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DRYLAND GRASS SEEDING IN WYOMING

By
O. K. Barnes, R. L. Lang, and A. A. Beetle

June 1950
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Dryland Grass Seeding in Wyoming

By
O. K. BARNES, R. L. LANG, AND A. A. BEETLE*

INTRODUCTION

A natural vegetative cover is dependent on a balance of nature which is frequently disturbed either by natural causes or by man. Thus fire, flood, and drought take their own toll or indirectly cause temporary excess of grazing by wild animals and domestic livestock. Man, too, by cutting of the forest, cultivation, and drainage may cause similar disturbances, any of which may necessitate artificial reseeding.

Normally there are balanced relationships between the soil and the plants which result in plant societies; for example in Wyoming, correlated with rainfall and elevation are the deserts, the plains, the sagebrush transitions, the timbered mountain slopes, and the alpine summits, to name only the most obvious. The balance between plants and soil, and between different species of plants, is a reality only at a given time. Over any period there is a change, the geologic processes of erosion and soil building, and the change in the make-up of plant associations as the soil changes.

While good range management—through the proper period of grazing use by the kind and numbers of livestock best suited to the area—can prevent all but the most unusual causes of overgrazing, there still remain the fire hazard, abandonment of cultivation, drainage, and other activities which are normal in agricul-

ACKNOWLEDGMENT

The work reported in the section “Seeding in the Plains” was started by Mr. W. W. Austin, formerly assistant chief of the Regional Nursery Division, Soil Conservation Service, Lincoln, Nebraska, in cooperation with the Wyoming Experiment Station and the Federal Bureau of Plant Industry. The Research Division of the Soil Conservation Service entered into this work in 1940. Mr. A. L. Nelson, agronomist in the Bureau of Plant Industry and superintendent of the Archer Field Station, has actively participated in this work from the beginning.

*Respectively:
Associate Agronomist, Soil Conservation Service, Research Division; Associate Agronomist, University of Wyoming; Associate Agronomist, University of Wyoming.
tural pursuits. Artificial revegetation can be used to (1) heal scars made by forest burns, (2) make sagebrush lands more productive, (3) heal road cuts and aid in the maintenance of highways, (4) restore more rapidly the productive capacity of abandoned farm land, and (5) alleviate gully, sheet, and stream-bank erosion.

The objective in this report is to bring together a summary of artificial reseeding work as to the methods of seeding and as to species adapted to various non-irrigated situations in Wyoming.

HISTORY OF RANGE SEEDING IN WYOMING

Aven Nelson, through his thorough botanical exploration work and floral collections which not only built the Rocky Mountain Herbarium but supplied material to specialists the world over, made the first large contribution to the basic knowledge upon which depends any agronomic attempt at establishment of vegetation. The value of the early work of B. C. Buffum, Elias Nelson, and H. G. Knight depended greatly on his identifications. The naming of range grasses and the delimiting of their ranges still depend greatly on his specimens.

Although the work of Buffum was of short duration, it is worthy of mention as the first work attempted by the newly founded Wyoming Agricultural Experiment Station. As reported in Station Bulletin 16 (1893), dryland establishment of 20 species, of which 10 were grasses, was attempted at Laramie. Notable among these was smooth brome, a grass which has not even yet reached its full potential in Wyoming.

Elias Nelson, working for the Experiment Station from 1902 to 1907, had a primary interest in forage plants, of which he had an intimate knowledge that has seldom been matched since. He published both technical and popular articles on forage plants, not only describing new species but bringing the potentialities of smooth brome, hairgrass, sheep's fescue, and the like to the attention of the ranchers. With few changes his "Forage Plants for Arid Regions" (April 1902), "Forage Plants for Arid and Semi-arid Regions" (March 1902), "Cultivated Hay Grasses and Forage Plants" (May 1902), "Native Hay Grasses in Arid Regions" (April 1902), and "Forage Plants for Alkali Lands" (May 1902), originally printed in the Twentieth Century Farmer, could be reprinted with profit today.
From 1907 until revival of interest in the 1930's very little of either time or money was spent on trials of forage grasses in Wyoming. The only exception worthy of mention is the trials on crested wheatgrass carried on by R. S. Towle at Sheridan and by A. L. Nelson at Archer. With the drought years of the 1930's, interest was revived in range problems, and increased government expenditures led to new experimental work conducted by the Agricultural Experiment Station, the U. S. Soil Conservation Service, the U. S. Bureau of Plant Industry, and, to a very limited extent, the U. S. Forest Service. Location of the forest and range experiment stations in Montana, Utah, and Colorado led to much research which had application to Wyoming conditions, but very little work was actually carried on within the borders of Wyoming.

In order to evaluate the results of the increased expenditures on range-revegetation research during the years since the Great Drought, a questionnaire was sent to county agents and Forest Service and Soil Conservation officials within the state to determine what program had been in operation and what was to be expected. This questionnaire brought out the following facts:

(1) Reseeding interest dies down during years of good moisture. This is, of course, unfortunate because it is during these years that the greatest benefits can be expected from such a program.

(2) Although the limitations of crested wheatgrass are recognized, it is still the only grass receiving any great attention. It is the mainstay of all reseeding programs throughout the state. Smooth brome, western wheatgrass, and sweet clover are the only other plants used to any extent.

(3) Much more is known about reseeding than is put into practice in mountain areas. Many chances to protect disturbed areas, or to increase the productivity of meadows, are neglected.

(4) Reseeding in the desert areas has been very limited, because it is recognized that ordinary methods are not adapted to these arid conditions. More extensive reseeding in these areas awaits further research.

(5) Goshen County leads all others in the amount of reseeding undertaken, and Eastern Wyoming in general leads the rest of the state. Abandoned farm land, deteriorated shortgrass plains, and heavy sagebrush areas have received the most attention, generally with good success.

(6) Pellet and airplane seeding, still in the experimental stage, have received only very limited trials in Wyoming.
SEEDING IN THE MOUNTAINS

The high elevations in Wyoming present a problem in revegetation distinct from that of the plains, desert, or sagebrush transition. Most of this land is potentially either forest or meadow. Fire has been the principal disturbing influence and probably will continue to be. Although the effects of fire may be ameliorated (see part on reseeding after burns), such areas have usually been neglected.

On truly alpine areas, usually above 10,000 feet, little is known of the plants that can be sown. There is need to develop a commercial source of seed of some plant which is adapted to this extreme. The best possibilities would appear to lie in selection of tufted hairgrass (*Deschampsia caespitosa*) for wet sites and *Festuca ovina* (the alpine form) for dry sites. The only other grasses reported to any extent above tree line include five bents, *Agrostis bakeri*, *A. humilis*, *A. idahoensis*, *A. rossae*, and *A. thurberiana*, and four poas, *Poa alpina*, *P. artica*, *P. lettermannii*, and *P. rupicola*. With the addition of *Alopecurus alpinus* the end is reached of the alpine grasses in Wyoming.

Between the alpine zone and the lower transition belts of sagebrush and deerbrush lie the principal timbered slopes of Wyoming, largely within national forest boundaries and for the most part between 8,000 and 10,000 feet elevations. Within this belt may be found fully one-half of the roughly 200 grasses known in Wyoming. Of these about 9 are strictly aquatics; another 15 are primarily associated with open meadows. The rest occur on a variety of slopes, exposures, and soils supplying the principal feed for cattle and sheep in mixed associations.

The nine aquatic grasses are *Alopecurus aequalis*, *Bechmannia syzigachne*, *Catagrosa aquatica*, *Cinna latifolia*, *Glyceria borealis*, *G. elata*, *G. grandis*, *G. pauciflora*, and *G. striata*. Since disturbance in these areas is rare, there is seldom any necessity for reseeding aquatics. However, these grasses, as well as certain aquatic sedges and rushes, should be kept in mind for planting around newly formed bodies of water behind dams. Although these species will spread naturally and fairly rapidly, a program of planting will greatly hasten an increase in wildlife about such areas.

The 15 meadow grasses include some of the best-known grasses in Wyoming and some of those of which seed is most available. They are *Agropyron repens*, *Agrostis alba*, *A. exarata*, *A. hiemalis*, *Bromus inermis*, *Calamagrostis canadensis*, *C. inexpansa*, *Dactylis*
FIG. 1—Slender Wheatgrass Seeded in the Pole Mountain Nursery Area. Elevation 8600 ft.
glomerata, Deschampsia caespitosa, Festuca elatior, Hordeum nodosum, Phalaris arundinacea, Phleum pratense, Poa palustris, and P. pratensis. Abundance of any of these in mountain meadows may be considered as an indication of good conditions. Of these, tufted hairgrass is the best of the natives and is widely recognized as indicating native meadows of high quality. Of the introduced and cultivated grasses, timothy has received the most attention and produces hay of good quality, particularly if cut at the proper stage of maturity. Smooth brome, increasingly important, is slowly replacing timothy as the most important hay grass in Wyoming. This grass shows particular promise in mixture with alfalfa and/or other legumes.

FIG. 2—Timothy and Redtop Seeded Near a Stream in the Mountains.

As there was little experimental evidence of the adaptability of various new introduced grasses and of many natives to the different altitudinal conditions common in the mountains, an adaptation nursery was established at each of three elevations in 1948. The lowest of these nurseries was established at the experimental farm west of Laramie, Wyoming, at an elevation of approximately
7400 feet above sea level. The next higher nursery was established on Pole Mountain at an elevation of 8500 feet, and the highest was established in the upper limits of the spruce/ fir at an approximate elevation of 10,500 feet.

Although only one year's data have been collected from the two lowest nurseries, these data seem to indicate that tall wheatgrass (Agropyron elongatum) intermediate wheatgrass (Agropyron intermedium) and Canada wildrye (Elymus canadensis) are the most productive at the lowest elevation, although Russian wildrye, Primar slender wheatgrass, and western wheatgrass were equally well established.

Tall wheatgrass, smooth brome, Russian wildrye, Primar slender wheatgrass, and meadow foxtail (Alopecurus pratensis) have all appeared to be well adapted at the 8500-foot level.

Information obtained from these nurseries will be of great value in the future in recommending the proper species for high elevation sites in need of revegetation.

SEEDING IN THE DESERT

The desert lands of Wyoming are considered to be those having less than 10 inches of precipitation annually. In their natural state these lands usually support vegetation which is predominantly browse, although there is a scattered stand of drouth-resistant grasses and forbs mixed in with the browse.

On the lowlands, which are usually quite alkaline in character, the saltbushes (Atriplex spp.) and greasewood (Sarcobatus vermiculatus) are the dominant species present. However, there may be present considerable amounts of such grasses as squirreltail (Sitanion hystrix), western wheatgrass (Agropyron smithii), and saltgrass (Distichlis stricta), depending upon the alkalinity of the soil.

On the higher lands, which do not contain as great concentration of alkali, the predominant shrubs are sagebrush (Artemisia tridentata), shadscale (Atriplex confertifolia), winterfat (Euratia lanata), and various species of rabbitbrush (Chrysothamnus). The most commonly found grass and grasslike species are thickspike wheatgrass (Agropyron dasystachyum), Indian ricegrass (Oryzopsis hymenoides), Sandberg's bluegrass (Poa secunda), and thread-leaf sedge (Carex filifolia).

Many other species of shrubs, forbs, and grasses are present usually in minor quantities, but the above-named plants are those most common to the desert areas.
Because of the low rainfall and the tendency for alkali conditions to be prevalent, seeding in the desert areas is quite hazardous. The species used must be adapted to these conditions of extreme aridity and alkaline soils.

Generally it is best to use a method of seeding which will put the seed at the proper depth under the soil. However, under conditions of very sandy soils it may be possible to obtain good stands by broadcast seeding with no further treatment than the trampling by sheep as they graze over the area during the following fall and winter. Outstanding examples of this may be noted by two experiments carried out by the United States Grazing Service in the vicinity of Rock Springs, Wyoming.

FIG. 3—A Young Stand of Crested Wheatgrass Seeded into a Sagebrush Area in the Red Desert of Wyoming.

The first of these experiments was a hand broadcasting in early May of 1940 of one strip (approximately 10 acres) each of crested wheatgrass (*Agropyron cristatum*), slender wheatgrass (*Agropyron trachycaulum*), and western wheatgrass (*Agropyron smithii*). Of the three species used, only the crested wheatgrass has become established, persisting to date. Inspected in September of 1947, this seeding of crested wheatgrass showed an excellent stand of vigorous plants and many young plants, apparently from seed produced on the area.

The second seeding trial referred to above was an airplane seeding on April 12, 1946. The area seeded was 1,250 acres at the
rate of $5\frac{1}{2}$ pounds of crested wheatgrass seed per acre. In fall 1947 this area showed a good stand of crested wheatgrass seedlings which were apparently well established, and it is expected that they will persist as well as the hand-broadcast seeding previously described. It must be emphasized that both of these trials were on very sandy soils and that on these soils the seeds tend to become covered because of the action of the elements as well as by the movement of sheep during their winter grazing of the area.

Earlier seeding trials in the vicinity of Church Buttes were conducted in winter of 1940, spring of 1941, and spring of 1943. Although six grass species were tried on some of these tests, a check in 1947 showed that fair to good stands were attained only with crested wheatgrass and western wheatgrass. The plots of species which had the best stands were those on which the area had been disked after broadcasting the seed to attain seed coverage.

Other seeding trials also in the vicinity of Church Buttes were started in the fall of 1944 and repeated each spring and fall through the fall of 1949. Four species are seeded in replicated plots. The seed was broadcast and covered with a disc. The species used have been varied since the original 1944 seeding with the following results:

1. Fair to excellent stands obtained with crested wheatgrass seeded either in the early spring (usually April) or the early fall (about September 10), from every seeding during the 5-year trial period.
2. Western wheatgrass and intermediate wheatgrass were substituted for four-wing saltbush in 1946 and Indian ricegrass in 1947. Satisfactory stands were obtained only from the fall of 1948 seeding.
3. Poor-to-no stands obtained with Indian ricegrass, four-wing saltbush, and Russian wildrye.

In summing up the available data regarding desert seeding trials, it should be noted that of the species tried to date, crested wheatgrass has proved to be the outstanding successful species, with western wheatgrass as the second most easily established.

Some coverage for the seed should be given if at all possible. Broadcasting followed by diskng gives some coverage for the seed in addition to eliminating a portion of the brush usually present.

Broadcasting with no mechanical coverage, either by hand or by airplane, has proved successful on very sandy soil types but
must be considered a more risky procedure than one in which some type of mechanical coverage may be attained.

SEEDING IN THE PLAINS

Extent of Research

As has been previously indicated, the greatest amount of grass seeding has been accomplished in the plains of Eastern Wyoming. Likewise the greatest amount of research pertaining to seeding has been conducted in this area.

A. L. Nelson reported in 1933 on a study of grass establishment and species adaptation at the Archer Station. The work reported here is an elaboration of his earlier study.

Most of the seeding studies reported here have been on cultivated lands, although a small amount of work has been conducted in attempting to establish grasses and/or legumes in the unbroken native range.

FIG. 4—A Drilled Stand of Russian Wildrye and Crested Wheatgrass Seeded in the Plains Area of Wyoming.

Species Seeded for Adaptation Studies

Between 1936 and 1948, grass adaptation nurseries of more than 30 species and strains were established at the Archer, Sheridan, and Gillette Stations in the plains area of Wyoming. With a few minor exceptions the same species succeeded at all three locations. The Sheridan Station has a slightly higher average precipitation than either of the other two locations. During the periods of these tests the precipitation was about two inches
above the long-time average for Sheridan, whereas at least one year of moisture deficiency occurred at the other two locations.

Standard crested wheatgrass, fairway crested wheatgrass, western wheatgrass, and Russian wildrye were the outstanding species for all three locations from the standpoint of ease of establishment and ability to resist weed competition and drouth.

Indian ricegrass, green needlegrass, slender wheatgrass, and smooth brome were apparently adapted at these locations but are not equal to the above grasses in yield or ability to compete against weeds.

Blue grama produced satisfactory stands only at the Archer Station in later trials. The early failures with this species probably were due to the use of fall and early spring seeding dates in the early adaptation trials. Late spring seeding was found to be the proper time to seed blue grama, and such seedlings have been successful at the Archer Station. Successful establishment of blue grama properly seeded could be expected at the other locations or under similar conditions.

Species that became established but were short-lived from lack of ability to persist against weed competition, to drouth, or to lack of winter hardiness included:

- Beardless wheatgrass
- Bluebunch wheatgrass
- Sand dropseed
- Prairie junegrass
- Canada wildrye
- Sandberg bluegrass
- Nevada bluegrass
- Mountain brome

Other species became established in the first year but survived only when planted in 35-inch rows. These species appeared to have little or no value for reseeding in the plains area and included:

- Big bluestem
- Little bluestem
- Sideoats grama
- Hairy grama
- Rescue brome
- Prairie sandreed
- Idaho fescue
- Switchgrass
- Reed canarygrass
- Creeping bentgrass
- Giant wildrye

Intermediate wheatgrass and tall wheatgrass have recently received considerable attention for reseeding. Both species appear important for reseeding in Wyoming but have been included in tests for only a short period. Preliminary results indicate that intermediate wheatgrass is well adapted to the better dryland
situations, but not equal to crested wheatgrass on extremely dry areas. Tall wheatgrass appears to be important in reseeding alkali areas.

**FORAGE PRODUCTION:** Hay yields were determined by clipping the grass at about the bloom stage. From each drilled plot three permanent square-meter plots were clipped to determine yields. Any regrowth that occurred was not included in these yields; in some years this would add a considerable amount. The hay yields obtained from seedings at the Archer and Sheridan Stations are given in Table 1.

<table>
<thead>
<tr>
<th>Table 1—Hay Yields from Drilled Grass Plots¹</th>
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<tbody>
<tr>
<td><strong>Species</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Standard crested wheatgrass</td>
</tr>
<tr>
<td>Fairway crested wheatgrass</td>
</tr>
<tr>
<td>Western wheatgrass</td>
</tr>
<tr>
<td>Russian wildrye</td>
</tr>
<tr>
<td>Green needlegrass</td>
</tr>
<tr>
<td>Indian ricegrass</td>
</tr>
<tr>
<td>Smooth brome</td>
</tr>
<tr>
<td>Mountain brome</td>
</tr>
<tr>
<td>Canada wildrye</td>
</tr>
<tr>
<td>Sandberg bluegrass</td>
</tr>
<tr>
<td>Grass-legume mixture²</td>
</tr>
</tbody>
</table>

¹ Average yields for 1940 to 1942 at Archer and 1939 to 1942 at the Sheridan Station.

² Mixture includes 20% western wheatgrass and 20% crested wheatgrass, 10% blue grama, 20% green needlegrass, 20% Russian wildrye, and 10% Ladak alfalfa. At Sheridan, smooth brome (10%) was included in this mixture at the expense of 10% western wheatgrass. All other species were in the same proportions as above. The rate of seeding was approximately 10 pounds per acre.

Later studies show that the fairway crested wheatgrass does not maintain its production quite as well as the standard strain, although the difference is small. Either strain ranks at the top in production among the species tested on the plains.

Western wheatgrass, while lower in hay production than crested wheatgrass, has proved to be a valuable, hardy species in reseeding work. This species produces the most ground cover of any of the grasses included in these trials.
Russian wildrye is strictly a pasture-type grass, although it was included with these other species for hay measurements. As may be noted from Table 1, smooth brome ranked high in forage yield among the species tested at the Sheridan Station. However, in other studies reported by Sheridan, and over a longer period, smooth brome seeded without a legume shows a yield about 25 percent below crested wheatgrass. At the Archer Station smooth brome ranked low in yield. The stand has persisted, but moisture conditions are a little below the requirement for good production.

The grass-legume mixture at the Sheridan Station produced about the same volume of hay as crested wheatgrass alone. At the Archer Station it was slightly under the production of crested wheatgrass alone for the 3-year period considered in these yield comparisons. It is probable that, if yields had been measured over a longer period, the presence of a legume would show the mixture to better advantage in comparison with the grasses seeded alone.

**Seedbed Preparation**

Preparation of a suitable seedbed is an important step in getting a successful stand of grass. Grasses need to be seeded on a firm seedbed with as little competition from weeds as possible.

Comparison of grass seedings was made on summer fallow, small grain stubble, corn stubble, and sudan grass stubble. During the period of this study, 1940 to 1943, favorable moisture conditions prevailed. Consequently, large differences between methods of seeding did not develop. However, certain points were emphasized by the situation and general trends brought out.

Seedings on summer fallow and corn stubble generally resulted in good stands when planted in the spring. Planting on this type of seedbed in the fall is risky because of wind action during the winter. For this reason the average stand establishment was higher on stubble land than from fallow or corn stubble when the four dates of seeding are considered. Use of a nurse crop of small grain seeded with grass or at the time the grass is seeded proved to be a poor practice. The nurse crop failed to protect the grass seedlings during the winter and offered excessive competition to grass establishment during the first growing season. In some instances the nurse crop noticeably set the grass stand back several years.

All of the indications from this study have been that seeding into relatively clean stubble is the best seedbed. Protection is afforded the seedlings against wind damage during the winter.
besides some shading during the first growing season. Sudan grass stubble was the outstanding seedbed. This stubble was stronger and held up better than small grain. However, satisfactory stands were obtained on both types of stubble.

In general, duckfooting or diskimg the stubble before seeding showed no advantage over drilling the seed directly into the stubble. The advantage of prior tillage, of course, comes from reduced competition from weeds and volunteer grain. The disadvantage comes from having a loose and often rough, uneven seedbed. Under the conditions of this study this disadvantage had as much or more effect on the grass stand than did the competition from weeds or volunteer grain. Tillage for spring seedings showed very slight advantage over no tillage, although not enough to justify the operation.

Under conditions where a dense weed or volunteer-grain stand exists in the stubble, a tillage operation prior to seeding the grass would be advisable. Packing the seedbed after tillage or seeding operation will generally improve the stand.

**Implements and Methods**

A single-disc surface drill and double-disc deep-furrow-type drill were the two types of implements tested in this study. The deep-furrow drill gave slightly better results than the surface drill, as it throws up a ridge and plants the seed into firmer and moister ground. During the period of this study there was no great difference between these two drills, although, if both types were available, the deep-furrow drill appears best under conditions at this location; in addition, on weedy ground with no prior tillage, the deep-furrow type would have the advantage of eliminating some weed competition which the surface drill would not.

**Date of Seeding**

Four dates of seeding during this 3-year period were compared. The early September and early April dates were distinctly superior to the early May dates of seeding and slightly better than the late October seeding of the cool-season species such as western wheatgrass, crested wheatgrass, and Russian wildrye. There was little difference between the seedings made at approximately September 10 and April 1 each year on stubble land. On clean-tilled ground, in one year out of the three, the grass stand for fall seedings was almost a total failure because of wind action; consequently, clean-tilled land should be seeded in early April to obtain the best stands with the least risk of failure.
Blue grama grass seedings in the fall failed completely, and the May seedings were far superior to those made in early April. Blue grama is a warm-season grass and it appears that seeding during the fore part of May is the best date of seeding for this species.

Smooth brome grass seeded in early September or early May resulted in better stands than when it was seeded in late October or early April.

Mixtures of cool-season grasses with sweet clover and alfalfa seeded in the spring resulted in the best stands of alfalfa. In 1946 there was four times more alfalfa in the mixture seeded in early April of 1940 and 1941 than in the early fall seeding made during these same two years.

**Depth of Seeding**

Excepting for a broadcast type of seeding and that made at one-half to one-inch depth with the surface drill, comparative studies of seeding depths were not undertaken. The shallow seeding with the surface drill was accomplished by letting the discs just ride the surface. This resulted in covering the seed by about one-fourth inch of soil and generally gave satisfactory stands although not equal to deeper seedings.

All available information and general observations indicate that crested wheatgrass and other grasses of similar size of seed should not be covered more than an average of one inch of soil and preferably one-half to three-quarters of an inch. For blue grama, a maximum seeding depth of about one-quarter inch is recommended.

The small seeded grasses should be covered with less soil than large seeded grasses, and the depth of seeding for any species would be less in a heavy type of soil than in a sandy type of soil.

**Row Spacing**

Data collected at the Archer and Sheridan Stations indicate that hay yields are slightly higher from drilled plantings than from the wide-spaced rows. See Table 2.

**Table 2—Crested Wheatgrass Hay Yields**

<table>
<thead>
<tr>
<th></th>
<th>7-in drill rows (Pounds per acre)</th>
<th>35-inch rows (Pounds per acre)</th>
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<tbody>
<tr>
<td>Archer station</td>
<td>1462</td>
<td>1323</td>
</tr>
<tr>
<td>Sheridan station</td>
<td>1925</td>
<td>1875</td>
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</table>

*Taken from Annual Reports of Sheridan Field Station.*
In extremely dry years the wide-spaced rows have shown some advantage in production. However, the average yields have not shown the wide-row spacing to be advantageous. The actual ground cover on established drilled stands of crested wheatgrass has run approximately double the amount of cover on established 35-inch row plantings.

There appears to be some variation in species response to close vs. wide-spaced plantings. Russian wildrye in the few comparisons made shows a somewhat higher yield in wide-spaced plantings. Western wheatgrass often becomes quite dense after a few years; the drilled plantings are, of course, the first to thicken. In dry years an excessively thick stand of western wheatgrass shows the greatest decline in forage production. However, for crested wheatgrass, which is the principal species used at this time for reseeding, the results indicate no advantage for wide-spaced row plantings for forage or hay production. Nelson reported in 1933 on a row-spacing study at Archer. A 5-year average hay yield shows 1224 pounds of crested wheatgrass per acre with 35-inch rows as compared to 1220 pounds from 7-inch row spacing. This study reported very slight differences for a mixture of alfalfa and crested wheatgrass in rows 17 inches apart as compared to rows 3½ inches apart.

**SUMMARY AND CONCLUSIONS**

The seeding of certain types of range lands in Wyoming is an important range-improvement practice. The establishment of grass, which was once thought to be a very difficult and hazardous undertaking, has been proved, through research, to be a relatively simple and successful procedure in many areas if attention is paid to the small details of seeding methods and to selection of species best adapted to the site involved.

Wyoming has a great diversity of topography, climatic conditions, and soils, and consequently no single species or establishment method can be recommended for all. General recommendations as to seed coverage, preparation of a firm seedbed, elimination of competition, etc. may well be applied to all locations, but the varieties must be selected for their adaptation to site, and the actual method of putting the seed into the soil must be modified to conform to the physical characteristics of the site involved.

Less is known about species adaptation and seeding methods for the high elevations than for other areas. However, many of the newer cultivated species and strains of grasses, as well as many
of the natives, are showing promise for the mountain areas. Principal grasses which seem to be promising for high-elevation seedings are: Tall wheatgrass, meadow foxtail, Primar slender wheatgrass, Russian wildrye, smooth brome, and such natives as tufted hairgrass.

On the desert areas, where the annual precipitation averages under 10 inches, consistently good results have been obtained only with seedings of crested wheatgrass. Seeding in the early fall (about September 10) and early spring (about April 10) have been equally successful in establishing this species. Western wheat-

FIG. 5—Russian Wildryegrass Seeded in the Mountains of Wyoming. Elevation approximately 8600 ft.
grass and Russian wildrye seedings have infrequently given fair to good stands under desert conditions.

The greatest amount of research pertaining to grass seeding has been conducted on the plains area of Eastern Wyoming. The species which were most easily established and apparently best adapted to this area were crested wheatgrass, western wheatgrass, and Russian wildrye. Blue grama grass is well adapted to the area but more difficult to establish.

Early spring and early fall seeding dates were about equally successful in establishment of the early-season grasses, and late-spring seeding was the only date when blue grama was successfully established.

Clean crop stubble was the best seedbed, being superior to clean, cultivated land principally because of reduced damage to seedlings through wind action. The type of drill used appeared to have little effect upon the stand as long as the seed was planted at proper depth.

Nurse crops proved detrimental to a grass seeding. The seeding of a legume with the grass was found to maintain the yield of the area at a high level for a greater period of years than where the grass was seeded alone.

APPENDIX A

List of Scientific Names and Corresponding Common Names

<table>
<thead>
<tr>
<th>SCIENTIFIC NAME</th>
<th>COMMON NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agropyron cristatum</td>
<td>Crested wheatgrass</td>
</tr>
<tr>
<td>A. dasystachyum</td>
<td>Thickspike wheatgrass</td>
</tr>
<tr>
<td>A. intermedium</td>
<td>Intermediate wheatgrass</td>
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<tr>
<td>A. repens</td>
<td>Quackgrass</td>
</tr>
<tr>
<td>A. smithi</td>
<td>Western wheatgrass</td>
</tr>
<tr>
<td>A. spicatum</td>
<td>Bluebunch wheatgrass</td>
</tr>
<tr>
<td>A. trachycaulum</td>
<td>Slender wheatgrass</td>
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<tr>
<td>Agrostis alba</td>
<td>Redtop</td>
</tr>
<tr>
<td>A. bakeri</td>
<td>Baker bentgrass</td>
</tr>
<tr>
<td>A. exarata</td>
<td>Spike bentgrass</td>
</tr>
<tr>
<td>A. hizemalis</td>
<td>Winter bentgrass</td>
</tr>
<tr>
<td>A. humilis</td>
<td>Alpine bentgrass</td>
</tr>
<tr>
<td>A. idahoensis</td>
<td>Idaho bentgrass</td>
</tr>
<tr>
<td>A. palustris</td>
<td>Creeping bentgrass</td>
</tr>
<tr>
<td>A. rossea</td>
<td>Ross bentgrass</td>
</tr>
<tr>
<td>A. thurberiana</td>
<td>Thurber bentgrass</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Common Name</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Alopecurus aequalis</td>
<td>Shortawn foxtail</td>
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<tr>
<td>A. alpinus</td>
<td>Alpine foxtail</td>
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<tr>
<td>Andropogon furcatus</td>
<td>Big bluestem</td>
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<tr>
<td>A. scoparius</td>
<td>Little bluestem</td>
</tr>
<tr>
<td>Beckmannia syzigachne</td>
<td>American sloughgrass</td>
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<tr>
<td>Bouteloua curtipendula</td>
<td>Sideoats grama</td>
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<tr>
<td>B. gracilis</td>
<td>Blue grama</td>
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<tr>
<td>B. hirsuta</td>
<td>Hairy grama</td>
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<tr>
<td>Bromus catharticus</td>
<td>Rescue brome</td>
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<tr>
<td>B. inermis</td>
<td>Smooth brome</td>
</tr>
<tr>
<td>B. marginatus</td>
<td>Mountain brome</td>
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<tr>
<td>Calamagrostis canadensis</td>
<td>Bluejoint reedgrass</td>
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<tr>
<td>C. inexpansa</td>
<td>Northern reedgrass</td>
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<tr>
<td>Catabrosa aquatica</td>
<td>Brookgrass</td>
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<tr>
<td>Cinna latifolia</td>
<td>Drooping woodreed</td>
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<tr>
<td>Dactylis glomerata</td>
<td>Orchardgrass</td>
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<tr>
<td>Deschampsia caespitosa</td>
<td>Tufted hairgrass</td>
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<tr>
<td>Distichlis stricta</td>
<td>Inland saltgrass</td>
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<tr>
<td>Elymus canadensis</td>
<td>Canada wildrye</td>
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<tr>
<td>E. junceus</td>
<td>Russian wildrye</td>
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<tr>
<td>Festuca elatior</td>
<td>Meadow fescue</td>
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<tr>
<td>F. idahoensis</td>
<td>Idaho fescue</td>
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<tr>
<td>F. ovina</td>
<td>Sheep fescue</td>
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<tr>
<td>Glyceria borealis</td>
<td>Northern mannagrass</td>
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<tr>
<td>G. elata</td>
<td>Tall mannagrass</td>
</tr>
<tr>
<td>G. grandis</td>
<td>American mannagrass</td>
</tr>
<tr>
<td>G. pauciflora</td>
<td>Weak mannagrass</td>
</tr>
<tr>
<td>G. striata</td>
<td>Fowl mannagrass</td>
</tr>
<tr>
<td>Hordeum nodosum</td>
<td>Meadow barley</td>
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<tr>
<td>Koeleria cristata</td>
<td>Prairie junegrass</td>
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<tr>
<td>Oryzopsis hymenoides</td>
<td>Indian ricegrass</td>
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<tr>
<td>Panicum virgatum</td>
<td>Switchgrass</td>
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<tr>
<td>Phalaris arundinacea</td>
<td>Reed canarygrass</td>
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<tr>
<td>Phleum pratense</td>
<td>Timothy</td>
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<tr>
<td>Poa alpina</td>
<td>Alpine bluegrass</td>
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<tr>
<td>Poa arctica</td>
<td>Arctic bluegrass</td>
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<tr>
<td>Poa lettermanni</td>
<td>Letterman bluegrass</td>
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<tr>
<td>Poa nevadensis</td>
<td>Nevada bluegrass</td>
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<tr>
<td>Poa palustris</td>
<td>Fowl bluegrass</td>
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<tr>
<td>Poa pratensis</td>
<td>Kentucky bluegrass</td>
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<tr>
<td>Poa rupicola</td>
<td>Timberline bluegrass</td>
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<tr>
<td>Poa secunda</td>
<td>Sandberg bluegrass</td>
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<tr>
<td>Sitanion hystrix</td>
<td>Bottlebrush squirreltail</td>
</tr>
<tr>
<td>Sporobolus cryptandrus</td>
<td>Sand dropseed</td>
</tr>
<tr>
<td>Stipa viridula</td>
<td>Green needlegrass</td>
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</tbody>
</table>
## Plants Other Than Grasses

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
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<tbody>
<tr>
<td>Artemisia tridentata</td>
<td>Big sagebrush</td>
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<tr>
<td>Atriplex confertifolia</td>
<td>Shadscale saltbush</td>
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<tr>
<td>A. sp.</td>
<td>Saltbush</td>
</tr>
<tr>
<td>Carex filifolia</td>
<td>Threadleaf sedge</td>
</tr>
<tr>
<td>Chrysothamnus sp.</td>
<td>Rabbitbrush</td>
</tr>
<tr>
<td>Eurotia lanata</td>
<td>Common winterfat</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>Alfalfa</td>
</tr>
<tr>
<td>Melilotus officinalis</td>
<td>Yellow sweetclover</td>
</tr>
<tr>
<td>Sarcobatus vermiculatus</td>
<td>Black greasewood</td>
</tr>
</tbody>
</table>

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