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Grasses and Cultural Methods for Reseeding Adandoned Farm Lands in Southern Idaho

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Introduction

LARGE acreages of rangeland in the semiarid portions of the Pacific Coast states were plowed and used for wheat production during World War I. Wheat production proved feasible even though the rainfall was low. However, when yields declined from continued cultivation and prices returned to more normal levels, the enterprise was not profitable and the land was abandoned. During this brief period of cultivation by the alternate wheat and fallow system, erosion by wind and water removed some of the topsoil.

It has been estimated that there are about 5,000,000 acres of abandoned cropland in the Intermountain zone alone *(26[3])*. No accurate estimate is available for the other portions of the Pacific Coast states but the acreage is at least as large as in the Intermountain zone. The principal vegetation on these lands is cheatgrass[4], or cheatgrass interspersed with sagebrush. Perennial grasses of the native vegetation have not been able to invade the cheatgrass during the 25 to 30 years since abandonment *(10)*. The grazing capacity of the annual cheatgrass is low, frequently being only a fraction of that for the perennial grassland type in good condition.

During World War II, abandoned lands and rangelands were again plowed for wheat production. A large acreage has been plowed and used in this manner in southern Idaho. Some of these lands will again be abandoned and gradually return to a cheatgrass cover.

Abandoned croplands are usually interspersed in rangeland. They are capable of providing substantial amounts of livestock feed when reseeded to adapted perennial grasses. This feed could be used as pasture or hay to supplement native range. Several new grasses are suited for reseeding abandoned lands and could provide pasture during seasons when range feed is low or of poor quality. The range improvement program could be materially advanced by seeding and using abandoned lands in this way.

The trials reported in this bulletin compare several ways by which abandoned lands can be successfully reseeded. Several cultural methods were tested. Plantings were made with both common grasses and newly introduced or recently domesticated species and strains. Yields are reported, grazing capacity and costs are indicated.

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[1] Cooperative studies of the University of Idaho, Agricultural Experiment Station with the Soil Conservation Service, Nursery Division, U. S. Department of Agriculture.

[2] Manager, Aberdeen Nursery Unit, Soil Conservation Service; Superintendent, Aberdeen Branch Experiment Station, University of Idaho; and Chief, Regional Nursery Division, Soil Conservation Service, U. S. Department of Agriculture, respectively.

[3] Figures in parentheses refer to "Literature cited," page 31.

[4] A list of common and scientific names used in this bulletin is given on page 30.

Description of Area

These seedings were made on land near Aberdeen, Idaho, that was abandoned from wheat production in 1919. The vegetation on the area was primarily cheatgrass with a few scattered plants of big sagebrush, rabbitbrush and death camas, and isolated small patches of squirreltail, bluebunch wheatgrass, thickspike wheatgrass and Sanberg bluegrass. In 25 years, the invasion of perennial grasses from the native vegetation was negligible. This is in agreement with observations on abandoned wheatland in the Palouse prairie area *(10, 17)*.

The soil type of the field was Portneuf silt loam *(19)*, an upland prairie soil found throughout southern Idaho. A conservation survey indicated that more than 25 percent of the topsoil had been removed by erosion[5]. The depth of soil to the calcareous layer (typical of this series) varied from 12 to 18 inches. The slope gradient varied from 2 to 4 percent. The field was considered quite uniform with respect to conditions affecting plant growth. This was confirmed by the uniformity among similar grass seedings throughout the area. The low fertility was indicated by the fact that cheatgrass produced only enough growth to give a maximum grazing capacity of 0.25 animal-unit-months per acre.

The field was fenced with rabbit-tight fencing[6]. Other precautions were taken to prevent rodent damage to young seedings. Precautions were taken to prevent damage to the plantings by range fires.

The field was located in an area receiving an average annual rainfall of less than 9 inches. Records maintained at the Aberdeen Branch Experiment Station of the University of Idaho show that the average annual precipitation for the period 1912 to 1944 was 8.89 inches. The lowest rainfall was 4.87 inches for the calendar year 1939, and the highest was 13.04 inches for the year 1940. It is generally recognized that incidence of rainfall may influence plant growth more than total precipitation in semiarid areas. Distribution of rainfall by 10-day periods and by crop years is shown in Figure 1. Planting dates are indicated to show the influence of rainfall on establishment of the grasses. It will be seen that the rainfall varies greatly from year to year and widely from the 33-year average.

Methods of Seeding Abandoned Land

The common practice of seeding abandoned land without seedbed preparation has given satisfactory results in many areas. This method is, however, more uniformly successful in areas receiving more than 10 inches of rainfall annually. It requires fall seeding and several years for establishment. Crested wheatgrass and bulbous bluegrass have given best results with this method of

[5] The survey was made by John L. Parker, Assistant Soil Scientist, Soil Conservation Service.

[6] Fencing was necessary because the field was in an area having a heavy population of jack rabbits that would have done unmeasurable damage to the plots. A maximum of less than 10 acres was seeded annually. When seeding large fields, fencing against these rodents would not be necessary although it is desirable to reduce the population of the rabbits within practical limits.

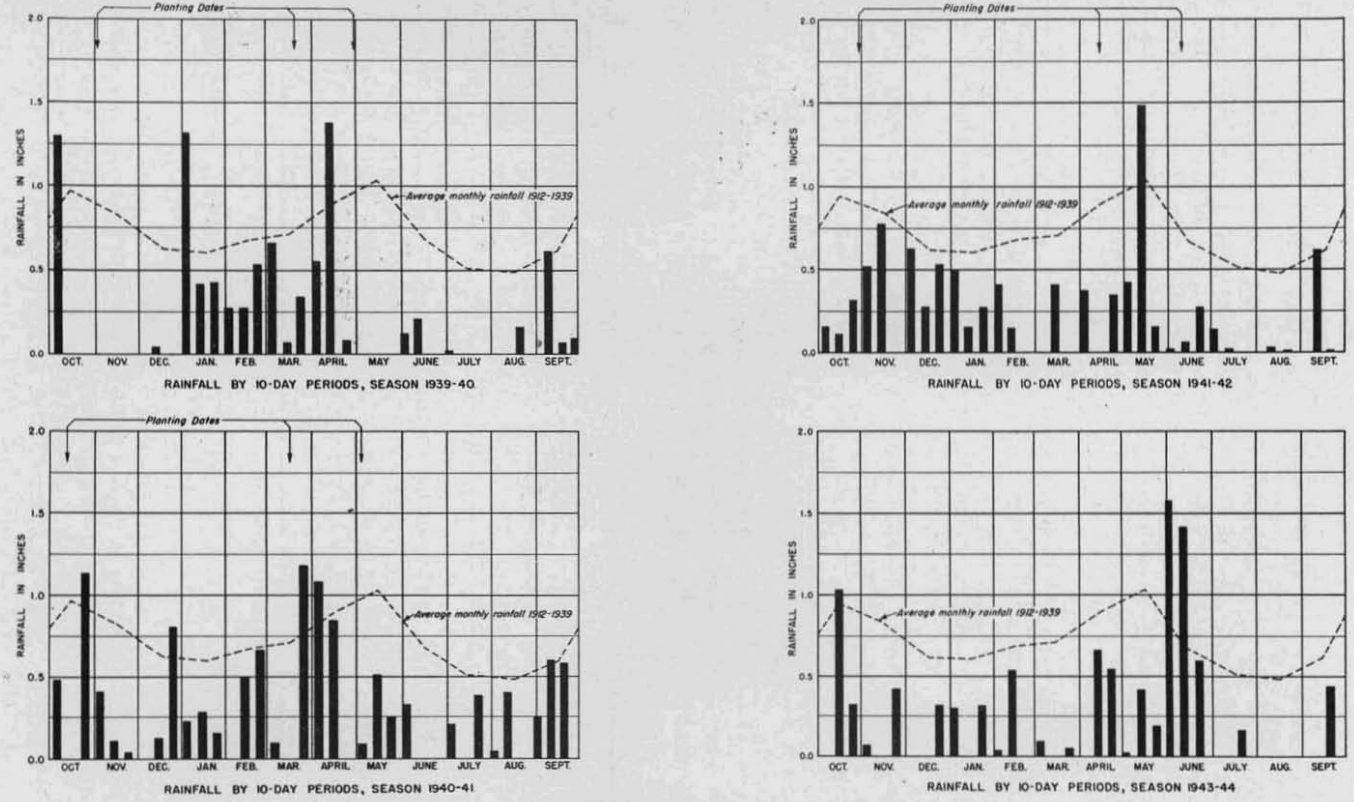

Figure 1.—Rainfall by 10-day summations for the three crop years when plantings were made and for the year for which harvest data are presented. Average monthly rainfall for 1912-1939 is also shown. Rainfall distribution is not shown for the crop year 1942-1943.

seeding. The seed is usually planted with grain drills. In years of abnormally low seasonal rainfall, seedings made without seedbed preparation may fail or the stands may be spotted.

Several methods of preparing land prior to seeding were used in this study. Crested wheatgrass and bluebunch wheatgrass were used to determine the relative effect of the different methods on the establishment of stands and development of the grass. Seedbeds were prepared and seedings were made for the three crop years 1939-40, 1940-41 and 1941-42. Complete harvest data were taken in the summer of 1944 where the stands were 3, 4, and 5 years old, respectively. Seed was harvested from the first two plantings in 1943. In the fall of 1943 the entire field was mowed while the plants were dormant, and the residue was removed with a hayrake. The harvests made in 1944, therefore, represented only the spring and summer growth made in the 1944 season, and contained no old growth from previous seasons.

The grasses were harvested at the hay stage by mowing above a 2½-inch stubble. The values thus obtained represented a measure of total production and, when proper conversions were made, an estimate of relative grazing capacity was obtained. The results, expressed as yield, are shown in Figure 2. They indicate that some seedbed preparation makes it possible to establish both grasses, allows spring seeding, and materially increases production. Seeding after seedbed preparation also resulted in the establishment of more uniform stands than seeding without seedbed preparation. This is shown in Figures 3 and 4.

Summer Fallow

Summer fallow was made by plowing in the spring with a moldboard plow just before the annual cheatgrass had headed out. It is necessary to plow early to control cheatgrass and to promote nitrification by conserving moisture. The growth of annual weeds was controlled by rod-weeding in the early summer, one rod-weeding usually being sufficient. Rod-weeding resulted in a cloddy surface that prevented loss of soil by wind erosion. The presence of cheatgrass roots aided in erosion control. The area was rod-weeded again just before seeding, both to control weeds and to compact the seedbed. No other tillage operations were necessary. Although other implements such as disk tillers, heavy sweeps and rod-weeders with shovel attachments were not used for plowing in these trials, experience has shown that they give essentially the same results when properly handled.

The advantages of summer-fallowing are shown in Figures 2, 3, and 4. Summer-fallowing was of definite advantage in the establishment and development of bluebunch wheatgrass. Crested wheatgrass produced more than twice as much forage on fallow as when seeded directly into cheatgrass. The uniformity of the stands obtained and the vigor of the plants contributed to the high yields recorded. Summer fallow produced these results. Uniform and vig-

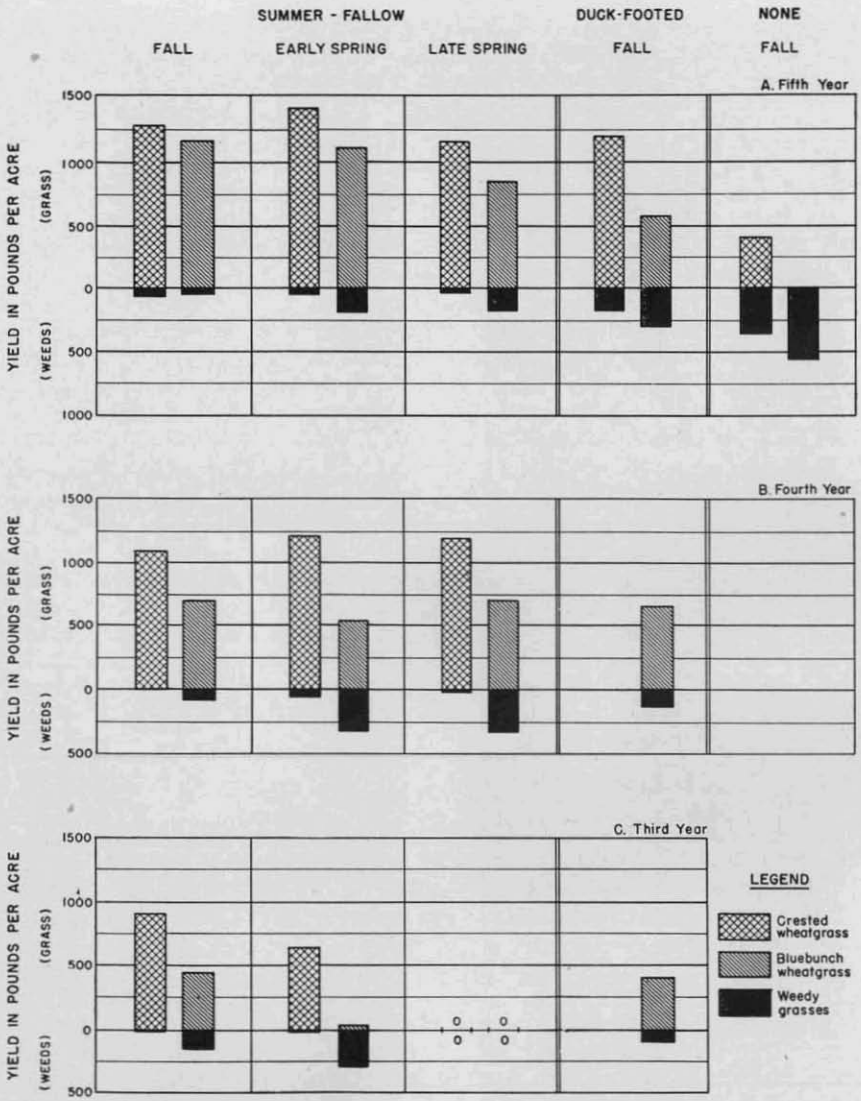

Figure 2.—Yield in pounds per acre of crested wheatgrass, bluebunch wheatgrass and weedy grasses as affected by age of stand and cultural practices. Values taken from Appendix Table 2.

orous stands of both grasses were able to keep out the low-yielding and weedy annual grasses. This can be seen from the figures and from Table 2 (Appendix).

The advantages of summer-fallowing are attributed primarily to the elimination of competition between the seeded grasses and the

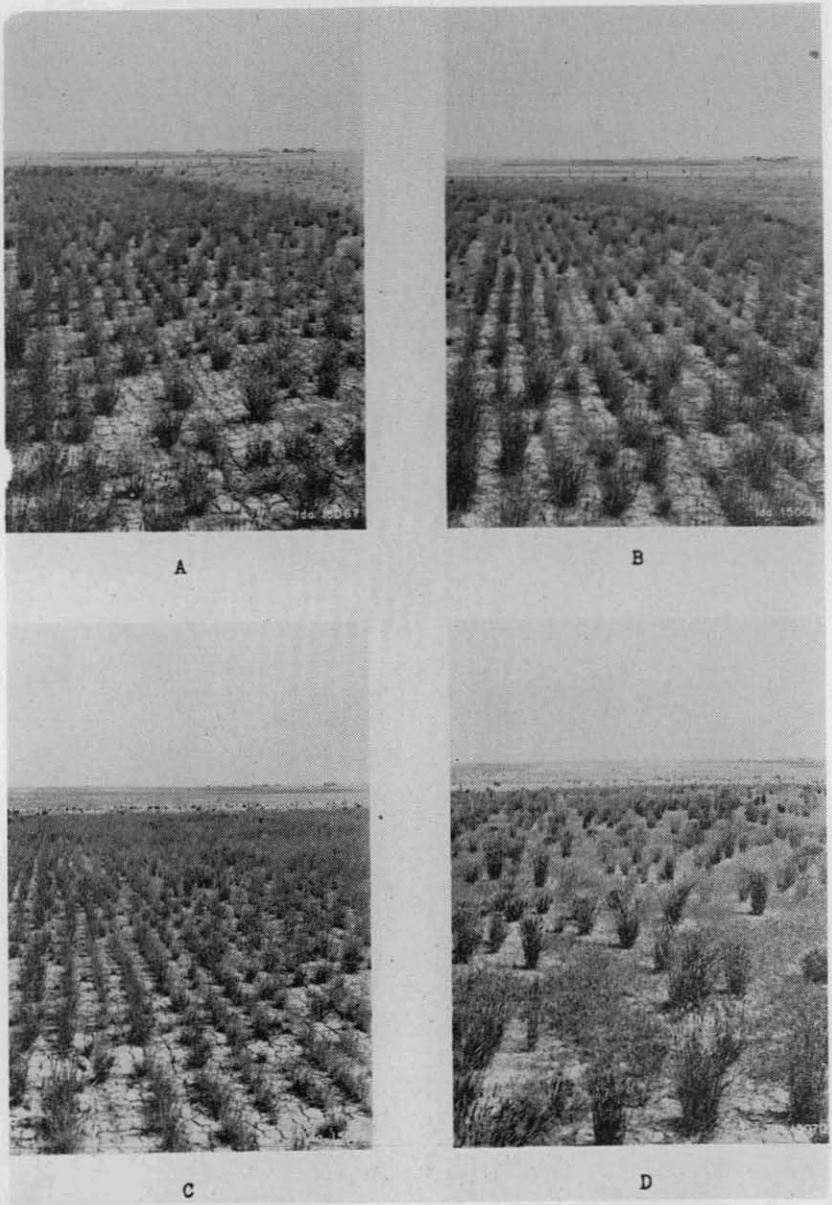

Figure 3.—Stands of crested wheatgrass on abandoned land as affected by types of seedbeds and date of seeding. A, Fall seeding on summer fallow. B, Early spring seeding on summer fallow. C, Fall seeding on duck-footed land. D, Fall seeding without seedbed preparation.

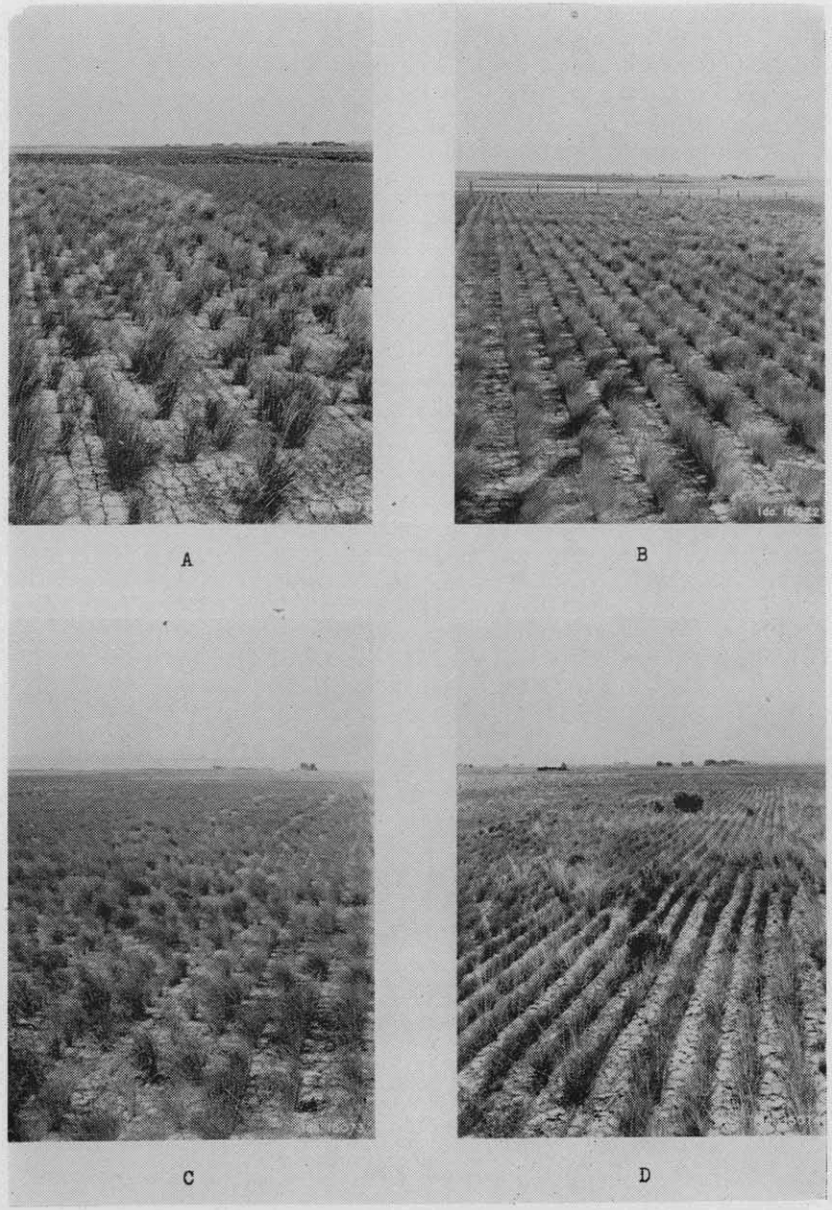

Figure 4.—Stands of bluebunch wheatgrass on abandoned land as affected by types of seedbeds and date of seeding. A, Fall seeding on summer fallow. B, Early spring seeding on summer fallow. C, Fall seeding on duck-footed land. D, Fall seeding on burned-over land. No stands were obtained from fall seeding in cheatgrass without seedbed preparation.

weedy cheatgrass, for both moisture and plant nutrients. Plowing and summer-fallowing also eliminated sagebrush, rabbitbrush, and poisonous weeds. Other advantages of fallowing will be discussed in the sections that follow.

Duck-footing Just Prior to Seeding

Duck-footing was accomplished with a duck-foot cultivator equipped with 14-inch sweeps and set to operate at a depth of approximately 4 inches. It was done after the cheatgrass had begun growth with early fall rains. No other operation was done before seeding. Seedings were made within a few days after cultivation and at right angles to the cultivating operation. Previous experience had shown that if seeding was done in the same direction as cultivating it was too difficult to control the depth of planting. When sloping land is to be seeded by this method, the cultivation should be on the contour to provide the maximum erosion control.

The results from seedings on duck-footed land, shown in Figures 2, 3 and 4, indicate that satisfactory stands were obtained. The stands of bluebunch wheatgrass seeded in 1939 were an exception. They were thin and uneven. The fall of that year was abnormally dry, as indicated in Figure 1. It may be concluded, therefore, that rainfall following seeding was a factor influencing the results obtained with duck-foot cultivation and that bluebunch wheatgrass may require more favorable moisture conditions for seedling development than does crested wheatgrass. The soil was moist from October rains but the seedbed was loose and open and dried out quickly. There was no effective rain for nearly 60 days after seeding. Because seedbeds prepared by duck-foot cultivation require favorable rainfall following seeding, they were not used for spring plantings. When good stands were obtained from fall seeding on duck-footed land, they reached full establishment at essentially the same rate as those on summer fallow, as shown in Figure 2.

Duck-footing materially reduced competition from cheatgrass but was not completely effective for the removal of sagebrush, rabbitbrush or perennial poisonous weeds. Brush is usually well established and has attained considerable size on old abandoned fields and slips between the sweeps of an ordinary duck-foot cultivator.

Burning

In 1941 an area was control-burned in the late spring, just before the cheatgrass had shattered seed, and planted to bluebunch wheatgrass in the succeeding fall. The stand obtained was excellent as shown in Figure 4-D. In 1944, when 3 years old, the grass produced an average of 632 pounds of air-dry forage per acre. This yield was not significantly different from production obtained with fall seedings in the same year on summer-fallowed and duck-footed land.

Burning the cheatgrass from abandoned land just before it shatters seed was an effective way of eliminating competition with this

plant. Burning did not eliminate rabbitbrush or perennial poisonous weeds. Burning was carefully done *(11)*. Fires should not be used where erosion may be serious or the fire cannot be controlled *(16)*.

No Preparation

Many stands of crested wheatgrass have been obtained by drilling directly into cheatgrass without seedbed preparation, usually in the fall. In the present trial on low-producing land and with low rainfall, fall seedings without seedbed preparation resulted in no stand with bluebunch wheatgrass and poor stands, low production

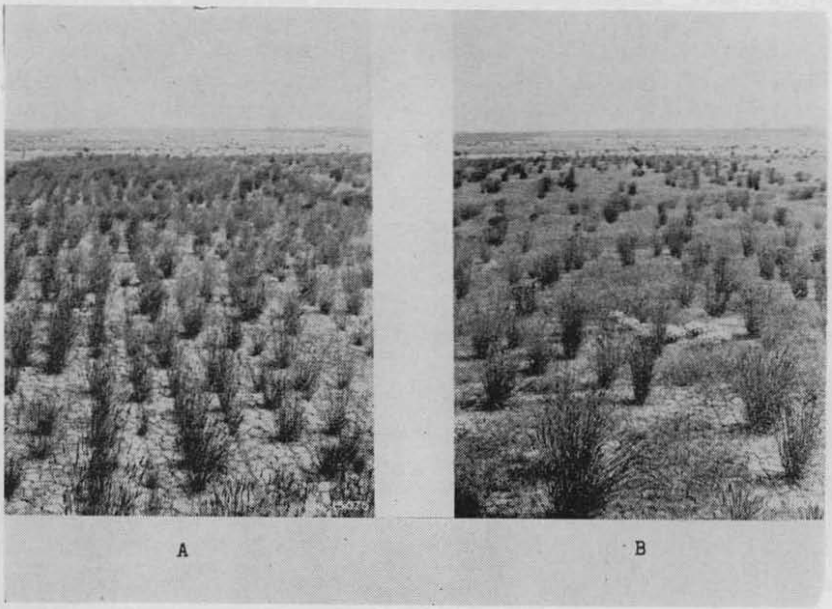

Figure 5.—Stands of crested wheatgrass on abandoned land with no seedbed preparation as affected by types of drills. A, Seeded with deep-furrow drill. B, Seeded with single disk drill.

and greater weediness with crested wheatgrass, as indicated in Figures 2 and 5. The stands of crested wheatgrass on unprepared seedbeds produced significantly less per acre than any of the stands obtained by other methods. Even where fair stands were obtained, the plants required more years to reach full production. One or more additional years of protection would have been necessary before these stands could have been grazed as compared to stands from fallowed or duck-footed land.

Drills Used for Seeding

As special equipment is usually not available for seeding abandoned lands, the drills on hand are generally used. These vary,

depending on the requirements for successful grain production in the respective communities. In order to determine the influence of common types of drills on the establishment of grass, single-disk, double-disk, deep-furrow-press (disk type) and beet drills were used in these trials. The deep-furrow-press drill was equipped with narrow press wheels. The results are given in Table 1 (Appendix). Analysis of the data showed that there was no significant difference among the drills used[7]. Neither the species of grass nor the year of seeding affected the results obtained with the different drills; first order interactions among these factors were not significant. Only the results obtained with crested wheatgrass when sown directly into cheatgrass showed a significantly lower yield for the single-disk drill. This difference is shown in Figure 5. It is largely due to the difference between stands.

When there is a choice among drills, the deep-furrow drill has been preferred by most workers especially for seeding abandoned land without seedbed preparation *(11, 12, 23, 25, 28)*. The results obtained in these studies are in accord with this preference. In addition, there appeared to be some advantage in having this drill equipped with narrow press wheels. When seedbed moisture was a determining factor for obtaining stands, the use of press wheels was observed to result in more uniform germination of the grass seed.

On summer-fallowed land satisfactory stands were obtained with all drills, as shown by the absence of significant differences in yield from the use of different drills. Observations in the field showed that the most uniform stands were obtained with beet drills, although the yield per acre was not influenced. Observations supported by data from quadrats (not given) indicated that more uniform stands were obtained with bluebunch wheatgrass on duckfooted land when seeded with a double-disk drill, than when seeded with a deep-furrow drill, even though the average yields did not vary significantly.

Depth of seeding grass on abandoned land is usually regarded as an important factor in establishment *(1, 2, 4, 9, 11, 23* and *25)*. Recommendations vary from ½ inch to 1 inch. Plummer *(18)* made a detailed study with some of the same grasses as were used in these field trials. He obtained results in the greenhouse indicating that there was some reduction in total emergence and rate of germination of crested wheatgrass when planted more than ¾ inch deep. Bluebunch wheatgrass showed reduced germination beyond ½ inch depths. When the data are judged according to field standards, satisfactory germination with both grasses was obtained at 1½ inches, although crested wheatgrass produced the greater number of seedlings from this depth.

Precautions were taken in the present study to control depth of seeding within the practical limits for field conditions and for the drills used. Special precautions were taken to obtain a uniform depth of seeding. The seedbeds on summer fallow were firmed by

[7] The authors gratefully acknowledge the assistance of Dr. Herman K. Schultz, University of Idaho, for assistance with the analysis of data.

shallow rod-weeding just before planting, the spring tension was removed on the disk drills and narrow press wheels were used on deep-furrow drills. A medium and uniform rate of speed was used when drilling. This precaution aided materially in reducing the depth of seeding and in keeping the depth uniform. The beet drill was used for spring seedings and in some cases for fall seedings (data for fall seedings not given) to obtain positive depth control. The disk drills seeded at 1 to 1½ inches on summer fallow, 1 to 2½ inches on duck-footed seedbeds, and ½ inch on land with no preparation. The beet drill was regulated at ¾ inch. As previously stated, there were no significant differences in yield due to type of drill, and consequently none attributable to differences in depth of seeding within the limits of these trials. The stands were exceptionally uniform for this kind of land as can be seen in Figures 3 and 4; those obtained with the beet drill were outstanding.

Date of Seeding

Three dates of seeding were used on summer-fallow land; fall, early spring and late spring. The dates for each season were adjusted to correspond with normal farm operations in the community. Fall seedings were made when farmers began seeding wheat, early spring seedings when field operations were begun by farmers and late spring seedings near the close of the spring seeding operation. The exact dates are shown in Figure 1.

Fall seedings on prepared seedbeds were successful with both crested wheatgrass and bluebunch wheatgrass. Bluebunch wheatgrass failed from fall seeding on unprepared seedbeds and crested wheatgrass produced poor stands. The stands of bluebunch wheatgrass on land duck-footed in the fall just before seeding were inferior to those obtained with fall seedings on summer fallow in 1939. Rainfall in the fall of this year was below normal. In the other years when fall rains were favorable, the stands and production on duck-footed land were not significantly different from those on summer fallow.

Early spring seedings on summer fallow were not significantly different from fall plantings on summer fallow. The results with bluebunch wheatgrass in the spring of 1942 are an exception. Rainfall was particularly low during the establishment period, adding support to the belief that this grass requires more favorable conditions during the seedling stage than does crested wheatgrass.

Late spring seedings were satisfactory in 1940 and 1941, but appeared to be complete failures with both grasses in 1942; although a very weak stand of crested wheatgrass was in evidence by 1944. The reason for failure in 1942 has been given and can be seen in Figure 1.

These results indicate that crested wheatgrass and bluebunch wheatgrass can be established satisfactorily both in the early spring and in the fall on prepared seedbeds. Early spring seedings on summer fallow can be relied upon unless a prolonged dry period follows seeding. In such cases bluebunch wheatgrass may fail. Late

spring seedings depend entirely on weather conditions following planting. When good stands were obtained from spring seedings, they produced as much feed after they were fully developed as did fall seedings but they required at least an additional year to reach full development.

Pure Stands and Mixtures

One of the major problems of range livestock production in the Pacific Coast states is the lack of seasonal uniformity in the availability of feed. Range feed is usually abundant during the late spring and early summer, short or of low quality during the late summer and early fall, and production is usually below requirements in the early spring. Additional feed during the early spring and late summer months would maintain livestock gains and would provide a means of improving the condition of the native ranges. Experience has indicated that most native ranges are over-utilized in the early spring and investigations have indicated that bluebunch wheatgrass, one of the major grasses in native range, may be seriously damaged by heavy use before the 7-inch-height stage is reached *(14)*. Abandoned farm lands could be seeded to perennial grasses to provide feed during these critical periods.

The seeding of a mixture of grasses is frequently recommended as a means of extending the grazing season *(1, 2, 5, 11* and *23)*. The components of recommended mixtures vary widely. In some cases they contain species with widely different seasons of use. In areas having abundant rainfall, legumes are frequently added *(7)*. No tests have been reported that compare production between pure stands and mixtures under conditions of low rainfall.

A grass nursery was established at the Aberdeen Branch Experiment Station in 1939. It contained material from the native vegetation of the Pacific Northwest, exotics from plant introduction by the U. S. Department of Agriculture, and commercial grasses and legumes. Each grass and legume species was represented by selected typical strains chosen from a large collection that had been assembled with a view toward supplementing available material for soil conservation and other uses. Among these materials were several grasses that had indicated promise for use under conditions of low rainfall and eroded and depleted soils. The most promising species were chosen for planting on the abandoned farm land area.

Figure 6 illustrates the production obtained in 1944 from pure stands of six grasses and eight different grass mixtures. Three ages of maturity are represented. These plantings were made in the fall on summer fallow. They were treated and harvested in the same manner as were the materials from the cultural trials.

The values for production in Figure 6 have been expressed in terms of grazing capacity. Forage production was converted to grazing capacity by applying the proper-use-factor to total air-dry yield above a 2½-inch stubble and converting the net yield thus obtained to the alfalfa hay equivalent on the basis of relative total digestible nutrients *(3, 13, 15, 24* and *25)*. The proper-use-factors

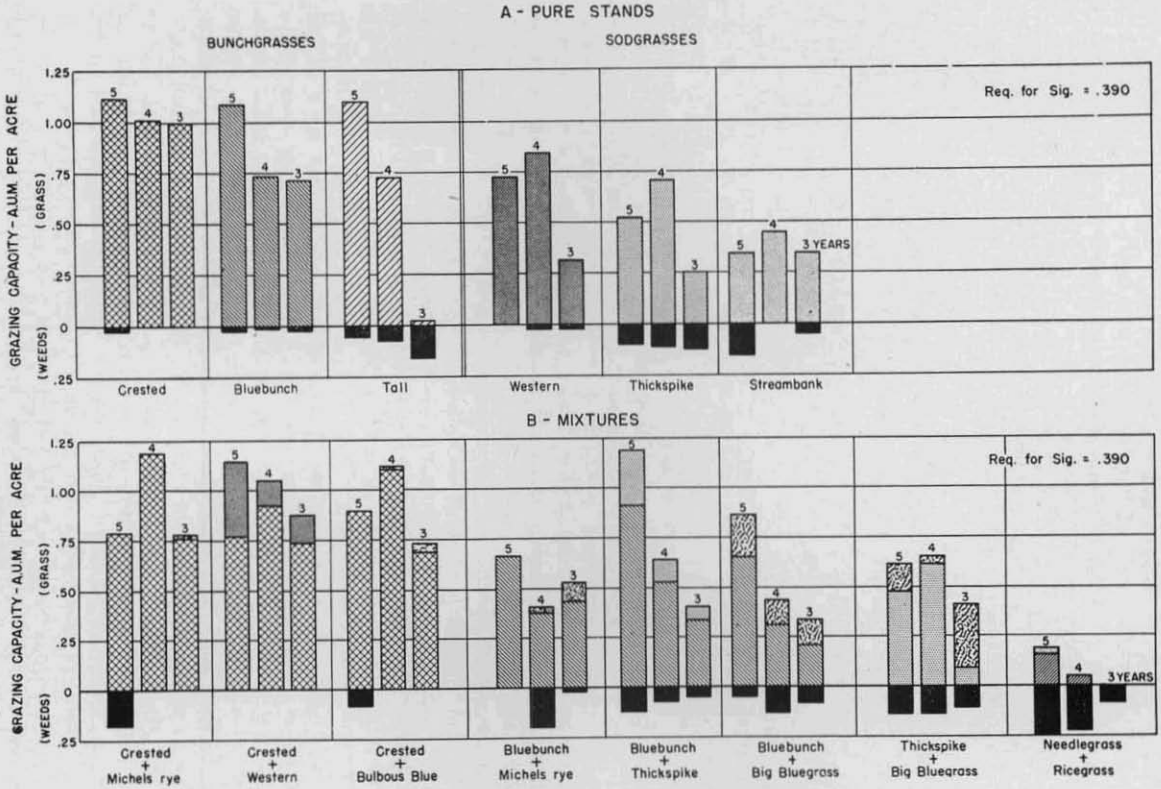

Figure 6.—Grazing capacity in 1944 of pure stands and mixtures seeded on abandoned land at Aberdeen, Idaho. Values taken from Appendix Table 3.

were taken from the standard table used for range survey work in southern Idaho. They were 60 percent for the wheatgrasses, big bluegrass, needlegrass, and ricegrass; 50 percent for bulbous bluegrass; and 20 percent for cheatgrass[8]. The final conversion to animal-unit-months per acre was based on the alfalfa hay requirements of 670 pounds per month for optimum production for a 2-year-old steer *(4)*. The limitations of converting total production to grazing capacity in this manner are recognized, but this method allows for a more direct comparison among the grasses and mixtures than would the use of yields alone. The complete data for both production and computed grazing capacity are tabulated in Table 3 (Appendix).

Pure Stands

The adaptation of the wheatgrasses to the climatic and soil conditions of these plantings is evident from Figure 6. The bunch-type wheatgrasses as a group produced more than the sod-type wheatgrasses when the stands were fully matured. The differences in grazing capacity among mature stands of the three bunch-type wheatgrasses and western wheatgrass were not significant. This indicates that western wheatgrass, a sod-type grass, may be adapted to this use. There would probably have been no difference between western wheatgrass and thickspike wheatgrass had the mature stands of the latter been as uniform as those of the former. Both of these grasses occur naturally on rangelands in the area, the latter predominating. In younger stands that were more uniform, the production from these sod-forming grasses was not significantly different; neither did they differ from the production of the bunch-type wheatgrasses of the same age. A 3-year-old stand of western wheatgrass is shown in Figure 7-D. The so-called "streambank" wheatgrass is similar to thickspike wheatgrass in appearance and seasonal development, but has a dwarf growth habit. It is adapted to the conditions found on abandoned land, but the estimated grazing capacity in pure stands was low. This wheatgrass is easy to establish.

It is especially important that the production from mature stands of the three bunch-type wheatgrasses—crested wheatgrass, bluebunch wheatgrass and tall wheatgrass—was almost the same and not significantly different. Because each of the three bunch wheatgrasses can be established on abandoned land when proper cultural practices are used and have essentially the same grazing capacity when the stands are fully developed but differ in season of use, they can be used to extend the grazing season. It is generally recognized that the proper season of use for crested wheatgrass is early spring and fall. Observations by Soil Conservation Service technicians show that this grass may become unpalatable as it reaches maturity. This stage is usually reached in early summer, at low and medium elevations[9]. After this time, it has been difficult to maintain nor-

[8] Cheatgrass may be used for fall grazing when favorable rainfall occurs. This would add slightly to per-acre grazing capacity. In the present study such estimates were not possible.

[9] At higher elevations where the seasonal rainfall is more evenly distributed, crested wheatgrass may remain green and palatable for longer periods.

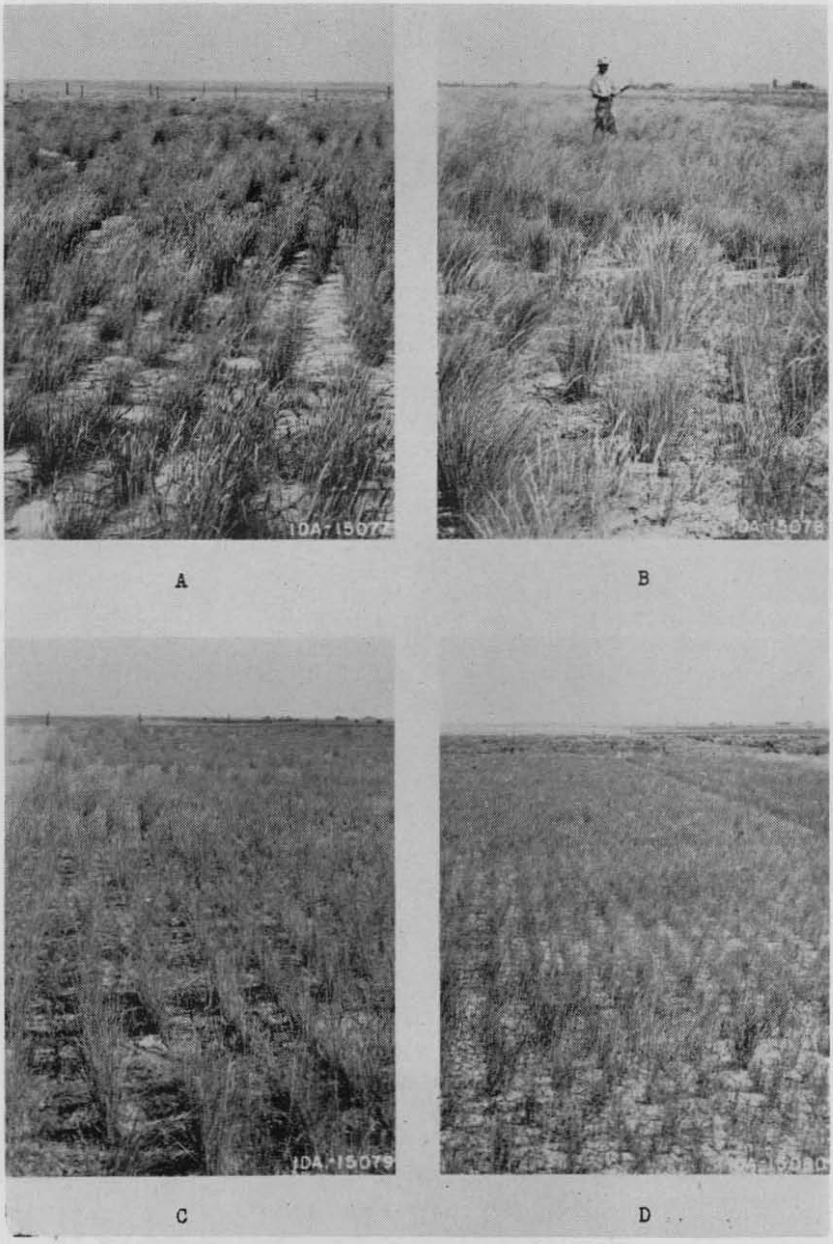

Figure 7.—Stands of adapted wheatgrasses seeded on summer-fallowed abandoned land showed no significant differences in density or production when they reached full production. A, Crested wheatgrass. B, Bluebunch wheatgrass (selected strain). C, Tall wheatgrass. D, Western wheatgrass (selected strain).

mal gains with steers on crested wheatgrass pastures seeded on abandoned land. The same results have been obtained by other workers *(22)*.

Observations indicate that range readiness for bluebunch wheatgrass is at least 14 days later than for crested wheatgrass. This is supported by nursery observations at Aberdeen and elsewhere, and by physiological studies *(14)*. Also, steers readily graze the characteristically leafy growth of the native bluebunch wheatgrass as the crested wheatgrass becomes unpalatable. The essential differences in seasonal growth, leafiness, palatability and development of these two grasses provide the basis for improved rotational grazing. By growing them in adjacent pastures, the crested wheatgrass could be grazed for a period of 30 to 40 days after range readiness in the spring followed by an equal period of grazing on bluebunch wheatgrass. Range readiness for crested wheatgrass is usually given as about 5 inches and for bluebunch wheatgrass as not less than 7 inches. These values are supported by detailed studies *(3, 7, 14, 22* and *24)*.

The outstanding characteristic of tall wheatgrass is its exceptionally late maturity. Data from the nursery show that this grass blossoms from 4 to 6 weeks later than crested wheatgrass and reaches seed maturity from 6 to 8 weeks later. Under dryland conditions these differences are approximately 3 to 4 weeks. Tall wheatgrass appears quite coarse but in comparative trial with 12 grasses at the hay stage the average palatability was 66 percent, comparing favorably with Alta fescue, Canada wildrye, reed canary grass, and wheat hay *(21)*[10]. It would appear, therefore, that this grass could be used to advantage to supplement seedings with crested wheatgrass and bluebunch wheatgrass on abandoned land and to provide feed after native ranges become unpalatable. Should this be found feasible it would provide grazing after midsummer, a season when green forage is normally lacking on nonforested ranges in the Pacific Coast states. Tall wheatgrass could be seeded on abandoned land in pastures adjacent to native range or seeded bluebunch and crested wheatgrass pastures and provide feed after the bluebunch wheatgrass had been grazed[11].

It is often regarded desirable to include legumes in mixtures when seeding abandoned land. The results from several trials have been erratic. One of the reasons for failure has been that such seedings are usually made in the fall. Legumes are difficult to establish from fall seedings. Because spring seedings on summer fallow were successful with grass in these trials, alfalfa was seeded in the spring. A good uniform stand of alfalfa was obtained in 1942, but the production was too low to measure by the third year. It was evident that the environmental conditions of abandoned cropland in this rainfall belt were too rigorous even for this hardy legume.

[10] In these same trials the relative palatability of crested wheatgrass and bluebunch wheatgrass was slightly more than 90 percent.

[11] The adaptation of tall wheatgrass and other similar late maturing grasses to abandoned land with low rainfall is, as yet, only partially established.

Mixed Seedings

All mixed seedings contained only two grasses. They were made in alternate drill rows to eliminate seedling competition and to facilitate study of each grass in the mixture. The results are presented in Figure 6. Yields are expressed in terms of grazing capacity as was done in the case of pure stands. The grazing capacity for weedy grasses is also shown. Complete data for total yield and grazing capacity are given in Table 3 (Appendix).

There were three mixtures containing a bunchgrass and a sodgrass. Crested wheatgrass was seeded with western wheatgrass, bluebunch wheatgrass with thickspike wheatgrass and big bluegrass with thickspike wheatgrass. All native grasses were represented by selected strains. Typical stands are shown in Figures 8 and 9. The total grazing capacity of the mixtures was correlated with the grazing capacity of the bunchgrass fraction and the relationship was highly significant ($P>.01$). The correlation between total grazing capacity and grazing capacity of the sodgrass in the mixture was not significant ($P<.05$). In the mixture of big bluegrass and thickspike wheatgrass the relationship was not consistent for the three seedings. There were no significant differences between the grazing capacity of mature bluebunch wheatgrass or crested wheatgrass when grown alone or in mixtures with sodgrasses. Consequently, there was no advantage from the standpoint of production in using mixtures of sod-forming grasses with bunch wheatgrasses. However, where plantings are made under conditions that might result in irregular stands, the sodgrass has been observed to spread and thus improve the stand. Even under the conditions of these trials, the stands of sodgrass have been maintained and have provided an understory ground cover although they did not contribute toward yield.

It should be pointed out that these plantings were made in an area regarded as being a transition between the Palouse prairie and the short-grass prairie climaxes. The results obtained indicate that the conditions favor the development of the bunch-type wheatgrasses characteristically found in the Palouse prairie.

Observations in the nursery and from the field plantings indicate that western wheatgrass should have been planted with bluebunch wheatgrass and thickspike wheatgrass with crested wheatgrass. These combinations would bring together grasses having essenially similar seasonal development and hence similar season-of-use under grazing conditions.

Mixtures of bluegrass with bunch wheatgrasses were predominantly wheatgrass when the stands had reached mature age. Bulbous bluegrass had almost disappeared from the mixtures with crested wheatgrass (Figure 8). This grass is easy to establish, competes with cheatgrass, but is very short-lived in southeastern Idaho. It yields best in the second year. Big bluegrass, a recently domesticated native species, was compatible in mixtures with both bluebunch and thickspike wheatgrass. This is illustrated in Figure 9. In both of these cases the wheatgrasses in mature stands provided

Figure 8.—Mixtures of crested wheatgrass and three other grasses seeded in alternate rows in the fall on summer fallow. A, Crested wheatgrass and Michels' rye. B, Crested wheatgrass and western wheatgrass. C, Crested wheatgrass and bulbous bluegrass.

most of the harvested forage. Big bluegrass can be established from fall seedings on summer fallow when care is taken in planting. No observations were made of mature stands of big bluegrass under grazing conditions on abandoned land, but from extensive information regarding its growth habits, it apparently has the same season-of-use as thickspike wheatgrass.

Mixtures of needlegrass with ricegrass had a low grazing capacity. Poor stands were obtained. Both grasses proved difficult to establish under the conditions of these trials, yet several good stands of ricegrass have been obtained elsewhere but on more sandy soils.

Miscellaneous mixed seedings were made to observe adaptation to the site conditions and compatibility between grasses. Mixtures

Figure 9.—Mixture of thickspike wheatgrass and two adapted bunchgrasses seeded in alternate rows in the fall on summer fallow. A, Thickspike wheatgrass and bluebunch wheatgrass. B, Thickspike wheatgrass and big bluegrass.

of "streambank" wheatgrass were successful with crested wheatgrass. Green needlegrass failed in mixture with ricegrass. Some Canby bluegrass was established in a mixture containing crested wheatgrass.

Michels' rye was seeded in alternate rows with crested wheatgrass and with bluebunch wheatgrass. These mixtures were characterized by a rapid development of the rye so that it produced a hay crop the first year after seeding. The average yield of the rye hay was 2,563 pounds per acre. This amount, based on total diges-

tible nutrients, is equivalent to approximately one ton of alfalfa hay. The second year after seeding, there was a small amount of feed from a few weak perennial rye plants and from volunteer growth, but it did not warrant harvesting. By the third year it had nearly disappeared from the seedings and made almost no contribution to grazing capacity as shown in Figure 8.

Crested wheatgrass and bluebunch wheatgrass were able to successfully establish themselves when planted in alternate rows with Michels' rye although there was evidence that they were retarded in development. It appeared that the rye retarded bluebunch wheatgrass more than crested wheatgrass. Accordingly, the rye may have had a slightly different effect on these two grasses and tests should be made before seeding it in such mixtures. Where it can be used with perennial grasses it would give surface protection against erosion by wind and water and produce considerable hay the first year. Such mixtures should not be grazed during the first or second year because of the danger of permanently injuring the stand of the perennial grass.

Effect of Age on Production

The grazing of new seedings should be delayed until the grasses are established so that the stands are not reduced and the plants remain vigorous and productive. The age at which planted grass reached full production on abandoned land varied with the grass and the method used for establishment. This is illustrated in Figures 2 and 6. On prepared seedbeds, crested wheatgrass, big bluegrass and "streambank" wheatgrass reached full development by the fourth growing season and approached it by the end of the third season. Bluebunch wheatgrass, western wheatgrass and thickspike wheatgrass required an additional year to reach full development. Tall wheatgrass made very little growth until the fourth season and reached full development in the fifth season. Fully developed stands can support a full grazing load but should be grazed with caution prior to that time. Establishing the grass on summer fallow or duck-footed land advanced development by at least one year over grass planted directly into cheatgrass. The data on grazing capacity given in Tables 2 and 3 (Appendix) may be used as a guide when stocking seeded areas, provided allowance is made for seasonal climatic fluctuations.

Immature stands of perennial grasses were characterized by a high density and yield of cheatgrass. As the stands reached full development, the cheatgrass was reduced. Grazing immature stands may retard development of the perennial grasses and thus promote the growth of the annual cheatgrass *(8)*. In this way the total grazing capacity will be reduced.

Effect of Culture on Relative Vigor of Perennial Grass and Cheatgrass

Figure 2 shows the relationship between the average total yield of planted grass and volunteering cheatgrass as influenced by

methods of culture. It will be seen that the yield of the cheatgrass decreased as the yield of planted grass increased. This relationship is important because of the lower production of the cheatgrass. Conversions of the yields shown in Figure 2 to grazing capacity are given in Table 2 (Appendix). The highest grazing capacity per acre for cheatgrass was .15 animal-unit-months. On these plots there was no perennial grass and the cheatgrass yielded only 550 pounds per acre.

Good vigorous stands of perennial grasses were capable of preventing the growth of the annual cheatgrass. In order to measure stand and vigor, determinations were made by the square-foot density method commonly used in range surveys[12]. Care was taken to obtain an adequate intensity of sampling *(6)*. The average values for basal density at the ground level just before harvesting the grass are given in Table 2 (Appendix). The yield of both crested wheatgrass and bluebunch wheatgrass was correlated with basal density. Similarly, the yield of cheatgrass was correlated with its basal density. Both gave a highly significant coefficient of correlation ($P>.01$). The basal density of cheatgrass decreased as the density of the planted grasses increased. The correlation was negative and highly significant ($P>.01$). Therefore, land preparation and careful seeding to insure uniform vigorous stands of perennial grass suppressed the lower yielding cheatgrass.

The results given in Table 3 (Appendix) were used to determine if other planted grasses gave essentially the same results as those used in the cultural trials. The relationships were the same for comparisons between yield of grass and basal density, yield of cheatgrass and basal density, and yield of grass and cheatgrass. All correlations were highly significant ($P>.01$); those between yield and basal density being positive and those for yield of grass and cheatgrass being negative. The positive relationship between yield of grass and basal density was obtained for both pure seedings and mixed plantings. It is recognized that the grasses were planted on good seedbeds and were in uniform stands. They were chosen for their adaptation to the conditions found on abandoned land, and most of them were represented by selected and uniform strains. It would, therefore, appear that the planting of selected strains within adapted species has merit when seeding abandoned land.

Cost of Seedbed Preparation and Seeding

The cost of seeding abandoned land to perennial grasses depends upon the method used. The present study reports the results from different methods and compares them. The principal objective was to determine the advantage of one method over the other. All figures given are on the basis of large-scale operations.

The cheapest method is to seed directly into cheatgrass without seedbed preparation. The only expenses are those for seed and an average cost of 35 cents per acre for drilling *(5, 27)*. The results obtained in the present study show that this method limits the

[12] Acknowledgment is made to Waldo R. Frandsen, Range Conservationist, Soil Conservation Service, for assisting with these determinations.

grasses that can be used, may result in thin or spotted stands, retards maturity of the stands, thus decreasing yields during the first few years, and does not eliminate sagebrush, rabbitbrush, or perennial weeds. Direct seeding has the advantage of not disturbing the soil so that it may be susceptible to erosion.

The best and surest method of obtaining good, uniform and vigorous stands was to prepare a seedbed by summer-fallowing. Several grasses were successfully established on summer fallow, both fall and early spring seeding were possible, stands were uniform and vigorous, and perennial weeds and shrubs were eliminated at least for the duration of the trial (5 years). The additional cost for fallowing will vary with the method of plowing. Plowing with a moldboard plow has averaged slightly less than 75 cents per acre *(5, 27)*, plowing with heavy sweeps has averaged 50 cents per acre, and plowing with a one-way disk has varied from 50 cents to 75 cents per acre, depending on the depth of plowing. These costs will increase somewhat as the size of the operation is reduced. Rod-weeding twice has cost 50 cents per acre. The total cost of seedbed preparation and drilling will therefore vary from about $1.35 per acre to $1.60 per acre. These costs do not include charges for seed, interest or taxes, since these values would be the same regardless of the type of seedbed used.

An intermediate method such as cultivating with a duck-foot cultivator just prior to seeding, has cost approximately 30 cents per acre. To this must be added 35 cents for drilling, making a total of 65 cents per acre. This method applies only to fall seedings and was used only with crested wheatgrass and bluebunch wheatgrass. It can be used for early spring seedings only when favorable rainfall conditions are likely to prevail.

Burning cheatgrass and sagebrush from abandoned lands was a satisfactory method of preparing a seedbed but did not eliminate rabbitbrush or perennial weeds. Costs for burning under controlled condition have been given at 19 cents per acre *(16)*. To this would be added the cost for drilling, which makes a total of 54 cents per acre.

The cost of seed varies greatly from season to season. One of the most important factors influencing cost is the supply. Seed of a new grass or of an improved strain may at first be available only in small quantities and command a relatively high price. This price is reduced as the demand increases and more seed is grown. However, new or improved grasses have special merit that outweighs the higher initial cost. This is true for several of the grasses that were successfully used in the present study. Satisfactory seeding rates, representing those used in these trials, are given in Table 4 (Appendix).

Higher initial costs of seeding may easily be offset by greater yields or grazing capacity per acre or by an extension of the grazing season. The results shown in Figures 2 and 6 bear this out. They indicate first that some form of seedbed preparation was superior to direct seeding and that better and more productive stands were

obtained. Secondly, they show that good yields were obtained with grasses that should be grazed after others are no longer palatable. When computing grazing capacity an average daily gain of 1½ pounds per day for a 2-year-old steer was assumed *(2)*. On this basis steers on crested wheatgrass seeded directly into cheatgrass, and having a grazing capacity of .47 animal-unit-months (including cheatgrass), could produce only 21 pounds of gain per acre. The gain from this same grass when planted on cultivated or fallowed land, and having an average grazing capacity of 1.13 animal-unit-months, could average more than 50 pounds of gain per acre. The difference in returns more than offsets the difference in cost of preparing a seedbed. Further, when crested wheatgrass was seeded on summer fallow it reached maturity and could have been grazed at least one full season sooner than when seeded directly into cheatgrass.

Seedbed preparation is even more essential to the establishment of some grasses as was illustrated by the results with bluebunch wheatgrass. As previously pointed out this grass may extend the normal grazing season by as much as 3 to 4 weeks beyond that for crested wheatgrass. In terms of returns from steers this may mean as much as 30 to 40 pounds additional gain per season. The difference should warrant the extra cost of establishing this grass. Similarly, the use of a grass like tall wheatgrass should add sufficiently to the grazing season to defray the expense of using it. These comparisons are based on a single season, but the values should be recurrent if the pastures and ranges are properly managed.

Summer fallow also enabled the establishment of grass in alternate-row seedings with Michels' rye. The value of the rye hay produced in seedings of this type would offset the delay in the development of the perennial grass as well as the higher cost of special seeds.

Discussion and Summary

Thousands of acres of abandoned lands in the semiarid portions of the Pacific Coast states are now producing only low yields of annual cheatgrass. These lands were once in native range and were plowed for wheat production during World War I. Some of these lands and additional rangelands have been plowed as a result of the increase in wheat prices during World War II and will revert to cheatgrass when abandoned. They can support good stands of perennial grasses that will produce two to four times more feed than cheatgrass (Figure 10). Seeded abandoned land can supplement native rangeland, thus providing a means for instituting improved range management practices. Many acres of these lands have been seeded to crested wheatgrass during the past decade. The results have been variable and this grass has exhibited limitations for use as season-long pasture or range. Many new grasses and improved strains of grasses are now at hand that could be used for such seedings. In the present study a number of grasses and grass mixtures, several methods of preparing seedbeds and methods

and dates of seeding, were compared on typical eroded abandoned land in southern Idaho. Relative costs and returns were computed.

Summer-fallowing was the surest and best method of preparing abandoned land for seeding. It reduced competition from annual cheatgrass and weeds and eliminated sagebrush, rabbitbrush and poisonous plants. Summer-fallowing made it possible to obtain good, uniform stands of perennial grasses from spring seeding as well as from fall planting. The ability to make seedings in the spring has the advantage of compensating for unfavorable conditions that sometimes occur in the fall and distributes the the work load on the ranch. Seedings on summer fallow developed to full production one and two years earlier than those on other seedbeds. Various types of grasses were successfully established on summer-fallowed abandoned land. Several kinds of drills were used with equally good success.

Figure 10.—Perennial grasses produced more than twice the forage provided by annual cheatgrass on abandoned land.

Other methods of seedbed preparation resulted in satisfactory stands of crested wheatgrass and bluebunch wheatgrass when the plantings were made in the fall. Duckfooting just prior to seeding resulted in good establishment, but there was evidence that the stands were retarded in reaching full production. This method of land preparation limits the kinds of drills that can be used and is not satisfactory for spring planting under low rainfall conditions. Cheatgrass containing some sagebrush and rabbitbrush was burned to prepare land for seeding. Good stands were obtained from fall seedings. Burning is inexpensive but has recognized limitations. Rabbitbrush and perennial weeds are not destroyed. Burning should be done early in summer just as the cheatgrass matures, but before it shatters seed. The fire may spread to adjacent fields or ranges unless carefully managed and, on sloping lands, the exposed soil surfaces may erode.

In the present study, stands of perennial grasses seeded in cheatgrass without seedbed preparation were erratic. Some were failures, others were uneven and some were satisfactory. However, satis-

factory stands of such hardy species as crested wheatgrass required one and two years longer to reach full production than when planted on prepared seedbeds. These results can be expected on abandoned lands that are usually located in areas of low rainfall and on low fertility soils.

The costs of preparing seedbeds by summer fallowing, duck-foot cultivating and burning have averaged $1.10, $0.30 and $0.19 per acre respectively. These costs are taken from large-scale operations carried out on soils similar to the one used in these trials. The per-acre costs would be somewhat higher with smaller operations. To land preparations, must be added fixed charges for drilling, taxes, interest and seed. Drilling has averaged $0.35 per acre, taxes and interest vary with the locality and the cost for seed varies with the kind and amount used and with market fluctuations. All of these costs would be uniform when comparing the relative merits of different kinds of seedbeds. When good uniform stands of bunch-type wheatgrass had reached full production they had an average grazing capacity of 1.13 animal-unit-months per acre. This grazing capacity should return slightly more than 50 pounds of beef per year. This return would easily offset the additional cost for a method of seedbed preparation that assured stands and provided one or two additional years of full grazing use. The most intensive method used in these trials was summer-fallowing. The average cost for fallowing exceeds other methods by $0.80 and $0.91 per acre. One year of grazing use would easily compensate for these differences. Summer-fallowing has other advantages that are difficult to evaluate.

The type of drill used to seed two standard grasses had no significant effect on production when the plantings were made on summer fallow. Single-disk, double-disk, deep-furrow and beet drills were compared. The beet drill produced the most uniform stands, but the others were entirely satisfactory. On land duck-footed just prior to seeding, the most uniform stands were obtained from the use of double-disk drills, but this result was not reflected in production. When seeding directly into cheatgrass without seedbed preparation, the results obtained with deep-furrow drills were better than the others and the stands were noticeably more uniform.

Depth of seeding is usually regarded as a primary factor when seeding grass on abandoned land. Depth of seeding varied from ½ inch on land with no preparation to 2½ inches on seedbeds prepared by duck-footing. The results obtained in these studies reflected the importance of uniform depth of seeding. The beet drill gave positive uniform depth control and in all cases the uniformity of stands was exceptionally good. Uniform seeding depth was accomplished with other drills within the practical limits of large-scale field operations by a moderate and uniform rate of speed when seeding. Shallow rod-weeding of summer fallow just before planting facilitated depth control and provided uniform seeding conditions.

Fall seedings are usually recommended for planting abandoned land to perennial grasses. Climatic conditions fluctuate widely under the semiarid conditions where such lands are usually found. These

frequently are unfavorable and consequently the seeding season is short. Fall seedings occasionally are lost by a long dry period or are damaged during the winter, necessitating replanting. In the present study, fall, early spring, and late spring seedings were compared with two grasses on summer fallow. The results showed that there was no significant difference in production between fall and early spring seedings of crested wheatgrass. The same result was obtained with bluebunch wheatgrass except that spring seedings made in 1942 were sufficiently retarded in their development to give significant differences in yield in 1944. Late spring seeding with both grasses was successful in two of the three years. Weather conditions must be favorable following late spring seedings or the seedlings do not become sufficiently established to survive the rainless summers. Spring seedings on unprepared land cannot compete with established and growing cheatgrass under the semiarid conditions. Duck-footing cannot be recommended for spring seedbeds. It loosens the seedbed so that it dries out quickly and the seedlings do not survive. Only one spring planting was made on burned-over land. It was less uniform than fall seeding. Date of seeding, therefore, is determined more by seedbed conditions than by other factors. The seeding season can be extended by intensifying seedbed preparation.

Several grasses from extensive collections in the nursery proved adapted for reseeding abandoned land. Native and exotic wheatgrasses and native bluegrasses were best adapted. Improved strains of native bluebunch wheatgrass and introduced tall wheatgrass produced essentially the same grazing capacity per acre as did crested wheatgrass when the respective stands reached full production. Crested wheatgrass reached full production on summer fallow by the end of the third growing season, bluebunch wheatgrass in the fourth season and tall wheatgrass in the fifth season. Each of these grasses differ in seasonal development and consequently in season-of-use for grazing. They should therefore be chosen with this in mind. Crested wheatgrass should be grazed in the early spring and in the fall, bluebunch wheatgrass in late spring and early summer, and the late-maturing tall wheatgrass in mid-summer. Where extensive plantings can be made, the seeding of these three grasses in separate adjacent pastures that are grazed in succession could materially extend the grazing season.

Selected strains of native western wheatgrass and the closely related thickspike wheatgrass did not differ in grazing capacity when seedings of the same age were compared. Each of these grasses required one year more than did crested wheatgrass to reach full production. When these sod-forming grasses were fully developed, the grazing capacity did not differ from that of bunch-type wheatgrasses. The so-called "streambank" wheatgrass, a dwarf form of thickspike wheatgrass, was admirably adapted to rigors of soil and climate but was definitely low in grazing capacity. It was easy to establish and reached full production at least as soon as crested wheatgrass.

Trial plantings were made with Orestan alfalfa, a dryland strain of mountain bromegrass and green needlegrass. They were not successful under the conditions of these trials.

Mixtures of grasses are often recommended for seeding abandoned land. Legumes are sometimes added. Critical comparisons among mixtures and between mixtures and pure stands in the present study showed that the mixtures had no advantage from the standpoint of production over pure stands. Neither were there any significant differences among mixtures. The production from mixtures of bunch and sod wheatgrasses was determined by the yield of the bunchgrass. Production from mixtures of wheatgrasses and bluegrasses was determined by the yield of the wheatgrass. The trial with alfalfa in mixtures resulted in good stands but no production from the alfalfa.

Observations on mixed alternate-row seedings of perennial grasses showed that sod-forming grasses tended to spread to an optimum density in mixtures where the bunchgrasses were thin. If sod and bunchgrasses are seeded together, those having similar season-of-use should be combined; crested wheatgrass should be planted with thickspike wheatgrass and bluebunch wheatgrass with western wheatgrass. The easily established dwarf form of thickspike wheatgrass, the so-called "streambank" wheatgrass, can be used with either bunchgrass to provide understory ground-cover. Bulbous bluegrass was easy to establish but disappeared from mixtures with the wheatgrasses; it showed lack of adaptation to southeastern Idaho conditions. Good stands of native bluegrass, such as big bluegrass, were obtained in mixtures with wheatgrasses. Big bluegrass is an excellent hay plant *(21)*, but its adaptation to grazing has not been determined. This and other native bluegrasses are common on the ranges of the area and are adapted to the rigorous conditions of abandoned land, but care must be taken when preparing seedbeds and making the seedings.

A successful and useful combination of grasses was the alternate-row seeding of Michels' rye with the wheatgrasses, with the rye harvested for hay the year after seeding. The yield of rye hay in these tests was 2,500 pounds per acre and good stands of perennial grasses were obtained. The perennial grasses may be somewhat retarded in development to full production, but the use of such a mixture gives a net return more than sufficient to pay for seedbed preparation by fallowing. Cereal rye could be used in the same manner.

The preparation of seedbeds by fallowing, cultivating or burning reduced the cheatgrass that prevailed on the area. This made conditions favorable for the establishment of perennial grasses. The better the stand and vigor of the perennial grass, the less was the invasion and growth of cheatgrass. This relationship was brought out by determining the basal density of the planted grass and of the weedy cheatgrass. This is important because mature perennial grasses produced nearly twice as much as cheatgrass and had a grazing capacity at least 3 to 7 times greater. The yield of all per-

ennial grasses was positively correlated with their basal density. Similarly the yield of cheatgrass was correlated with its basal denity. Good, uniform and mature stands of adapted perennial grasses had basal densities averaging 2.67 percent and varying from 2.0 percent to slightly less than 4.0 percent. The average production from these stands was 1173 pounds. Cheatgrass stands having basal densities between 2.0 and 4.0 percent and averaging 2.64 percent produced an average of only 607 pounds. This brings out the relative merits of these grasses and shows the importance to production and grazing capacity of having good stands of perennial grasses. In addition the perennials, when properly chosen species and strains are used, have a longer grazing season, are less of a fire hazard and are not susceptible to smut *(8)*.

Good stands of perennial grasses must be obtained so that cheatgrass cannot become established. The perennial grass pastures must be properly managed to preserve good vigorous stands.

List of Common Names and Scientific Names of Species Mentioned

Bluegrass, big	*Poa ampla*
Bluegrass, bulbous	*P. bulbosa*
Bluegrass, Canby	*P. canbyi*
Bluegrass, Sandberg	*P. secunda*
Bromegrass, mountain	*Bromus marginatus*
Cheatgrass ("cheatgrass brome," "bromegrass," "cheat," "junegrass," "bronco grass")	*Bromus tectorum*
Canary grass, reed	*Phalaris arundinacea*
Deathcamas	*Zigadenus venenosus*
Fescue, Alta	*Festuca elatior arundinacea*
Needlegrass	*Stipa comata*
Needlegrass, green	*S. viridula*
Rabbitbrush	*Chrysothamnus viscidiflorus* or *C. nauseosus*
Ricegrass, (Indian)	*Oryzopsis hymenoides*
Sagebrush, big	*Artemesia tridentata*
Squirreltail	*Sitanion hystrix*
Wheatgrass, bluebunch	*Agropyron spicatum*
Wheatgrass, crested	*A. cristatum*
Wheatgrass, streambank	*A. riparium*
Wheatgrass, tall	*A. elongatum*
Wheatgrass, thickspike	*A. dasystachyum*
Wheatgrass, western	*A. smithii*
Wildrye, Canada	*Elymus canadensis*

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Appendix

Table 1.—Total production in 1944 of crested wheatgrass and bluebunch wheatgrass seeded on abandoned land at Aberdeen, Idaho. Values[1] are expressed in pounds of air-dry forage per acre and are the average of three quadrats, each containing 100 square feet.

			5th year—Seeded 1939-1940		4th year—Seeded 1940-1941		3rd year—Seeded 1941-1942	
Preplanting Treatment	Season of Seeding	Drills	Crested wheatgrass	Bluebunch wheatgrass	Crested wheatgrass	Bluebunch wheatgrass	Crested wheatgrass	Bluebunch wheatgrass
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Summer fallow	Fall	Single disk	1237	1217	1093	591	822	303
		Double disk	1224	1189	1124	831	1111	806
		Deep furrow	1432	1169	1047	752	794	331
		Av. for species	1298	1192	1088	725	909	480
		Av. for treatment	1245		906		694	
Summer fallow	Early Spring	Beet	1254	1125	1236	572	755	38
		Deep furrow	1604	1090	1197	540	592	39
		Av. for species	1429	1108	1217	556	674	39
		Av. for treatment	1268		886		356	
Summer fallow	Late Spring	Beet	1131	954	1199	649	0	0
		Deep furrow	1240	796	1198	733	0	0
		Av. for species	1186	875	1199	691	0	0
		Av. for treatment	1030		945		0	
Duckfooted just prior to seeding	Fall	Single disk	1040	446	.....	.....	.....	.....
		Double disk	1355	572	.....	629	.....	377
		Deep furrow	1243	737	.....	656	.....	446
		Av. for species	1213	585		643		412
		Av. for treatment	899					
None	Fall	Single disk	129	0	.....	.....	.....	.....
		Double disk	511	0	.....	.....	.....	.....
		Deep furrow	622	0	.....	.....	.....	.....
		Av. for species	421	0				
		Av. for treatment	210					

[1]Standard error for a single determination = 126.89 lbs.

Table 2.—Average total production, basal density and grazing capacity in 1944 of crested wheatgrass and bluebunch wheatgrass, seeded on abandoned land at Aberdeen, Idaho. Values are averages by species for all plots, three quadrats each, irrespective of drills used for seeding.

			5th Year—Seeded 1939-1940							4th Year—Seeded 1940-1941							3rd Year—Seeded 1941-1942						
Preplanting treatment	Season of seeding	Seeded species of wheatgrass	Basal density grass	Yield grass per acre	Grazing capacity grass	Basal density weeds	Yield weeds[1] per acre	Grazing capacity weeds	Total Grazing Capacity	Basal density grass	Yield grass per acre	Grazing capacity grass	Basal density weeds	Yield weeds[1] per acre	Grazing capacity weeds	Total Grazing Capacity	Basal density grass	Yield grass per acre	Grazing capacity grass	Basal density weeds	Yield weeds[1] per acre	Grazing capacity weeds	Total Grazing Capacity
			%	lbs.	AUM	%	lbs.	AUM	AUM	%	lbs.	AUM	%	lbs.	AUM	AUM	%	lbs.	AUM	%	lbs.	AUM	AUM
Summer fallow	Fall	Crested	3.02	1298	1.16	.47	52	.02	1.18	3.15	1088	.97	.05	0	0	.97	2.50	909	.81	.18	11	0	.81
		Bluebunch	2.86	1192	1.07	.22	40	.01	1.08	1.44	725	.65	1.05	74	.02	.67	1.28	480	.43	.89	153	.04	.47
Summer fallow	Early Spring	Crested	3.88	1429	1.28	.45	52	.01	1.29	4.25	1217	1.09	.36	59	.02	1.11	1.83	674	.60	.13	10	0	.60
		Bluebunch	3.88	1108	.99	1.12	178	.05	1.04	1.71	556	.50	1.80	335	.09	.59	.08	39	.03	1.96	299	.08	.11
Summer fallow	Late Spring	Crested	6.88	1186	1.06	.34	28	.01	1.07	4.63	1199	1.07	.13	4	0	1.07	0	0	0	[2]0	0	0	0
		Bluebunch	3.17	875	.78	1.50	195	.05	.83	2.04	691	.62	1.50	330	.09	.71	0	0	0	[2]0	0	0	0
Duck-footed just prior to seeding	Fall	Crested	3.06	1213	1.09	.72	166	.04	1.13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Bluebunch	1.33	585	.52	1.42	300	.08	.60	.63	643	.58	.80	132	.04	.62	1.25	412	.37	1.71	93	.02	.39
None	Fall	Crested	.79	421	.38	1.49	356	.09	.47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
		Bluebunch	0	0	0	2.25	550	.15	.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[1]Weeds were almost entirely *Bromus tectorum*.

[2]No weedy grasses on these seedings, yield of ruderals too low to measure. These values omitted in determination of r.

Values for r: Yield grass x basal density grass = + .820**
Yield weeds x basal density weeds = + .878**
Basal density grass x basal density weeds = — .592**

** Significant at 0.01 level.

Table 3.—Total production, basal density and grazing capacity of grass and weeds in 1944 for species and mixtures seeded on abandoned farm land at Aberdeen, Idaho. Values are averages of three quadrats, each containing 100 square feet.[1]

Species or Mixture	Yield of Grass			Yield of	Basal density		Grazing capacity		
	No. 1	No. 2	Total	Weeds	Grass	Weeds	Grass	Weeds	Total
	lbs.	lbs.	lbs.	lbs.	%	%	AUM	AUM	AUM
5th YEAR — SEEDED FALL 1939									
Pure Stands:									
Crested wheatgrass	1237	.....	1237	92	2.95	.65	1.11	.02	1.13
Bluebunch wheatgrass	1217	.....	1217	62	2.92	.21	1.09	.02	1.11
Tall wheatgrass	1233	.....	1233	206	2.33	.58	1.10	.05	1.15
Western wheatgrass	[2]820	.....	820	.....	.....	.....	[2].73	.....	.....
Thickspike wheatgrass	585	.....	585	362	1.25	1.67	.52	.10	.62
"Streambank" wheatgrass	383	.....	383	560	2.33	2.08	.34	.15	.49
Mixtures:									
Crested wheatgrass + Michels' rye	887	0	887	649	1.17	2.42	.79	.17	.96
Crested wheatgrass + Western wheatgrass	[2]861	[2]413	1274	.....	.....	.....	[2]1.14	.....	.....
Crested wheatgrass + Bulbous bluegrass	994	0	994	306	1.17	1.17	.89	.08	.97
Bluebunch wheatgrass + Michels' rye	[2]741	[2]0	731	.....	.....	.....	[2].66	.....	.....
Bluebunch wheatgrass + Thickspike wheatgrass	994	322	1316	451	1.83	1.83	1.18	.12	1.30
Bluebunch wheatgrass + Big bluegrass	710	231	941	203	2.00	1.08	.86	.05	.91
Thickspike wheatgrass + Big bluegrass	518	160	678	514	1.58	1.67	.61	.14	.75
Needle grass + Ricegrass	163	20	183	925	.40	4.42	.18	.25	.43
4th YEAR — SEEDED FALL 1940									
Pure Stands:									
Crested wheatgrass	1124	.....	1124	1	2.83	.05	1.01	0	1.01
Bluebunch wheatgrass	831	.....	831	51	2.08	.58	.74	.01	.75
Tall wheatgrass	817	.....	817	274	1.75	1.42	.73	.07	.80
Western wheatgrass	934	.....	934	80	2.58	.75	.84	.02	.86
Thickspike wheatgrass	780	.....	780	405	2.58	.75	.70	.11	.81
"Streambank" wheatgrass	[2]496	.....	496	.....	.....	.....	[2].44	.....	.....
Mixtures:									
Crested wheatgrass + Michels' rye	1318	0	1318	1	2.17	.17	1.18	0	1.18
Crested wheatgrass + Western wheatgrass	1032	145	1177	1	2.58	.17	1.05	0	1.05
Crested wheatgrass + Bulbous bluegrass	1228	14	1242	4	3.42	.08	1.11	0	1.11
Bluebunch wheatgrass + Michels' rye	408	39	447	713	.70	2.50	.40	.19	.59
Bluebunch wheatgrass + Thickspike wheatgrass	585	130	715	280	1.08	1.42	.64	.07	.71
Bluebunch wheatgrass + Big bluegrass	336	142	478	476	.75	1.67	.43	.13	.56
Thickspike wheatgrass + Big bluegrass	667	58	725	527	1.67	2.58	.65	.14	.79
Needle grass + Ricegrass	7	36	43	833	.11	3.42	.04	.22	.26
3rd YEAR — SEEDED FALL 1941									
Pure Stands:									
Crested wheatgrass	1111	.....	1111	12	3.03	.12	1.00	0	1.00
Bluebunch wheatgrass	806	.....	806	71	2.25	.42	.72	.02	.74
Tall wheatgrass	17	.....	17	574	.03	2.92	.02	.15	.17
Western wheatgrass	346	.....	346	81	2.00	1.08	.31	.02	.33
Thickspike wheatgrass	279	.....	279	449	.83	3.00	.25	.12	.37
"Streambank wheatgrass"	382	.....	382	203	1.33	1.17	.34	.05	.39
Mixtures:									
Crested wheatgrass + Michels' rye	851	27	878	4	2.11	.50	.78	0	.78
Crested wheatgrass + Western wheatgrass	831	150	981	1	3.33	.33	.87	0	.87
Crested wheatgrass + Bulbous bluegrass	770	53	823	1	4.83	.08	.73	0	.73
Bluebunch wheatgrass + Michels' rye	473	142	615	58	1.67	1.00	.53	.02	.55
Bluebunch wheatgrass + Thickspike wheatgrass	370	77	447	198	1.37	1.17	.40	.05	.45
Bluebunch wheatgrass + Big bluegrass	235	129	364	316	1.42	1.92	.33	.08	.41
Thickspike wheatgrass + Big bluegrass	99	336	435	405	1.50	1.17	.40	.11	.51
Needle grass + Ricegrass	3	1	4	303	.06	1.67	0	.08	.08

[1]Required for significance, P = .05: Yield of grass = 435.57 lbs. Yield of weeds = 445.04 lbs. Grazing capacity grass = .390 Animal-unit-months. [2]Missing plots, values computed. Values for r: Grazing capacity grass x basal density grass = + .470**. Basal density grass x basal density weeds = — .781**. **Significant at 0.01 level.

Table 4.—Species, accessions and seeding rates. Used for trials on abandoned land at Aberdeen, Idaho.

Common Name	Accession or Variety	Rate in lbs. per acre
Bluebunch wheatgrass	P-736[1]	6-8
Crested wheatgrass	Com[2]	5-6
"Streambank" wheatgrass	P-2415	5-6
Western wheatgrass	P-3194	6-8
Thickspike wheatgrass	P-1822	6-8
Tall wheatgrass	P-2326	6-8
Michels' rye	Com	15
Alfalfa	Orestan	2-3
Indian ricegrass	P-4705	4-6
Big bluegrass	P-2716	4-6
Bulbous bluegrass	Com	2-3
Needlegrass	P-4903	7-8

[1] Accession number of the Nursery Division, Soil Conservation Service.
[2] "Com" indicates commercial seed.