Journal of

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American Society of Range Management

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JOURNAL OF RANGE MANAGEMENT

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Cover Photo— Managing Crested Wheatgrass in Southeastern Oregon

See Management Note by D. W. Hedrick, page 53

Residual Effects of Ammonium Nitrate and Ammonium Phosphate on Some Native Ranges of British Columbia

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Highlight

Applied nitrogen was effective in increasing forage production on some native ranges of British Columbia. The effect was residual showing response after six years. However, it was only economically feasible at the Summerland site where production was increased 76% over a six-year period. Phosphorus appeared to be of little value, either alone or in combination with nitrogen.

The forage production of native ranges in the Kamloops area is low. This is due in part to prolonged overgrazing and limited precipitation, particularly at the lower elevations.

Production has been increased by nitrogen fertilizers at a number of places. Mason and Miltimore (1959) increased the yield of native bluebunch wheatgrass from 640 to 1060 lb/acre in 1957, and from 678 to 1725 in 1958, by the application of 60 lb of N as ammonium nitrate. Clarke and Tisdale (1945) indicated that the productivity of the short grass prairie of southern Alberta could be increased 32 to 36% by the application of commercial nitrogeneous fertilizers. Lodge (1959) found that there was a significant increase in yield as a result of application of 32 lb/acre of nitrogen. Rogler and Laurenz (1957) showed that the application of 90 lb/acre of nitrogen annually produced an average of 2271 lb of dry forage as compared to 1326 and 748 respectively for 30 lb and no nitrogen treatment. They also pointed out that two years of heavy fertilization did more to improve range condition and production than six years of complete isolation from grazing. As part of a broader study Kilcher et al. (1965) found that nitrogen was effective in increasing yields of native vegetation at several locations in western Canada.

The present work was performed to determine the increase in productivity from nitrogen fertilizer on several grassland types in British Columbia over a period of years.

Material and Methods

Fertilizer plots were located at three elevations in the Kamloops area as representative of the lower, mid, and upper grassland zones of the Interior. The soil is Brown, Dark Brown, and Black, respectively, with some degradation of the Black. The Summerland site which was used as a reference has a bluebunch wheatgrass-sage cover and is on a silt loam soil in the Brown soil zone. The lower grassland site at Kamloops is very similar to the Summerland site dominated by *Agropyron inerme* (Scribn. & Smith) Rydb. (bluebunch wheatgrass) and *Artemisia tridentata* Nutt. (big sagebrush). The main difference in the site is the soil texture. The Summerland site is silt loam while the Kamloops site varies between sandy loam and fine sandy loam. The long-term average precipitation is 11.16 inches at Summerland and 9.52 inches on the lower grasslands of the Kamloops region. The midgrass site is level to gently rolling being dominated by a *Stipa comata* Trin. & Rupr. (needleandthread) *Poa secunda* Presl (Sandberg bluegrass) dis-climax. The upper grassland site is dominated by *Stipa columbiana* Macoun, (Columbia needlegrass) and *Stipa richardsonii* Link, (Richardson needlegrass), but originally an *Agropyron inerme* and *Festuca scabrella* Torr. (rough fescue) association.

On the lower grassland site at Kamloops and the Summerland site the sagebrush was cut down to ground level with a farm-type rotary mower and left on the ground. Because of the effect of the standing sagebrush on reducing soil temperature and also using the limit precipitation it was decided to leave the sagebrush on one set of plots at the lower grassland site at Kamloops and to remove it just prior to cutting the grass in the fall.

The lower grassland site at Kamloops and the Summerland site had not been grazed for many years because of lack of watering facilities. The other sites had all been heavily grazed. All sites were fenced in 1959 to prevent further livestock grazing during the years of the experiment. The experiment was a randomized block of four replicates. Four levels of nitrogen 0, 30, 60, and 100 lb/acre plus 60 lb of P_2O_5, and a final treatment of P_2O_5 plus 60 lb of nitrogen. The source of the nitrogen was ammonium nitrate and the source of the P_2O_5 was ammonium phosphate. This means, of course, that the treatments receiving phosphate were getting an additional amount of nitrogen. The test was repeated for three years on adjacent areas so residual effect could be observed. The plots were 6 ft x 28 ft. At the time of harvest a sample was taken through the centre of the plots after trimming off the ends to avoid border effect. The Summerland plots were harvested the first week in July but the Kamloops plots were not harvested until the first week in September. The yields were reported on an oven-dry basis. Crude protein was calculated as N x 6.25. Nitrogen was deter-

Table 1. Average yields of native forage in lb/acre as affected by the addition of ammonium nitrate and phosphorus.

Treatment (lb/acre)	1959	1960	1961	1962	1963	1964	Total	Increase over check	Percent increase
KAMLOOPS									
Lower grassland									
Check	322	312	361	374	386	394	2150		
N — 30	393	351	351	381	470	437	2383	233	11
N — 60	490	365	375	373	438	426	2467	217	15
N — 100	411	381	345	320	477	541	2475	325	15
P_2O_5 — 60	409	330	332	375	382	446	2273	123	6
P_2O_5 — 60 + N – 60	432	363	379	343	470	433	2420	270	13
Upper grassland									
Check	656	442	468	998	1560	1840	5965		
N — 30	702	429	521	1163	1620	1780	6216	251	4
N — 60	670	473	495	1138	1820	1800	6397	432	7
N — 100	673	464	531	1030	1620	1900	6218	254	4
P_2O_5 — 60	778	428	530	1133	1960	1780	6610	645	11
P_2O_5 — 60 + N – 60	892	455	583	1171	1800	2080	6981	1017	17
Mid grassland									
Check	187	166	153	154* c	192 c	205	1058		
N — 30	243	261	185	209 abc	201 c	235	1335	277	26
N — 60	267	256	179	249 ab	250 b	252	1454	396	37
N — 100	266	241	217	255 a	291 a	251	1522	464	44
P_2O_5 — 60	221	215	182	193 bc	189 c	238	1238	180	17
P_2O_5 — 60 + N – 60	274	307	208	258 a	221 bc	248	1517	459	43
SUMMERLAND									
Lower grassland									
Check	687 d	509 d	490 d	496 c	396 d	370 c	2948		
N — 30	959 bcd	872 bcd	610 cd	541 c	457 bcd	421 c	3859	911	31
N — 60	1218 ab	986 abc	694 bc	676 b	470 bc	442 bc	4485	1537	52
N — 100	1138 abc	1184 ab	878 a	814 a	646 a	543 a	5203	2255	76
P_2O_5 — 60	848 cd	678 cd	563 d	541 c	432 cd	370 c	3432	484	16
P_2O_5 — 60 + N – 60	1318 a	1224 a	850 ab	710 b	503 b	520 ab	5125	2177	74

* Values followed by different letters are significantly different (P 0.05) as determined by Duncan's multiple range test.

mined by the micro-Kjeldahl method.

Results

Productivity was not increased by nitrogen fertilizer except at the Summerland location and the mid-grass zone of the Kamloops area. Phosphorus was also ineffective except for a small increase obtained at the upper grassland site (Table 1, Fig. 1). The N - P interaction resulted in very minor increases in yield in most locations.

Residual response was measured up to a period of five years after the initial yields had been taken. The major response was at the mid-grassland site, Kamloops, and at the Summerland site with a maximum residual response of 76% shown at Summerland with the application of 100 lb of N, and 44% residual response with a similar application on the mid-grassland site, Kamloops.

The application of commercial fertilizers to range areas not only stimulates the production of desirable forage species but also weeds. This is most evident at the more mesic sites. On the upper and mid-grassland sites in the Kamloops area there was a noticeable increase in weed growth the first year after application of the fertilizer. This decreased to practically nothing the second year after application.

Discussion

In almost all dryland sites in the interior of British Columbia forage production is controlled in the main by the amount of precipitation that occurs. This is, of course, assuming that the vegetation is a climax stand. If we compare the upper and lower site at Kamloops (Table 1, Fig. 1), and use the total figures of forage production, the upper grassland site produced almost three times as much as the lower grassland site on the check plots.

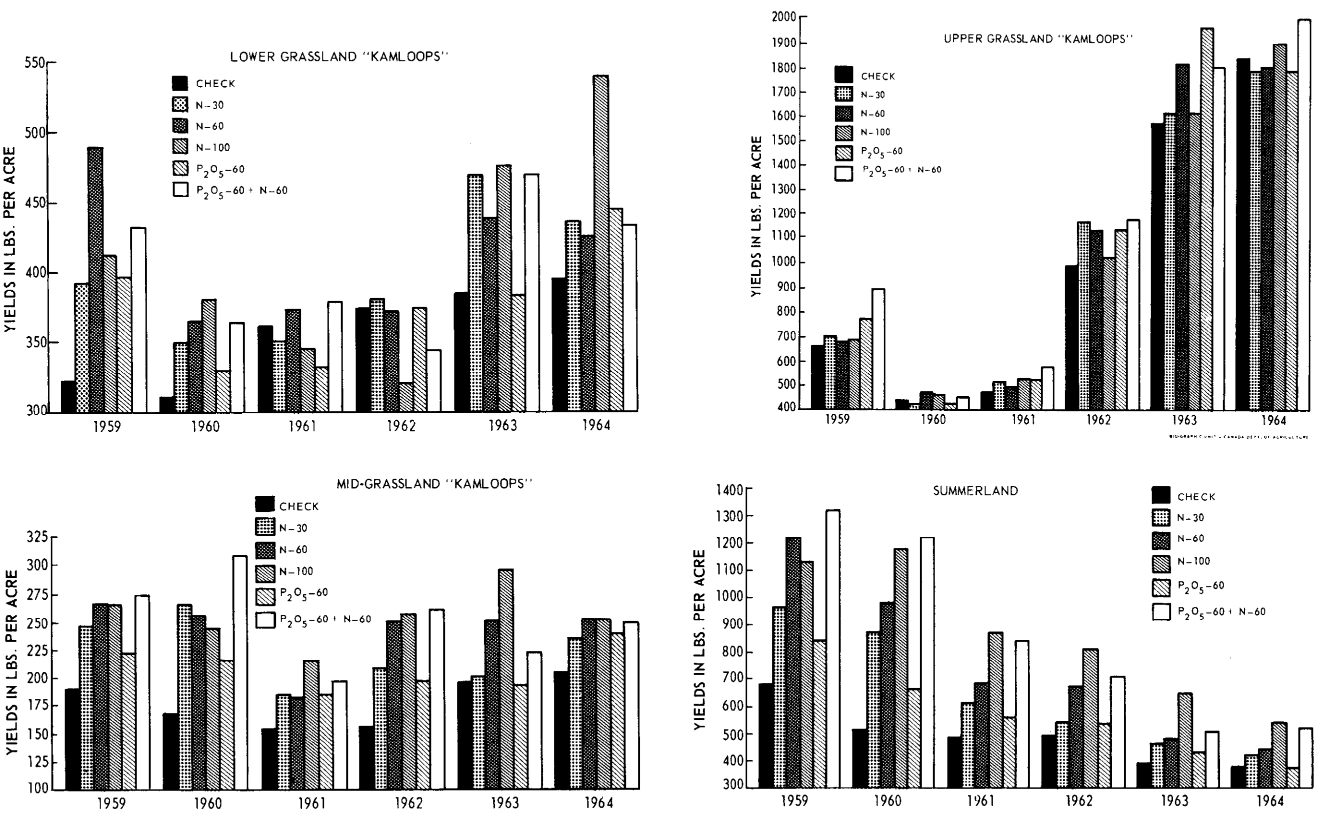


FIG. 1. Graphic presentation of forage yields as influenced by years and the application of commercial fertilizer.

Table 2. Averages of yearly and monthly rainfall in inches 1959 to 1964.

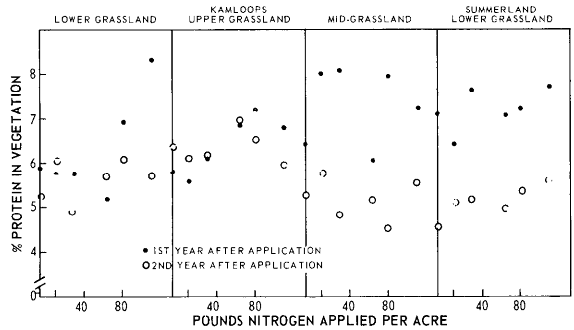
Location	1959	1960	1961	1962	1963	1964	Avg. rainfall Apr.-Sept. (incl)	Avg. ppt. (yearly)
SUMMERLAND								
Lower grassland	4.93	3.93	6.08	5.58	8.53	7.30	6.06	12.05
KAMLOOPS								
Lower grassland	6.60	3.06	4.67	6.84	5.36	5.43	5.33	9.80
Mid grassland	7.34	3.44	5.02	6.54	5.30	5.70	5.56	11.70*
Upper grassland	8.80	5.08	6.26	7.78	7.18	8.67	7.30	13.20*

Location	Long term average	Annual precipitation Apr. 1 to Sept. 30 1958-59	1959-60	1960-61	1961-62	1962-63	1963-64
SUMMERLAND							
Lower grassland	11.16	13.80	7.98	11.69	11.51	12.74	13.00
KAMLOOPS							
Lower grassland	9.52	12.33	7.00	8.70	11.77	8.13	7.17
Mid grassland	10.25	21.11	8.01	9.01	12.15	9.96	8.10
Upper grassland	12.57	14.86	10.93	11.26	12.78	13.21	12.20

* Estimate

At Summerland the check plot was only slightly better than the lower grassland site at Kamloops. What is most striking is the response at Summerland to the addition of commercial fertilizers. This was not evident on the lower grassland site at Kamloops. It is difficult to explain the tremendous response at Summerland to nitrogen fertilizers and the general lack of response in the Kamloops region, particularly at the lower grassland zone. Both of these sites are in the Brown soil zone (Table 2), Summerland having a silt loam texture while the Kamloops site has a fine sandy loam texture. Both sites have similar vegetation being dominated by bluebunch wheatgrass.

On both the Kamloops site and the Summerland site percentage



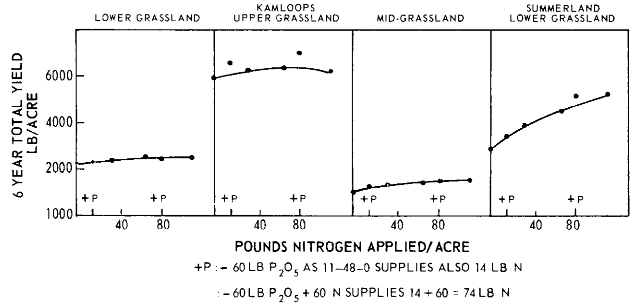


FIG. 2. Cumulative yields of forage at four locations on British Columbia ranges.

FIG. 3. Percent protein in the forage as related to amount of nitrogen applied.

increase follows a similar relationship with the highest rates of nitrogen giving the greatest increase in forage production, and lowest increase to the phosphorus plus a small amount of nitrogen. Because ammonium phosphate was used it is difficult to say that the phosphorus was of no benefit, but this perhaps can be assumed as the poorest response at both locations was with the 60-lb treatment of ammonium phosphate which contained 14 lb of nitrogen, which would represent the lowest rate of nitrogen.

Fig. 2 depicts the six-year total yields graphically. It is quite evident from the shape of the line that there is a very definite response to ammonium nitrate at Summerland. While the yields of forage are relatively high on the upper grassland site the line is almost straight with the exception of the two nitrogen rates which also received phosphorus. Under irrigated conditions phosphorus is required on all soils of the Kamloops area for maximum forage crop production. However, it is obvious that the only site responding to phosphorus application was the upper grassland where more moisture is available for plant growth. At lower elevations moisture is a limiting factor to forage production and hence restricts the effectiveness of the application of commercial fertilizer.

Nitrogen analysis was done on the forage harvested after the initial application and for the second year after application (Fig. 3). The protein level in general was higher the first year after application of the fertilizer. This perhaps is to be expected. The drop in percent protein the second year is quite pronounced for the mid-grassland site at Kamloops and the lower grassland site at Summerland.

As there was virtually no difference in yields between the site that had the sagebrush removed and the one on which it was removed just prior to harvesting only one set of data are included for the lower grassland site at Kamloops.

A botanical survey indicated an increase in ground cover due to nitrogen fertilization at the Summerland site but not at the Kamloops sites. This increase in the basal area of bluebunch wheatgrass and Sandberg bluegrass, as well as an increase in height and leafiness, was a major factor in the large forage production response to nitrogen. In the Kamloops area an increase in forage production was due to an increase in height of the existing plants with no apparent increase in basal area.

There were no changes in the species composition with the exception of an increase in weedy plants the first year after fertilization.

Summary

Nitrogen when applied to native ranges of British Columbia can be expected to increase forage production. At the Summerland site the increase is very substantial. However, at the lower grassland site at Kamloops it is doubtful if fertilizing would be a profitable venture.

Phosphorus appears to be beneficial to the higher ranges.

On both the lower and mid-grass Kamloops sites and the Summerland site the percentage forage increase follows a similar relationship with the highest rates of nitrogen giving the greatest increase.

Range fertilization may be a useful management tool for increasing forage production and consequently livestock numbers. The range areas in British Columbia where the application of fertilizer may be economical have not been fully explored. The residual effect is a most important factor in any evaluation.

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Rotation of Deferred Grazing

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Highlight

Deferred grazing is good for the range resource. It benefits the livestock, wildlife, and watershed quality and dependability. It makes the countryside look better and enhances recreation. It reduces costs of livestock production. If deferred grazing is good for one pasture, then rotation of deferred grazing is good for a number of pastures over a period of years.

Resting the range once in a while from the beginning of growth until key forage plants have matured, or until vegetative reproduction is completed, has proven to be economically beneficial and biologically sound. This is Deferred Grazing. If Deferred Grazing is understood, then Rotation of Deferred Grazing should be understood easily. It is merely the application of Deferred Grazing to all, or some, of the grazing units of a ranch or allotment with a portion being treated each year. If Deferred Grazing is beneficial to a single pasture, then Rotation of Deferred Grazing is beneficial to a number of pastures over a period of years.

Across the range country rotation of Deferred Grazing is known by a variety of names. These include: Deferred-Rotation Grazing; Rotated Deferred Grazing; Rotation-Deferred Grazing; Rest-Rotation Grazing, and probably others. Basically, they all stand for the same thing. These various names for the same thing have been troublesome. Special connotations have been added with the result that in the minds of individuals, each name stands for something slightly different. Attention is diverted away fom the basic principles involved.

Commonly, it is thought that the word "rotation" refers to moving the livestock in and out of pastures periodically as is the case with "rotation grazing" on irrigated pastures. In Rotation of Deferred Grazing, the word '"rotation" refers to a rotation of *deferred grazing* among various pastures over a period of years. Moving livestock from one pasture to another is involved obviously.

These named systems of forage management do exist in range terminology. It behooves each person in range work to sharpen his understanding of the principles involved and of the situations to which they apply. This will improve personal effectiveness. It will bolster the adoption of sound forage management. In time, range terminology may be improved.

It is imperative to dispel any misunderstanding or concept that rotation of deferred grazing, or whatever it is called, is some sort of highly complex, razzle-dazzle juggling of livestock and pastures that is neither practical nor effective. Properly applied, rotation of deferred grazing is practical and highly beneficial, both economically and biologically. It can be complex under certain conditions but this can be true also with most ranching operations including haying, marketing, and animal husbandry.

Definitions

In the Glossary of Range Terms published by the American Society of Range Management, this system of forage management is called "Deferred Rotation Grazing." It is defined as: Discontinuance of grazing in various parts of a range in succeeding years, allowing each part to rest successively during the growing season to permit seed production, establishment of seedlings, or restoration of plant vigor. Two, but usually three or more, separate units are required. Control is usually insured by unit fencing, but may be obtained by camp unit herding."

In the practice standards of the Soil Conservation Service, it is called Rotation-Deferred Grazing and defined as: "Grazing under a system where one or more range units are rested at planned intervals throughout the growing season of key plants, and generally no unit is grazed more than half of any growing season or at the same time (of year) in successive years."

A simplified definition which does not also contain specificatons is "A system for rotating deferred grazing among several range pastures or grazing units over a period of years in a planned sequence." The name "rotation of deferred grazing" is simple, too, and clearly states the principle involved.

Objectives

The objectives of rotation of deferred grazing include: (1) To apply Deferred Grazing to a number of pastures or grazing units over a period of years in order to allow the key forage species occasionally to complete a full growth cycle uninterrupted by grazing; (2) Improve uniformity of utilization in a number of grazing units; and, (3) at the same time, judiciously manage the livestock and range in other (non-deferred) pastures of the ranching enterprise. These in turn will maintain or improve plant cover and vigor for soil, water, and plant conservation and for optimum, stable forage production.

Where It Applies

Rotation of deferred grazing applies wherever deferred grazing is beneficial and practical. In terms of kind of range in the Pacific Northwest, this includes all upland range sites and grazed woodland sites and most bottomland sites which are grazed during the growing season. This is true irrespective of range condition class PROVIDED that some desirable perennial vegetation exists in the stand to benefit from the deferment. It does not apply to range reserved only for fall or winter grazing where key forage plants are allowed to mature each year. Also, on certain bottomland sites the forage becomes practically unusable when allowed to mature without being grazed, for example, saltgrass.

In terms of range facilities, rotation of deferred grazing applies where there is adequate stockwater within each pasture; where the range has been subdivided into pastures so that deferment does not involve too large a segment of the operating unit; and where sufficient forage is available for each season of grazing, particularly in the spring, to permit delayed grazing on the portion being deferred.

Principle

It is important to note that this system of forage management does NOT propose non-use of the forage on the deferred or rested area. Rather, it provides for harvesting the entire forage crop every year. Harvesting the deferred areas is merely postponed until after the key forage plants have matured. This can be very important from an economic standpoint. Non-use for a year or more may be desirable, however, to allow a crop of grass seedlings to become established or for some other logical reason which normally must be determined on-site.

Number of Pastures

Spring-Fall Range—Normally, at least three pastures or grazing units are needed to rotate deferred grazing on an area of range used in the spring and again in the fall of the same year. This situation exists where special summer pasture, range or a summer-allotment permit provides the forage during the summer months. Within one year on the spring-fall range, the first pasture is grazed during early spring and the remainder of the forage crop is harvested that fall. The second pasture is grazed during late spring only and the crop is fully harvested to Safe Use during this time. The third pasture is reserved for fall grazing and, therefore, is the pasture that is deferred.

More than one pasture to provide forage needed for the early spring grazing season has proven to be practical and effective. In this case, more than three pastures are needed.

Experience has shown that the pasture deferred one year should be grazed during the early spring the following year, if practical. It accomplishes several things: It helps clean up the weathered forage that commonly accumulates when native forage is grazed after maturity. This helps with the utilization pattern in subsequent years. It provides roughage (weathered forage) along with the washy spring growth for improved nutrition and animal health. It also sets up a sequence that helps one figure out how to rotate the deferred grazing uniformly among all the pastures over a period of years and helps avoid over-treating some pastures and not treating others.

Summer Range—Two pastures or grazing units are enough for rotating deferred grazing on an area of range or native meadow adapted for summer grazing. The first pasture is grazed during early summer. The second pasture is grazed in late summer or fall after the major forage species have matured. This pattern of use should be alternated in successive years. More than two summer pastures can be used effectively in sequence in this manner.

Range in Summerfallow-Wheat Units—Range fenced in with areas of cropland used to grow dryland grain in alternate years normally is grazed in a system that provides for deferred grazing every other year. The range is not grazed during the growing season of the year that a grain crop is grown on adjacent cropland. It is grazed during the growing season the following year when the cropland is fallow. Alternate-year deferment is ideal for maintenance or improvement of the range forage PROVIDED that safe degree of use on key forage species is observed.

In this situation it is generally best to divide the range area that will be grazed during a single spring-summer season into several pastures. This provides for moving the livestock to fresh forage occasionally during the spring-summer season. It also helps avoid grazing that portion of the range continuously from spring turn-out until after the grain is harvested, i.e. the full growing season.

Sufficient suitable late spring and summer forage commonly is a limiting factor on wheat-livestock ranches. Management which maintains optimum production of good quality forage is as economically important to this type of ranching operation as it is to a livestock ranch.

Type of Operation—Ranches running two or more separate herds, such as a registered herd, a heifer herd, or a steer herd, in addition to a cow-calf herd may need a group of pastures for each herd and a system for rotating deferred grazing for each group of pastures.

Needed Facilities

In order to rotate deferred grazing, it is essential that an adequate supply of stockwater be provided in each pasture for the number of grazing animals that will be there at any one time. This may require additional developments, storage facilities or water hauling.

Fences or stock barriers are needed for control of cattle and where sheep are grazed without herding. New fences, fence relocation or fence removal may be required for best results.

Subdividing the range into pastures should involve a minimum of fence costs needed to achieve practical and economically beneficial forage management. Careful study of proposed fence locations is important. Building the fences one-at-a-time, so to speak, meanwhile watching their effects on grazing efficiency by annual utilization checks, is a practical consideration.

Additional forage from seedings, pastures, or from improved distribution of grazing within existing range units commonly may be required for getting started in a system for rotating deferred grazing.

Frequency of Deferment

Generally speaking, most range sites in the Pacific Northwest should be given a rest during the growing season once every three to five years, depending upon the range conditions. Sometimes it is most desirable to rest the same range two or three growing seasons in succession to allow seedling establishment or increased vigor. The final decision on frequency should be based on the needs of the range and limitations of working out a practical system for each ranch or allotment.

Safe Use

No system of grazing will be effective unless SAFE USE of key forage species is observed. SAFE USE alone will maintain or improve the range no matter what system is used to attain it. Deferred grazing and its rotation over all the range in a planned sequence merely speeds up the process of range improvement and makes it easier to obtain satisfactory grazing distribution.

The risk of overuse, both too close and for too long a time, in the grazing unit(s) used first in the spring requires special attention when planning and practicing this system of forage management. Overuse during the spring season is especially detrimental to the livestock as well as to the soil and plant community. Normally, overuse can be avoided by shortening the grazing period in spring-grazed units to half or less-than-half of what the units could be grazed later on in the season when a full crop of forage would be available.

Moving the livestock too many times can be detrimental to the animal gains. Some moves to fresh forage are beneficial according to ranchers practicing rotation of deferred grazing. This is true particularly when the forage is green. The manner in which the livestock are moved probably contributes about as much to the favorable or adverse results obtained as does the number of moves. Gates strategically located in fences where stock will drift through naturally will help. Moving small bunches at a time rather than a general roundup also has been pointed out as a successful procedure. Opening the gates and drifting small bunches takes more time but gets the job done more effectively.

Benefits

Some of the benefits that result when Rotation of Deferred Grazing is properly applied are:

1. The important forage plants are given due consideration regarding their needs for optimum production just as consideration is given to the livestock and their needs. Restored grasslands contribute greatly to wildlife, rural beauty, and recreation and, at the same time, reduce silting of streams, lakes and reservoirs and improve the quality and dependability of watersheds.

2. More intensive grazing for shorter periods of time reduces selective grazing of certain forage plants and promotes a more uniform pattern of use—better grazing efficiency—within a pasture or range unit. This may contribute to reducing the cost of producing livestock products.

3. It results in an increased and more dependable forage supply for livestock and game.

Subterranean Clover Versus Nitrogen Fertilized Annual Grasslands: Botanical Composition and Protein Content[1]

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Highlight

Application of N increased the percentage grass and depressed annual legumes. Subterranean clover not N fertilized was very competitive with grass when the sward was grazed or mowed. The establishment of subterranean clover resulted in higher protein forage when need was greatest during the dry season, compared with N fertilization which depressed protein levels during the same period.

Nitrogen fertilization of California's annual grasslands generally has produced a marked increase in production of forage. The effect of applied N on botanical composition and on protein level in the plants is also of interest on these extensive grasslands. Hoglund et al. (1952) indicated that neither nitrogen nor phosphorus had any important effect upon botanical composition where plots were clipped. However, Evans and Love (1956) indicated that annual grassland species such as soft chess *(Bromus mollis)*, ripgut brome *(B. rigidus)*, and wild species of oat *(Avena fatua* and *A. barbata)*, and broadleaf filaree *(Erodium botrys)* increased in percentage when nitrogen, especially in combination with phosphorus and sulfur, was applied. Jones and Evans (1960) studied the effect of applied nitrogen on botanical composition of annual grasslands. They concluded that the species reacted differently to fertilization under grazing than where no grazing occurred. However, the percentage of clover was reduced where nitrogen was applied, whether the plots were grazed or not. Subterranean clover *(Trifolium subterraneum)* was reduced much more on ungrazed plots than on grazed plots by the application of nitrogen. Davies et al. (1966) fertilized plots in a pasture of soft chess and subclover with three levels of ammonium sulfate (0, 250, or 700 lb/acre at emergence and in late winter for 3 years. Each plot was grazed continually with Merino sheep at two stocking rates: 3.5 and 5.0 sheep/acre. The heaviest rate of N eliminated clover from the pasture at both stocking rates by the second year. At the intermediate nitrogen rate, clover was reduced more with light stocking than with heavy stocking. Jones et al. (1961) measured botanical composition on N-fertilized and unfertilized range at 11 locations in the California annual type grasslands. Annual grasses and filaree increased on the fertilized pastures. The percentage of legumes was reduced when N was applied the same season of sampling; but where N had been applied only in years previous to the season of sampling, the percentage of ground covered by legumes was not different from that on the unfertilized pastures. Woolfolk and Duncan (1962) also reported that applications of N increased percentage of grass in the total forage.

Due in part to changes in botanical composition and to physiological changes within the plants themselves, N fertilization has important effects on the protein levels in forage from annual grassland pastures. Hoglund et al. (1952) reported that percent protein at maturity was slightly decreased where N was applied at 84 lb/acre. Jones (1960) reported that the effect of N fertilizer on the protein level in the plant varied with the date N was applied. When N was applied early in the fall, the percent in the plant increased during the winter and spring but decreased at maturity, compared with the unfertilized grass. When N was applied in the spring, the percent N in the mature plants was higher than in the unfertilized plants. In another study, Jones (1963) followed the protein level in individual species through the season after various levels of N had been applied in the fall. All rates of N increased the protein level early in the season. As the plants matured, the percent protein in the nonleguminous species usually was decreased with the addition of 40 lb N/acre. Apparently N stimulated growth to such an extent that N levels in the plant were more dilute. By the end of the growing season the decrease in forage production by clover species had resulted in a decrease in the protein level in the total forage. Plants fertilized with 80 lb N/acre generally had concentrations of protein equivalent to those of unfertilized plants; 160 lb N generally increased percent protein in the nonleguminous plants. McKell and Graham (1960) reported that increasing rates of N fertilization increased the protein level in mature plants grown in a 10-inch rainfall zone. It seems apparent that under their conditions moisture was limiting for plant growth, and thus protein levels were not diluted in the plant tissues. In the study by Davies et al. (1966) samples of

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soft chess and subterranean clover taken late in the fall had concentrations of 2.6 and 11.8% protein, respectively. The variation in protein level in the two species illustrates the importance of changes in botanical composition on protein levels in annual pasture species. Sheep produced more wool and meat on pastures high in subterranean clover than on pastures where heavy amounts of nitrogen had reduced the pasture to grass species.

The purpose of the present experiment was to compare changes in botanical composition and protein levels of plants on an area fertilized with N with similar changes where subterranean clover was established.

Table 1. Botanical composition (percent[1]) of N-fertilized resident grassland and unfertilized subterranean clover sward under three types of management on a Sutherlin loam site.

Management	Subterranean clover sward	Resident grassland (lb N/A)			
		0	40	80	160
Grasses					
Grazed	18[a]	41[cd]	49[de]	73[ghi]	81[hi]
Mowed	17[a]	29[b]	39[bcd]	63[fg]	71[gh]
Ungrazed-unmowed	34[b]	36[bc]	53[ef]	69[g]	83[i]
Forbs					
Grazed	9[ab]	24[def]	26[f]	16[bcde]	13[abc]
Mowed	6[a]	19[cdef]	28[f]	21[cdef]	25[ef]
Ungrazed-unmowed	8[ab]	15[abcd]	14[abc]	16[bcde]	14[abc]
Annual clover					
Grazed	16[c]	35[e]	25[d]	11[bc]	6[ab]
Mowed	11[bc]	52[f]	33[e]	16[c]	4[ab]
Ungrazed-unmowed	30[e]	49[f]	33[e]	15[c]	3[a]
Subterranean clover					
Grazed	57[b]	......	......	......	......
Mowed	66[b]	......	......	......	......
Ungrazed-unmowed	28[a]	......	......	......	......

[1] Within each species group, percentages having the same letter in the superscript do not differ significantly at the 10% level.

Procedure

This three-year study was made on two soils—Sutherlin loam (resident annual grassland) and Willits loam (hardinggrass *(Phalaris tuberosa)* stand) —on the University of California's Hopland Field Station. Both plot areas were fertilized uniformly with 1,000 lb/acre singlesuperphosphate in October, 1960, and 500 lb/acre singlesuperphosphate in October, 1961 and 1962. There were three main plot treatments in a split-plot design: grazing, mowing, and ungrazed-unmowed. The main plots in each of the four replications were divided into eight subplots treated as follows: (1) check, (2) subterranean clover seeded in October, 1960, which resulted in a good stand of subterranean clover mixed with grasses during the three years of the study; (3), (4), and (5) 40, 80, and 160 lb N/acre applied in October, 1960, and again in October, 1962; (6), (7), and (8) 40, 80, and 160 lb N/acre applied in October, 1961. The nitrogen was applied as urea. Size of individual subplots was 10 x 20 ft.

Plots were sampled three times during the growing season as indicated in the figures of protein values. At each sampling date in the grazed treatments eight or ten sheep were grazed for two or three days until most of the forage had been removed. It was the objective to graze the plots down to about the same level as the mowed plots. The sheep were kept in a corral during the night so that deposits of excretion on the plots would be minimized. Fecal material that was dropped on the plots was removed after each grazing. The mowed treatments were clipped at about 1 inch with a rotary mower at each sampling date. The ungrazed-unmowed plots were mowed only at the end of the season when the plants had matured and dried.

During each summer all plots were mowed and cleared of remaining dry forage. Percent protein in the forage was determined by the Kjeldahl method. Data were analyzed by means of IBM computer. Botanical composition was determined by visually estimating percentages of grasses, forbs, and clovers in three 1-square-foot quadrats per plot at each of the three sampling dates in each of the three years. Occasionally clipped samples were sorted and dry weights were taken to check estimates. Since changes in botanical composition due to treatment were relatively the same at each sampling date only the data collected in May are reported in this paper. The values reported in Tables 1 and 2 are the means of 36 estimates (three quadrats per plot, four replications, and three years). Measurements given in the tables and figures were made during the growing season immediately following the October application of N. More details on measuring yields and N uptake are given in another paper (Jones, 1966).

Results and Discussion

Botanical composition.—Botanical composition at the two sites, as affected by N fertilization or subclover, is given in Tables 1 and 2. Composition was significantly different each year, but the changes due to treatment were in the same direction. Therefore, treatment means averaged over the three-year experimental period are given. There was no consistent difference in plots fertilized 1960 and 1962 compared with those fertilized only in 1961. There was no significant effect from N in the second year after application.

The major annual grasses in the resident pasture (Sutherlin loam site) were soft chess and ripgut brome. Other grasses were foxtail fescue *(Festuca megalura)*, annual blue grass *(Poa annua)*, medusahead *(Elymus caput-medusae)*, and slender oat *(Avena barbata)*. The percentage of these annual grasses increased with increasing rates of N regardless of management. However, there was a tendency for the percentage of grass to be less in the mowed plots than in the two other management treatments. Total forage yield data indicated no significant difference between mowing and grazing (Jones, 1966). There was no significant nitrogen-management interaction in the percent grass data. The percentage of grass on the ungrazed-unmowed plots seeded to subterranean clover was about double that on the subterranean clover plots that were mowed or grazed. Obviously the subterranean clover was much less competitive where the grasses grew unchecked throughout the growing season.

Table 2. Botanical composition (percent[1]) of N-fertilized hardinggrass stand and unfertilized subterranean clover sward under three types of management on a Willits loam site.

Management	Subterranean clover sward	Hardinggrass stand (lb N/A) 0	40	80	160
Hardinggrass					
Grazed	50^{ab}	61^{cdef}	48^{a}	53^{abc}	68^{ef}
Mowed	54^{abc}	66^{def}	59^{be}	58^{bcd}	70^{f}
Ungrazed-unmowed	57^{ad}	59^{bcde}	51^{abc}	50^{ab}	63^{def}
Annual grasses					
Grazed	9^{a}	22^{b}	36^{de}	39^{de}	32^{cd}
Mowed	8^{a}	26^{bc}	33^{cd}	36^{de}	27^{bc}
Ungrazed-unmowed	9^{a}	22^{b}	33^{cd}	44^{e}	37^{de}
Legumes and broadleaf herbs					
Grazed	2	17	16	8	0
Mowed	0	8	8	6	3
Ungrazed-unmowed	8	19	16	6	0
Subterranean clover					
Grazed	39^{b}	......	......	......	......
Mowed	38^{b}	......	......	......	......
Ungrazed-unmowed	26^{a}	......	......	......	......

[1] Within each species group, percentages having the same letter in the superscript do not differ significantly at the 5% level. No statistical analysis was run on the legume and broadleaf herbs group because of the high variation between years, there being practically none in this category in the first and third year of the experiment.

The forbs consisted of filaree *(Erodium botrys)*; fiddleneck, *(Amsinckia sp.)*, and a few others. The percentage of such herbs was not consistently affected by the N treatments except on the grazed plots, where the percentages decreased at the higher levels of N. Percentages of broadleaf herbs were at their lowest levels on the subterranean clover plots.

The percentage and yield (Jones, 1966) of annual clovers decreased consistently with increasing levels of N. The annual clovers consisted of California burclover *(Medicago hispida)*, and native clovers such as *T. ciliolatum*, *T. microcephalum*, and *T. variegatum*. There was no significant difference in annual clover percentages among management treatments except where no N was applied. On the check plot, grazing reduced the amount of annual clover compared to the mowed or the ungrazed-unmowed treatments. This was a reflection of the reduction in California burclover. Where subterranean clover was growing, the annual clover species were at about the same level as where 80 lb N/acre had been applied except in the ungrazed-unmowed management treatment. The increase in the percentage of annual clover on this treatment was primarily a reflection of the increased growth of California burclover in the ungrazed treatment.

Percentages of subterranean clover were highest on the grazed and mowed treatments. These data indicate that the growing habit of subterranean clover is well adapted to grazing during the growing season. In fact subterranean clover must be grazed to maintain a stand competitive with the other grassland species.

On the hardinggrass plots (Willits loam site) the application of 40 lb N/acre consistently decreased the percentage of hardinggrass, the result primarily of an increase in percentage of annual grasses. The percentage of hardinggrass where 80 lb N were applied was similar to that with the 40 lb rate. The highest percentage of hardinggrass was obtained with 160 lb N. In the subterranean clover plots the percentage of hardinggrass was about equal to that in the 40 lb N treatment.

The annual grass at the Willits loam site was mainly ryegrass *(Lolium multiflorum)*. Increasing the level of N up to 80 lb/acre increased the percentage of annual grass, but the percentage of ryegrass was less at the 160-lb N level than at the 80-lb level. The percentage of annual grass on the subterranean clover plots was lower than where no N had been applied.

The major legume at the Willits site was lupine *(Lupinus* sp.) Broadleaf herbs also were included with this category because there were very few except in the mowed treatment. Mowing greatly reduced the percentage of lupine. Application of N also reduced this species.

In the present study changes in botanical composition result-

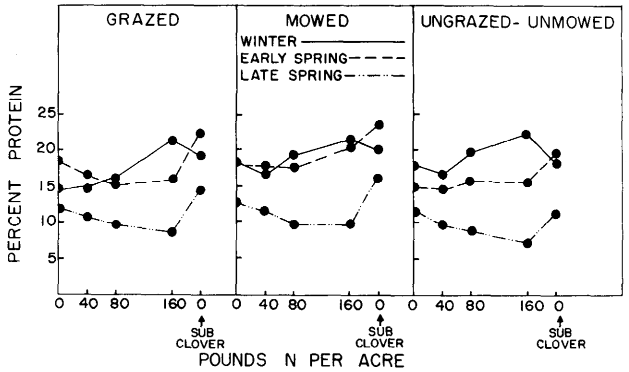

Fig. 1. On a Sutherlin loam, the percentage of protein in forages from grazed, mowed, and ungrazed-unmowed plots at different seasons of the year, as affected by increasing rates of N or seeding of subterranean clover. L.S.D. (.05) = 2.4% protein.

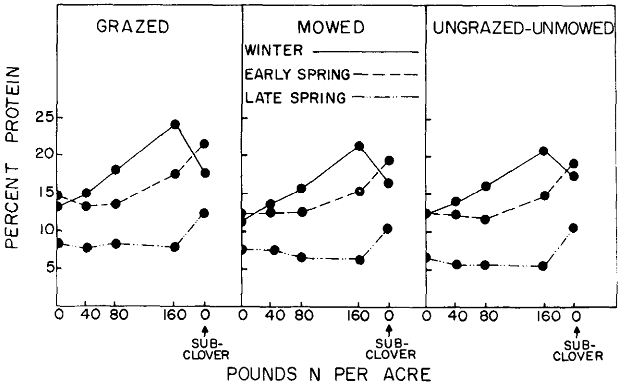

Fig. 2. On a Willits loam, the percentage of protein in forage from grazed, mowed, and ungrazed-unmowed plots at different seasons of the year, as affected by increasing rates of N or seeding of subterranean clover. L.S.D. (.05) = 1.4% protein.

ing from N applications generally appeared to be independent of management treatment except for broadleaf herbs. This observation does not necessarily contradict the findings reported earlier by Jones and Evans (1960). In that study individual grass species were delineated, and the relationship among percentages of these species was found to differ under grazing as compared with no grazing. In this study all the grasses were grouped together. As a group the grasses increased with increasing N under all three management treatments. Of particular interest was the relationship between the legumes and the nonlegumes. These relationships changed but little under the various management systems, with the exception that burclover was consistently less abundant on grazed plots than on mowed or ungrazed-unmowed plots, and subterranean clover was less abundant on ungrazed-unmowed plots.

Protein levels.—Protein levels in the forage from the Sutherlin loam site are given in Fig. 1. The levels generally increased with increasing rates of N during the winter period. The level of protein in the forage from subterranean clover plots was greater than from plots where 80 lb N had been applied, but less than where 160 lb N had been added.

The levels of protein remained high in the spring, but the response to fertilization was somewhat different than in the winter period. On the grazed plots the application of N actually decreased the level of protein, as compared with the unfertilized plots, and the subterranean clover plots had the highest level of protein of any treatment. On the mowed and ungrazed-unmowed treatments, N had little effect upon the protein level except where 160 lb/acre was applied to the mowed plots. But in each instance the subterranean clover plots had the highest level of protein.

At the last sampling date, when plants were approaching maturity, the effect of N on each of the management treatments was somewhat similar. Application of N decreased the level of protein, and the subterranean clover plots had the highest level. Forage from the ungrazed-unmowed plots was consistently lower in N than forage from the other management treatments. This was true for all levels of N and the subterranean clover treatment.

On the Willits soil the response to N fertilization at the first sampling date in late winter or early spring was consistent for all management treatments. Each increment of N increased the level of protein in the forage; and forage from the subterranean clover plots was somewhat lower in protein than that from plots where the highest rate of N had been applied. As the season advanced the effect of the lower rates of N on protein level of the plants became insignificant while the level in the subterranean clover plots was relatively high. At the final sampling date there was no effect from N even at the highest rate and subterranean clover forage had the highest level of protein. Where N had been applied, the ungrazed-unmowed plots were lower in protein than the other management plots. Forage from mowed plots had less protein than forage from grazed plots.

Summary and Conclusions

The effect of increasing levels of N applied to nonirrigated California grasslands was compared to swards of subterranean clover-grass under three types of management: grazed, mowed, and ungrazed-unmowed. Establishment of a subterranean clover stand with resident annual grassland species, or in a stand of hardinggrass, reduced the percentage of all species present other than subterranean clover in each of the three types of management except on the ungrazed-unmowed treatment where California burclover percentage remained high. Subterranean clover was most competitive on grazed or mowed plots. But clover percentages were reduced by grazing.

Application of increasing rates of N increased the percentage of annual grasses and decreased that of native legumes in the three management treatments. The percentage of hardinggrass did not consistently increase except when the highest rate of N was applied.

Protein levels in forage from subterranean clover plots were as high or higher during the winter period as where 80 lb N/acre had been applied. As the season advanced, protein levels remained high longer on subterranean clover plots, and did not drop to such low levels as where N had been applied.

Fall-applied N increased the protein percentage in the forage during the winter and early spring. At plant maturity, the percentage of protein in the forage was lower where N had been applied than where it had not. As indicated in previous studies, this resulted from a decrease in the percentage of legumes and also from a decrease in the level of protein in the grass species. In areas with less rainfall, the addition of N to annual grasslands may increase the protein level, because all of the applied N is not utilized in plant growth. But in the higher rainfall areas of the state, protein levels are likely to be decreased at plant maturity by the application of N the preceding autumn.

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Yield Responses to Time of Burning in the Kansas Flint Hills[1]

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Highlight

The effect of time of spring burning on herbage yields in pastures grazed throughout the growing season was investigated. Early and mid-spring burning reduced forage yields but late-spring burning caused no reduction. Weed yield was significantly reduced by late-spring burning. Differences in grazing distribution apparently affected treatment responses in ordinary upland and limestone breaks range sites.

[1] *Contribution No. 962, Department of Agronomy, Kansas Agricultural Experiment Station, Manhattan.*

Grazing management in the Kansas Flint Hills has traditionally included spring burning of ranges. Studies there have indicated that burning ungrazed plots reduces herbage yield. This study was to determine the effect of time of spring burning on herbage yields in pastures grazed by steers throughout the growing season.

The literature indicates that yields of herbage on burned range vary widely. A primary factor in this variability is time of burning.

In the True Prairie near Manhattan, Kansas, yields of herbage were reduced by burning at all dates tested (Aldous, 1934; McMurphy and Anderson, 1965). Their trials showed that as time between burning and resumption of spring growth lengthened, forage yields diminished. Duvall (1962) studied burning on slender bluestem range of central Louisiana and, in contrast to the work reported in Kansas, found no difference in 8-year tests in herbage yield between areas burned in January and those burned in March. The disagreement may be explained by differences in when rapid growth starts and in precipitation in the two areas, about 58 inches annually in central Louisiana and about 32 inches in the Flint Hills. McMurphy and Anderson (1963) stated that differences in soil moisture brought about by burning appear to be the major cause of herbage yield reductions.

Fall burning near Guthrie, Oklahoma, reduced herbage yields as much as 59% during an 8-year period (Elwell et al., 1941). In the Trelease Prairie of Illinois, Hadley and Kieckhefer (1963) found that with almost pure stands of protected indiangrass *(Sorghastrum nutans* (L.) Nash) and big bluestem *(Andropogon gerardi* Vitman), living shoot biomass was greater after spring burning than after protection from fire, apparently from excessive accumulation of mulch in protected areas. Large accumulations of herbaceous litter can cause yield reductions.

Duvall (1962) concluded that a key to high herbage production in the slender bluestem area of central Louisiana was preventing large accumulations of herbaceous litter. Burning accomplishes that. Litter on protected native pastures of Iowa also retarded plant growth (Ehrenreich, 1959).

However, livestock gains, another indicator of the impact of range burning, have provided a major incentive for range burning in the Flint Hills. Smith et al. (1965) have reported the 15-year average of beef gains in mid and late spring burned pastures to be 20 and 23 lb/steer higher than gains on an adjacent, unburned pasture. Increased gains from burning are attested to by numerous lease arrangements for transient steer grazing requiring that Flint Hills pastures be burned (Kollmorgen and Simonett, 1965).

Time of burning affects many factors which, in turn, affect herbage yield. Hanks and Anderson (1957) indicated reduced infiltration and increased evaporation, which decreased water use efficiency in ungrazed fall and spring-burned plots in the Flint Hills, Higher soil temperatures and concurrent increased evaporation and transpiration caused soil water supplies to be depleted more rapidly in burned areas in the Hayden Prairie of Iowa (Ehrenreich and Aikman, 1963).

A summary of the literature cited indicates that moisture relations, influenced mainly by time of burning, are a primary factor affecting herbage yield. Removing excess herbaceous litter from the soil surface by burning can, in some instances, increase herbage yields. To determine effects of burning on herbage yield, one should investigate time and frequency of burning. Some data indicate that ungrazed and grazed areas may respond differently to time of burning. Duvall (1962) found that grazed paddocks in slender bluestem range of central Louisiana produced significantly more herbage than ungrazed ones.

Materials and Methods

The study area is 5 miles northwest of Manhattan, Kansas, in the Flint Hills region of the True Prairie. It is occupied largely by warm-season perennial grasses, i.e., big bluestem, little bluestem *(Andropogon scoparius Michx.)*, indiangrass, switchgrass *(Panicum obtusum* L.) and sideoats grama *(Bouteloua curtipendula* (Michx.) Torre.). Numerous other grasses and forbs also present make up only a small portion of the total vegetation.

Three 44-acre pastures have been burned annually at three different dates from 1950 to the present: early spring (March 20), mid-spring (April 10), and late spring (May 1). A 60-acre unburned pasture served as a check. The pastures consist primarily of two range sites 1) ordinary upland and 2) limestone breaks. Botanical composition within Flint Hills range varies within any given area due to topographic and edaphic features, and that variation significantly influences herbage yield. Anderson and Fly (1955) categorized areas with like vegetation into range sites to permit segregation of effects of site as such from those of grazing management practices.

Each pasture was stocked at 1 animal unit to 5 acres for the growing season. Steers (500-550 lb) were placed in the pastures at the start of each growing season (approximately May 1) and removed in early October weighing 700-750 lb each.

Ten wire cages, 1 meter square and approximately 75 cm high, were randomly placed in the ordinary upland and limestone breaks range sites within each of the four pastures to prevent grazing on sampling areas. At the close of the grazing season, herbage in a plot (area = 4.36 ft^2) in each of the caged areas was clipped to ground level. A like plot was also clipped in an adjacent unprotected area. In each case, the herbage was separated into forage, weeds, and mulch (no mulch remained in the burned pastures). Forage consisted of grasses, grass-like plants, and perennial forbs.[2] Weeds consisted of forbs not found in climax; mulch was the plant residue that had accumulated from season to season. Differences between caged and grazed areas were termed disappearance and considered an index of grazing use.

Plant census data were obtained by measuring the basal area along 20 to 30 randomly placed 5-m line transects in each range site within the four pastures. Data thus obtained were used to estimate range condition on the basis of original vegetation remaining.

Results and Discussion

Forage.—In ordinary upland bluestem range late spring burning did not reduce herbage yields significantly while mid-and early-spring burning did (Table 1). Forage yields from limestone breaks range showed that only early-spring burning reduced yield significantly. Ordinary upland range produced significantly more forage than limestone breaks range in all burning dates and in the unburned check.

Table 1. Forage and weed yields in lb/acre airdry for indicated times of burning (8-year average) on ordinary upland (OU) and limestone breaks (LB) sites.

Time of burning	Forage yield OU	Forage yield LB	Weed yield OU	Weed yield LB
Early	2612a*	2114a	335b	430c
Mid	3238b	2440ab	289b	269b
Late	3529bc	2681b	161a	106a
Check	3919c	2562ab	300b	337bc

* Yields within each range site followed by the same letter are not significantly different at the .05 level.

[2] *Perennial forbs included in forage are those found in climax and grazed by livestock.*

Forage disappearance (an index of grazing pressure) did not differ significantly in response to time of burning. That was expected, because the areas were stocked at the same rate. However, disappearance was greater on ordinary upland, a gently sloping area, than on limestone breaks, a steep, rocky area (Table 2). That explains the apparent difference between range sites in yield response to time of burning (Table 1). Differences in yield response between the two range sites were probably a consequence of lighter grazing on the limestone breaks range.

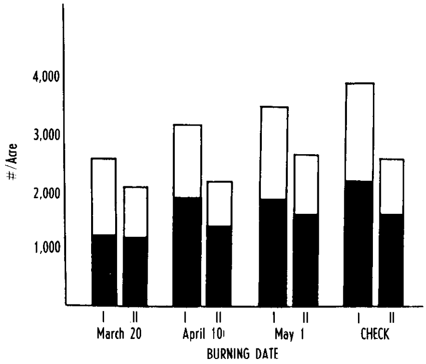

FIG. 1. Forage yields, lbs/A air-dry weight, with residual after grazing represented by blackened portion of bar for indicated times of burning (8-year average). I = ordinary upland range site and II = limestone breaks range site.

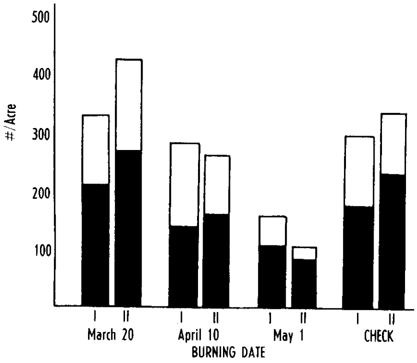

FIG. 2. Weed yields, lbs/A air-dry weight, with residual after grazing represented by blackened portion of bar for indicated times of burning (8-year average). I = ordinary upland range site and II = limestone breaks range site.

Table 2. Forage and weed disappearance in lb/acre airdry for indicated times of burning (8-year average) on ordinary upland and limestone breaks sites.

Time of burning	Forage OU	Forage LB	Weed OU	Weed LB
Early	1304a*	870a	121ab	156b
Mid	1278a	993a	143b	101b
Late	1628a	1009a	53a	18a
Check	1670a	863a	125ab	106b

* Yields within each range site followed by the same letter are not significantly different at the .05 level.

Long-term effects of overgrazing, in this case a result of reduced forage yields due to time of burning, limit the productive potential of vegetation. Therefore, ordinary upland range appeared to show more response to time of burning than did limestone breaks range (Fig. 1 and 2) because grazing pressure was greater on the former.

Year-by-year forage yields are shown in Fig. 3. Over the 8 years, early spring burning consistently gave the lowest forage yield; and, with few exceptions, yield on the unburned area was highest. In 1958-1959 and 1964-1965 the unburned check yielded less than pastures burned in mid and late spring. Those years followed drought periods. A several-year drought preceded 1958-1959 and a severe 1-year drought (precipitation only about half the average) preceded 1964-1965. Anderson (1965) has indicated that range burning reduced soil moisture, and the yields in this experiment were lower than the check in the burned areas in 1963. However, the following

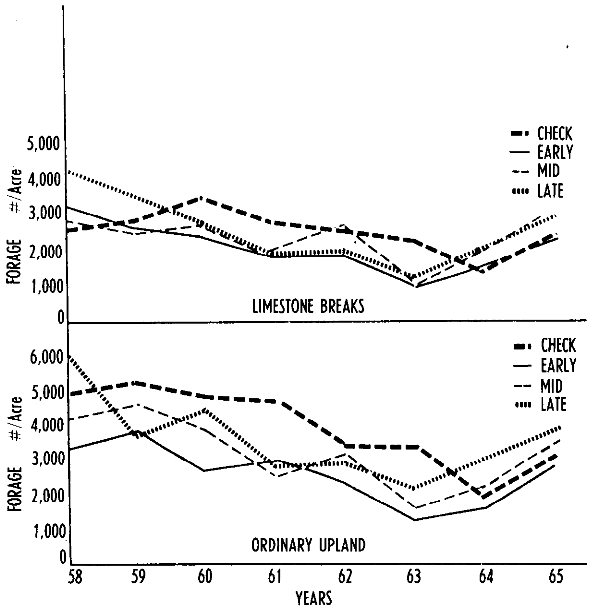

FIG. 3. Forage yield, lbs/A air-dry weight, over 8 years for indicated times of burning.

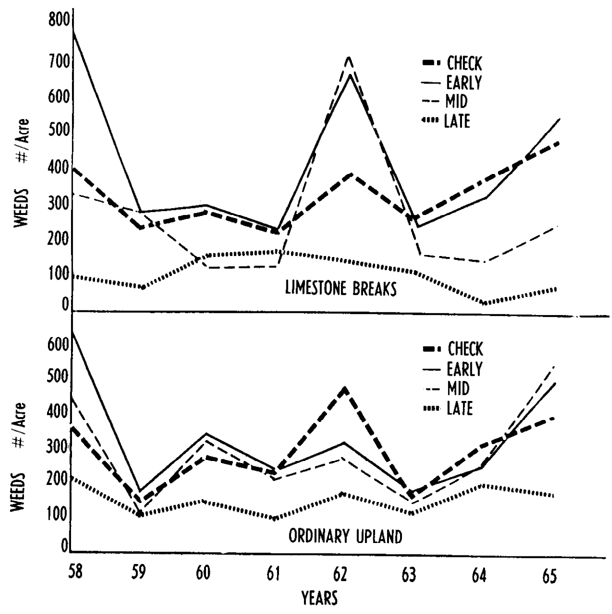

FIG. 4. Weed yields, lbs/A air-dry weight, over 8 years for indicated times of burning.

years, 1964-1965, the check yielded less forage than mid- and late-spring burned pastures. A possible explanation is fewer competing weeds in the mid- and late-spring burned pastures. Range condition in mid- and late-spring burned pastures is considerably higher (contain fewer weeds) than in unburned pastures.

Weeds.—Weed yields in both range sites were significantly lower in late-spring burned pastures than in any other treatments (Table 1). In ordinary upland range, differences in weed yields were not significant among early-spring burning, mid-spring burning, and the unburned check. However, yields in limestone breaks range for early- and mid-spring burning were different from each other but not from the check. No differences in weed yield between the two range sites within the various treatments occurred.

Throughout the 8 years, weed yields fluctuated widely in early- and mid-spring burned pastures as well as in the unburned check (Fig. 4). Late-spring burning kept weed yields rather uniformly low from year to year as late-spring burning comes when many weedy forbs are growing actively and are susceptible to fire injury. Plant census data indicated that weedy species definitely decreased in late-spring burned pastures.

Grazing use (disappearance) of weeds was lowest in the late-spring burned pasture, primarily from lack of quantity available for grazing. Disappearance of weeds was not significantly different in early- and mid-spring burned pastures and the unburned check (Table 2).

Range condition.—Range condition, as expressed by original vegetation present, is shown year by year in Fig. 5. The late-spring burned pasture was consistently high in range condition,

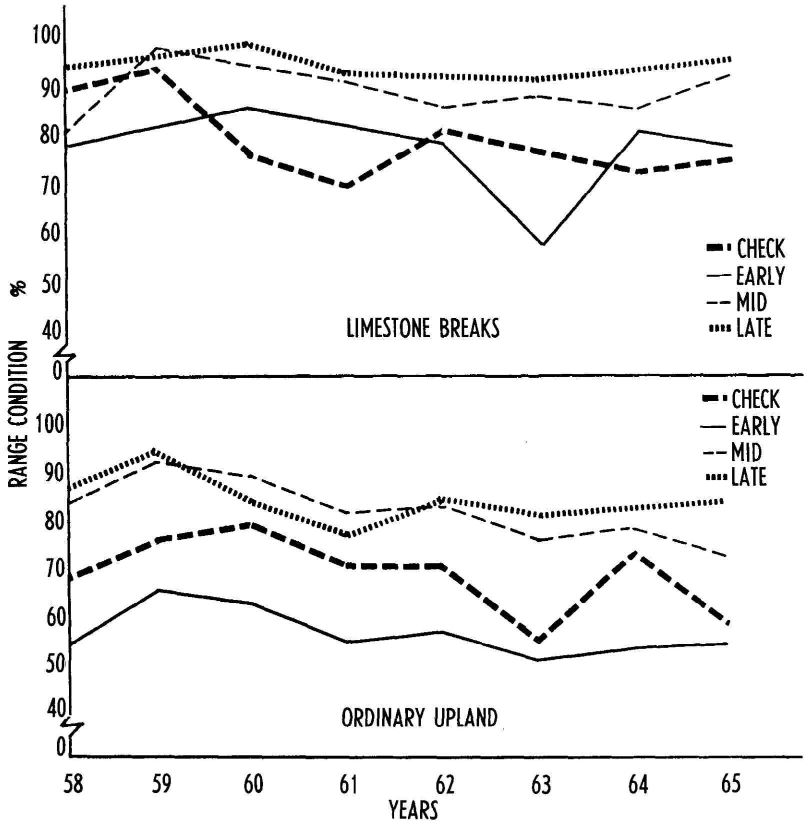

FIG. 5. Range condition as percentage of original vegetation over the 8-year period for indicated times of burning.

while the unburned check and early-spring burned pastures were lower and varied more. However, mid- and late-spring burning did not eliminate all weeds. Smooth sumac (*Rhus glabra* L.), a woody increaser pest, increased significantly.

Summary

Time of burning in the Kansas Flint Hills markedly affected yields of forage. Late-spring burned pastures and unburned pastures gave equal forage yields in both ordinary upland and limestone breaks range. Early- and mid-spring burning reduced forage yields in ordinary upland range but not in limestone breaks.

Weed yields were considerably lower in the late-spring burned area than in the unburned check, while weed yields in early- and mid-spring burned pastures did not differ significantly from those in the unburned check.

Range condition was higher in mid- and late-spring burned pastures than in early-spring burned or unburned pastures.

Since there were no significant reductions in forage yield, and range condition was excellent with late-spring burning, it appears that burning, if practiced in the Flint Hills, should be done in late spring (May 1).

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Fall Fertilization of Intermediate Wheatgrass in the Southwestern Ponderosa Pine Zone[1 2]

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Highlight

The effects of one fall broadcast application of N and P fertilizers on mature intermediate wheatgrass in the Southwestern ponderosa pine zone was investigated. Nitrogen increased herbage production for four growing seasons. It also affected P content and increased crude protein and moisture content of the herbage; increased green growth, plant height, weed growth, and soil nitrates. P and N-P interaction had little or no significant effects.

Intermediate wheatgrass, *Agropyron intermedium* (Host) Beauv. is widely used for range and pasture plantings in the cool, moist sections of the Southwest. This study evaluated the use of fertilizer for improving forage quantity and quality, for lengthening the greengrowth period, and for increasing the vigor and longevity of dry-land intermediate wheatgrass. Some of the components affecting fertilization results were also investigated.

Humphrey (1962) has summarized range fertilization research through 1960. He states that lack of nitrogen limits range forage production more than the deficiency of any other nutrient element. Phosphorus is deficient in most soils, but for many range soils this deficiency is so slight as to be of little importance.

Intermediate wheatgrass in the Southwest attains its greatest forage production during the 3rd and 4th years after establishment and then gradually declines. Nitrogen fertilization, which has been effective for renovating and maintaining the productivity of crested wheatgrass (Houston, 1957; Lorenz and Rogler, 1962), holds promise of being equally effective upon intermediate wheatgrass.

Considerable advantage often accrues from applying fertilizer in the fall (Kresge, 1965; Nelson, 1965). Off-season discounts, elimination of storage, and other economic benefits can be obtained. The time interval that fertilizer can be applied is longer and not so critical. Also the risk of a severe winter or wet spring impeding fertilizer application is avoided. Where winter-spring precipitation is adequate, nitrogen will move down into the root zone and be available for plant growth as early as needed (Christensen, 1963). The main disadvantages of fall fertilization are the losses from erosion, leaching, volatilization, and the conversion of phosphates to insoluble compounds (Thompson, 1957). Fall fertilization also may stimulate early growth of cool-season weeds (Rogler and Lorenz, 1957). Nutrient elements supplied by fertilizers are used mainly during the active growing period of the plant. Fall fertilization, therefore, is usually most effective for cool-season species (Rogler and Lorenz, 1957).

Site Description

Location and history—The study was located at Fort Valley, 9 miles north of Flagstaff, Arizona, in a natural ponderosa pine opening, at an elevation of 7,300 ft. The original native cover was mainly grass, with

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[1] *Contribution from Crops Research Division, Agricultural Research Service, USDA, in cooperation with the Rocky Mountain Forest and Range Experiment Station and the University of Arizona Agricultural Experiment Station.*

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Arizona fescue *(Festuca arizonica* Vasey) and mountain muhly *(Muhlenbergia montana* (Nutt.) Hitchc.) predominating. This cover was destroyed by dry-farming with marginal crops of rye and oats. Intermediate wheatgrass was planted in 1951 and a good stand secured. The planting received complete protection from livestock until 1954, though it was cut for hay in 1953. In 1954 and 1955 the pasture received moderate to heavy use by cattle during spring, summer, and fall. At the beginning of the study in 1956 stand density was still good, but plant vigor and forage production were declining.

Climate.—Climatic data were obtained from the Fort Valley Weather Station located 0.5 mile west of the study area. Annual precipitation over the past 48 years has averaged 22.56 inches. In pattern this precipitation peaks in two periods, with 40% falling December through March and 29% falling July through August. Mean annual snowfall is 88.3 inches, but as much as 60 inches has fallen in a single month.

The mean annual temperature is 43 F with extremes ranging from 97 to -33F. Normal date of first freeze (32F) in the fall is September 5, and of last freeze in the spring June 20. The mean temperature for November is 35F, cold enough so that nitrogen can be applied by broadcasting without excessive loss from volatilization (Thompson, 1957; Kresge, 1965).

Soil.—The soil, a Mortiz gravelly loam, is derived from parent materials of basalt, cinders, and andesite alluvium. It has an average pH of 6.5 and does not contain excessive salts or alkali. Soil depth ranges from 3 to 4 ft. The study area is located on a well-drained alluvial fan with a 2% slope and a south aspect. The relief is slightly convex. Soil nitrates range from 23.5 ppm to a trace too small to measure, and are variable even among samples taken from the same soil depth. There is a tendency, however, for amount of nitrate to decrease with soil depth, especially at the 2- to 3-ft level. Soil phosphates range from 11.10 to 1.65 ppm and decrease with depth.

Methods and Procedure

Field work on the study was begun in 1956 and completed in 1961. Experimental design was a randomized complete block with three replications. Individual treatment plots were 0.01 acre (12 by 36.3 ft).

Ammonium sulfate, 21-0-0, and treble superphosphate, 0-45-0, were applied by broadcasting in November 1956. Twelve fertilizer treatments were used consisting of four levels of nitrogen, 0, 33, 66, and 99 lb/acre, and three levels of phosphorus pentoxide, 0, 32, and 64 lb/acre, applied in all possible combinations.

An attempt was made to follow movement and loss of nitrogen and phosphorus in the soil. Soil samples for chemical analysis were taken before fertilizer application in November 1956, to a 3-ft depth, and again after application in June 1957 and July 1958 to a 2-ft depth. These samples were kept separate for each treatment and each replication by 1-ft soil-depth intervals. Analyses were made for soil nitrates and phosphates.

Observations and measurements were made during the first growing season after fertilization on plant height, basal leaf length, green foliage growth, and plant regrowth after harvesting. Herbage samples were first collected when grass was in the vegetative stage at an average height of 6 inches and again when the seed was in the hard-dough stage. Samples were analyzed for crude protein and phosphorus. An additional set of samples in the vegetative stage at 6-inch average leaf height was collected from the 0- and 99-lb/acre-nitrogen treatments on May 19, 1959, and analyzed for crude protein. Plant height was measured at weekly intervals from April 11 through October 10. Leaf length, using the longest basal leaf and including only green growth, was measured at weekly intervals from April 11 through August 21. Ocular estimates of percentage of green foliage growth were made February 12 through October 10. Regrowth in terms of plant height was measured twice in September and twice in October. These measurements were made on plants that had been mowed in late July.

Herbage yields were measured at the hard-dough seed stage in late July or early August each year from 1957 through 1961. A belt transect 3 ft wide running the length of the plot and constituting 20% of the total plot area was mowed to a 2-inch stubble each year. Transect location was changed each year, so that the same plants were not harvested twice in any 2 consecutive years. All weeds were removed from the grass cuttings before they were weighed. Weed green weights were taken the 1st year.

A sample was removed from each cutting to determine herbage moisture. One additional set of samples also was collected late in May 1957 at the 6-inch-high vegetative stage. Green samples were weighed in the field immediately after cutting and then oven dried at 55 C to compare succulence among fertilizer treatments.

Results and Discussion

Soil Nutrients.—For the June 1957 sampling the 66- and 99-lb/acre nitrogen fertilizer treatments increased soil nitrates significantly above the control at the 0- to 12-inch depth:

N, lb/acre:	N-0	N-33	N-66	N-99
NO_3, ppm:	9	13	26	23

At the 12- to 24-inch depth soil nitrates increased with the two highest rates of nitrogen applied, but the differences were not significant. For the July 1958 sampling there were no significant differences. Russell and Russell (1950) state that for grasslands both the soil ammonium and nitrate levels remain constant throughout the year, and even large applications of nitrogen increase these components for only short periods of time.

Soil phosphates after fertilization ranged from six to eight ppm at the 0- to 12-inch soil depth and from two to three ppm at the 12- to 24-inch depth, with no significant difference among treatments. Phosphorus applied as top dressing moves down into the root zone very slowly and may become fixed in the soil surface (Millar et al. 1958).

Plant growth characteristics.—During 1957 new green growth on intermediate wheatgrass was first observed on February 12. Maximum green growth occurred during the period of April 11 through June 20. Green growth then gradually declined until October 10 when plant foliage was mainly cured but some new green basal leaf regrowth was present.

Start of green growth and percentage of green growth during spring and early summer were not significantly different among fertilizer treatments. Late summer and early fall green growth, however, differed significantly with amounts of nitrogen applied (Table 1). Levels of phosphorus fertilizer, either alone or in combination with nitrogen fertilizer had no observable effect on the green growth of intermediate wheatgrass. Fertilized plants may not be able to start green growth earlier than unfertilized ones because of temperature or moisture limitations. Once started, however, growth is usually more rapid with fertilization (Honnas et al., 1959).

Table 1. Percent green intermediate wheatgrass foliage as affected by four levels of nitrogen fertilization.[1]

Date	N fertilization (lb/acre)			
1957	N-0	N-33	N-66	N-99
June 20	100	100	100	100
July 18	95	96	97	97
Aug. 3	86	91	95	93
Sept. 12	34	39	58	57
Oct. 3	9	12	16	17
Oct. 10	6	9	8	8

[1] Values underscored by the same line are not significantly different at the 5% level.

Intermediate wheatgrass regrowth averaged 0.14 ft on September 19, increasing to 0.42 by October 10. The range on October 10 was from 0.37 ft with no nitrogen to 0.44 ft with 99 lb/acre of nitrogen, but differences were not significant. Neither phosphorus nor N-P interaction produced any significant differences.

Plant height maintained a relatively steep gradient of increase from May 7 to August 21 when it reached an average of 2.91 ft and then leveled off. Nitrogen fertilizer produced a significant but not striking increase in plant height by the second week in June. Differences then continued to be significant through the remainder of the measurement period. Phosphorus fertilizer effected a significant increase in plant height only for measurements made on July 4 and 11. Differences were significant only between the non-fertilized and the heaviest phosphorus fertilizer treatments. Differences for N-P interaction were not significant.

Basal leaves reached their maximum length, an average of 0.47 ft, by May 23. Length then decreased after culm elongation started because basal leaves frequently changed to stem leaves between measurements necessitating the use of other shorter leaves in subsequent measurements. A second lower peak in basal leaf length averaging 0.41 ft occurred on June 20. Length then decreased, gradually at first and then sharply, until the end of the measurement period from die-back of leaf tips.

Significant increases in basal leaf length with nitrogen application occurred only for the June 13, 20, and 27 measurements, and differences were mainly between fertilized and non-fertilized treatments. Phosphorus fertilization effected a significant increase in maximum basal leaf length only for the measurements made on June 20. Differences occurred only between fertilizer and non-fertilized treatments. Interaction between nitrogen and phosphorus fertilizer was not significant.

Smika et al. (1960) found that nitrogen, but not phosphorus, increased the height of crested wheatgrass, bromegrass, and Russian wildrye. Honnas et al. (1959), with ammonium phosphate fertilization, obtained an increase in stem length for some of the range grasses tested. Effect on leaf length was inconsistent. The present study indicates that plant height is a better indicator than basal leaf length of intermediate wheatgrass response to nitrogen fertilizer, but neither is very striking. Results also indicate that intermediate wheatgrass reaches maximum leafiness in May and then increases in steminess with further advance of the growing season.

No treatment differences were detected for time of culm elongation, flowering or seed maturity from observations made at weekly intervals throughout the 1957 growing season. Sneva et al. (1958) found that crested wheatgrass fertilized with nitrogen depleted soil moisture more rapidly than non-fertilized plants. This moisture depletion resulted in an advance of maturity and a shortening of the green growth period.

Damage to the intermediate wheatgrass plants from the treatments tested was negligible. During the first growing season a few plants with burned leaf tips were observed for the heaviest nitrogen application.

Weed growth.—The first growing season after application nitrogen fertilizer increased the weed content of intermediate wheatgrass stands from 8 to 20% on a green weight basis. Weed growth expressed as lb/acre of green weeds and significant differences among nitrogen fertilizer treatments were as follows:

N, lb/acre:	N-0	N-33	N-66	N-99
Weeds, lb/acre:	213	1,000	1,173	1,427

Differences among phosphorus treatments and N-P interaction were not significant. Other investigators have noted the effects of fertilizers on weed growth. Kay and Evans (1965) found that nitrogen favored cheatgrass over intermediate wheatgrass. Increased cheatgrass growth hastened depletion of early spring moisture, and over 4 dry years caused a marked deterioration of the wheatgrass stand. Rogler and Lorenz (1957) found that nitrogen stimulated the growth of cool-season weeds as well as cool-season grass, particularly during the first growing season after application.

Table 2. Annual production of intermediate wheatgrass for 5 years following one late fall application of four nitrogen fertilizer levels.[1 2]

	N fertilization (lb/acre)				
Year	N-0	N-33	N-66	N-99	Mean
1957	887	1,394	2,025	2,080	1,596
1958	1,456	1,820	2,295	2,632	2,051
1959	489	646	691	700	632
1960	632	624	743	763	690
1961	228	288	254	256	256

[1]Pounds/acre of oven-dry weight from herbage mowed to a 2-inch stubble height.

[2]Values underscored by the same line are not significantly different at the 5% level.

Herbage yields.—Nitrogen fertilization increased intermediate wheatgrass dry-matter production for 4 years following application (Table 2). Increases during the first growing season were substantial with a maximum of 134% from 99 lb/acre nitrogen. By the fourth growing season, fertilizer effects were greatly reduced. Only 66 and 99 lb nitrogen produced significant increases, and the largest increase was 21%. By the fifth growing season, differences among treatments were no longer significant.

Intermediate wheatgrass did not take advantage of more than 66 lb/acre of nitrogen for any growing season during the experimental period. Thirty-three lb/acre nitrogen produced herbage increases that were more variable and of shorter duration than the higher nitrogen rates. Over the 4-year period that showed increased production, levels of 33, 66, and 99 lb/acre of nitrogen produced 31, 35, and 27 lb of dry matter per lb of nitrogen, respectively. Costwise, these results indicate that 66 lb/acre of nitrogen is the most efficient rate.

The nitrogen fertilizer carry-over effect obtained was as long or longer than that reported for most other range fertilization studies. Unusually long residual effects commonly result from applying large amounts of nitrogen, a dry site, below normal precipitation, or a combination of these factors (Sneva et al., 1958).

Some of the carry-over effects from nitrogen on dry-matter production may be caused by factors other than residual soil nitrogen. Sneva et al. (1958) hypothesized that at least part of the residual nitrogen was not stored in the soil but was carried over as root reserves. Residual effects, however, have also been found for annuals (Kay et al. 1957) and these cannot store nitrogen as root reserves. Eckert et al. (1961) found that nitrogen stimulated crested wheatgrass root growth. A larger root system makes moisture and nutritive elements available to the plant from a greater soil volume. Indirect benefits that may carry over for several years are the increase of soil micro-organisms and decomposition of organic matter, and the improvement of the soil's physical properties (Millar et al., 1958).

Differences in herbage yields among fertilizer treatments indicate that nitrogen was a limiting factor for intermediate wheatgrass growth at the test site. Production of dry matter per unit of nitrogen compares favorably with that obtained for the northern Great Plains (Rogler and Lorenz, 1957; Smika et al., 1960).

Phosphorus applied alone and in combination with nitrogen did not increase production of intermediate wheatgrass significantly during any year of the study. Lack of grass response to phosphorus on western rangelands soils is fairly common (Cook, 1965; Leven and Dregne, 1963). Various factors and their interaction may have been responsible for lack of phosphorus response. Intermediate wheatgrass may have low sensitivity to phosphorus (Humphrey, 1962). Cumulative phosphorus absorption without fertilization may have been adequate for maximum herbage production in the mature plant (Black, 1957). The fertilizer rates applied, especially when broadcast on the soil surface in fall, may not have contained sufficient amounts of water-soluble phosphates to overcome the fixing power of the soil (Millar et al., 1958).

Herbage composition.—Crude protein was greater for herbage from 6-inch-high plants collected in May than for herbage from plants in the hard-dough seed stage collected in late July-early August 1957 (Table 3). For both growth stages crude protein content increased with increasing amounts of nitrogen fertilizer. Differences among phosphorus treatments and N-P interaction

Table 3. Percent crude protein in oven-dry intermediate wheatgrass herbage at two growth stages as affected by four levels of nitrogen fertilization.[1]

Growth	N fertilization (lb/acre)				
stage	N-0	N-33	N-66	N-99	Mean
Veget. (6" ht.)	13.70	14.58	15.90	17.68	15.46
Hard dough	5.25	5.62	5.88	6.79	5.88

[1]Values underscored by the same line are not significantly different at the 5% level.

were not significant. For the additional samples collected in May 1959, there were no significant differences between the control and nitrogen fertilized treatments, and crude protein averaged 13.55%.

Percent phosphorus was greater in herbage collected at the 6-inch-high vegetative stage than at the hard-dough seed stage (Table 4). At the vegetative stage phosphorus increased with increasing amounts of nitrogen fertilizer. Nitrogen may have stimulated root growth so that the fertilized plants were able to absorb phosphorus from a greater volume of soil. At the hard-dough seed stage, phosphorus decreased with increasing amounts of nitrogen fertilizer. Results are similar to those obtained by Smika et al. (1960) and by Thomas (1964). This inverse relationship is sometimes called "the dilution effect." Herbage phosphorus content was not significantly different among phosphorus fertilizer treatments or for N-P interaction.

Herbage moisture. — Nitrogen fertilizer increased herbage moisture significantly only during the first growing season at the hard-dough seed stage:

Nitrogen, lb/acre	N-0	N-33	N-66	N-99
Herbage moisture, %:	57	59	61	60

Phosphorus fertilization and N-P interaction did not affect herbage moisture significantly during any year of the study. Young intermediate wheatgrass growth harvested May 24-25 averaged 71% moisture compared with 59% for mature herbage harvested July 30 through August 1.

Weather conditions at harvest time influenced herbage moisture strongly. For the 3 years of the study when harvest weather was damp with overcast sky, high humidity, and intermittent rain, herbage moisture averaged 55%. For the 2 years when harvest weather was clear and dry with some wind, herbage moisture averaged 36%.

Table 4. Percent phosphorus in oven-dry intermediate wheatgrass herbage at two growth stages as affected by four levels of nitrogen fertilization.[1]

Growth stage	N fertilization (lb/acre) N-0	N-33	N-66	N-99	Mean
Veget. (6" ht.)	0.305	0.330	0.341	0.361	0.334
Hard dough	0.253	0.217	0.198	0.191	0.214

[1]Values underscored by the same line are not significantly different at the 5% level.

Hyder and Sneva (1961) found that crested wheatgrass fertilized with nitrogen contained more moisture during active growth but lost moisture and cured more quickly than the non-fertilized control. Herbage at the time of anthesis contained 50% moisture for both the fertilized and non-fertilized crested wheatgrass.

Summary

The influence of one fall application of nitrogen and phosphorus fertilizer on the soil and on growth, yields, and chemical composition of a mature dryland intermediate wheatgrass stand in the southwestern ponderosa pine zone was investigated.

Nitrogen fertilization increased herbage production over four growing seasons following application. Increases were substantial the 1st year, but declined each year, until by the 5th year differences were no longer significant. Intermediate wheatgrass did not take advantage of more than 66 lb/acre of nitrogen. Phosphorus alone or in combination with nitrogen did not increase production during any year of the study.

Nitrogen fertilizer exerted the following effects during the first growing season after application: (1) increased soil nitrates at the 0- to 12-inch depth; (2) increased amount of green growth during late summer and early fall; (3) increased plant height beginning the 2nd week in June and continuing through the remainder of the growing season; (4) increased basal leaf length during the last 3 weeks in June; (5) increased crude protein content of both young and mature herbage; (6) increased phosphorus percentage of young herbage, but decreased it for mature herbage; (7) increased moisture content of mature herbage; and (8) increased weed growth. Phosphorus fertilization increased basal leaf length the 3rd week in June and plant height the 1st and 2nd weeks in July. No significant effects were detected for N-P interaction.

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Food Preferences of Antelope and Domestic Sheep in Wyoming's Red Desert[1]

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Highlight

A food habits study, in a big sagebrush-grass type in Wyoming's Red Desert, revealed very little overlap in use of native range forage by pronghorn antelope and domestic sheep. Generally, sheep preferred grasses whereas antelope utilized shrubs.

The Red Desert region is the most important winter sheep range in Wyoming. It is also a major pronghorn antelope range. Although these two animal species have apparently been compatible in this area for several decades, new livestock management practices have tended to focus additional attention on this multiple-use region. Future management plans include using this area as a year-long, sheep and cattle range. This study, designed to yield data on competition for forage between pronghorn antelope and sheep, will assist land managers in making more precise evaluations of management practices such as sagebrush spraying and game-or-stock-only programs.

The information used in this discussion was obtained in a cooperative study initiated by the Bureau of Land Management, the Wyoming Game and Fish Department, and the Plant Science Division of the University of Wyoming. The primary objectives of the study were to determine the degree of overlap in use of native vegetation and to determine grazing capacities of pronghorn antelope and domestic range sheep.

The degree of forage competition between these two herbivores varies greatly and appears to depend on the geographic area, season, and the vegetative types being used.

Einarsen (1948) did not put too much emphasis on forage competition between antelope and sheep. He stated that antelope preference is for a wide variety of foods including most range weeds and browse plants, while sheep are more restricted in their diet. Hoover et al. (1959), however, stated that ". . . . because their annual diet consists of a high proportion of browse and forbs, antelope are in direct competition with sheep, whose diet comprises the same type of forage." Buechner (1950) maintained that competition is severe on overgrazed sheep ranges because the forbs and weedy species preferred by antelope were eliminated, but that it may be almost absent on properly grazed ranges. During World War II, Wyoming went as far as to hold special hunting seasons to reduce the antelope herds in an attempt to ". . . . reduce competition between domestic stock and antelope . . . to cope with the feed shortage for domestic stock" (Allred, 1943).

Study Area and Procedures

The study area was located in the Red Desert region in the south central part of Wyoming north of Wamsutter. The greater portion of the observations were taken from a pasture system designed and constructed by the Bureau of Land Management which consisted of six pastures; 2 of 120 acres, stocked with antelope; 2 of 120 acres, stocked with sheep; and 2 of 240 acres, stocked with both antelope and sheep. The pastures were located in a uniform big sagebrush community. The major species in the study area were: big sagebrush, *Artemisia tridentata;* Douglas rabbitbrush, *Chrysothamnus viscidiflorus* var. *pumilis;* western wheatgrass, *Agropyron smithii;* needleandthread, *Stipa comata;* Indian ricegrass, *Oryzopsis hymenoides;* bottlebrush squirreltail, *Sitanion*

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hystrix; winterfat, *Eurotia lanata;* Sandberg bluegrass, *Poa secunda* and obtuse sedge, *Carex obtusata.*

The methods and procedures used were all based on standard range analysis methods. Percent compressed crown cover and precent utilization by weight of the plant species were estimated from plots 1 x 10 ft in size. Ninety of the plots were analyzed during each sample period. Production was determined for all species except sagebrush by clipping 96 caged plots, 2 x 4 ft in size. Sagebrush production was obtained by clipping 15 plots, 4 in wide x 50 ft long, in an exclosure adjacent to the pastures. Sagebrush utilization was estimated by examining 150 plants in each pasture. All sample numbers were obtained by statistical analysis and all weights given are oven dried weights.

Under the direction of the Wyoming Game and Fish Commission, two antelope and two sheep were collected for rumen samples each month. Other data obtained from the collected animals included body, viscera and organ weights, jaws for age determinations and information on internal parasites.

Forage Production

Forage production varied significantly between 1964 and 1965 (Table 1). The most significant increase was noted in the annual production of big sagebrush, from 147 lb/acre to 266.7 lb/acre. All species except Douglas rabbitbrush and winterfat demonstrated some increase. The difference in annual production between 1964 and 1965 can be explained by variations in climate. Annual precipitation increased every year since 1962 when 4.5 in were recorded. Five inches fell in 1963, 5.5 inches in 1964 and in 1965, 6.5 in were recorded. The long-term average for the Wamsutter station is 5.47 in. Particular attention should also be given to the forb production for this area. The forb category as shown in Table 1 includes one species each of *Arabis, Penstemon, Astragalus, Allium, Cryptantha* and *Gayophytum.* Of these only *Arabis* was utilized. The minor contribution by forbs to the vegetation is fairly characteristic of the entire desert, except in disturbed areas where russianthistle *(Salsola kali)* and halogeton *(Halogeton glomeratus)* are found. This is the reason that the information obtained in Wyoming doesn't even remotely resemble that collected in Texas by Buechner (1950) or Russell's (1964) studies in New Mexico. In both of these areas forbs were predominant in the antelope diet and in Texas, the floral composition.

Table 1. Average annual forage production on the study area for 1964 and 1965, determined by clipping of 2 x 4 ft plots. (Lb/acre, oven dried).

Species	1964	1965
Big sagebrush	147.0	266.7
Douglas rabbitbrush	89.4	88.7
Western wheatgrass	51.6	57.2
Needleandthread	19.3	21.1
Indian ricegrass	14.5	19.2
Bottlebrush squirrel tail	13.0	14.9
Winterfat	10.0	6.7
Sandberg bluegrass	3.6	7.7
Obtuse sedge	3.1	8.1
Forbs	T	2.6
Total	351.5	492.9

Utilization

Utilization figures are given in pounds consumed per acre over a particular season and related to animal days of use. Table 2 compares data gathered in the summer of 1964 with that collected over the same period in 1965. The excellent replication demonstrated by western wheatgrass is, at best, unusual. It does, however, demonstrate the trend that will become obvious after examining the entire table—and that is the preference for grasses by sheep as compared to antelope. The trend in shrub utilization is indicated by Douglas rabbitbrush which was preferred more by antelope than by sheep. Indian ricegrass and needleandthread were taken infrequently by antelope, but were the two most important species in the sheep diet. Needleandthread appeared to be more preferable than Indian ricegrass. There was some difference in sheep use of these two species from 1964 to 1965, notably a decrease in the use of needleandthread and increased use of Indian ricegrass. The possible reasons for these differences will be discussed later. Sandberg bluegrass followed the same trend—that is, use to a greater extent by sheep. However, both animal species used this plant heavily in the spring because it was the first species to exhibit green growth, but sheep utilized it later into the summer. Winterfat, in the summer, was used infrequently by sheep and not at all by antelope.

Big sagebrush, another important species in the antelope diet,

Table 2. Summer forage consumption by antelope and sheep detected by agronomic methods.

	Summer, 1964		Summer, 1965	
	Antelope	Sheep	Antelope	Sheep
Western wheatgrass	.1	1.8	.1	1.8
Douglas rabbitbrush	9.5	.2	10.1	.3
Indian ricegrass	.1	1.0	.1	2.7
Needleandthread	T	6.6	—	3.7
Sandberg bluegrass	T	.3	T	.9
Winterfat	—	T	—	.1
Big sagebrush	1.2	2.4	1.5	—
Bottlebrush squirreltail	.1	1.3	—	.4
Obtuse sedge	T	T	T	—
Lb used/acre	11.1	13.6	11.8	9.9
Animal days use/pasture	833	750	1041	864
Lb used/animal/day	1.6	2.1	1.4	1.4

was utilized to a rather small extent in the summer, but was still the second most important species. Sagebrush use by sheep was quite variable. This difference, as well as all other major variations between 1964 and 1965 may be explained through dissimilarities in the growing seasons. Big sagebrush also presented a problem when it came to determining use. The growth form of this plant was very low, scrubby, and had tight, knotty leader groups. Quantitative measurement, tagging twigs and weighing browsed and unbrowsed leader groups were tried but the time involved and the sample numbers required made these methods infeasible, so ocular estimates were used. However, big sagebrush utilization was well replicated between years. Also, the number of sagebrush plants examined in each pasture was increased for the second year, which would increase the precision for the determination of use in the pastures. Another reason for variations in utilization could be the length of growing seasons. Green growth was available from the end of April to mid-July in 1964 and from the end of April to mid-August in 1965, or about one month longer. Sagebrush use was detected on the pastures in the November transects in 1965 so it appears that it was not used by sheep until the grasses had cured. Bottlebrush squirreltail was also more important to sheep than to antelope and again there was a substantial difference from 1964 to 1965 in the sheep diet. Obtuse sedge was fairly common in all pastures but utilization of this species was minimal by both animals.

Sheep data in Table 3 are absent from the fall and winter column and also from the summary of all-seasons column because of the severity of the 1964-65 winter. Enough sheep were lost from these pastures to render the data invalid and weather conditions made restocking completely infeasible. As for antelope, western wheatgrass use was absent in winter and contributed very little to the yearly total. Douglas rabbitbrush use decreased from summer to winter but was still very important. Most of the utilization shown in the fall-winter column was from September to mid-November, after which it was pretty well covered by snow. In the yearly total this was the most important species. Indian ricegrass and needleandthread use was not found in winter and both were unimportant as to their contribution to the animal's diet. Sandberg bluegrass followed this same grass trend in the antelope foods and was only important early in the spring. Winterfat use demonstrated a notable increase in late summer and fall, but like rabbitbrush, its use was limited to fall, as it was covered by snow by November. Big sagebrush was the most important species in the antelope diet in the winter and often the only species available. The snow depths ran from 6 inches to 4 ft in drifts during the winter of 1964-65, and sagebrush was the only visible species on some areas. Most of the use indicated in the winter column of this table was after mid-November. Squirreltail grass was relatively little used. No use was found on needleleaf sedge during the winter and this plant also contributed little to the final total. In 1965, the fall data were separated from the winter data and although not presented in the utilization chart, the 1965 data were used to interpret when the listed species were utilized. The data from the combination pastures were not included here but utilization on these pastures does show intermediate results when compared to the single use pastures.

Table 3. Winter and year-long forage consumption by antelope[1] in 1964, detected by agronomic methods.

Species	F & W[2]	YL[3]
Western wheatgrass	—	.2
Douglas rabbitbrush	10.4	20.1
Indian ricegrass	—	.1
Needleandthread	—	T
Sandberg bluegrass	—	T
Winterfat	.8	.9
Big sagebrush	11.6	13.2
Bottlebrush squirreltail	—	.1
Obtuse sedge	—	.1
Lb used/acre	22.8	34.7
Animal days use	1544	2377
Lb used/animal/day	1.7	1.8

[1] No information available for sheep because of missing data from the winter of 1964-65.
[2] F & W Fall and winter.
[3] YL Summary, 1964.

Table 4. Forage consumed on feeding trials and in pastures (oven-dried lb/day/animal).

Animal and item	Feeding Trials	Pastures
Antelope		
No. observ.	18	10
Range, lb/day	0.5-2.6	1.3-1.8
Average lb/day	1.5	1.7
Sheep		
No. observ.	12	10
Range, lb/day	1.7-4.4	1.0-2.5
Average lb/day	2.9	1.6

Closely controlled feeding trials were also conducted with penned animals (Table 4). Several animals were given various combinations of different forage types in excess of what they would need and the following day that remaining forage was weighed, subtracted from that given, and converted to pounds consumed/animal/day. Again, all weights were based on oven dried samples. Eighteen days of data were collected in this manner for antelope and compared to data collected from the pastures. Each of the 10 observations from the pastures was an average derived from one season's use on one pasture. For example, antelope averaged 1.7 lb/day during the fall and winter in one pasture. This explains the smaller range noted in the pasture data. When the two means were compared, using a simple t-test, no significant difference was noted. There was, however, a significant difference in daily consumption by sheep. Sheep consumption in feeding trials averaged almost twice as much as was found by the range analysis methods. This can be partially explained by observing the feeding habits of sheep. They appeared to use as much forage as possible when it was offered to them in such a manner that they didn't have to work to obtain it. The time spent in seeking preferred plants on pastures was used in eating when feeding from a trough. Palatability may also have been an influence. Some alfalfa was used in the feeding trials along with native forage—however, the largest daily consumption found (4.4 lb/day) was on native hay. Because the sheep in the pastures were feeding primarily on grasses, some utilization may have been obscured by regrowth, which could help account for the lower figure reached through range analysis methods.

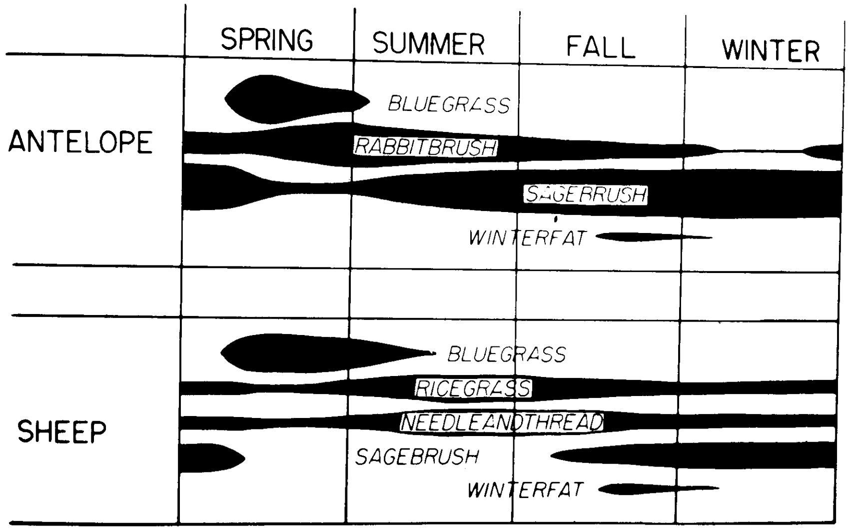

FIG. 1. Summary of seasonal preferences by sheep and antelope.

Observations and measurements taken throughout the grazing season provided information that enabled utilization of plant species to be broken down even further (Fig. 1). Sandberg bluegrass, as mentioned before, was taken readily in early spring by both antelope and sheep because it was the first species to initiate spring growth and for a period of 10-14 days it was the only green plant in the pastures. As soon as Douglas rabbitbrush started to grow, antelope began to use it, and it remained the species most used by antelope from late spring to mid-summer. As late summer-early fall approached, rabbitbrush, although still available, either decreased in palatability or sagebrush increased. There was a notable trend in increased sagebrush use that reached a peak in winter. One of the reasons for this was availability governed by snow depth. The slight use of rabbitbrush in winter represents limited availability rather than a decrease in palatability. Winterfat was not used by either antelope or sheep until late fall and its use again, as with rabbitbrush, was terminated by decreased availability. Grass use by antelope, with the exception of bluegrass, was very minor for the entire year.

Sheep went to Indian ricegrass and needleandthread as soon as these species started to grow and they were utilized quite heavily until availability was limited by snow depth. Use was less on these species in the early spring when they were seeking the green bluegrass. Some sagebrush use was noted when the grasses dried up and this use increased through the winter as the availability of grasses decreased due to increasing snow depth. Douglas rabbitbrush, western wheatgrass and bottlebrush squirreltail utilization by sheep was minimal over the entire year.

Feeding Habits

The results on feeding habits from this study paralleled those noted by other investigators (Cory, 1927; Einarsen, 1948; Buechner, 1950; Gregg, 1955). Antelope move about much more than sheep while feeding, covering about 1.5 times the linear distance in an equal period of time. Antelope were much less gregarious than sheep. From early spring to late August they remained well distributed over the pastures as singles or in groups of two to three. As individuals they had no apparent pattern to their daily movements. Antelope acted independently even when in groups. The pronghorn was also a very delicate feeder, they took less of each plant grazed than a sheep. This is so common, especially on sagebrush, that it became very difficult to determine utilization. Sheep on the other hand, tend to be much more gregarious. Generally speaking, when one was feeding all were feeding. Sheep also fed, primarily, early and late in the day, especially in the summer. Antelope, apparently less affected by heat, fed on and off all day.

Conclusions

It can be concluded from the preceding information that there is little competition between pronghorn antelope and domestic sheep for range forage on the northern desert sagebrush-grass type in Wyoming. The two major species in the antelope diet were big sagebrush and Douglas rabbitbrush as compared to needle-andthread and Indian ricegrass in the sheep diet. There was some overlap in use of Sandberg bluegrass and winterfat. However, these two species contributed so little to the annual production of the area that they could be designated as sacrifice species if need be. Past records give no evidence that winterfat is ever abundant in this vegetative type. Furthermore, Sandberg bluegrass and big sagebrush have wide ecological tolerances, both are common increasers in this area and would not be eliminated from the composition unless extreme intensity of use occurred.

The only notable overlap was with big sagebrush, but again, this probably isn't critical because the basic definition of competition states that the resource for which two organisms are competing must be in limited supply. It is difficult to visualize big sagebrush as being in short or limited supply in Wyoming's Red Desert. This species is the dominant plant on from 50 to 60% of the area and the subdominant on another 10% (Vass and Lang, 1938). Under severe winter conditions, with deep snows, it would be conceivable that big sagebrush could become limiting, especially on key antelope winter ranges. These areas are, however, limited in extent and winters this severe occur infrequently.

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The General Environment of The South[1]

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Highlight

The best laid plans often fail if human (socio-cultural) factors are not taken into account. Certain socio-cultural factors, particularly those which are significant in the emerging mass society, are indicated in the following sketch of the general environment of the South. Changes are occurring in the region that are certain to have direct bearing upon the social and economic situation in which the stockman will carry on his activities. Furthermore, a new kind of agricultural operation is emerging and with it a new type of agricultural man—the farm businessman.

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A potential that is exciting enough to quicken the pulse of any far-sighted individual is present in the southern United States. Some of the potential takes the form of large tracts of land no longer utilized for intensive agriculture and now available for other use. The potential takes the form of expanding mass markets. The potential also takes the form of manpower resources—people who each year migrate to other regions, reluctantly, because of limited employment opportunities within the South.

Generally, it is still a potential—not yet a reality. And, as with all potentials, foresight, planning, and effort are required before goals are realized.

What is the South like? That question can best be answered by replying that there are many Souths. There is the South of history — the Confederate South that included Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, Arkansas, North Carolina, Tennessee, Texas, and Virginia. There is the South of tradition, a pleasant land of moonlight and magnolias, endless fields of cotton, gentle sweet womanhood, courageous men and loyal slaves. There is the South of tobacco road; the South of the television and Hollywood stereotype.

There is the South as seen by outsiders—a dangerously violent region of moral ruin, of wayward women and degenerate men, of smoldering racial hatreds, and inescapable poverty. There is the South as seen by Southerners—a misunderstood region, the whipping boy of the nation. Politicians see it in one light, historians in another, sociologists in yet another.

To see either of these pictures alone is wholly misleading. The region is too complex for any naively simple interpretation. In the South there are sharp contrasts of wealth and poverty, tolerance and intolerance, progressivism and reaction, of cultural achievement and ignorance.

Ideally, the sociologist aims at an objective picture of the South as a social system. He attempts to tone down the distortions that both insider and outsider alike may read into the picture. He recognizes that emotions—often highly charged—are a very real part of the situation and, while he tries to take them into account, struggles not to become so involved with them that his facts become twisted.

Social Change and the Emerging Mass Society

Perhaps the best way to gain a correct perspective of the South as a region is to conceive of it in terms of social change. It is at this point that the discipline of sociology can be of assistance to a group of technical specialists who must carry on their work in such a context. Sociologists, for a number of years, have conducted systematic research in the area of the human factors involved in social change so that now there is a considerable fund of research knowledge to draw upon.

Looked at in this way, the South is seen as a region confronted by the mass society, (Bertrand 1965). The mass society—which has for its characteristic features urbanism, mass production, mass marketing, mass psychology, and mass communication — exerts strong and continued pressure upon Southerners to change certain ways of behaving.

Changes are indeed occurring — some dramatically abrupt, others quiet and continuous. Let us look at some of them.

One of the most noticeable processes contributing to the situation is the rapid urbanization of the South. While all of us know that the cities are growing, it is instructive to determine the extent to which the city has become a feature of the Southern way of life. Within 100 years the population of the Deep South has shifted from 90% rural to less than 50% rural. In 1960 only 2 states had more rural inhabitants than urban ones—Mississippi and South Carolina. And within these two the trend toward urbanism was unmistakable (Patrick 1964).

Table 1. Money Income of Families by States.[1]

State	Distrib. of families under $3000 (%)	Median income ($) 1949	Median income ($) 1959	Increase 1949-59 (%)
U. S.	21.4	3,083	5,660	83.5
Ala.	39.1	1,820	3,937	116.3
Ga.	35.6	1,902	4,208	121.2
Miss.	51.6	1,228	2,884	134.9
Texas	28.7	2,716	4,884	79.8
La.	35.6	2,140	4,272	99.6

[1] Adapted from U.S. Bureau of the Census, *Statistical Abstract of the United States: 1963.* Eighty-fourth edition. (Washington: GPO, 1963), p. 340.

Florida became urban in the 30's, Louisiana in the 40's, and Alabama and Georgia in the 50's. Most of the Southern city dwellers, however, are less than one generation from the farm environment. These people, more often than not, retain rural values beneath a very thin urban veneer.

Not only is the place of residence being changed, but the racial composition of the population continues to be altered. Many rural people are moving from the farms and a significant number of nonwhite rural people are migrating to cities outside the region. Today Illinois has more Negroes than Mississippi, New York more than Georgia, and California more than South Carolina. The population of the South was about 50% Negro in 1860. Today, Negroes constitute about 29% of the population (Patrick, 1964). They are not a majority in any Southern state though Negroes are unevenly distributed and do predominate in some counties.

A rise in income and levels of living has been dramatic in the region. This is all the more remarkable when contrasted with the desperate poverty of the 1930's. At that time though the South had 29% of the national area and 27% of the population, it had less than 5% of the great corporations, less than 19% of the wholesale firms, and paid less than $5 out of each $100 paid in income taxes. This prevailed despite the fact that the South produced 45% of the oil, 40% of the coal, 46% of the lumber, and nearly 37% of the 64 leading crops (Webb, 1964).

The South has been steadily narrowing the economic and occupational differentials between itself and the rest of the nation, especially during the last two decades. The increase in per capita income has been above the national average. Nevertheless, the South still included in 1960 disproportionately large numbers of persons in the lower income categories (Table 1).

At the end of the 19th century the South was a tragic figure with many afflictions. One by one the handicaps have been removed. Once it was said that the South could not industrialize because it lacked fuel. Then came oil with the South having about 50% of the nation's supply.

Once it was said that the South was handicapped by its hot humid climate. Air conditioning is now virtually universal.

It used to be said that the South could not grow beef cattle because of its lack of grass and its abundance of ticks and flies. Now bulldozers clear the land for grass and improved insecticides have been introduced to kill the flies and ticks.

The South's soil was once said to be depleted. Then scientific agriculture rebuilt the soil and chemical fertilizers repaired the destruction.

Another process of major importance in the changing situation is that of the legislation, programs, and policies which originate from various levels of centralized government and are applied to the South. These controls, ranging over such areas as regulating race relations, controlling livestock and crop production, retraining unskilled manpower and promoting community development, bring local people face to face with others from outside the region who can and do impose new norms. The situation is structured by the fact that these new ways carry the sanction of authority.

Many of the social characteristics associated with the South are those which are typical of rural social structures in other parts of the world. Sociologists, in analyzing rural social systems and urban social systems, sometimes treat these characteristics as opposites on a kind of continuum. In a rural society there are usually tendencies toward social homogeneity, primary or face-to-face associations, narrower ranges of social tolerance, primary means of social control, restricted social mobility, and a conservative outlook on life. As the South becomes more urbanized these characteristics will be overshadowed by their opposites on the rural-urban continuum.

Characteristics of Urban Living

City living, as a way of life, involves a wide acquaintance with things and people, and a tolerance born of this acquaintance. The urban person aims at mastering the art of external conformity and superficial politeness. He learns how to lead different lives in different contexts. In general he treats the multitude of people he meets in daily contact as animated machines rather than as human beings.

The city is too large to be a primary group, thus it is a secondary one. People associate constantly and at close quarters with strangers who are different in background and interests. As a result the limits of tolerance are usually wider than those found in rural areas.

Primary social controls such as those imposed by the family, the neighbors, etc. can be evaded in the city. The city then must resort to secondary forms of social control such as police, courts, and legal restrictions.

The groups one finds in the city are usually voluntary associations. Here are all kinds of cliques, clubs, and interest groups. The individual counts for little. The group must organize or the cause will perish.

As the South becomes urbanized these characteristics of the city and of mass society generally will gradually become a way of life for the region. The hinterlands of the city will not escape the influence because of the increased interaction of the hinterlands with the cities. This process will be augmented by means of an expanding highway system, increased specialization of occupations with a corresponding interdependency of country to city, and increased exposure to urban ways via mass communications media. The mass society will not fail to leave its imprint upon the region.

Resistance to Change

Like most rural social structures, the South has tended to have a conservative or traditional orientation. It seems to be a characteristic of human society that once a way of behaving manages to become established, it is difficult to uproot. Quite often the practice persists long after the factors that brought it into being have vanished. People seem to feel comfortable with old ways and old things; they are supports—certainties in a world of uncertainity.

It is in respect to the conservative outlook of the South that the human problems of technological change are brought into focus. At first glance it would appear that all people would be willing to support the objectives of soil conservation in the United States. But it is well known that the application of these objectives to concrete situations has not always been a simple task.

In certain parts of the South technological change has been met with fierce resistance because of conflict with traditional patterns of behavior. This is illustrated by the experience of some pulp mills in buying and leasing land for pine production. As a part of their program of developing pine, the hardwood which had previously provided food for wild game was systematically removed.

Though these pine plantations were the essence of conservation of trees and soil, it was not a form of conservation acceptable to local residents. Resistance was expressed in incendiarism and threats. On a post in a country lane this bit of poetry was found:

You may cut out the hardwoods,
  And string up new lines
But we'll tear down your fences
  And burn up your pines.
(Corty, 1962).

Elsewhere, similar problems were encountered when new ways came into conflict with traditional practices. Spring burnings to "freshen up" the grass had become annual events in some areas. A social structure built around this custom was resistant to change and conflict was inevitable when it was threatened.

Long-range reaction to government programs of Southern cattle owners is illustrated by the following research. In 1941 George Weltner studied attitudes in Vernon Parish, Louisiana, toward the U. S. Forest Service and its program of fencing the range—an act by which the Forest Service gained control of range utilization. At that time 70% of the residents were unfavorable toward the regulations, 22% were favorable and 8% were neutral. A total of 67% of those interviewed felt that the fire regulations made for worse conditions for grazing cattle. (Jones, 1962). There is evidence that a number of fires were deliberately set as a result of the controls imposed by the Forest Service.

In 1963 Arthur Jones studied the same area and found that the proportion of cattle owners who approved of regulations had increased to 65%. This change is explained by the fact that in the interaction between the two systems (cattle owners and government agency) the Forest Service was able, through legal sanctions, to achieve a significant measure of social control over the local residents. (Jones, 1962).

During this era of change in the South a large number of rural people have not benefited either socially or economically. These are the ones displaced by technology in agriculture and related fields who have not migrated out of the region or have failed to make a successful adjustment within the region. Changes, however, are taking place to alleviate the low income problem. Large numbers of rural people *are* migrating and industry is moving into some of the problem areas.

The South continues to lag behind the rest of the nation in the educational attainment of its people and in expenditures upon education. The gap still persists between the region and the nation though improvement has been made in both of these categories.

In 1950 the average annual expenditure per pupil in the South was $165 whereas the national average was $224 (U.S. Census, 1955). In 1960 the national average had increased to $375/pupil whereas the Southern average had increased to $279 (U.S. Census, 1963).

Religion had a large part in daily life in the Old South. God counted in Dixie. He counted in various ways—according to one's persuasion. People believed in a personal God, sought his favor, prayed with fervor and conviction. Preachers carried the Word with zeal and energy. Religion had stronger flavor in the South than elsewhere. It still does.

As for politics, it seems apparent that the South is moving into a more realistic mood. Southerners who, more than other Americans, are having to endure the effect of wrenching changes in race relations, are coming to realize that this is not the only issue that matters.

These, then, are some of the more salient features of the changing situation where rangemen and other agriculturalists will work. In the midst of a technological revolution, where modernization in agriculture brings about the same economic and social changes that occur in industry, efficiency is more and more crucial. Small, inefficient agricultural enterprises, characterized by limited capital and unskilled labor, are passing from the scene. Large-scale operations are emerging and, with them, a new type of agricultural man—the farm businessman.

The general environment of the South is thus a unique social complex of old ways standing against technological innovation where conservatism, reactionism, fatalistic realism, and optimism are the prevailing attitudes according to area and personal inclination. It is a region which will assume, perhaps a bit unwillingly, increased importance in the emerging mass society of which it is a part.

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The South Needs Range Men[1]

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Highlight

Forest range is an important source of forage for the big and growing business of livestock production in the South. People trained in management of southern ranges are needed for effective utilization of the South's grazing resource but the supply is too limited. The South needs a range curriculum.

Livestock production is a big and growing industry in the South. In 1964 southern states produced about one-third of the total national production of beef cattle. With a growing season of 5 to 12 months and plenty of rain, the South can produce the necessary forage and will play a major part in meeting future demands for beef. Forest range is an important source of this forage.

But for effective utilization of the South's grazing resources, there's a definite need for people trained in the management of southern ranges. Unfortunately, the supply is too limited. For example, we have 115 rangers on the 33 National Forests in the 13 southern states and only one has a degree in range management. Of the total of some 4,700 Forest Service employees in the Region, fewer than 10 have a background of formalized training in range management. And all but two of these are western born, western trained and western oriented.

Although formal range education began in the East at Yale University and Iowa State College, the hard core science of range management was largely developed in and for the West. By 1917 the University of Idaho and Montana State University were offering formal training in range management with a course of study designed to assist with the problems of the West. Today all 17 institutions offering curriculums in range management are west of the Mississippi River.

What is more, most people trained in range management prefer to work out West. Although the South in the past has recruited western-trained people and attempted to get on top of the range job, few have stayed long enough to recognize the difference between the range job needed in the South and that practiced in the West. At the first opportunity they are gone, leaving behind foresters who by training and choice are not prepared for, or interested in, the range job.

The two Forest Service employees in the Southern Region who are native southerners and have training in range management are excelling in performance and accomplishment. However, they are lacking in several areas of formalized training desirable and eventually necessary for working with ranges in the South. On the 115 Ranger Districts, 61 rangers are involved in analyzing the grazing resource and designing plans and programs for managing this resource. All of them recognize their lack of training in the range management disciplines. All are begging for trained help.

Although we have an intensive on-the-job training program to try to help compensate for their lack of formal range training and experience, we are a long way from scientific range management. Apparently, we also are still further away from getting the type of trained people we need to do the southern range job.

There are several areas peculiar to the South that require certain disciplines or emphasis not stressed in western-oriented range schools. I realize that in adjusting curricula to Regional needs, graduates of the baccalaureate program may not be professional range men in the strictest sense of the word. They can be, but it may take five years instead of four. Let's look at some of the areas where Regional emphasis in training is needed to do the southern range job.

Most of the grazing in the South that is not on improved pasture is under a commercial forest canopy. Here both the overstory and understory are kept in a vigorous subclimax condition by short cutting cycles, prescribed burning and extensive ground preparation for regeneration. These are normal silvicultural practices for the southern forest types. Not only does volume of forage follow these changes in overstory but dynamic changes occur in understory composition over relatively short periods of time. It is within this rapidly changing environment that our range program is conducted.

Analysis and interpretation of understory condition and trend is a delicately complex job. Commonly used systems for measuring these changes and for interpreting them with reference to grazing programs are not satisfactory for use in the South since they do not take into consideration the suppressive effects of tree crown density and related factors. The short range vegetational changes in the forest cover create problems in developing and coordinating practical range programs in the South that are uncommon in the West. Because of the influence of the timber overstory and its management on the range resource and the delicate timber-range coordination job, the southern range man should have a background in forestry, oriented toward silvics and silviculture.

The South has never been fully botanized and much is still unknown about species composition and relative forage values of many native ranges and range

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plants in the South. Southern-trained foresters know their trees and most of them know the principal browse and some field and pasture plants. However, agrostology is completely foreign to most. True, western schools include some southern species in botany and agrostology courses. But the emphasis is regional. Range management requires a complete knowledge of native forage species and their relative value and importance. The expansion and improvement of the range livestock industry provides a need and a reason for southern regional emphasis on agrostology, including both native and introduced species. Until there is a southern-oriented range curriculum developed, knowledge of range forage plants by southern range men will generally be less than satisfactory.

One big factor in an argument for a southern-oriented range curriculum is the social and economic structure of the South. There are sharp contrasts in this structure and regional differences of the southern individual and the southern society. Range-trained people working in the South must have a knowledge of and feeling for these differences. The southern range man must be able to interpret the social, political, and economic environment in which his company or agency operates. Computer and research techniques will help but in the final decision, the southern range man must draw from his imagination, training, and experience in the areas of human behavior where scientific predictions are highly fallible.

There are a number of other regional differences that require regionally-oriented techniques. Such things as animal breeds and breeding, woodland ecology, plant and animal pathology, plant and animal nutrition, and many others have their best training effectiveness when taught in the area where they are to function. Regional training is mandatory in programs where knowledge of the physical and social environment is necessary to success. To be most effective in the South, the southern range man must be generally southern-raised, southern-trained, and oriented in southern physical, socio-political, and economic disciplines.

In 1952 a standard range curriculum was developed by a committee in the American Society of Range Management for guidance of schools interested in establishing a range curriculum. These standards were divided into three groups: (1) basic courses in English, mathematics, chemistry, economics, etc., (2) technical courses for all professional range managers, and (3) elective courses for broader preparation for range managers in certain fields or certain agencies. To these should be added the importance of recognizing regional differences to fully meet the needs of various agencies and various fields of range management. The entire standard curriculum—basic, technical and elective—should be geared, when possible, to the conditions and needs of the region in question.

I contacted 10 major colleges and universities in the South sometime ago, exploring their attitude toward establishing a range curriculum in their schools. In making these inquiries, I listed generally the standard or core requirements as outlined by ASRM, called special attention to those needing regional emphasis, and added several subject areas particularly needed for regional application in range management. Four of the 10 contacted were enthusiastic and could orient subjects in all three categories—basic, technical and elective — toward a southern range curriculum without major adjustments in their program. Three stressed adding range at the elective and graduate level only and three were skeptical though encouraging. Of course, all were interested if there was a market for their students once they were trained in range management. Clemson University said it could justify a range curriculum if it could be assured that 10 graduates each year would be absorbed into the profession. Louisiana State suggested that 50 a year would be necessary for it to justify a curriculum.

A brief analysis of the market for southern-oriented range students was quite enlightening. In my own agency, the U. S. Forest Service, we have 73 positions where range training either is mandatory now or will be necessary eventually. The salary for these jobs ranges from a low of $5,100 a year to as high as $14,600. The average tenure is three years with about 26 positions to be filled each year where a range management background is desirable or mandatory.

The U.S. Soil Conservation Service needs range-trained people in the South and 11 large timber companies have requested aid in planning and carrying out range programs on their lands. All could use range-trained people and all expressed the desirability of these range-trained people being southern oriented.

The fact that there are now over 100 members in the Southern Section of ASRM is a good indication of growing interest in the field in the South. Director John Gray, University of Florida, had this to say in his reply to my letter to colleges and universities: "If a committee of the American Society of Range Management could be set up to survey potential employers in the southern states and come up with some convincing figures as to the number of men who would be hired by them, starting in 1970, I believe this, more than any other single action, would help break the ice and get some of us going in the training of men in this field."

A committee of the American Society of Range Management is needed to analyze the need for a range curriculum and to make its analysis available to the major schools of forestry in the South. If such a curriculum is established it should follow the recommendations of the Range Education Council as to specific disciplines needed for maintaining high professional standards.

The South, in my opinion, certainly needs a southern range school.

Season of Burning Affects Herbage Quality and Yield on Pine-Bluestem Range

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Highlight

Burning different portions of a range in winter, spring, and summer provided adequate protein in herbage for a much longer period than winter burning alone. Phosphorus was deficient the year round, regardless of burning schedule.

Herbage on unburned pine-bluestem range is generally deficient in protein after early summer and in phosphorus all year (Campbell and Cassady, 1951). The widespread practice of burning in late winter increases protein and phosphorus in new growth, but the benefit endures only until May, when the young-leaf stage ends (Campbell et al., 1954). Heavy grazing in spring prolongs the young-leaf stage, but herbage on winter burns contains appreciably less protein and phosphorus from summer to early fall than in spring, regardless of harvesting intensity (Cassady, 1953; Duvall and Whitaker, 1964).

The nutrient content on range burned in late spring or summer has not previously been studied in the longleaf pine-bluestem type. On Kansas bluestem pasture, protein content in June was higher following a late-spring burn than earlier burns (Aldous, 1934). This result indicated that burning different segments of a range at intervals from winter until midsummer might furnish forage high in nutrient content throughout the growing season. This paper compares herbage quality and quantity following winter fire with that following spring and summer fires.

Procedure

A well-drained, sandy upland site on the Palustris Experimental Forest in central Louisiana was chosen for the experiment. The site is typical of much of the longleaf pine-bluestem range. The area had been logged and was burned in 1961. It was not grazed. Ground cover consisted mainly of grasses, predominately pinehill bluestem (*Andropogon divergens* (Hack.) Anderss. ex Hitchc.) and slender bluestem (*A. tener* (Nees) Kunth). The soil is Ruston fine sandy loam. Rainfall in the area averages 58 inches/year and more than 4 inches/month in every month except October.

In 1962, plots 100 ft square were burned on March 1 (winter), May 1 (spring), or July 15 (summer). The winter burn was considered the control, because most burning is done in the South at this time. Burning treatments were replicated four times in a randomized block design. The burns were repeated on the same plots in 1963, except that the summer plots failed to burn uniformly and hence were not measured.

Nine 1.55-ft-square quadrats were systematically located on each plot after burning. To simulate grazing, the quadrats were clipped monthly during the growing season. In 1962, two clippings were omitted because growth was negligible. Herbage was clipped 2 inches above the ground except on the last harvest of each year, when it was clipped to 1 inch. In February 1963, a sample of vegetation that had remained undisturbed since burning was taken adjacent to every quadrat. Samples were oven-dried at 75C, weighed, ground in a Wiley mill, and analyzed for crude protein and phosphorus.

Results

Protein Content.—On June 1, protein content of herbage was significantly higher (0.05 level) on spring-burned than on winter-burned plots (Fig. 1). In both years, protein content was 8.4% on spring-burned plots, whereas the winter-burned averaged 6.4% in 1962 and 7.1% in 1963. On July 1, and on all subsequent sampling dates, values for winter and spring treatments were not statistically different.

On August 15, herbage on summer-burned range contained 9.7% protein, or about twice the average of earlier treatments. Thereafter, the protein content on the summer burn diminished sharply; in November, it was not significantly higher than on winter or spring burns.

Because summer fire was evaluated during only 1 year, its effects on protein content were difficult to assess. Drought during the month after burning may have influenced results. Indications are, however, that summer-burned range will supply adequate protein in late summer when grass on earlier burns averages considerably less than 8%—the minimum required by dry cows (Duncan and Epps, 1958).

In addition to improving protein content during the 30 days after treatment, summer fire increased this nutrient in undisturbed mature vegetation. Herbage collected in February 1963 from plots burned during the previous July averaged 3.8% protein—significantly more than the 2.4 and 2.6% values for winter and spring treatments.

Phosphorus Content.—Phosphorus content was improved by late burning in 1962 but not in 1963 (Fig. 1). June 1962 samples from spring-burned plots averaged 0.13% phosphorus, compared with 0.10% on winter-burned plots. Thereafter, values for the two treatments were similar. A month after summer fire, herbage averaged 0.16% phosphorus—significantly more than the 0.11% on winter and spring burns. By November, phosphorus on summer burns dropped to 0.13%, and treatment differences were not significant. In February 1963, undisturbed herbage on plots burned the previous summer averaged 0.13% phosphorus; both the winter and spring burns averaged 0.12%.

Phosphorus content was unaffected by date of burning in 1963.

At no time during the study did the phosphorus content reach 0.18%, the minimum required by cows nursing calves (Duncan and Epps, 1958).

Herbage Yield.—Even though 650 lb/acre of new herbage was destroyed by the May fire (Table 1), post-treatment yields on spring-burned plots were not significantly less than on winter-burned plots in either year. Total production—combined pre- and post-treatment yields—was significantly greater on spring-burned than on winter-burned range in 1963.

Herbage produced after summer fire averaged 382 lb/acre, substantially less than post-treatment yields on winter- or spring-burned range. Relatively low yield after summer fire was expected; Cassady (1953) reported that, on plots harvested periodically, about 80% of the herbage was produced by mid-July. With pre-burn yield included, total herbage on the summer burn was significantly higher than that on the two earlier burns.

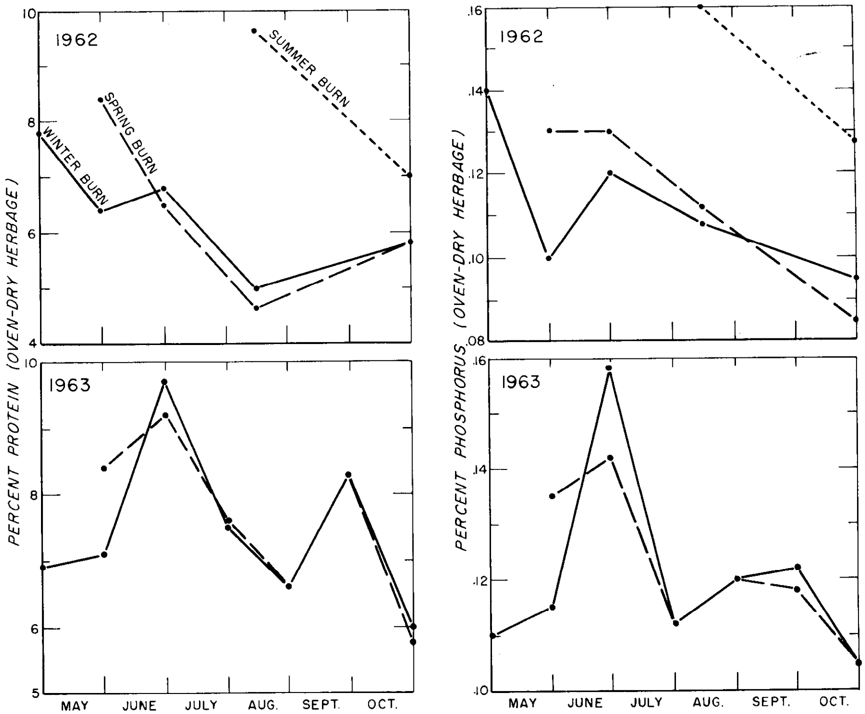

FIG. 1. Nutrient content of herbage after burns.

Conclusions

Burning different parts of a range unit at intervals from late winter until midsummer appears to provide herbage of relatively high quality during most of the growing season. A combination of winter and spring fires looks particularly promising. Burning in spring materially improved protein content in June without loss of yield. Further study is needed to fully evaluate effects of summer fire, but 1-year findings indicate that range burned in mid-July will yield substantial quantities of high-protein herbage.

Burning in midsummer and deferring use until after growth ceases could improve winter forage. Mature herbage on summer-burned range, though deficient in protein, contains substantially more than herbage on winter or spring burns. Cattle would require supplemental phosphorus all year, and protein supplements during winter, regardless of burning treatment. Cattle grazing summer-burned range would require appreciably less supplemental protein, however, than those on range burned earlier.

Table 1. Herbage yields on plots burned in winter, spring, and summer (in lb/acre, oven-dry).

Yield	Winter burn		Spring burn		Summer burn
	1962	1963	1962	1963	1962
Pre-burn	——	——	412	887	1365
Post-burn	1226	1526	1000	1070	382
Total	1226	1526	1412	1957	1747

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Nitrogen Availability on Fall-Burned Oak-Mountainmahogany Chaparral[1]

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Highlight

Nitrogen availability, as shown by short-term uptake by barley, was significantly higher on soils from burned than from unburned areas 10 months after burning. Increased soil-nitrogen concentrations were observed at all depths on the burned as compared with the unburned treatment.

Management practices of chaparral vegetation in the Southwestern U. S. A. have included burning as a means to alter density and, to some extent, composition of chaparral stands. Chemical and physical properties of soils also may be altered by burning. The extent of such changes is generally related to the fire intensity.

Nitrogen in litter is generally unavailable for plant use and may remain so until the litter is decomposed by soil microorganisms. Burning hastens litter decomposition, but forms nitrogenous compounds which may be lost by volatilization, and total nitrogen in the biosphere may be expected to decrease as a result of burning. On the other hand, total nitrogen in the mineral soil may be increased as a combined result of burning litter and standing vegetation and leaching of nitrogen-containing compounds. The relative availability of soil nutrients, especially nitrogen, may be enhanced as a result of burning (Kucera and Ehrenreich, 1962; Sampson, 1944).

Fire effect on nitrogen, phosphorus, and sulfur availability has been evaluated on soils under burned and unburned California chamise *(Adenostoma fasciculatum* and *Ceanothus cuneatus)* by Vlamis and Gowans (1961). The soil, sampled shortly after burning, gave a higher bioassay to all three elements on the burned than on an adjacent unburned area. Miller and FitzPatrick (1959) have shown that this increased availability of nutrients may be temporary however.

Nitrogen performs an important role in forage production. Its availability may mean the difference between success or failure in a revegetation program. The present study determined nitrogen availability one season after burning of defoliated Arizona chaparral.

Experimental Methods and Materials

The study site was on the Sierra Ancha Experimental Forest near Globe, Arizona at 5300-foot elevation. The chaparral type was shrub liveoak *(Quercus turbinella)* and true mountainmahogany *(Cercocarpus montanus)*. Alternate 50-foot strips across a small watershed were treated with a defoliant in August 1961, and 6 weeks later subjected to controlled burning (Pase and Glendening, 1965).

Soil and litter or ash samples were obtained 10 months after the burn, immediately before the summer rainy season. Composited samples were collected from each of three unburned and three burned treatments. Surface litter or ash, 0- to 1.5-inch and 1.5- to 4-inch mineral soil depths were sampled separately. In addition, samples were taken from the 0- to 1.5-inch depth on bare areas on both burned and unburned treatments where little or no vegetation had grown. The latter represented about 5% of the total area and, statistically, was treated as a fourth depth.

The soil samples were air dried and passed through a 2-mm sieve. Saturated soil paste pH was determined by use of a glass electrode. Total soil and plant nitrogen was determined by the Kjeldahl procedure using a selenium catalyst, but not modified to include nitrate nitrogen.

Nitrogen availability was determined using the Stanford-DeMent-Hunt (1959) technique with Arivat barley (92% germination) as the indicator crop. One hundred seeds were planted in 12-oz cartons containing 400 g of coarse, acid-washed sand. Deionized water was added as necessary and growth continued for 3 weeks, at which time the plants were well rooted. The previously prepared false barley-pot bottoms were removed and the pots stacked on similar containers having 50 g of soil to be tested in triplicate. The barley, then in contact with the test soil, was watered with a minus-nitrogen nutrient solution. Soil water was maintained between ⅓ and 5 bars. The plants were grown in contact with the test soil for 20 days. Above-ground portions were harvested and analyzed for total nitrogen.

The experimental design of N-availability included four depths on three burned and three unburned plots. The analysis of variance for a three-factor experiment with 3 replications was used to analyze the nitrogen yield data.

Results

Total nitrogen. — Total nitrogen concentration in ash and mineral soil increased as a result of burning chaparral (Table 1). Litter on unburned strips contained an average of 0.48% nitro-

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gen compared to 0.59% nitrogen in the litter and ash remaining after the burn. Pase and Glendening (1965) reported 6.8 tons of litter on this same site with a 28.6% reduction by burning. Direct calculation of total nitrogen in litter yielded 65 lb/acre nitrogen before burning and 57 lb/acre in ash after burning, resulting in an apparent net loss of 8 lb/acre nitrogen in the surface organic matter.

Two factors complicate the interpretation of these data. First, ash on the soil after burning represented the oxidation products of some of the previously defoliated stems and twigs which burned as a result of the fire. This addition of ash probably added some nitrogen to the soil surface. The amount of nitrogen in the standing vegetation was not determined. Secondly, oxidation products containing nitrogen were leached into the lower depths of soil during the 10-month period following the fire. This amount was greater on the burned treatments than on the unburned (Table 1). Greater nitrogen concentrations on bare spots were found on the burned treatment than on the unburned. This small watershed had a 15-25% slope and oxidation products or ash components may have been transported by water, wind, or gravity through and across the soil. In revegetation management, this would be important in improving the nitrogen status of the small bare spots.

Nitrogen availability. — Nitrogen was significantly more available on the burned than on the unburned soils (Table 2). Nonsignificant differences are presented by the analysis of variance for soil depth because of nitrogen contribution to the lower profiles by the burning but not by the nonburning treatment.

The above interaction between treatment and soil depth is more easily explained by the appropriate Duncan's multiple range test (Table 1). Nitrogen was consistently more available in the burned than the unburned mineral soil but the differences were not always significant. The unburned litter contained a significantly lower amount of available nitrogen than the burned ash or the 0- to 1.5-inch soil layer under the ash.

Table 1. Mean total nitrogen concentration, pH values and nitrogen uptake by barley of burned and unburned chaparral soils.

Item and Treatment	Litter or ash	Depth in inches 0 to 1.5	1.5 to 4	bare soil[1]
% Total N[2]				
Burned	0.59	0.21	0.11	0.14
Unburned	0.48	0.20	0.08	0.09
pH[3]				
Burned	7.1	7.2	7.0	6.8
Unburned	6.4	6.6	6.7	6.3
mg N uptake[4]				
Burned	27.93 a	26.29 ab	25.07 abc	25.14 abc
Unburned	22.18 c	23.83 bc	23.57 bc	24.08 bc

[1] Represents 0- to 1.5-inch soil from nonvegetated areas within treatment areas.
[2] $s_{\bar{x}} = \pm 0.014\%$ N.
[3] $s_{\bar{x}} = \pm 0.12$ pH units.
[4] Means followed by the same letters are not statistically different (F = .05).

Table 2. Analysis of variance for nitrogen availability of burned and unburned chaparral soils.

Source		d. f.	M. S.
Burned vs. unburned	(A)	1	106.82**
Soil depths	(B)	3	4.38
Blocks	(C)	2	4.54
Interaction			
AB		3	26.26**
AC		2	4.45
BC		6	7.30
ABC		6	4.52
Error		48	4.04

** Significant at the 1% level.

pH.—Ten months after burning, soil pH was 0.5 unit higher than on the unburned soils (Table 1). The bases contributing to the pH increase were leached into the mineral soil as well as transported across to soil previously bare of vegetation. Accumulation of oxidation products, change in pH, and in the physical structure of the soil after burning could be important in establishment of vegetation. Reduced moisture competition is also an important factor. Glendening and Pase (1964) and Pase (1965) have shown that burning does in fact influence revegetation.

Conclusion

Nitrogen availability measured by short-term nitrogen uptake by barley was significantly greater on soils from burned than from unburned areas 10 months after burning. These differences, however, were not statistically different for the three depths of mineral soil. The burned ash contained significantly more available nitrogen than the litter and also had a higher concentration of total nitrogen. The apparent net nitrogen loss by burning of 8 lb/acre, was confounded by the contribution of nitrogen contained in the ash from shrub-stems and by leaching of some soluble nitrogen into the mineral soil. The pH of burned soils averaged 0.5 unit higher than that of unburned soils.

Nitrogen may be frequently limiting on brush-supporting soils (Hellmers et al., 1955). Burning may increase the nitrogen available for plant growth in the nitrate form (Sampson, 1944), or in generally available nitrogen as demonstrated in the present study. Revegetation could be encouraged by increasing the amount of available nitrogen through burning. Burning could also improve the accessibility where the chaparral type is grazed by livestock or game animals. Burning decreases the total nitrogen by volatilizing certain fractions and this probably increases as the fire intensity increases. This nitrogen loss could be minimized by fires of low intensity and infrequent intervals, or offset by supplemental fertilization.

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A Chemical-Fallow Technique for Control of Downy Brome and Establishment of Perennial Grasses on Rangeland[1]

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Highlight

Downy brome was controlled with three soil-active herbicides: atrazine, EPTC, and IPC. Seedings were made 1 year after herbicide application. If fallow were effective during this year, soil moisture was conserved. Seeding in deep furrows resulted in superior seedling stands and greater 2nd and 3rd year production than did surface drilling. Performance of Amur intermediate wheatgrass was superior to Standard crested and Topar pubescent wheatgrasses.

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Downy brome or cheatgrass (*Bromus tectorum* L.) is established on many acres of rangeland in the big sagebrush (*Artemisia tridentata* Nutt.) type. When brush is killed and dominance of perennial grasses is low, downy brome will fully occupy a site and form a closed community (Robertson and Pearse, 1945). Undesirable characteristics of this species include variable yield, short green-feed period, and a fire hazard when dry. Conversion of downy brome to perennial grass without weed control usually has been unsuccessful (Hull and Stewart, 1948). Competition by downy brome for soil moisture and perhaps for soil nitrates and light in seedling stands of perennial grasses contributes to these failures. Effects of weed control and method of seeding on stand density, survival, and production of seeded species in downy brome stands need to be evaluated.

This paper describes a chemical-fallow technique for control of downy brome and associated weeds with perennial grasses seeded 1 year after herbicide application. Chemical fallow was used by Alley and Chamberlain (1962), and Bovey and Fenster (1964), in wheat production studies. Robocker et al. (1965), used chemical fallow in range seeding studies without success.

Chemical fallow is effective if: (1) after fall application, the herbicide remains active in the soil to control weed species in late winter or early spring, and (2) at the time seeded species germinate (usually 1.5 years after treatment) the herbicide has either broken down or leached or both, and toxicity to perennial seedlings is minimized. A desirable herbicide should control a broad spectrum of weeds and dissipate rapidly after weed control is accomplished.

Procedures

Investigations were initiated at one location in 1959 and at three locations in 1962. Characteristics of the four study sites are given in Table 1.

Two soil-active herbicides were

Table 1. Characteristics of the four study sites.

	Hallelujah Junction						Paradise Hill			Italian Canyon			Emigrant Pass		
	59-60	60-61	61-62	62-63	63-64	64-65	62-63	63-64	64-65	62-63	63-64	64-65	62-63	63-64	64-65
Precip. (in.)															
Annual	5.0	7.2	9.4	17.1	6.1	11.8	12.4	9.8	11.7	12.4	10.5	11.6	13.4	15.7	15.9
Oct.-May	5.0	3.9	7.6	15.5	5.5	6.6	8.8	8.3	9.8	8.2	6.6	7.9	8.4	12.9	13.1
Mar.-May	1.1	0.9	2.3	4.5	3.0	1.4	4.7	3.1	2.0	5.6	3.2	5.0	5.2	4.5	6.9
Description															
Location	N. Eastern Calif.						N. Central Nev.			Central Nev.			N. Eastern Nev.		
Soil classification[1]	Typic Argiustoll						Duric Mollic			Mollic Haplargid			Entic Haplic Durustoll		
Soil depth (in.)	60						60			60			24		
Cause of downy brome dominance	Brushbeat and disc in 1959						Wildfire in 1940			Reseeding failure in 1960			Wildfire in 1956		
Broadleaf species	None						Tumble mustard			Russian thistle			Tumble mustard and annual borage		

[1] U. S. Department of Agriculture, 1960.

applied in December, 1959 at Hallelujah Junction. A 5% granular formulation of ethyl N,N-dipropylthiolcarbamate (EPTC) at rates of 1, 2, and 4 lb/acre was mixed with sand, hand sprinkled, and incorporated into the surface soil by raking. A 75% wettable powder of isopropyl N-phenylcarbamate (IPC) was applied at rates of 5 and 10 lb/acre in water at 32 gpa and 30 psi. Herbicides were applied preemergence to downy brome. Treatments were seeded in the fall of 1960, one year after herbicide application. Herbicide plot size was 20 by 20 ft. Experimental design was a four-replicated split-split-plot with herbicides the whole plot and methods of seeding and species the subplots.

Gypsum soil-moisture units were installed in the herbicide and check treatments. These units were placed at depths of 3, 12, 21, and 48 inches corresponding to the A_1, B_1, B_2, and C horizons. Weekly readings were made during the spring and summer of 1960 and 1961. Less frequent readings were taken at other times.

In the fall of 1962, 80% wettable powder of 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (atrazine) was applied at 1 lb/acre in water at 26.4 gpa and 30 psi on the Emigrant Pass, Italian Canyon, and Paradise Hill study sites. Atrazine was applied preemergence or early postemergence to downy brome. Treatment plots were 24 x 100 ft. Each species and method-of-seeding treatment was replicated four times. Weed control and check treatments were analyzed as separate experiments. then combined and analyzed as a series of experiments (Cochran and Cox, 1957). Soil moisture in the check and atrazine treatments was determined by gypsum soil-moisture units buried at 3, 12, and 24 inches and at one location, 36 inches.

In the studies at Hallelujah Junction, Standard crested *(Agropyron desertorum* (Fisch.) Schult.), Amur intermediate *(A. intermedium* (Host) Beauv.) and Topar pubescent *(A. trichophorum* (Link) Richt.) wheatgrasses were evaluated. At the other locations Standard crested and Amur intermediate wheatgrasses were evaluated.

In all studies, two methods of seeding were used: drill into the surface soil and drill in the bottom of deep furrows. For brevity, these two methods will be termed surface and furrow, respectively. Furrows were made immediately before seeding. After settling over winter, they were approximately 5 inches deep, 5 inches wide at the bottom, and 10 inches wide at the top. Seeding depth was 0.5 to 0.75 inch for crested wheatgrass and 0.75 to 1 inch for intermediate and pubescent wheatgrasses. Seeding rate for all studies was two live, pure seeds per inch of row.

During the study an individual seeded plot varied from three to four rows wide and from 10 to 25 ft long. In 1960, row spacing was 12 inches. In 1963, spacing was increased to 18 inches to facilitate use of tractor-drawn furrowing and seeding equipment.

Downy brome control was evaluated by plant density, yield, or both, during the fallow year and during the seedling year of perennial species. Performance of seeded species was evaluated by plant density, height, and 1st-year survival during the seedling year; and by frequency of occurrence per linear foot of row, and yield in the 2nd and subsequent years. In the results, statistical significance is reported as $P < .05$.

Results

Hallelujah Junction

Fallow year - 1960.—The check and 1 and 2 lb/acre of EPTC gave similar responses. Results from EPTC at 4 lb/acre and from IPC at 5 and 10 lb/acre were also similar. Therefore, data from the check and from IPC at 10 lb/acre are compared in Table 2, as representative of each group.

A significant decrease in downy brome density due to treatment (Table 2) reduced soil moisture extraction during the fallow year. Soil moisture tension at the 12-inch depth on the check was below 1 bar until the last of May. By October, tensions increased to about 6 bars. During the same period, moisture tension on plots treated with IPC remained below 3 bars. At the 21-inch depth, moisture tension on the check was below 1 bar until the middle of July, then increased to a maximum of 5.5 bars by October. On treated plots tensions did not exceed 1 bar at

Table 2. Density of downy brome and seeded species during fallow and seedling years, and yield of perennial grasses for 4 years after establishment at Hallelujah Junction. Herbicide applied in the fall of 1959 and perennial grasses seeded in the fall of 1960.

Treatment	Density				Production — lb/acre			
	Plants/sq ft Downy brome 1960	1961	Plants/ft of row — 1961		1962	1963	1964	1965
			Intermediate wheatgrass					
Check	13.7	6.3	1.3	Surface Drill	634	424	106	454
			2.0	Furrow Drill	840	1128	189	778
			Pubescent wheatgrass					
			0.3	Surface Drill	274	354	148	324
			1.7	Furrow Drill	455	509	261	546
			Crested wheatgrass					
			0.2	Surface Drill	236	351	85	157
			0.8	Furrow Drill	443	657	109	201
			Intermediate wheatgrass					
IPC-10 lb/A	0.05	0.5	0.8	Surface Drill	1234	1097	161	673
			2.5	Furrow Drill	1283	1130	139	768
			Pubescent wheatgrass					
			0.4	Surface Drill	182	378	141	524
			1.4	Furrow Drill	1201	448	152	720
			Crested wheatgrass					
			0.2	Surface Drill	176	302	90	163
			0.4	Furrow Drill	740	674	73	180

the 21-inch depth. The soil profile was not wet to 48 inches during 1960 or 1961.

Seedling year of perennial grasses - 1961.—A significant reduction in downy brome competition in 1961 (Table 2) increased soil moisture available to perennial seedlings. Soil moisture at the 3-inch depth fluctuated with wet and dry periods. At the 12-inch depth, moisture tension on the check was 4 bars in April and increased rapidly to 13 bars by the first of May and to 15 bars by the end of May. On the treated plots, tension was below 1 bar until the middle of June, 11 bars by the end of June, and above 15 bars by the middle of July. Soil moisture at the 21-inch depth followed a similar trend, however, the time of peak extraction was about 2 weeks later than at the 12-inch depth. In addition, maximum tension was 12 bars on check plots and 6 bars on treated plots.

Reduced downy brome competition and more favorable soil moisture conditions on treated plots did not result in a significant increase in seedling density of perennial grasses in 1961 (Table 2). Three factors may have contributed to the lack of response: (1) downy brome density of 6.3 plants per ft^2 on the check was not extremely competitive; (2) residual herbicide may have killed some seedlings on the treated plots; and (3) approximately 2 inches of precipitation fell during the first few days of June when perennial seedlings on the check were under severe moisture stress. Following this precipitation, soil moisture tension at the 3-inch depth remained below 1 bar for at least 1 week and below 15 bars for about 2 weeks. A slight change in tension at the 12-inch depth indicated that moisture percolated almost to 12 inches.

In contrast to herbicide treatment, species and methods of seeding did result in significant variation in density and height of seedlings. For all treatments, average seedling density per foot of row was: intermediate wheatgrass—1.7; pubescent wheatgrass—1.1; and crested wheatgrass—0.3. Seeding in furrows resulted in about twice as many, and also in more vigorous seedlings than did surface seeding (1.3 plants 15.3 inches high and 0.7 plants 10.9 inches high, respectively).

Production in second and subsequent years after seeding.—Although use of herbicides did not result in more seedlings, field observations indicated that seedlings in treated plots were more vigorous than in the check. Second-year production in 1962 supported this observation (Table 2). Treated plots produced significantly more herbage than did the check. Average production of intermediate and crested wheatgrasses on treated plots was 1,258 and 458 lb/acre, respectively. On the check, respective yields were 737 and 340 lb/acre. Pubscent wheatgrass was intermediate in response. Intermediate wheatgrass produced more than did the other two species in all years except 1964.

The effect of furrows on productivity was evident in 1962 and 1963 (Table 2). In 1962, a comparison of species seeded in furrows and on the surface showed: intermediate wheatgrass 1,062 and 934 lb/acre; pubescent wheatgrass 828 and 228 lb/acre; and crested wheatgrass 592 and 225 lb/acre, respectively. All species-seeding method comparisons, except for intermediate wheatgrass, were significantly different. In 1963, all combinations of species and methods of seeding except intermediate and pubescent wheatgrasses in the IPC treatment produced significantly more in furrows than by surface seeding. A gradual soil sloughing and filling of furrows may explain the lack of response after 1963.

Production in 1963, 1964, and 1965 showed no relation to original herbicide treatment (Table 2). In the very wet year of 1962-63, production on the check increased to the production level of the treated plots. In 1964, production of all species was low. Low total precipitation in 1963-64, together with heavy precipitation in March, April, and May of 1964, reduced growth of perennial species by increasing growth and competitive ability of downy brome. Production increased again in 1965 because total precipitation was adequate for growth of perennial species, and light spring precipitation resulted in a poor stand of downy brome.

The work at Hallelujah Junction in 1960 and 1961 was conducted during years of below normal precipitation and weak downy brome competition. With little competition, a thorough evaluation of herbicide effect on weed control, seedling establishment, and subsequent production was not possible. However, we were able to: (1) measure a fallow effect from soil-active herbicides; (2) evaluate the effectiveness of furrows on seedling establishment and subsequent production, and (3) increase our knowledge of species performance. Results from these studies formed a background from which to evaluate similar treatments and species under different climatic and edaphic conditions.

FIG. 1. An effective chemical fallow at Paradise Hill in 1963, created by atrazine at 1 lb/acre applied in the fall of 1962.

Paradise Hill, Italian Canyon, and Emigrant Pass

Fallow year - 1963.—At Paradise Hill, an effective chemical fallow was obtained in 1963 from atrazine applied at 1 lb/acre in the fall of 1962. Downy brome and tumble mustard (*Sisymbrium altissimum* L.) production on the check were 1646 and 106 lb/acre, respectively. On the fallow plots, these two species were virtually eliminated for 1 year (Fig. 1), and soil moisture was conserved. On the check, soil moisture tensions at the 12 and 24-inch depth were above 15 bars by June 1. On the fallow plots, soil moisture tensions at the same depths did not exceed 0.7 bar through October.

No fallow was obtained at Italian Canyon. Downy brome was reduced from 1,421 lb/acre on the check to 202 lb/acre with atrazine, however, Russian thistle (*Salsola kali* var. *tenuifolia* Tausch.) was not controlled. Production by this summer annual on the check was 86 lb/acre as compared to 690 lb/acre on the atrazine treatment. On the check treatment with a dense cover of downy brome, soil moisture tensions at the 12 and 24-inch depths were above 15 bars by July 1. On the atrazine treatment, with a dense cover of Russian thistle, soil moisture tensions reached 15 bars by August 1.

A fallow was obtained at Emigrant Pass. Downy brome and mustard production on the check plots was 1,421 and 192 lb/acre, respectively. On the fallow, production of downy brome was reduced to 307 lb/acre with no mustard. By October, soil moisture tensions at 12, 24, and 36 inches on the check reached a maximum of between 4 and 10 bars. On the fallow, maximum tensions were between 0.6 and 1 bar.

Seedling year of perennial grasses - 1964.—A second-year effect from chemical fallow in terms of soil moisture conservation was evident only at Paradise Hill. On the check, soil moisture tensions at 12 and 24 inches reached 15 bars between May 1 and June 1. Moisture tensions on the treated plots did not exceed 1.7 bars by July 1. Mustard, which was absent on the check produced 1,536 lb/acre on the

Table 3. Weed yield and density of seeded species during seedling year, 1964. Percent frequency (frequency in seeded rows) and yield of seeded species in 1965. Atrazine was applied in the fall of 1962 and plots seeded in the fall of 1963.

Location / Weed control and seeding treatment	Weed Yield 1964 lb/acre Downy-brome	Weed Yield 1964 lb/acre Broad-leaf	Intermediate wheatgrass 1964 Seedlings No./ft of row	Intermediate wheatgrass 1965 Percent frequency	Intermediate wheatgrass 1965 Yield lb/acre	Crested wheatgrass 1964 Seedlings No./ft of row	Crested wheatgrass 1965 Percent frequency	Crested wheatgrass 1965 Yield lb/acre
Paradise Hill								
Atrazine								
Surface drill—mustard control	307	325	1.5	95	692	0.3	20	92
Surface drill—no mustard control	336	1536	0.7	35	106	0.1	25	50
Furrow drill	24		2.0	90	1341	2.5	88	744
Check								
Surface drill	614		0.2	0	0	0.0	0	0
Furrow drill	998		3.2	80	369	1.0	62	95
Italian Canyon								
Atrazine								
Surface drill	490		0.0	0	0	0.0	0	0
Furrow drill—Russian thistle control	121	0	4.0	95	1084	2.0	70	422
Furrow drill—no Russian thistle control	47	718	2.1	45	28	0.3	45	272
Check								
Surface drill	384		0.1	0	0	0.1	0	0
Furrow drill	624		4.1	85	234	1.4	63	54
Emigrant Pass								
Atrazine								
Surface drill—no borage control	979	624	0.1	5	14	0.2	0	0
Furrow drill—no borage control	2093	432	0.2	25	65	0.4	13	24
Check								
Surface drill	2592	60	0.2	8	2	0.1	5	1
Furrow drill	1430	240	0.5	18	2	0.3	0	1

atrazine fallow. Use of furrows in the atrazine treatment further reduced downy brome from 336 to 24 lb/acre and eliminated mustard. Mustard appeared to be a potentially strong competitor on the atrazine surface-drill treatment. It was controlled with propylene glycol butyl ether esters of 2,4-D at 1 lb/acre applied in water at 10 gpa and 30 psi on May 20, 1963. With broadleaf control, an average of 0.8 more seedlings per foot of row of intermediate wheatgrass and 0.2 seedlings of crested wheatgrass survived the summer. Seedling density of perennial grasses was similar on the atrazine and check treatments (Table 3). Low seedling density on the atrazine treatment was attributed to some residual herbicide toxicity. In the atrazine treatment, seedling density of the two seeded species was similar, however, in the check seeding density of intermediate wheatgrass was significantly greater than crested wheatgrass. Seedling density of both species was also significantly greater in furrows than in surface seeding. In the check, intermediate wheatgrass benefited more from furrows than did crested wheatgrass. Survival on the atrazine and check were 64 and 36%, respectively. Survival in furrows was 64% compared to 14% by surface seeding. Survival of intermediate and crested wheatgrasses was 42 and 36%, respectively. Control of mustard in the atrazine surface-drill treatment increased survival of intermediate wheatgrass from 29 to 75%; of crested wheatgrass from 17 to 33%.

At Italian Canyon, downy brome averaged 490 lb/acre on the check during the seedling year. In the atrazine treatment, furrows significantly reduced downy brome competition from 490 to 47 lb/acre. However, Russian thistle, which was absent in the surface-drill plots, produced 718 lb/acre in furrows. Russian thistle, a potentially strong competitor in the atrazine-furrow treatment, was controlled with 2,4-D at 1 lb/acre applied on June 1, 1963. With broadleaf control, an average of 1.9 more seedlings of intermediate wheatgrass and 1.7 more seedlings of crested wheatgrass survived the summer. Seedling density was similar on the check and atrazine treatments. In the atrazine treatment, seedling density of seeded species was similar, but on the check, density of intermediate wheatgrass was significantly greater than for crested wheatgrass. In both treatments, seedling density was significantly higher in furrows than when surface drilled. In the check, furrows were more beneficial to intermediate wheatgrass than to crested wheatgrass. First-year survival was 75 and 69%, respectively, on the atrazine and check treatments. Furrows resulted in 58% survival, while 32% of the plants survived in the surface-drill treatment. Survival of both intermediate and crested wheatgrasses was 34%. Control of Russian thistle in the atrazine-furrow treatment increased survival of intermediate wheatgrass from 44 to 79%, and of crested wheatgrass from 50 to 100%.

At Emigrant Pass, average downy brome production during the seedling year on the atrazine treatment was 979 lb/acre as compared to 2,592 lb/acre on the check. Here, as at the other two locations, a decrease in downy brome was accompanied by an increase in competition from annual broadleaf species. An annual borage produced more on the atrazine treatment than on the check and resulted in extreme competition from 1603 lb/acre of annual weeds. In contrast to the other two locations, use of furrows in the atrazine treatment resulted in a doubling of the cheatgrass competition from 979 to 2,093 lb/acre. Severe competition from downy brome and broadleaf weeds on the atrazine and check treatments resulted in poor seedling stands of both species. Average survival for the atrazine and check treatments was 22 and 11%, respectively. Survival in furrows was 29% compared to 9% when surface seeded. Survival of intermediate and crested wheatgrasses was 12 and 25%, respectively. Because of this seeding failure, results from Emigrant Pass will not be discussed further.

Seedling heights taken in August generally were indicative of treatment effectivenesss. When downy brome was controlled, average plant height was 10.1 inches, compared to 4.9 inches on the check. Control of broadleaf species did not increase plant height. Seedling heights in furrows averaged 8.0 inches compared with 6.2 inches in the surface-drill treatment.

Second year after seeding.— High-density stands were found in the weed control and furrow treatments (Table 3). In comparable treatments, frequencies of intermediate wheatgrass were higher than for crested wheatgrass. Use of furrows in the check treatment was especially beneficial for establishment of perennial grasses under very competitive conditions.

Seedling density and 2nd-year frequency indicate only the relative abundance of perennial species among treatments and locations. Second-year yield, however, indicates the effectiveness of a treatment to alter the environment and to increase site productivity.

At Paradise Hill, in the atrazine treatment, intermediate wheatgrass produced 1,341 lb/acre in furrows compared with 106 lb/acre when surface seeded (Table 3). Production of crested wheatgrass increased from 50 lb/acre on the surface plots to 744 lb/acre in furrows. Greater production in furrows can be attributed to less competition from downy brome and mustard, to better moisture relations, and, in some instances, to a greater density of perennials than on the surface-drill plots. Production of intermediate wheatgrass on surface-drill plots was increased from 106 to 692 lb/acre with mustard control. Crested wheatgrass did not respond to mustard control. Neither species produced any herbage on the check surface-drill treatment. Comparative yield in the check-furrow treatment was intermediate wheatgrass 369 lb/acre and crested wheatgrass 95 lb/acre.

At Italian Canyon, as at Paradise Hill, the atrazine treatment also increased productivity. However, success was dependent upon the use of furrows and broadleaf weed control. With furrows and Russian thistle control, intermediate wheatgrass produced 1,084 lb/acre while crested wheatgrass produced 422 lb/acre. Corresponding yield without broadleaf control was 28 and 272 lb/acre, respectively. Neither species produced a stand on the atrazine surface-drill or check surface-drill treatments. In the check-furrow treatment, yields of intermediate and crested wheatgrasses were 234 and 54 lb/acre, respectively.

Discussion

Benefits from an effective chemical fallow are twofold: (1) weed seed production is reduced or eliminated, and (2) soil moisture and perhaps soil nitrates are conserved.

The disadvantages of atrazine for weed control and chemical fallow are related to: (1) spectrum of weed control; (2) competition during the seedling year from uncontrolled grass and broadleaf species; and (3) residual toxicity.

The most competitive weed species encountered in this study were downy brome, mustard, an annual borage, and Russian thistle. Atrazine gave excellent control of the first three during the fallow year. In application of a fallow technique, the control spectrum of the herbicide should coincide with the weed species present. Control of annual grass is of primary importance, since most broadleaf species can be controlled with 2,4-D.

Although a fallow condition is maintained, seeds of grass and broadleaf weed species may germinate during the seedling year and offer severe competition to perennials. A dense stand of downy brome in the atrazine treatment during the seedling year at Emigrant Pass resulted in a seeding failure. Residual seed in the soil and litter appears to be the source for downy brome reestablishment. The tumbling nature of mustard and Russian thistle suggest that the major reinvasion of these species was due to wind movement.

Atrazine at 1 lb/acre has not shown any selectivity between downy brome and seeded species. Therefore, under our conditions a 1-year waiting period between herbicide application and seeding is required. By this procedure degradation and leaching of atrazine in the soil was sufficient to prevent serious damage to perennial species during germination in the spring. A residual effect of atrazine is perhaps the most serious problem in use of this material since complete seeding failure may result. Before atrazine or any other soil-active herbicide can be recommended for a chemical fallow on rangeland, more information is needed on herbicide residues in the 8 to 12-inch precipitation zone.

Regardless of weed control or species seeded, drilling in furrows most always resulted in superior seedling stands and higher 2nd and 3rd year production when compared to drilling in the surface soil. Improved seedling stands in furrows can be attributed to better soil moisture relations and protected microenvironment (McGinnies, 1959).

Use of furrows in a chemical fallow may have additional values: (1) remove weed seeds from a band next to the seeded row and cover weed seeds adjacent to the furrows to a depth from which emergence is greatly reduced; and (2) remove soil with herbicide residue from the vicinity of the seeded row.

For the duration of the studies, Amur intermediate wheatgrass was superior to Standard crested wheatgrass. Superiority was in density of seedling stands and production in most treatments. Intermediate and pubescent wheatgrasses also have the ability to spread by rhizomes. Five-year-old plants of these two species at Hallelujah Junction have spread to occupy most of their individual plots. Two-year-old plants at Paradise Hill have started to spread vegetatively, particularly into the open spaces in the furrows. Where evaluated, Topar pubescent wheatgrass was inferior to intermediate wheatgrass, but superior to crested wheatgrass. The relative merits of crested, intermediate and pubescent wheatgrasses in a seeding program can be evaluated only over a period of environmental variation and under grazing management.

Conclusions

1. Atrazine applied at 1 lb/acre in the fall shows promise for chemical fallow and downy brome control followed by seeding perennial grasses 1 year after treatment.
2. Residual herbicide in the soil may be a potential problem in the use of soil-active materials for chemical fallow.
3. Control of broadleaf-weed species may be necessary to maintain a fallow.
4. Control of broadleaf-weed species in seedling stands was necessary for survival and for high productivity of perennial species.
5. With or without weed control, seeding in furrows resulted in superior seedling stands and higher production of perennial grasses than did drilling in the surface soil.
6. In most treatments, seedling stands and forage production of Amur intermediate wheatgrass were superior to Standard crested and Topar pubescent wheatgrasses.

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Correlation Between Annual Rings of Woody Plants and Range Herbage Production[1]

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Highlight

Good correlations have been reported between precipitation and herbage production, and between precipitation and radial increment of growth rings in trees and shrubs. Because herbage production and ring growth are both affected by precipitation, the direct correlation between herbage production and tree-ring width was evaluated to determine the usefulness of tree rings for estimating herbage production. Significant positive correlation coefficients were obtained for 10 of 31 woody plant-herbage plant combinations from 11 locations in the western United States. It was concluded that the use of annual rings for estimating herbage yields is feasible, and that the technique warrants further investigation.

Correlations between precipitation and herbage yield have been frequently studied. The levels of correlation have varied from poor to excellent. Sneva and Hyder (1962) demonstrated good correlations between yield and precipitation in Oregon and other locations.

Where a high correlation exists between herbage yield and precipitation, it is possible to estimate herbage yield by a regression equation from precipitation data for those years where records are available. By comparing yields estimated from the regression equation with actual yields, the effects of a treatment can be evaluated independent of yield differences caused by fluctuations in yearly precipitation. Thus, herbage yields can be adjusted to a "normal year".

A. E. Douglass (1909), pioneered the use of tree-ring widths as indicators of climatic cycles and fluctuations, and started a vast amount of research in the field of dendrochronology (McGinnies, 1963). Schulman (1956) compiled extensive data on tree rings as they reflect variation in rainfall and streamflow throughout the west. Roughton (1962) has reviewed in detail much of the literature on dendrochronology with particular emphasis on applicability to game range. Ferguson (1964), in his detailed study of big sagebrush[2] in the southern portion of its distribution, found ring width more closely correlated to winter precipitation than summer precipitation. Speaking of a number of conifers, Fritts (1965) concluded "that there is a close relationship between widths of annual rings from trees on semi-arid sites and variations in the aridity of the yearly climates."

Because good correlations between ring width and precipitation, and between herbage production and precipitation have been reported, the present study was undertaken to explore and evaluate the direct correlation between ring width and herbage yield. Such correlations, if high enough, offer many advantages over correlations with precipitation because of the long-time record offered by the tree rings and because precipitation records are frequently not available for the locations being studied.

Methods

Eleven locations were selected where (1) herbage yields were available for 6 or more years and (2) a woody species suitable for ring measurements was available in the immediate vicinity.

The woody plant samples were obtained from areas where they did not receive extra moisture from flooding, snowdrifts, or subsurface seepage. Whenever possible, the samples were chosen from the side or top of a hill adjacent to the area from which the herbage data were obtained. The individual shrubs and trees used for ring measurements were carefully selected to avoid individuals damaged by fire, porcupines, grazing or other disturbance.

The samples of woody species used for ring measurements were of two kinds: For big sagebrush and mesquite, cross-sections were cut from the lower stem. In the case of the tree species, cores were obtained with an increment borer, one core per tree. Both sample types were smoothed and polished on a belt sander with 400-grit belts. The annual rings were dated, and measured to the nearest 0.001 inch under a low-power microscope. Measurements were taken along two to four radii on each cross-section of sagebrush or mesquite. The number of woody plants sampled at each location is shown in Table 1.

Linear correlation coefficients (r) were computed for all of the ring width-herbage yield combinations. Significance of the correlation coefficients was then determined by a "t" test.

Results and Discussion

The coefficient for correlation values between the width of the annual rings and herbage production ranged from good to very poor (Table 1). Slightly less than half of the correlation co-

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[2] *Botanical names of species mentioned in text and tables are listed in Table 2.*

Table 1. Correlation coefficients for woody-plant annual-ring widths and forage species herbage yields.

Location	Woody Species	Number of woody plants sampled	Forage Species	Years of record	Coefficient of correlation
California					
Lassen Nat. For.	Ponderosa pine	6	Intermediate wheatgrass	12	.16
Colorado					
Fort Collins	Ponderosa pine	21	Crested wheatgrass	6	.63
	″ ″	21	Intermediate ″	9	.22
	″ ″	21	Smooth brome	9	.28
	″ ″	21	Ranger alfalfa	10	−.08
Central Plains Exp. Range	Ponderosa pine	16	Mixed shortgrass	24	.71**
Idaho					
Hartman 1939	Juniper	10	Crested wheatgrass	9	.34
planting	″	10	Big sagebrush [a]	9	.36
	Big sagebrush	12	Crested wheatgrass	9	.76*
Hartman 1946	Juniper	10	″ ″	9	.23
planting	″	10	Fairway ″	9	.21
	″	10	Russian wildrye	7	.40
	Big sagebrush	12	Crested wheatgrass	9	.65
	″ ″	12	Fairway ″	9	.70*
	″ ″	12	Russian wildrye	9	.50
Oneida County	Juniper	12	Fairway wheatgrass	18	.56*
Montana					
Miles City	Big sagebrush	12	Blue grama	6	−.01
	″ ″	12	Western wheatgrass	6	.71
New Mexico					
Jornada Exp. Range					
South Well	Mesquite	3	Mixed perennial native grasses	9	.17
West Well	″	2	″ ″ ″ ″	9	.37
Oregon					
Squaw Butte	Juniper	10	Mixed native grasses	10	.88**
	″	10	Big bluegrass	8	.71*
	″	10	Bluebunch wheatgrass	8	.61
	″	10	Crested wheatgrass	8	.57
	″	10	Big sagebrush [a]	12	.34
	Big sagebrush	6	Mixed native grasses	10	.32
	″ ″	6	Big bluegrass	8	.78*
	″ ″	6	Bluebunch wheatgrass	8	.71*
	″ ″	6	Crested wheatgrass	8	.78*
Utah					
Benmore	Juniper	9	Crested wheatgrass	15	.72**
	″	9	Big sagebrush[a]	15	.38
	Big sagebrush	10	Crested wheatgrass	15	.29
Ephraim Canyon	Juniper	10	Crested wheatgrass	8	.27
N. of Ephraim	″	8	Crested wreatgrass	13	−.23

[a] Sagebrush ring widths rather than herbage production.
* = 5% level of significance; ** = 1% level of significance.

efficients are .50 or above, but only 10 are significant according to a "*t*" test. For several locations the data were plotted; no evidence of non-linear relationships were found. The correlation coefficients appear to have been influenced by a number of factors.

The number of usable samples of the woody species was sometimes less than desired. Frequently, variation between individual woody plants was considerable; by using more samples, it was sometimes possible to reduce the effect of these variations. Where the annual rings indicated disturbance (for example, a sudden increase in ring width that results from removal of a neighboring tree), that individual plant was removed from the sample. For some trees it was not possible to be sure of the dating of the rings; these indviduals were also discarded. Elimination of these questionable individual woody plants reduced variability.

No doubt there are cases where either the woody plant or the forage plants were influenced by unknown or unrecognized factors. For example, it has been suspected that the intermediate

Table 2. Common and botanical names of species mentioned in text and tables.

Common name	Botanical name
Alfalfa	*Medicago sativa* L.
Bluegrass, big	*Poa ampla* Merr.
Brome, smooth	*Bromus inermis* Leyss.
Ephedra	*Ephedra spp.* L.
Grama, blue	*Bouteloua gracilis* (HBK.) Lag. ex Steud.
Juniper	*Juniperus sp.*
Mesquite	*Prosopis juliflora* (Swartz) DC.
Pine, ponderosa	*Pinus ponderosa* Dougl. ex Laws.
Sagebrush, big	*Artemisia tridentata* Nutt.
Saltbush, fourwinged	*Atriplex canescens* (Pursh) Nutt.
Wheatgrass, bluebunch	*Agropyron spicatum (Pursh)* Scribn. and Smith
Wheatgrass, crested	*Agropyron desertorum* (Fisch. ex Link) Schult.
Wheatgrass, fairway	*Agropyron cristatum* (L.) Gaertn.
Wheatgrass, intermediate	*Agropyron intermedium* (Host) Beauv.
Wheatgrass, western	*Agropyron smithii* Rydb.
Wildrye, Russian	*Elymus junceus* Fisch.

wheatgrass, smooth brome, and alfalfa at Fort Collins receive some additional water from a water table of variable depth. The junipers sampled at Hartman may have been near enough to a gully to have been influenced by occasional flooding.

A woody species sometimes showed a good correlation with a forage species at one location, while at another location, the correlation with the same forage species was poor. For example, in the 1939 planting at Hartman, the correlation between big sagebrush and crested wheatgrass was good and the correlation between juniper and crested wheatgrass was poor; the opposite was observed at Benmore where juniper had a good correlation with crested wheatgrass production while sagebrush was poorly correlated.

Correlations between ring widths of juniper and big sagebrush were poor at three locations where both species occurred. At Squaw Butte both woody species correlated well with production of big bluegrass. However, yields from the mixed native grass pasture were significantly correlated only with juniper, but correlation coefficients for bluebunch wheatgrass and crested wheatgrass were significant only for big sagebrush. Thus, two woody plants that respond differently to climatic fluctuations showed good correlations to one forage species. At the same time, these two woody species had widely divergent correlations with other forage species.

At Central Plains Experimental Range, no suitable woody species were available. Increment cores were obtained from ponderosa pine trees growing in the mountains about 40 miles to the west. The highly significant correlation coefficient of .71 demonstrates that it was not always necessary to obtain the woody plant samples from the immediate vicinity of the herbage samples. Perhaps one reason for this good relationship is that a region as a whole tends to be wet or dry in a given year, and the trees and forage are growing in the same climatic region.

While "ring width represents an integration of the favorableness of the environment of approximately a year's duration" (Fritts, 1965), one must recognize that precipitation and temperature have relatively more influence during specific seasons. Thus, Fritts et al. (1965) report that at Mesa Verde, Colorado, the "climate conditions which produce narrow rings in juniper are a dry, hot autumn; a dry, cool winter; and a dry, warm spring." Fritts (1965) also reported that "An average picture . . . indicates that low moisture and high temperature during December through May is most significantly related to narrow rings in ponderosa pine." The reported close relation between winter precipitation and width of annual rings in big sagebrush (Ferguson, 1964) probably accounts for the high correlation of big sagebrush with western wheatgrass and the low correlation with blue grama at Miles City. Western wheatgrass, a "cool-season" species, and big sagebrush were no doubt affected more by winter and spring precipitation than was blue grama, which normally responds strongly to summer rainfall.

Some woody plants (including fourwinged saltbush and ephedra) were unusable because annual rings could not be clearly defined. With other species (such as mesquite), the rings are difficult to discern and measure accurately. Still other species are subject to false rings, missing rings, or erratic ring growth. Juniper has been subject to considerable suspicion as to its usefulness in indicating climatic fluctuations. This study indicates that, at least in some cases, it can be a moderately reliable indicator of herbage yields.

Before herbage yields can be estimated, it is necessary to compute a regression formula for a specific woody plant-forage plant combination for each location. There is no standardized technique for obtaining annual-ring widths, so a regression formula will apply only to the set of annual-ring measurements from which the formula was derived. For this reason, no regression formulas are presented here.

Because of less consistent relations, attempts to obtain a "common herbage response" regression similar to that of Sneva and Hyder (1962) were unsuccessful.

Conclusions

The relatively high correlation coefficients obtained from some locations indicate that the use of annual rings to estimate herbage production can be a useful technique. However, considerably more experience is needed with this type of estimation. The occurrence of a number of low correlations shown in Table 1 is probably not as serious as it might appear; many correlations between precipitation and yield are just as low, but these low correlations seldom appear in print. It is hoped that other workers having access to more extensive yield data will be able to make additional correlations. Along with these, an evaluation of the sensitivity of the various woody species to rainfall or herbage production should be explored further; some species, such as the mesquite in this study seem relatively insensitive to climatic fluctuations (called a "complacent" species by the dendrochronologist in contrast to "sensitive" species). The applicability of this technique to any particular area will need to be determined for that area and for the specific forage plants and woody plants involved.

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Vegetation and Soils of No Man's Land Mesa Relict Area, Utah

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Highlight

On No Man's Land Mesa, a relict area in Kane County, Utah, two distinctly different soils were found which produce significantly different kinds and amounts of vegetation. The Upland sand (Pinon-Juniper) site yielded an average of about 1100 lb/acre airdry comprising 10% grass, 5% forbs and 85% trees and shrubs. The Upland shallow breaks (Pinon-Juniper) site yielded an average of nearly 800 lb/acre comprising 5% grass, 5% forbs and 90% trees and shrubs.

Ranchers should know what their rangelands can produce in order to evaluate how well range improvement practices will pay off. To assist them to determine this potential production, the Soil Conservation Service uses the range site concept. Range condition is also determined by the rancher and range conservationist on non-federal range lands to assess what departure from the potential may have occurred. With this basic information, the rancher can then consider the practices which result in improved range condition.

Passey and Hugie (1962) stated that soil, plant, and climatic relationships on relict areas can be used in the intelligent interpretations of soil survey data and to identify range sites. These interpretations are essential to the planning and application of optimum programs of management and treatment for rangelands. The use of range sites and condition class in range conservation was explained by Dyksterhuis (1958).

Hugie et al. (1964) show that the nature of plant communities is the result of soil differences. Williams and Hugie (1966) also discuss soil, climate, and vegetation characteristics that occur together under natural conditions. Several ecologists have described characteristic vegetation of relict areas and presettlement vegetation for specific geographic locations in Utah (Christensen and Johnson, 1964); Christensen and Welsh, 1963; and Welsh, 1957).

Jameson et al. (1962) report a study on Fishtail Mesa relict area in Northern Arizona which shows strikingly similar results to the current study. They found the most important species present were big sagebrush *(Artemisia tridentata)*, low sagebrush *(A. bigelovi)*, pinon pine *(Pinus edulis)* and Utah juniper *(Juniperus osteosperma)* making up a total of 88% of the cover. Soils were also similar.

In 1964 and 1965, we determined the plant yield and composition by weight on No Man's Land Mesa. From this data, we

FIG. 1. Upland sand (pinon-juniper) site. Prairie junegrass, tall native bluegrass, sand dropseed, Indian ricegrass, needle-andthread, big sagebrush, juniper, pinon pine, herbaceous sage, western wheatgrass, and prickly pear. Note open stand of trees with scattered clumps here and there.

concluded that there are two different range sites. They were described and range condition guides developed. These will be used to assist ranchers to plan and apply conservation practices wherever these sites occur in Utah.

Study Area and Procedure

No Man's Land Mesa is approximately 30 miles northeast of Kanab, Utah. It is roughly 4 miles long and 1 mile wide with a total of 1788 acres. The mesa varies from 6600 to 7222 ft in elevation and rises 600 to 1200 ft above the surrounding area.

The mesa was originally inaccessible to livestock. However, in 1927, a local rancher (Adams, 1965) constructed a goat trail and drove 800 goats to the top and 1300 to 1500 wether goats grazed the mesa for about six weeks the following spring. Although the goats did well, the area has not been grazed since by domestic livestock.

No big game were found and only 2 or 3 chipmunks, 2 porcupines and 3 or 4 mourning doves. No rabbits were seen, but old droppings and one old skeleton indicate they have been present.

Geologically, the mesa top is in the Carmel formation (Hintze, 1963). The cliff formation is Navajo sandstone.

The climate is sub-humid with cold, snowy winters and dry summers. The annual average precipitation is estimated to be from 14 to 16 inches. From 25 to 35% of the precipitation occurs during the plant growth period from April to October. The 65 to 75% that falls during the plant dormant period of October through March is the dependable supply for plant growth. The optimum growth period of plants is during May and June. The frost-free period is ordinarily about 150 days.

Soil scientists described several soil profiles in order to classify the soils and correlate them into the national standard soil survey system (USDA, 1951).

Vegetative yield and composition were determined by use of two methods. The double-sampling or weight-estimate method (Frischknecht and Plummer, 1949) was used on all species except pinon pine and Utah juniper for which the weight unit method (USDA, 1963) was used. Yield and composition information was taken from two 10-plot transects on the deep soil and one on the shallow soil in 1964. Four 10-plot transects were taken on the deep soil and 3 on the shallow one in 1965. Each plot was 9.6 ft^2 in area. Green weights were estimated in grams for each species on each plot. Errors of estimating were determined by actually clipping 2 plots on each transect and correction factors were computed. Corrected green weight was reduced to dry weight of each species. The center of plot 5 of each 10-plot transect was used as the southeast corner of a 0.1-acre plot from which total annual yield of pinon pine and Utah juniper were computed by use of the weight unit method (USDA, SCS, 1963). Annual dry weight production of Utah juniper was considered to be 0.5 the weight of the fruit added to 30% of the total weight of leaves and annual

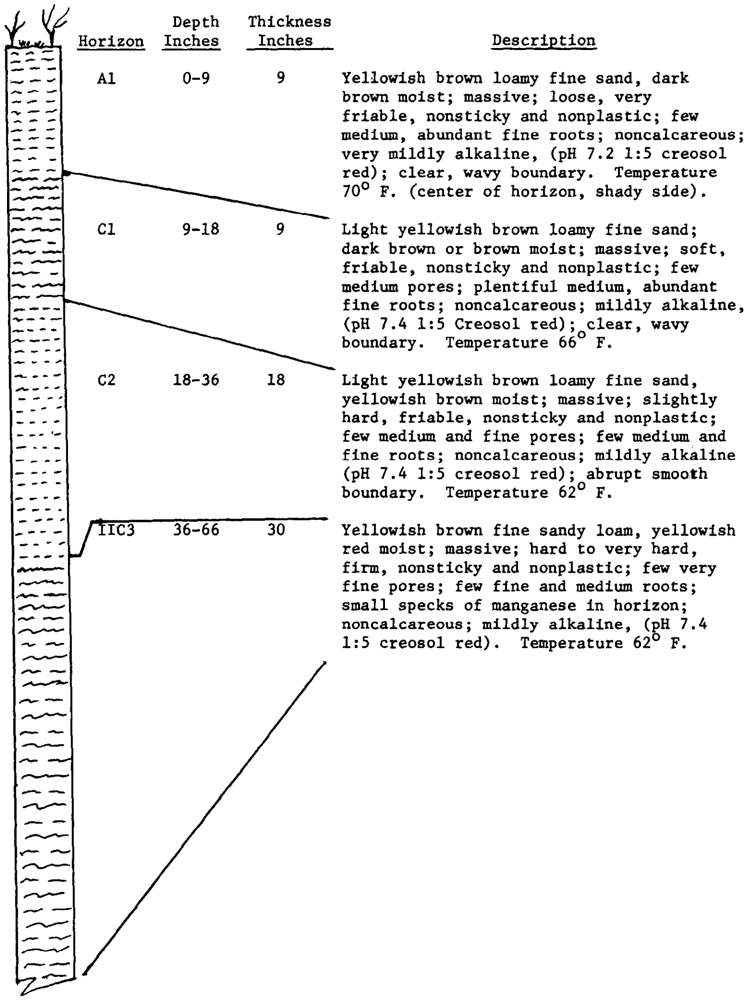

FIG. 2. Schematic profile description — Preston-like deep, loamy fine sand, typical soil in Upland sand (pinon-juniper) site.

twig growth (Mason and Hutchings, 1966). Pinon pine yields were computed by adding half the weight of cones to the weight of annual twigs and leaves which are easily recognized and can be accurately harvested. The weight of Utah juniper and pinon pine was calculated in lb/acre and added to all other species as a basis for species composition.

Posts were counted on the 0.1-acre plots. Ages of post-size juniper trees were determined by increment bore and potential in posts/acre/year was determined. Cordwood yield of both pinon pine and juniper was computed from yield tables after measuring diameter of trees at one foot height. (USDA, SCS, 1961). Cordwood potential was determined by dividing cords per acre by the average age of the mature trees.

Density of plants, litter, rock, and cryptogams were estimated directly as a percentage of the total area. Bare ground percentage was computed by subtracting the total of these four items from 100. Overstory density was computed from crown spread diameters of all trees on the plots, computed in percent of total surface area.

Results

On the basis of distinct differences in soil resulting in significant differences in kind and amount of vegetation, two range sites were found on the mesa.

Upland sand (Pinon-Juniper) Site.—The topography is gently sloping with some dune-like mounds. (Fig. 1). Slopes vary from 1 to 10% and are mostly gently sloping to the north. This site covers approximately 1198 acres.

The soil is deep, well-drained, Preston-like loamy fine sand. (Fig. 2). No active current water erosion is evident. This soil absorbs about 8.5 in of water during the plant dormant period. Moderate wind erosion and deposition are taking place.

The vegetation of this site consists of about 10% grasses, 5% forbs and about 85% trees and shrubs by total annual air dry weight. The important grasses are tall native bluegrass, Indian ricegrass, ring muhly, and needleandthread (Table 1). A large number of forbs occur but only cryptantha, perennial mustard and stickseed make up as much as one percent each of the total dry weight.

Table 1. Total annual yield in lb/acre airdry in 1964 and 1965 for two range sites on No Man's Land Mesa.

Plant Species	Upland Sand (Pinon-Juniper)			Upland Shallow Breaks (Pinon-Juniper)		
	1964	1965	Av.	1964	1965	Av.
Grasses and Grass-like						
Desert needlegrass (Stipa speciosa)				7	3	5
Dryland sedge (Carex sp.)				12	3	8
Indian ricegrass (Oryzopsis hymenoides)	10	49	30		1	T
Needleandthread (Stipa comata)	5	16	10	34	T	17
Prairie junegrass (Koeleria cristata)		4	2			
Ring muhly (Muhlenbergia torreyi)		20	10			
Tall native bluegrass (Poa fendleriana and P. nevadensis)	49	57	53	6	10	8
Western wheatgrass (Agropyron smithi)	2	4	3			
Total Grass & Grass like	66	150	108	59	17	38
Forbs						
Actinea (Hymenoxys bigelovi)		4	2	11	5	8
Cryptantha (Cryptantha sp)	8	5	6	2	12	7
Many-flowered sunflower (Viguiera multiflora)	1	2	2	21		10
Perennial mustard (Arabis pendulina)	4	10	7	1	8	4
Stickseed (Lappula redowski)		12	6			
Other forbs	13	40	29	11	16	12
Total forbs	28	73	52	46	41	41
Shrubs and Trees						
Big sagebrush (Artemisia tridentata)	185	119	152			
Birchleaf mahogany (Cercocarpus betuloides)				62	43	52
Bitterbrush (Purshia tridentata)	49	12	30		3	2
Buckwheat (Eriogonum sp)	3	11	7		1	T
Fremont mahonia (Mahonia fremonti)				65	150	108
Gambel oakbrush (Quercus gambeli)	176	120	148			
Hood's phlox (Phlox hoodi)	6	1	4	22	11	16
Horsebrush (Tetradymia canescens)	27	4	16			
Leptodactylon (Leptodactylon pungens)		9	4		5	2
Manzanita (Arctostaphylos patula)	8	82	45			
Mormon tea (Ephedra viridis)		17	8	135	41	88
Pinon pine (Pinus edulis)	404	229	316	228	374	301
Prickly pear (Opuntia spp)	147	34	90	2	5	4
Rock goldenrod (Solidage petradoria)				24		12
Serviceberry (Amelanchier mormonica)					36	18
Snowberry (Symphoricarpos oreophilus)	T	7	4			
Utah juniper (Juniperus osteosperma)	122	58	90	158	43	100
Yellowbrush (Chrysothamnus viscidiflorus)					7	4
Total shrubs and trees	1127	703	914	696	719	707
TOTAL ALL VEGETATION	1221	926	1074	801	777	786

Note: T in table indicates a trace or quantity less than 1.

The important shrubs and trees are Mormon tea, bitterbrush, horsebrush, Gambel oakbrush, buckwheat, prickly pear, big sagebrush, manzanita, pinon pine and Utah juniper.

Total annual air dry yield was 1221 lb/acre in 1964 and 926 lb in 1965.

Live-plant understory density averaged 12%, litter and mulch 29%, cryptogams 7%, and bare ground 52% of the total surface. Overstory density of pinon juniper was 14%.

The potential for producing cedar posts is about 0.2 post/acre/year. The potential for juniper cordwood is .02 cord/acre/year and for pinon pine .07 cord.

FIG. 3. Close up of Upland shallow breaks (pinon-juniper) site showing sparse understory and considerable geologic erosion.

Upland Shallow Breaks (Pinon-Juniper) Site.—This site is located in the breaks on the north end and as a smaller area on the west central part of the mesa, comprising 590 acres. (Fig. 3). Slopes vary from 5 to 30% on all exposures, but north is dominant.

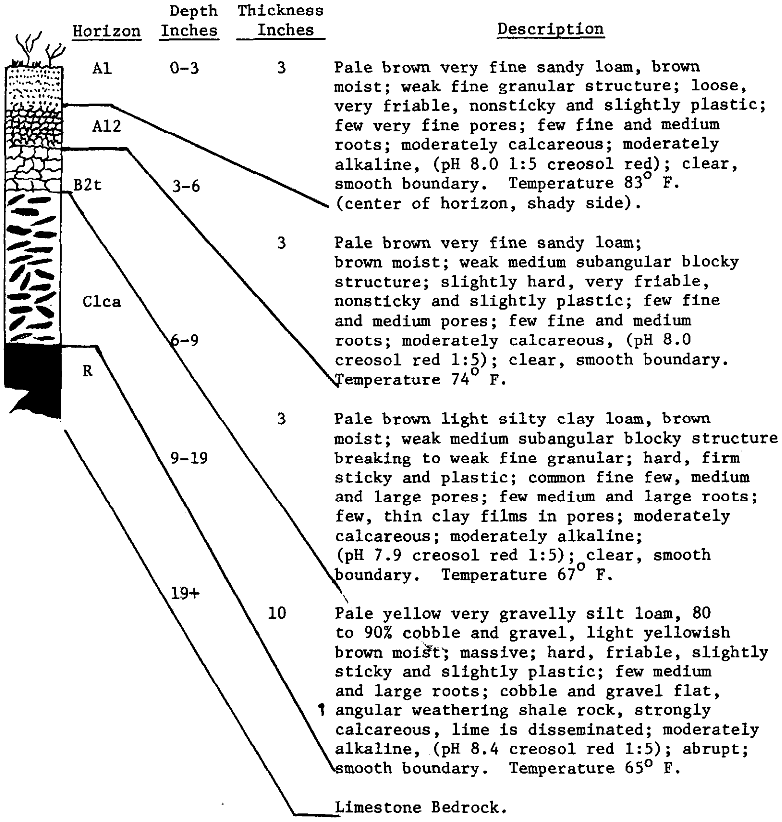

FIG. 4. Schematic profile description—Menefee-like very fine sandy loam, shallow over limestone bedrock, typical soil in Upland shallow breaks (Pinon-Juniper) site.

The soil is shallow, well-drained, Menefee-like very fine sandy loam (Fig. 4). It is a residual soil from limestone and sandstone parent rocks. The soil profile will hold only about 2 inches of moisture. Some moisture is held in the cracks of the bedrock. Runoff during the snowmelt period when the profile becomes saturated has resulted in scarcity of understory plants. Very little wind erosion or deposition occurs.

The vegetation of this site consists of 90% trees and shrubs with about 5% forbs by weight and 5% grasses and grass-like plants. Important grasses and grass-like plants are tall native bluegrass, needleandthread, and dryland sedge. Many forbs are present but only actinea, cryptantha and many-flowered sunflower comprise 1% or more of the total weight. The important shrubs and trees are serviceberry, birchleaf mahogany, Utah juniper, pinon pine, Mormon tea, Fremont mahonia, and rock goldenrod.

Total annual air-dry yields were 801 lb/acre in 1964 and 778 lb in 1965.

Live plant understory density averaged 6%, rock fragments 30%, litter and mulch 29%, and bare soil 35% of the total surface area. Overstory density computed from the plots averaged 24%.

Three or four ponderosa pines are found on the extreme north end of the mesa in this site. They are over-mature, about 3 ft in diameter, but only about 40 ft high. No reproduction exists.

The potential for producing cedar posts, pinon cordwood and juniper cordwood is the same as the Upland sand (pinon juniper) site.

General Comparisons of the Two Sites

There is no significant difference in wood production on the two sites. There is 10% more tree density on the shallow site. The deep sand site averages 67 pinon pine trees/acre and 20 Utah juniper while the shallow break site has 215 pinon pine trees/acre and 50 Utah juniper. What the deep sand site lacks in number of trees is made up in considerably more rapid growth so that the potentials for posts and cordwood are nearly equal on the two sites.

The deep sand site produces about 27% greater total annual yield of all vegetation than does the shallow breaks site. There is also a wide difference in the kinds of shrub species on the two sites. Big sagebrush, Gambel oakbrush and manzanita occur in substantial amounts on the deep sand site while birchleaf mahogany, Fremont mahonia, rock goldenrod and serviceberry are found on the shallow breaks site. Pinon pine and Utah juniper occur on both sites but collectively produce 37% of the total yield on the deep sand site and 50% on the shallow breaks site. Mormon tea is found on both sites but only 1% on the deep sand compared with 11% on the shallow breaks site. Prickly pear is found on both sites, but is 8% of the total on the deep sand and less than 1% on the shallow breaks site. Many other species are found exclusively on one site or the other, but only in quantities less than one percent of the total (Table 1).

Summary

No Man's Land Mesa is a relict area in Kane County 30 miles northeast of Kanab. It has been grazed only two years (1927 and 1928) for short periods by from 800 to 1500 goats.

Climate is sub-humid with cold snowy winters and dry summers. Average annual precipitation is from 14 to 16 inches.

Two different sites are found on the mesa—the Upland sand (pinon-juniper) and the Upland shallow breaks (pinon-juniper). The Preston-like loamy fine sand soil of the first site is deep and will hold 8.5 inches of moisture in a six-foot depth. The Menefee-like very fine sandy loam of the break site is shallow and will hold 2 inches of moisture in the profile, not considering the moisture in the cracks of the bedrock. No active water erosion is evident on the deep sand site, but generally moderate wind erosion and deposition is present. Moderate to severe geologic water erosion is occurring on the breaks site, but very slight to no wind erosion or deposition is evident.

No signs of big game or predators were found.

The vegetation of the Upland sand (pinon-juniper) site yielded an average of about 1100 lb/acre air dry, consisting of 10% grasses, 5% forbs, and about 85% trees and shrubs. Live plant density of understory is 12%, litter and mulch 29%, cryptogams 7% and 52% bare ground. Overstory density is 14%. The potential for production of cedar posts is about 0.2 post/acre/year; for juniper cordwood it is .02 cord; and for pinon pine .07 cord.

The Upland shallow breaks (pinon-juniper) site yielded an average of nearly 800 lb/acre air dry, consisting of 5% grasses and grass-like plants, 5% forbs, and about 90% trees and shrubs. Live plant density of understory is 6%, while rock fragments cover 30% of the surface and litter and mulch 29%, leaving 35% bare ground. Overstory density is 24%. The potential for production of cedar posts, pinon cordwood and juniper cordwood is about the same as the Upland sand (pinon-juniper) site.

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U. S. D. A. Researcher Summarizes Public Funds used for Agricultural Research — Some forty per cent of publicly funded agricultural research goes for crops and crop products and another forty per cent goes about equally into animal and animal-product research and for development of natural resources, according to research specialist Dr. Paul E. Schleusener, of U.S.D.A., speaking before a meeting of American Society of Agricultural Engineers.

TECHNICAL NOTES

Breaking Seed Dormancy in Parry's Clover by Acid Treatment

JAMES O. BLANKENSHIP and DIXIE R. SMITH

Range Conservationist, Black Hills National Forest, Custer, South Dakota; and Plant Ecologist, Rocky Mountain Forest and Range Experiment Station,[1] Laramie, Wyoming.

Highlight

Immersion in 75% sulfuric acid effectively broke seed-coat-imposed dormancy. Length of immersion had no influence on percent germination.

Parry's clover *(Trifolium parryi* Gray) is a common component of the vegetation found on subalpine and alpine meadows in Wyoming. It is much more palatable to sheep than other forbs on high-elevation sheep ranges (Johnson, 1962). Parry's clover contains up to 27% crude protein and high levels of other essential nutrients (Hamilton, 1961). The palatability and nutritive content make Parry's clover a valuable range plant. However, propagation is limited by a hard, impermeable seed coat. Some method is needed for breaking this dormancy.

Water-impermeable seed coats are particularly common among leguminous plants. Scarification by mechanical abrasion with sand, nicking or rasping, and chemical scarification with sulfuric acid or organic solvents are means of overcoming seed-coat-imposed dormancy (Bonner and Galston, 1952).

The purpose of this study was to measure the effects of chemical scarification on percentage germination of Parry's clover seed.

[1] *Forest Service, U. S. Department of Agriculture, with headquarters at Fort Collins, in cooperation with Colorado State University. Research reported here was conducted at Laramie, in cooperation with University of Wyoming.*

Table 1. Mean germination (percent) of Parry's clover. Arcsin transformation was used in computing means.[1]

Time of Immersion Minutes	0	35	55	75	Mean
	Concentration of Sulfuric Acid (%)				
10	21.5	23.6	31.2	73.5	37.4[a]
20	18.5	20.5	44.7	93.1	44.2[a]
30	17.4	13.1	39.2	89.8	39.9[a]
Mean	19.1[a]	19.1[a]	38.4[b]	85.5[c]	

[1] Means in the same row or column with similar superscripts are not significantly different.

Methods and Procedures

Seeds for the study were handpicked from plants at 10,700 ft elevation in southeastern Wyoming. They were collected in August 1963 and stored in paper bags at room temperature for four months.

The treatments involved a 4 x 3 factorial arrangement of sulfuric acid concentrations and time. Concentrations of 0, 35, 55, and 75% volume were tried at time intervals of 10, 20, and 30 minutes.

Solutions were allowed to reach room temperature. Seeds were then immersed for the designated time, drained, and then washed in cold tap water for about 5 minutes. They were subsequently placed on moist blotter paper within petri dishes. The dishes were then placed in a germination chamber where the temperature varied between 70-75 F. Photoperiod was controlled at 16 hours light with a 40-watt G. E. "Growlux" bulb.[2]

Within the chamber, the petri dishes were arranged in a randomized complete block with four replications. The experimental unit consisted of a single petri dish containing 24 seeds.

Seedlings were counted bi-weekly over a 21-day period. The cumulative percentage germination data were subjected to variance analysis after arcsin transformation. A probability level of 0.05 was assumed to be adequate protection, and interpretations were made at that level.

[2] *Trade names and company names are used for the benefit of the reader and do not imply endorsement or preferential treatment by the U. S. Department of Agriculture.*

Results

The concentration of acid had a pronounced effect upon percentage germination. Concentrations of 35% failed to influence germination, but the 55% concentrations doubled the rate from 19 to 38%. Immersion in the 75% solution resulted in still more germination—86%.

Length of immersion in sulfuric acid had no influence upon percentage germination (Table 1). This lack of influence was persistent throughout all acid concentrations.

We concluded that seed dormancy in Parry's clover could be broken effectively by immersion in 75% sulfuric acid for periods of 20-30 minutes. This treatment may provide a practical means of breaking dormancy when propagating the species.

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The Monarch Big Sagebrush of White Mountain

EDWARD R. SCHNEEGAS and EAMOR C. NORD

Wildlife Management Biologist, Inyo National Forest, Bishop, California; and Plant Ecologist, Pacific Southwest Forest and Range Experiment Station, Forest Service, USDA, Riverside, California.

Highlight

An unusually massive big sagebrush plant has been discovered growing in the White Mountains in eastern California. This plant is almost 15 ft tall, has an average crown spread of 11 ft, and its main trunk is 48 inches in circumference at ground level. The aggregate value of this monarch shrub is 65.4.

A big sagebrush *(Artemisia tridentata* Nutt.) plant—believed to be the most massive of its species—has been discovered in eastern California. It is growing in the shadow of White Mountain—one of the tallest mountain peaks in the United States. This plant is nearly 15 ft tall, its crown spread averages 11 ft, and its main trunk measures 48 inches circumference at ground level (Fig. 1 and 2).

Size of the plant was gauged by the formula developed to determine bigness in trees (Dixson, 1961), but the formula was modified to accommodate distinguished shrubs (Nord, 1962; Driscoll, 1963). The aggregate value of this plant is 65.4, based upon measurements shown in Table 1.

The plant branches appear just above the ground surface. Three main stems range from 20 to 25 inches circumference at 1 ft above the surface; the largest is 19 inches circumference at breast height.

The monarch specimen is located about 300 ft east of the road that fords Wyman Creek, in the NE ¼, Section 20, T. 6 S., R. 36 E.; it stands about 5 miles northeast of Deep Springs College, the nearest inhabited place, and 33 miles northeast of Big Pine. An unimproved road extends into the area; however, it is advisable to use either a jeep or pickup truck to drive to the site of this plant.

The sagebrush stand, where this specimen grows, is at an elevation of about 6,600 ft near the mouth of Wyman Creek. It covers several acres in a canyon bottom that is as much as 300 ft wide and about 0.5 mile long. The very deep, well drained soils are mostly loamy, coarse sand with a neutral to slightly acid reaction (pH 6.7). Composed of alluvial deposits, they are derived from quartz diorite rocks and some schistose materials, transported from higher elevations.

Fig. 1. Monarch big sagebrush plant in White Mountains, eastern California, estimated to be about 50 to 60 years old is nearly 15 ft high, its crown spread averages 11 ft across, and it has an aggregate value of 65.4.

The stand that includes this monarch consists of a dense cover of big sagebrush with lesser amounts of rubber rabbitbrush *(Chrysothamnus nauseosus)*, fourwing saltbush *(Atriplex canescens)*, desert bitterbrush *(Purshia glandulosa)*, rose *(Rosa* spp.), and willow *(Salix* spp.). Rubber rabbitbrush, like the sagebrush, tends to be very rank and tall; some of these plants are more than 10 ft tall. Fire swept over the area 50 to 60 years ago, judging from annual growth rings counted on some of the larger sagebrush plants. Rapid growth of sagebrush was indicated by the wide spacing between the annual growth rings.

Rank and rapid growth of the plants is in large measure attributed to the deep, well-drained soils; the availability of adequate subsurface moisture supplied throughout the year by Wyman Creek, which traverses the site; additional nutrients brought in by occasional deposition of materials as a result of flooding; as well as other favorable growing conditions. This growth is not due

Fig. 2. Crown spread shown by the position of the men supporting the bar is nearly 14 ft across in one direction.

Table 1. Plant dimensions and values of monarch big sagebrush in White Mountains.

Item	Dimension	Rating weight	Value[1]
Height-maximum exclusive of current year's growth	14 ft 8 in	1 per ft	14.7
Circumference-ground level	48 in	1 per in	48.0
Crown spread (14 x 8 ft)	11 ft	0.25 per ft	2.7
Aggregate value			65.4

[1]The weighted values in this index were obtained in the same way as those used to determine bigness in trees, except that stem circumference was measured at ground level instead of 4½ feet.

to the climate, which is very arid. Average annual precipitation is estimated to be about 6 inches, but in some years it may be much less. At the Deep Springs College gauging station, rainfall was less than 3 inches in 1964 (U. S. Weather Bureau, 1964).

We have found other unusually large sagebrush plants in the immediate area, including one reported by Al Noren[1], formerly a Forest Ranger on the White Mountain District, Inyo National Forest, that was 15.5 ft tall with a stem diameter of 12 inches at breast height. None of these other plants equals the aggregate size value of the specimen we regard as the monarch.

Other large sagebrush plants have been reported in other states. Little (1953) mentions that on favorable moist sites, big sagebrush has been recorded as a small tree up to 20 ft high, with a single trunk 4 to 14 inches d.b.h. Pase (1956) found a big sagebrush plant east of Kanab, Utah, that was 15 ft 7 in high, with an unbranched stem diameter of 8.9 inches at 1 ft above the ground surface. Beetle (1962) reported a big sagebrush in Park County, Wyoming, having stem circumferences of 41 and 34 inches, respectively, at the base and at 20 inches above the ground. No attempts to equate the over-all size of the plants were made. Therefore, we cannot make comparisons with other unusually large specimen plants—as in the case of bitterbrush (Driscoll, 1963; Nord, 1962)—or big trees (Dixson, 1961).

[1] *Personal communication.*

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A Device to Aid in Selecting and Counting Seeds

GARY R. BROWN

Range Technician, Rocky Mountain Forest and Range Experiment Station, Forest Service, USDA.[1]

The sorting and counting of small lots of valuable hand-harvested seeds is often tedious and time consuming. When *Carex* germination trials began, the need for an economical apparatus to aid in selecting and counting the small seeds became quite evident. To meet this need, the device described below was developed.

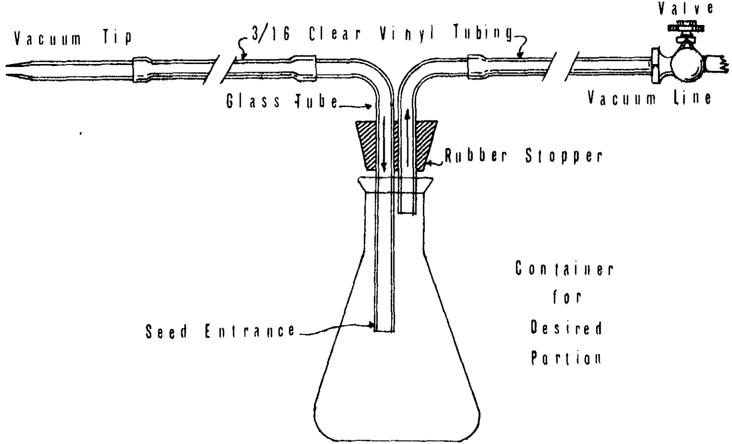

FIG. 1. Vacuum device for selecting small seeds.

The physical design of the device is shown in Fig. 1. Vinyl tubing is connected to a vacuum source and to a glass tube that extends about 0.25 inch through a rubber stopper. The stopper is inserted into a container (such as a 250 ml Erlenmyer flask). A second glass tube (connected by vinyl tubing to a vacuum tip) passes through the stopper and down into the container about 2 inches. The glass tubes are of different lengths to prevent seeds from being sucked directly into the vacuum source. The vacuum tip should be drawn to a diameter slightly larger than the seed.

The items needed for construction

[1] *Range Technician, Rocky Mountain Forest and Range Experiment Station, Forest Service, USDA, with central headquarters maintained at Fort Collins, in cooperation with Colorado State University. Research reported here was conducted at Laramie, in cooperation with University of Wyoming.*

are: vinyl tubing, glass tubing, rubber stopper, container that can be stoppered, and a source of vacuum. These items, readily available in most laboratories, will cost about $1, exclusive of the vacuum source.

To improve efficiency in counting and selecting, the seed should first be put through a small air-operated cleaner or a hand sieve to remove the larger chaff particles. The partially cleaned seeds can then be spread on the surface of a light-table to further facilitate the selection. The seeds are sucked through the vacuum tip and deposited in the container. Chaff or other organic material can be ignored. Once the required number of seeds have been collected in the container they can easily be transferred to a petri dish for germination.

Original procedures used involved partial cleaning, spreading material on a light table and hand-picking the seed to be used in the germination trials. Use of this device reduced the time required to select and count *Carex* seeds by about 90%. It should be equally effective for other seeds.

Managing Crested Wheatgrass for Early Spring Use

D. W. HEDRICK

Professor of Range Management, Oregon State University, Corvallis.

The Otley brothers, owners and managers of a large range operation in southeastern Oregon at Diamond, have applied an effective method of early grazing on crested wheatgrass *(Agropyron desertorum)*. Back in the early 1950's, Mr. Henry Otley and his three sons, Harold, Howard, and Charley, diagnosed an urgent need for spring feed. Only about 3,000 acres of deteriorated big sagebrush *(Artemisia tridentata)*, bluebunch wheatgrass *(Agropyron spicatum)* range were available for early use between the hay meadows where the cattle wintered and the lush summer grazing in the Steens Mountains.

With the cooperation of the Bureau of Land Management at Burns, Oregon, about 1,900 acres of this deteriorated foothill range under permit to the Otleys was plowed and seeded to crested wheatgrass in the late summer and fall of 1955. During the ensuing 10-year period, a pattern of grazing has been developed which is uniquely suited to the Otley's set-up and will be of interest to other range operators in need of early spring forage. Fortunately, when this seeding was undertaken some experimental plots to study understory grass species were established and subsequently data have been taken on stand, production, and relative vigor of plants from this area. These figures, along with those from exclosures established in 1960 and 1963, lend scientific support to a highly successful and practical technique for managing crested wheatgrass.

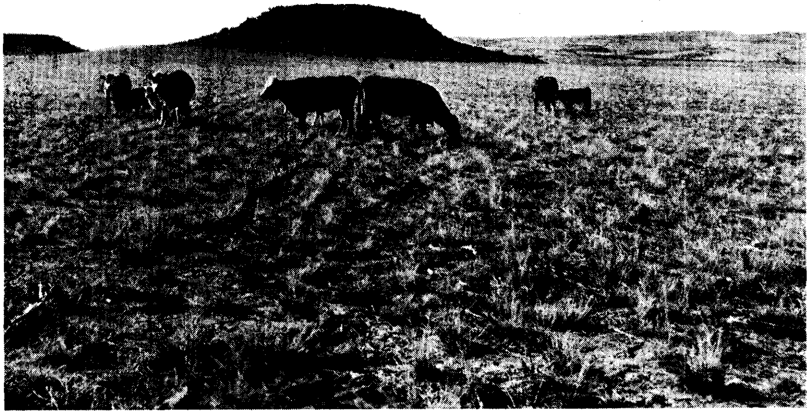

FIG. 1. Cows and calves on BLM crested wheatgrass allotment used by Otley brothers. Photograph April 28, 1966, when about one-half of available forage had been grazed. Animal use started on April 16.

At the time of seeding, production of native grass was extremely low with only scattered plants of Sandberg bluegrass *(Poa secunda)* and squirreltail *(Sitanion hystrix)* growing under a dense canopy of big sagebrush. A brushland plow was used to prepare the area for seeding, and it was drilled with 6 lb/acre of seed in October, 1955.

The area was protected from grazing in 1956 and 1957. A bumper seed crop was produced the second year and this was combined, leaving a tall, harsh stubble. To facilitate grazing in 1958, steers were confined to the area in late summer and fall of 1957 to remove the old growth. Starting in the spring of 1958, cows and calves have been grazed from mid-April to about the end of May. In all but extreme drought years, heavy grazing at this period has resulted in an excellent regrowth of fine-stemmed seed heads. This dry material provides feed for an early turnout even in cold years and together with the high-protein green growth is cropped off to a height of 1.5 to 2.5 inches by the end of May.

Grazing use since 1958 has averaged about 800 AUM's annually which amounts to a production of 2.5 acres/AUM. The greatest returns have come from increased livestock production. Use of crested wheatgrass by the Otleys in early spring has resulted in a 10% greater calf crop (up to 95 from 80-85 before) and calf weaning weights have been raised from an average of 400 to about 440 lb. This seeding has enabled more efficient breeding which has increased uniformity of market animals. Previously only about 75% of the calves were dropped early enough to be worked at the time of spring turnout whereas now about 90% are ready for marking at one time. Perhaps the greatest benefit has been an indirect one on the later spring and summer feed in the upper foothills of the Steens Mountains. Grazing crested wheatgrass during this crucial early spring period has deferred turnout on the native species with a resulting boost in their stand and production.

The question: "What has happened to crested wheatgrass under this management?" is interesting to evaluate. In 1960-61 after three years of drought and a heavy mouse infestation, one range conservationist thought that if present grazing practices were continued the stand would be ruined. On the contrary, in 1962 the plants came back better than ever. In fact, during the past spring, one of the driest on record, the combination of last year's accumulation plus late March and April growth bridged the critical gap between hay feeding and later grazing in the Steens Mountains. Detailed stand data and indirect measurements (growth-in-dark) of vigor were undertaken this year within and without exclosures established in 1960 and 1963. In line with results from northern New Mexico (Springfield, 1963) and along with more recent results by Sharp (1966) in southern Idaho, it was found that heavy grazing produced more but smaller plants per unit area. Growth-in-dark (dependent only on accumulated materials from the previous season) yields, indicating relative reserve carbohydrate stores and size of root systems, were not significantly different from plants grazed heavily since 1958 and those grazed only moderately since 1963. Very little brush is becoming established (none visible in the photograph) and *no* wolf (unutilized) plants are present in the entire seeding. Surface protection to the soil is equal to that in the 1960 exclosure (complete protection from grazing). Limited data on the occurrence of poisonous larkspur indicates less larkspur in the grazed area.

For western range operators with a critical need for early spring use, heavy grazing of crested wheatgrass and its subsequent protection for summer regrowth offers a promising opportunity to improve livestock production and adequately maintain a conservation cover of grass in big sagebrush-bunchgrass areas. The Otley's experience is a convincing example of how to match livestock and plant needs for improved overall range production.

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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

WSU Gets Plans for Developing Colockum

A tailor-made plan for management for Washington State University's Colockum multiple use research unit was handed over to the WSU representatives by the Soil Conservation Service.

The plan will be applied to a 10,000-acre block of land south of Wenatchee between the Columbia River and Wenatchee Mountains summit.

It will be used in the development of a center to study integrated use of wild land like the hundreds of thousands of acres on the east side of the Washington and Oregon Cascades.

The center will be used for basic research in management of forest, range, water, wildlife, recreation, and watershed values of the area, and as a schoolroom for undergraduate and graduate instruction in these aspects.

Colockum Plan Delivered—Washington State University land use specialists, Dr. Ben Roche, left, and Dr. Grant Harris, second from left, receive a conservation management plan for the Colockum multiple use research unit. Watching is Ted Klein, Department of Natural Resources range manager, and, making the presentation, Claude Dillon, Spokane, foreground, Soil Conservation Service range specialist.

Just off the press is the newest book in the Lippincott series of Living World Books, "The World of the Porcupine," by David F. Costello. The author used his own fine photographs for this beautifully illustrated, 157-page, fascinating account of a unique and much maligned rodent, the porcupine.

Dr. Costello, a charter member of the Society, was one of the early day Directors. In April 1965 he retired as Chief, Division of Range, Wildlife Habitat and Recreation Research at the Pacific Northwest Forest and Range Experiment Station in Portland, Oregon.

That he is serious about his new career is evident by his energy and his enthusiasm about other contemplated books. No sooner was the manuscript about porcupines off to the publishers than was Costello hard at work on another book to be titled, "The World of the Ant." Also in prospect is a book with the tentative title, "The Prairie World," which will explore and portray the entire ecology of the prairie.

Range Management Award to Don Cox

Donald A. Cox, Mullen rancher, received the "Nebraska Range Management Award" at the annual banquet of the Nebraska Section, American Society of Range Management at the Pawnee Hotel in North Platte.

He is the fourth to receive the award, which is presented annually to an individual in recognition of outstanding work in the development and use of Nebraska range resources.

The award was presented by Jim Peters, Sheridan County Extension agent and immediate past president of the Nebraska Section, and Dr. Donald Burzlaff, University of Nebraska agronomist who specializes in range management.

Cox is a past president of the Nebraska Section and has served a three-year term on the board of directors of the American Society of Range Management.

He practices his range management on his 6,165-acre ranch 28 miles northwest of Mullen, and has had a performance testing program for improving his cattle herd since 1955.

Cox is an active member of the Nebraska Stock Growers Association, Sandhills Cattle Association, Nebraska Beef Cattle Improvement Association, and civic organizations in Mullen.

Texas Tech Range Management Prof. Thadis W. Box received the E. Harris Harbison Award for Distinguished Teaching at the annual meeting of the American Council on Education October 14 in New Orleans.

Sponsored by the Danforth Foundation of St. Louis, the award is designed to honor outstanding teachers who excel not only in scholarship and classroom teaching, but also in concern for students as individuals.

Dr. Box, who joined the Tech faculty in 1962, was among nine faculty members from colleges and universities throughout the nation receiving the award for 1966-67. He is the first teacher in an agricultural or biological science to receive the award.

Maxwell T. Lieurance, a long-time member of the Pacific Northwest Section, manager of the Vale District, Bureau of Land Management, has received the Governor's Award as State Conservationist of the Year given by the Oregon Wildlife Federation. The Award is given in cooperation with the National Wildlife Federation in their Conservation Achievement Program sponsored by the Sears Roebuck Foundation.

Lieurance received the Award primarily for his work in formulating and directing the Vale Project rangeland rehabilitation program. He has been active in BLM conservation work since 1952.

Dr. James O. Klemmedson

Dr. James O. Klemmedson has been appointed as Professor of Range Management in the Department of Watershed Management, University of Arizona at Tucson. Dr. Klemmedson will be in charge of teaching and research in range science, ecology, and soil-plant-water relations. He received his B.S. degree at the University of California (Berkeley), his M.S. degree in range management at Colorado State University, and his Ph.D. in soils at the University of California (Berkeley).

Klemmedson has experience as a soil and range conservationist with the SCS in Colorado; he taught range management at both Colorado State University and Montana State University, was research assistant in soils and plant nutrition at the University of California, and was Project Leader of Range and Wildlife Habitat Research projects for the Intermountain Forest and Range Experiment Station at Boise, Idaho.

Slide Series on 1966 Range Youth Forum at Logan is Available

A slide series with script on the 1966 Range Youth Forum held at Logan in conjunction with the summer meetings has been completed. This slide series includes 22 slides showing activities at the Forum.

Reservations for use of this slide series should be made directly with: Mr. Karl G. Parker, Extension Range Specialist, Utah State University, Logan, Utah 84321.

There is no charge for use of this series. However, each person should give specific dates for showing when requesting the slide series and return them immediately after showing.

The Western Stockgrowers Association, an organization of Alberta ranchers has held its third annual Stockmen's Short Course in cooperation with the University of Alberta at the Banff School of Fine Arts. One third of the Week-long course was on the topic of Range Management and was conducted by our busy and competent Director, Alex Johnston of Lethbridge.

The following and Dr. Young's letter which appeared in the November issue were taken from the Texas Section News Letter. If others have comments, the Journal will be glad to print them.

Follow-Up On President Young's Article

You will recall the item "Perhaps Our Approach is Wrong" in the last issue. Dr. Young asks "If proper range management is as good as professional range workers know it to be, why haven't many more ranchers adopted good range management practices?"

That question has long tantalized many of us. Dr. Young has made a good start in searching for answers and asks for thoughts of others. Many individuals, both ranchers and professionals, could contribute on this question.

As Dr. Young said, there are opportunities on most ranches and livestock farms to achieve proper degrees and seasons of use on overstocked native pastures without reducing total livestock numbers. Following are some thoughts on this one approach.

First of all, it requires adjustments in land uses. Some land in cash crops will have to be put into use as tame pasture; or, some rangeland suitable for cultivation (capability classes I-IV) will have to be put into tame pasture.

The kinds and acreages of tame pasture must be planned to extend the period of high animal gains for a specific size of herd. Too often a kind of tame pasture is planted that simply adds to an already adequate supply for certain months.

You plan to graze different pastures at different times of the year in order to:

A. Graze as many months of the year as the climate will permit, and thus reduce needs for roughage and feeding.

Costs of harvesting and feeding roughage to breeding herds are almost always too great to justify feeding in any weeks of the year when grazing should have been possible.

B. Have the annual cycle in pasture quality coincide with the herd's cycle of production.

Pastures of high quality are most needed when animals are suckling their young. Moreover, high quality just prior to and during breeding can increase the conception rate. Sales of calves, lambs and yearlings are appropriate in summer or fall when pasture quality often declines, accompanied by poor animal gains. Lowest quality pasture can best be used in winter when gains are not essential.

C. Maintain or improve each kind of pasture in the yearly system of pastures.

A guiding principle is: "Livestock gains in any one year must not reduce chances for similar or greater gains in following years."

The foregoing "A, B, C" is not range management. Instead it is deciding upon proper land uses and acreages within an operating unit. Tame pastures do not "save" ranges any more than ranges "save" tame pastures. You plant a tame pasture to provide better and more grazing in months when it is needed, not to give range a rest. Acreages of tame pastures and native pastures, along with any needed roughages for winter feeding, must be planned to best support a certain sized herd through the 12 months. Needed rests from grazing on both tame and native pastures are on important by-product.

A range conservationist will fail if, with a rancher, he plans too much tame pasture, or too much harvested roughage; in relation to available range grazing. To verify this statement, simply look at native pastures on units that are long on tame pasture or roughage. This is where you see native pastures that look like "tromp lots."

You will find that numbers of livestock kept are largely based on the season of greatest pasturage or feed supply. That becomes the number that is turned onto native pasture. Often supplemental feeding is done there. Thus, stocking on the native pasture is not based on what it will carry, but instead is based on the number that could be wintered, or carried on tame pasture during the months it was "good."

In summary, good land-use decisions must usually precede good range management. That is why rangemen must consider land capabilities and land uses in relation to where the herd will be for the 12 months, as well as range management, on most livestock producing units.

Dr. E. J. Dyksterhuis,
Range Ecology
Dept. of Range Science,
Texas A & M

Dear Dr. Young:

I just received your Section Newsletter. I was very much impressed with your article "Perhaps Our Approach is Wrong."

I have had excellent results in selling range management here in Humboldt County without mentioning livestock numbers. It has been an intensive range educational job, but has paid off. Dollars are what we are interested in.

D. W. Cooper, President
California Section—ASRM

Dear Mr. Young:

I want to tell you how much I enjoyed your recent article in the Texas Section Newsletter. I, like you, have spent considerable thought as to what flaw in our reasoning has contributed to our ineffectiveness in getting range management on the ground. I know you agree that we just aren't getting the job done—all it takes is one trip by automobile across the state to be convinced of that. I believe that you have really hit close to home as to the "why."

The key to more popular range management is not just reduced stocking, which incidentally is our most common image in the state, but increased production leading to increased stocking.

We as members of the chemical industry have long attempted to sell products by this philosophy, and I have yet to observe a properly timed herbicide application which did not increase usable forage by twofold. This increased production indirectly leads to more production per animal, and less grazing pressure on the land while holding stocking at a constant level.

Conservation is an important word, an important word in our organization's constitution, but conservation can be made much more attractive by drawing its picture in dollar signs.

I think your comments are certainly well taken and should help launch us in a better oriented direction toward leadership in the science of grazing land management.

Phil J. Phillips,
Director Res. & Development
Stull Chemical Company

CHANGE OF ADDRESS

Due to a change in location of our branch post office our box number has been changed to 13302. Please use it in correspondence.

Erratum

In the November, 1966 issue, page 383, column one, the article on range production by Albert P. Thatcher quotes Brown and Everson (1952) as increasing rangeland productivity "25-fold"; this should read "2.5-fold."

LETTERS TO THE EDITOR

Letters may be accepted for publication which contribute to the objectives of the American Society of Range Management. The Society however, assumes no responsibility for statements and opinions by contributors.

Dear Sir:

I recently received my Journal Range Management for September, 1966. After reviewing the contents I was further convinced that the ASRM should have two publications. The current issue is strictly a conglomeration of technical and non-technical papers, and this situation should be corrected.

If two publications were offered, as does the Society of American Foresters for instance, then conditions as noted above would not exist, or would be minimized. Distinguished people in the field of Range Management (how about Range Science?), such as Dr. L. A. Stoddart or Mr. William Hurst, emphasize that the Society attempts to bring the rancher and technical person into closer contact, and dual use of the Journal is one means for obtaining this objective. I would maintain that such a policy is actually harmful to the Society in the following ways:

1. Dual servicing by the Journal is an effort to cater toward a small minority of non-technical persons, this detracting from the professional quality of the Journal,
2. Many research people shy away from the JRM and publish elsewhere, even when the material is range oriented,
3. People outside the field of range management judge the Society by its publication, and to date the judgments have been rather critical.

My personal opinion is that the Society would actually increase total membership and gain new respect among current members and those with related interests in other fields if two publications were offered. I think more ranchers and non-technical people would also join the Society, as a publication would be directed to them in language they could understand.

I know I am not alone in my feeling on this subject. I also know that the Society is striving to fulfill the needs of a rather diverse group, both in interests and attitudes. Please accept this short note as an expression of my feelings on one phase of Society business.

Yours truly,
Gerald F. Gifford
Reno, Nevada

Dear Sir:

The September issue of the Journal just hit my desk. Congratulations are well deserved for putting out this masterpiece. I feel you have come up with a combination of interest items which will fill a long-felt need and desire in many areas. This should have the effect of alleviating the anxieties of many ranchers and still satisfy the technicians. I hope you will continue to fill in with other items of such high quality.

Sincerely yours,
Eamor C. Nord
Riverside, California

WITH THE SECTIONS

TEXAS

Two Texas ranchers were presented certificates of merit October 14, 1966 at the noon luncheon of the Fourth Annual Ranch Management Conference held on Texas Tech campus.

Awards were made to Rob Brown of Throckmorton and O. J. Barron of Spur. Presenting the awards on behalf of Texas Tech Chapter of Texas Section of the American Society of Range Management was George Mitchell, Chapter President.

Brown is a director of the Texas Section of ASRM and a member of the Texas Experiment Ranch Committee. He also is a director of the Texas and Southwestern Cattle Raisers Association and the Tech Ex-Students Association. He was honored for ranch management achievements including a four pasture deferred rotation system, feed lot combination with grazing system and range improvements.

Barron, manager of Spur Headquarter Ranch, has been a leader in developing a cattle cross-breeding system and range and drylot combination system. His deferred rotation system and water spreading has resulted in rangeland improvement. He is a member of the Board of the Texas and Southwestern Cattle Feeders Association, and is on the governing body of the Texas Experiment Ranch at Throckmorton.

The twelfth annual Range Camp was held by the Texas Section August 1-6 at Texas A. and M. Thirty trainees were in attendance this year, which brings the total to 362 boys, who have had the advantage of this training.

SOUTH DAKOTA

Ranchers and farmers traveling across Eastern Nebraska would find a profitable stop to view what is happening for better grass and beef production. Since 1963, the south half of the Nebraska Ordnance Plant at Mead on Highway 63 has been transformed from a vast field of popcorn to a large 3,500-acre grass-beef laboratory.

Under the guidance of Warren Sass of the Agronomy Dept. of the University of Nebraska, 1,000 acres per year were seeded with certified mixtures of both cool season and warm season, grasses. Various species were tested for Vigor, forage which is leafier, and disease tolerance.

The main objective of this area was to furnish up to 10 months' pasture for the breeding herd. Five other secondary objectives included pasture and livestock management.

People traveling in this area can observe new ideas to put into action back home.

SOUTHERN

The management of native cattle and grass on central Louisiana forest range was the subject of a field trip of the Southern Section.

Southern Section members listening to Harold Grelen explaining the results of his study on the effects of time of burning on forage yield of native grasses on cutover pine lands.

COLORADO

Ray Paddock, who co-authored a recent article in our Journal entitled "You Can't Turn 'Em Loose, or Can You?", has become a member of our Society. Ray who used to keep busy managing two sheep allotments, now finds himself spending a great deal of time showing off his allotment to other persons interested in good sheep and range management. During the last two weeks of August and the first week of September, he entertained almost 50 people as they toured one of his two non-herded allotments. Ray, who helped pioneer the non-herded, non-fenced type of sheep allotment management, talked to our Section at the fall meeting. We certainly welcome Ray to our membership and are proud to add his name to our growing list of stockmen members.

PACIFIC NORTHWEST

Keynoted by our Society President M. S. Morris of the Pacific Northwest

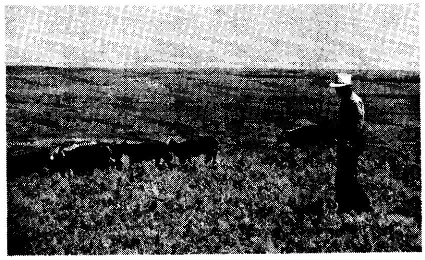
Joe Mohan, center, Chairman of the Section's Range Youth Camp Committee and the two top boys from the 1966 camps. Steven Nissen of White Swan, Wash., left and Chuck Ballard, of Dayville, Ore, right. **Boys were on an expense paid trip to the annual meeting of the Section.**

Section enjoyed another topnotch conference and program at the Ridpath Hotel in Spokane, Washington on November 28 and 29. From the illustrated talks by Dr. V. C. Brink of the University of British Columbia and George Garrison of the Forest Service research branch on their European tours last summer to the presentation of new officers at the end of the meeting, the 108 registrants were entertained, and edified by a program worthy of a Society meeting under the able direction of Robert W. Harris of Portland, Oregon. Features of the program were—panels on Range—Recreation Relationships where viewpoints from all angles were presented and a panel discussion on the Range Environment. Fun was had at the "Attitude Adjustment Hour" and the following banquet Mceed by our own Al MeLean of Kamloops B.C.

KANSAS-OKLAHOMA

Emmett W. McCord was appointed Extension Range and Forage Crops Specialist at Oklahoma State University in August, 1966. Prior to this, he was a County Agent in Coal County, Oklahoma. McCord received his B.S. in Agronomy at Oklahoma State University in 1951 and his M.S. in 1959 from Oklahoma State University, and plans to complete his Ph.D. in Forage Production in 1967. He belongs to the American Society of Range Management, American Society of Agronomy, and Epsilon Sigma Phi.

The Kansas-Oklahoma Section has made a recording of some early history of the Kansas Flint Hills country. Henry Rogler, father of longtime member Wayne Rogler, has lived on the same ranch in the Flint Hills near Matfield Green, Kansas



Henry Rogler, his cattle and range land in the Flint Hills where he was born in 1877 and has lived ever since.

since his birth in 1877. In a taped interview, he tells of some of the early day grazing and farming customs and range conditions as he has observed them through the years. This interesting and informative discussion can be had in ditto copy from the Kansas-Oklahoma Section.

The 1966 Fall Meeting was held in Manhattan on October 7 and 8. The banquet, meeting facilities, and tour were all excellent.

The tour participants heard discussions on such things as improved varieties of native grasses, catfish for commercial production, grass and steer response to different range management practices, and grasshopper investigations on Flint Hills range.

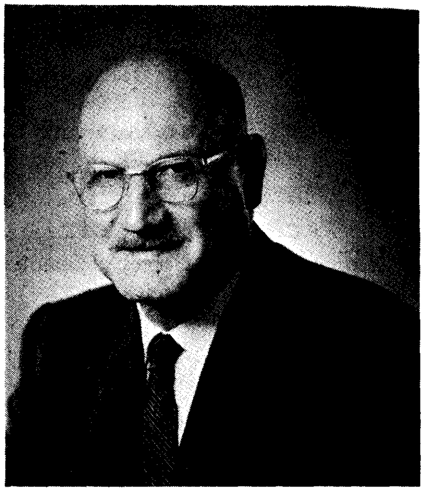
UTAH

Scholarship Award, The Utah Section $100 scholarship to the outstanding Senior Range Management student was awarded to Mr. George Wiggins, this year's Range Society President of the U.S.U. Chapter. George is a native of Elko, Nevada, who has demonstrated exceptional scholastic ability while at the same time being very active in extracurricular activities.

SOCIETY BUSINESS

Annual Report of the President

Melvin S. Morris
President, American Society of Range Management



It is hoped that this report will reveal that the American Society of Range Management has had a vigorous program this year, with a wide variety of activities representing a significant effort to achieve the aims and objectives of the Society.

Better communication between the membership and the Board of Directors should result from the creation of the Advisory Council of Section Presidents. This committee has been involved in several matters this year and is functioning well.

The activity of the Sections remains as the best measure of the strength of the Society. The field meetings are perhaps the most successful means of involving the membership in Society affairs. The opportunity for acquiring information; exchanging ideas and developing understanding among members occurs at such occasions. Programmed meetings which are more formal also provide an excellent opportunity for members to be active in Society affairs. I have attended three section and one chapter meeting for four Sections this past year and found them to be very stimulating. Program content was competitive with that of the annual meeting of the Society. Many of the Sections have excellent newsletters which provide an additional means of adding to the capability of the Society to serve more members. Special mention should be made of the South Dakota newsletter. It may be unique in selling subscriptions to non-members.

The Society has been represented at several important meetings in Washington, D. C. Dr. Ken Parker, Chairman of the Committee on Cooperation with Scientific Organizations ably coordinated the contacts with various organizations there as well as attending meetings. Bob Rummell represented the Society at a joint meeting with executive officers of the Society of American Foresters and the Wildlife Society to discuss mutual problems. Dr. Gerald Thomas represented us at a meeting on undergraduate education in the biological sciences for students in natural resources sponsored by the Commission on Education in Agriculture and Natural Resources, National Research Council, National Academy of Sciences. Dr. D. L. Klingman represented the Society at a joint meeting of the Policy Committee of Scientific Agricultural Societies to make recommendations to the Scientific Manpower Commission regarding the Selective Service System. Dr. C. E. Terrill attended the annual meeting of the Agricultural Research Institute. The International Biological Program meeting held in Washington was well attended by representatives of the Society. Bob Williams is our representative to the Grassland and Forage Council and participated in meetings of this organization. Dr. Don Cornelius was the official representative of the Society at the Tenth International Grassland Congress. He and several members presented papers at the meeting. Dr. Cornelius was also chairman of one of the panels. Society literature was made available to the delegates.

In any comparison with other professional societies, the program on youth activities is perhaps the one which should give us considerable satisfaction. Many of the Sections are directly or indirectly involved in range camps or achievement awards. Two $500 scholarships were also established by the Society this year. It is hoped that this will encourage outside financial support and permit us to enlarge the program. Student chapters at many universities are active and provide a means of encouraging recruitment into the profession. The range plant contest at the annual meeting stands at the apex of the preprofessional activities of the youth program. Effectiveness of our program will increase as greater participation is developed throughout the Sections.

A resolution was approved and sent to several members of Congress protesting contemplated changes in research programs and reduction of services to agriculture. A resolution on range management requirements, approved by the Board, was sent to several of the federal agencies and to the Civil Service Commission. We were pleased to learn that the requirements were raised, even though the full recommendations were not achieved. Careful attention was given to two bills still under consideration by Congress. One deals with congressional approval of appointments to the position of bureau chiefs. The other is an ecological bill sponsored by Senator Nelson, of Wisconsin, and deals with ecological research on public lands.

The Journal Study Committee, under the direction of Don Cox, continues to study ways and means of meeting the wide range of interests of members for *Journal* content. Charles Leinweber has been studying the possibilities of developing a research supplement to the *Journal* which will segregate some of the more technical papers, as well as provide a publication outlet for longer papers. The *Journal* continues to represent a real achievement of the Society and is readily available as a publication outlet. Our subscription list is quite large, reaching around the world. The *Journal* has had additional financing this year to better serve the Society and the profession.

Society membership show little gain over 1966. This leveling off in membership should not indicate that we are reaching the limit of potential for an organization of this kind. The number of technical people in range and range related work are many and should make a substantial addition to the membership. The greatest potential source of members is among the ranchers. They are the individuals with the greatest interest in range resource. A large share of their investment capital is in range. Production costs and returns are directly tied to forage management. Ranchers, generally, need to support and encourage research in range. They have no choice but good management. They should also share the responsibility for making the Society a significant force in the conservation field. If membership is to grow, the individuals making up the present membership will have to do the job.

A comprehensive public relations plan has been developed by our Public Relations Committee and approved by the Board of Directors. As this plan is implemented by the Society, it should do much to create a greater awareness of the importance of the range resource. One significant step taken by the Society in this direction has been to meet with representatives of the two major livestock associations with a proposal for joint action in a program of public education in range matters. If this proposal is approved by the officers of these two organizations, we will be committed to developing such a program. It is also expected that we ask other groups such as the Western Cattlemen's Association of Canada to join with us. Much more can be said about the need for increasing public interest in rangeland use and management. The ASRM is at the threshold of a major opportunity of providing significant leadership and to secure support for a program on the development and use of this major resource.

The first steps were taken in July to reorganize the operational procedure of the Society. An editorial assistant was employed to assist John Clouston in the enlarged responsibilities of the Executive-Secretary's office. This position will eventually enlarge into a managing editor's position. All the business and mechanical matters pertaining to the production of the *Journal* will center here. This will relieve the Editor of considerable work which can be done effectively elsewhere and free him for the more difficult and particular work of selection and editing of the professional papers.

The resolution from the Pacific Northwest Section on "Natural Areas" was approved in principle by the Board of Directors and a majority of Section Presidents. A temporary committee, with Bill Anderson as chairman, was established for consideration of this project. Formation of Section committees was encouraged and many Sections became involved in studying the need and possibilities in such a program. Recommendations from the Advisory Council and the kind of action taken by the Board of Directors at the Seattle meeting will determine the direction the Society will take on this matter. At this time, I can only encourage positive action by the Society. We, as a professional group, have greater need than almost any other group to develop such a program. The use of suitable reference areas is a part of our techniques in management recommendations over a large portion of the range area. We are in a unique position to involve vegetation types which are in private ownership. We are perhaps the last of the professional and scientific organizations to become concerned with "nature areas"; programs properly developed can engage a large number of the membership in a Society activity. I feel that we are at least ten years behind in work of this kind.

The Board of Directors approved the granting of recognition awards to five individuals for their contribution to the field of range management. The intent here is to recognize achievement of many people. We intend to make this an annual affair. We expect that our Committee on Awards will present a plan for establishing procedure for naming of fellows of the Society. A program of this kind is needed.

The program at the Seattle meeting will be somewhat different from those previously held. Attention is given to subjects not directly related to range, but in the field of natural resources. The position taken in developing the program was that the Society must enlarge its field of interest and give its members an opportunity to become acquainted with matters other than the range itself. The program was also planned to give maximum opportunity to a large number of technical and research people to participate in the program. The program is comprehensive and should appeal to a wide range of interests. The Program Committee and Local Arrangements Committee have worked long and hard to make the meeting a successful one. It is our hope that it will attract a large attendance to justify the efforts made to provide the program.

Finally, this has been a busy year for me. The accomplishments of the Society have been those of the membership itself. The President and the Board have tried to serve by implementing and directing the ideas which come from the membership. We need to acknowledge the excellent work done by our Executive Secretary, John Clouston, and by Dr. R. S. Campbell, Editor of the *Journal*. These two men had to meet the day-to-day deadlines in much of our Society business. Dr. Dillard Gates and his Program Committee, and Wallace Hoffman and the Local Arrangements Committee have carried a major load this past year. We owe them much for their accomplishments. To many of you, to Section officers, to the Board, to all the newsletter editors and hundreds of others, I wish to extend my appreciation for your contributions to a very active Society. To my successor, Dr. C. W. Cook, I can say you have our best wishes and cooperation for a successful year ahead.

In the largest vote in the history of the Society, more than 2,000 ballots, three new officers were elected to assume office in February at the annual convention.

To serve as President-Elect in 1967 and to assume the Presidency in 1968 the members chose Dr. E. J. Dyksterhuis of Texas A. & M. The two directors to serve three year terms are Laurence E. Riordan, assistant Director, Colorado Game, Fish and Parks Department and Sherman Ewing. cattle rancher from Claresholm, Alberta, Canada.

The Journal wishes these men successful terms of office during a time when great change in the Society affairs is expected.