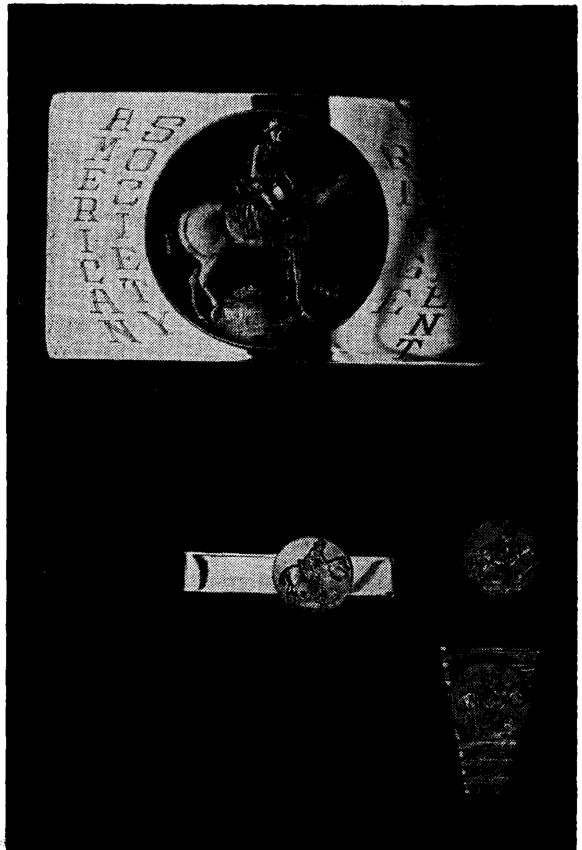
NEW OFFICERS

Newly elected officers of ASRM are:

President Elect, 1966
C. Wayne Cook
Utah State University
Logan, Utah

Board of Directors, 1966-68
Martin H. Gonzalez
Rancho Experimental la Campana
Chihuahua, Mexico

Charles E. Poulton
Oregon State University
Corvallis, Oregon



Wear Your Society Emblem

These 14-carat gold-filled replicas of our trade mark are attractive pieces of jewelry you will be proud to own. Use the accompanying form for ordering. Buckle is 2″ x 3¼″, nickelplated with bronze medallion.

American Society of Range Management
P. O. Box 5041, Portland 13, Oregon

Enclosed find (check), (money order) (cash) in the amount of $__________ for:

(No.)	Item	Price
_____	Lapel Button	**$3.00** each
_____	Tie Slide	**$3.00** each
_____	Tie Tack	**$3.75** each
_____	Tie Clasp	**$3.75** each
_____	Belt Buckle	**$9.50** each

Name ____________________
(Please print)

Address ____________________

____

____

Journal of Range Management
P. O. Box 5041, Portland, Oregon 97213
RETURN REQUESTED