Reeseeding Research in the Intermountain Region

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Organized reeseeding research within the Forest Service was begun in the Intermountain region in 1935. Prior to that time, reeseeding investigations had been fragmentary and lacked continuity. The scale of research could not cope with the need for restoring the millions of acres of depleted range land. Since 1935, the Forest Service has built up a research program that is becoming increasingly able to supply the details necessary for "action" seedings. Some of the investigations have been conducted in cooperation with the Utah State Agricultural Experiment Station, the Soil Conservation Service, and the Bureau of Plant Industry, Soils, and Agricultural Engineering.

In the development of the program an important consideration has been the assigning of seeding priorities to various types of range lands in the Intermountain region. For each type of land investigated, studies have been made on species suitability, methods of preparing seedbeds and seeding, the influence of site factors, plant breeding, and manner of grazing. The most outstanding methods and findings concerning each of these phases are described in the pages that follow.

Planting Zones

There are four generalized range types or planting zones in the region on which seeding programs of varying levels have so far been attempted. These are: the sagebrush zone (spring-fall range); the mountain brush zone (spring-summer range); the subalpine zone (summer range); and the salt-desert shrub zone (winter range).

From the very first, pilot plantings were made in all zones. This plan brought good results, for when the time had come to start intensive studies some rough guides were available. At present, the research program is farthest along for the sagebrush zone. "Action" recommendations have been made for several years but many of them have not been carried out principally because of lack of funds. Intensive research is well under way in mountain brush and aspen areas and a few recommendations have been made. A small beginning has also been made in weed areas of the subalpine zone but eradication of brush and weeds still needs to be intensively investigated. Subalpine areas with eroded soil also need attention as to time and methods of seeding. Only in the fall of 1947 were studies started on the low-precipitation areas locally designated as "desert" winter ranges, where the vegetation belongs mainly in the salt-desert shrub zone. The reeseeding problems here are more difficult and our studies too new as yet to have given any indication of what may be anticipated.

In addition to these projects, a program of eradication and reeseeding studies has been under way since 1945 on ranges occupied by cheatgrass. The entire field of preparing juniper-covered land for seeding is untouched except for one pilot test.

Search for Suitable Species

The study of species suitability has been comprehensive and has progressed rather rapidly. It has been conducted in four succeeding stages: collection of seed, row test plots, range plots, and area plantings.
Row plantings are made on well-prepared seedbeds where the competing vegetation has been removed. Even with these advantages about 80 percent of the species fail and are given no further tests. Those surviving are advanced to range plot tests, where they are seeded in solid stands. Before seeding, competition from the existing plant cover is reduced but thereafter the seeded species have to prove they can make their own way. A series of such plantings has shown that many species which succeed in the cultivated nurseries are not able to produce good forage yields in range plots. The practice has been to plant 20 to 40 of the most promising species in more than 120 site conditions throughout the region, representing the major variations in elevations, precipitation, soil, and exposure, (fig. 1).

Up to the present, seeds of approximately 400 forage species have been collected and planted in row tests. New material is being added whenever and wherever it can be obtained. For example, two species from South Africa were obtained in December 1948 and will be included in the row tests in 1949. During early studies, a number of nurseries were located in Idaho, Nevada, and Utah. After a few years it was found that, within the Intermountain country, variations of response within species arose from differences in elevation and precipitation rather than in geographic location. At present nursery studies are limited to four locations in Ephraim Canyon, Utah, ranging in elevation from 5,500 to 10,200 feet. Each nursery is located in an area representative of one of the major vegetational zones discussed previously.

In most cases, total yields of herbage are greater in the higher, cooler, and more moist zones than in the sagebrush zone (table 1). Crested wheatgrass clearly does better in the lower zone than any other species of grass, although it is definitely

Fig. 1. Experimental row tests and range plots in reseeding nursery near Huntsville, Utah
inferior to some others in the moister zones. At the higher sites intermediate and stiffhair wheatgrasses and smooth brome clearly outrank all other species. Alfalfa has given remarkably good yields in the lower two zones, but on the wet cool mountain areas it is rather poor. In any zone, however, its value for range reseeding is largely nullified by the fact that animals graze it severely and it is killed in a year or two.

It is probable that only crested wheatgrass is thoroughly drought-resistant on hot dry sites in the Intermountain region. Intermediate and stiffhair wheatgrasses have done remarkably well from 1945 to 1948 on sites somewhat more moist and cool. Three of these four years had above-average precipitation. In the drier sites, as for example at Paradise Valley, Nevada, these two grasses were found to be far inferior to crested wheatgrass in drought resistance. At higher elevations, where greater moisture and lower temperatures prevail, smooth brome, orchardgrass, tall oatgrass, and timothy have proved to be well adapted. Recent tests also indicate that intermediate and stiffhair wheatgrasses and Russian wildrye will prove suitable.

**METHODS OF ELIMINATING COMPETITION AND SOWING SEED**

Altogether more than 4,000 plots have been used to study methods of seeding and eliminating competition from one end of the region to the other, at all ordinary elevations, and within all important soil and vegetational types. It has been found that the most important factor in estab-

**TABLE 1**

*Herbage yields from 8 forage species used in reseeding at four different sites, Ephraim Canyon, Manti National Forest, Utah (1947)*

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SAGEBRUSH ZONE</th>
<th>MOUNTAIN BRUSH ZONE</th>
<th>ASPEN ZONE</th>
<th>SUBALPINE ZONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crested wheatgrass..</td>
<td>3,040</td>
<td>3,655</td>
<td>2,545</td>
<td>2,500</td>
</tr>
<tr>
<td>Intermediate wheatgrass</td>
<td>2,510</td>
<td>1,515</td>
<td>2,402</td>
<td></td>
</tr>
<tr>
<td>Stiffhair wheatgrass</td>
<td>1,575</td>
<td>6,650</td>
<td>11,537</td>
<td>1,000</td>
</tr>
<tr>
<td>Slender wheatgrass</td>
<td>1,245</td>
<td>3,575</td>
<td>3,650</td>
<td>2,402</td>
</tr>
<tr>
<td>Tall oatgrass</td>
<td>1,220</td>
<td>5,095</td>
<td>8,750</td>
<td></td>
</tr>
<tr>
<td>Smooth brome</td>
<td>987</td>
<td>5,275</td>
<td>9,540</td>
<td>5,450</td>
</tr>
<tr>
<td>Western wheatgrass</td>
<td>750</td>
<td>9,125</td>
<td>1,100</td>
<td></td>
</tr>
<tr>
<td>Mountain brome</td>
<td>300</td>
<td>3,460</td>
<td>1,760</td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>4,112</td>
<td>8,025</td>
<td>610</td>
<td>2,750</td>
</tr>
</tbody>
</table>

Average

<table>
<thead>
<tr>
<th>Elevation (feet)</th>
<th>5,500</th>
<th>7,200</th>
<th>8,850</th>
<th>10,205</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual precipitation (inches)</td>
<td>11</td>
<td>18</td>
<td>29</td>
<td>32</td>
</tr>
</tbody>
</table>

Establishment of seeded stands is the removal of competing vegetation. Burning has accomplished this most effectively where sagebrush and most other shrubs are to be eliminated. After brush burning, the land is ready without further treatment for seeding, preferably with a disk drill.

The most satisfactory mechanical means of removing sagebrush are the wheatland plow (one-way disk) and the offset disk, both of which will kill 75 or 80 percent of the sagebrush and provide a loose seedbed. A new plow, the brushland, which combines valuable points of wheat-
land and stump-jump plows, is now being tried by the Forest Service with promising results. On rocky, uneven ground, the Dixie harrow may be used and will kill 40 to 50 percent of the sagebrush plants. Various kinds of rails have been used for dragging down brush, but on the average they kill only 25 to 40 percent of the brush and do not provide satisfactory seed covering. In addition, the unskilled sagebrush may rapidly spread and seriously reduce the herbage yield of reseeded grass. In one Idaho experiment this reduction was from 2,100 pounds per acre per year to about 300. Data show grass yields are at least twice or three times as large after wheatland plowing as after railing. Considerably larger yields may result from seedings on burned-over areas than from plowed areas, because burning generally kills more of the sagebrush.

Practically no success has resulted from seeding in undisturbed sagebrush even where the stand is thin. The removal of sagebrush and rabbitbrush, however, is far from being solved. The plants not killed in preparing the seedbed renew growth and produce seed crops. Because rabbitbrush sprouts vigorously from the crowns, the accepted methods of sagebrush eradication are not adequate for rabbitbrush. Although we feel justified in recommending action reseeding programs, we have yet to work out dependable methods for eradication of rabbitbrush and miscellaneous species of sagebrush.

Seedlings of sagebrush and rabbitbrush often repopulate areas that have stands of grass not thick enough to utilize all the moisture and space. Too early or too heavy grazing on the reseeded ranges also encourages brush reoccupation. Whether 2,4-D and other sprays will solve this problem is now being studied. A preliminary study during 1947-48 has shown that sagebrush can be killed without injuring grass.

Brush removal in mountainous zones has not yet been successfully done except by burning. Oakbrush, scrub maple, chokecherry, and snowberry are not readily handled by the wheatland plow. Little is known about juniper eradication although some 15 million acres in Utah occupied by juniper are in need of reseeding. The presence of juniper has been found to prevent establishment and growth of grass. Apparently juniper roots completely remove available soil moisture and young grasses are not able to compete successfully.

Reducing Cheatgrass Competition

Although cheatgrass is often used for spring forage, particularly in southern Idaho, it has several shortcomings which usually make its replacement desirable. It is highly inflammable, has a short season of usefulness, and is very erratic in annual forage production. Early efforts to replace this aggressive intruder with more useful and productive forage species were not successful. Experimental drilling and broadcasting in undisturbed cheatgrass gave almost no establishment of crested wheatgrass and none whatever of smooth brome.

Soon after 1940, studies on reducing competition from cheatgrass and on reseeding were begun, at first in a minor way. Then after 1944 as sagebrush removal was partly solved, more attention was given to cheatgrass. Plowing, disking, deep drilling, and burning were investigated as suitable means of reducing competition from cheatgrass. A few opportunities to observe the effect of heavy grazing on cheatgrass stands were afforded. Since the danger of severe soil losses accompanied heavy grazing this did not seem a feasible method by which to prepare cheatgrass ranges for reseeding.
After an investigation of several years' duration, it was found that moldboard plowing gave the best kill of cheatgrass, 95 to 98 percent, and the best stands of crested wheatgrass. Next in order of mechanical methods came wheatland plowing, 80 to 98 percent; light disk ing, 40 to 75 percent; springtooth harrowing, 30 to 70 percent; spiketooth harrowing, 5 to 30 percent; and drilling alone, 5 to 30 percent. Deep-furrow lister drilling and early summer burning were later found to be particularly effective, 50 to 85 percent and 75 to 95 percent, respectively. Drilling after either of these methods resulted in better stands than did drilling after plowing or disk ing.

It has been determined that cheatgrass ranges can be successfully seeded to crested wheatgrass when proper eradication and reseeding methods are used. It has also been established that total herbage yields of crested wheatgrass are not only greater than those of cheatgrass but are more dependable in years of drought. In addition, grazing on seeded areas can begin 2 to 4 weeks earlier in the spring, and continue 2 to 4 weeks longer in the summer. Furthermore, there is a much greater chance of fall use on seeded ranges than on those left in cheatgrass.

METHODS AND RATE OF SEEDING

In exceptionally favorable circumstances, good grass stands have been obtained by broadcasting ahead of or immediately behind the wheatland plow, Dixie harrow, or rails, and allowing loose soil to cover the seed. The average of results, however, has been much better from drilling than broadcasting. The drill gives an even distribution of seeds and permits more control of the depth of planting. Plowing, to be followed by drilling, should be done well ahead of seeding time. This will allow the loose soil to settle and help prevent seed from being planted too deeply.

Tests on several thousand plots in sagebrush, cheatgrass, and timber have proved that no form of broadcasting is satisfactory without covering of the seed. Fortunately, on deteriorated aspen or mountain brush ranges, where the use of planting machinery is ordinarily impossible, autumn leaf fall provides a natural seed covering. This knowledge has led to successful hand and airplane broadcasting in these types prior to and during the period of leaf fall. However, it takes grass 2 to 3 years to establish itself when seed is broadcast under leaves instead of 1 to 2 years when drilled after brush has been removed. At Ephraim Canyon, an area of 1,300 acres seeded by airplane in October 1945, at a cost of about 25 cents an acre for distribution, produced seedlings in 1946, 1947, and possibly 1948. It was found in this experiment that flying at 100 to 150 feet above the ground gave much better control of seed distribution than flying at greater heights.

Pellet seeding was done in September 1948 on the Mesa-La Sal District of the Manti Forest in southeastern Utah. The soil pellets were well distributed. Laboratory tests indicate that some injury was sustained by seeds during pellet formation. Whether this damage will seriously affect the experiment remains to be seen. As yet, however, we have no information about what stands may be expected from pellets lying on the surface of the soil. We expect, however, to have definite information by 1949 or 1950 from the Mesa-La Sal experiment.

Airplane seeding is still in the exploratory stage. It seems likely that it will be much more fully tried than it has been. The possibilities of using helicopters need to be explored. Just now there is considerable speculation and not a great deal of proved performance.
In general, the requirements for successful establishment of seeded species have been found to be: removal of native competing vegetation, careful drilling of seed on a firm seedbed, and use of a proper amount of adapted seed. In the valleys and sagebrush foothills of the Intermountain region, 6 to 8 pounds of crested wheatgrass seed per acre is about right. Liberal seeding on rough seedbeds does much to hasten the occupation of the soil by roots of reseeded species, helping thereby to keep out weeds, sagebrush, or rabbitbrush. Seeding rates of 12 to 15 pounds in the mountainous zones have been found best. We find it wise also to use 20 to 50 percent more seed for broad-casting than for drilling.

TIME OF SOWING

Determining the best time to sow the seed is surrounded with several difficulties. Chief among these is the extremely great effect of variations in time and amount of seasonal precipitation. Over a period of 15 years the most favorable average time of seeding at lower elevations has been during October. In some years, such as 1941, 1944, and 1946, the occurrence of above-average spring rains made spring planting better than fall. However, years having dry springs are more numerous than those having wet springs. Another difficulty is the shortness of the time in early spring when successful seedings can be made. Small areas may be planted but a program for larger tracts may not be possible in the few days favorable to early spring planting. The recommendation for most of Utah and southern Idaho, therefore, is to seed in the fall at low elevations, and either in the fall or early summer in mountainous areas above 7,000 to 7,500 feet. Actually any period in which rainfall is dependable enough to keep the soil moist for 50 to 60 days is suitable, provided temperatures will permit plant growth.

INFLUENCE OF SITE FACTORS

The success of any range reseeding is, of course, dependent upon several ecological variables. The factors most easily observed and measured are precipitation, temperature, soil, and native vegetation. Very little is yet known about the degree of correlation that exists between these variables and the eventual yield of seeded grass, or other forage, from a given site. However, an attempt is being made to establish a few criteria which are readily observable but which are reliable enough to permit a high degree of accuracy in determining the potentialities of a given site.

Successful reseeding has been done in areas having as little as 8 inches of precipitation where temperatures and soils were favorable. The arid, lower perimeter of the sagebrush zone has about these qualities, except where the soil is too gravelly or sandy. In dry valley areas, high soil salinity is often encountered but does not ordinarily occur on land covered with sagebrush. For reseeding, precipitation of 12 to 16 inches is more advantageous and 16 to 24 inches is extremely favorable.

Many of the grasses that are suitable for reseeding do not thrive under the higher temperatures that exist in the lower valleys even though precipitation may equal that of higher elevations. In this class are smooth brome, orchardgrass, tall oatgrass, and to some degree, crested wheatgrass.

Success in establishing a stand on a reseeding site is not influenced by elevation as a separate site factor. High elevations are, however, correlated both with cooler temperatures and more precipitation in the Intermountain region. These factors directly affect the production of grasses.
Deep, well-granulated soils containing enough organic matter to absorb and retain good supplies of available moisture through long periods of dry weather are especially favorable to high production of range forage. When precipitation, temperature, and soils all improve with changes in elevation, herbage yields usually increase noticeably. In Ephraim Canyon this condition prevails in three of the sites used for plot tests (see table 1). The still higher site at the summit decreased in yielding capacity, most likely due to less favorable soil conditions, shorter growing season, and greater drainage of the soil moisture.

**PLANT BREEDING**

One phase of the plant-breeding project is the production of strains of forage species by controlled pollination, conducted by the BPISAE at Logan, Utah. Several superior strains have already been developed. In the second phase of the project, different strains obtained either by controlled pollination, geographical isolation, or selection are test-planted in the nursery near Ephraim. Approximately 200 strains of smooth and mountain bromes, slender, western, crested, and spiked wheatgrasses, blue wildrye, and orchardgrass are now under test.

Different strains show great variations in yield, palatability, longevity, and winter hardiness. Some are 3 to 5 times more productive than unslected stock. It seems likely that all forage species when subjected to breeding will yield superior strains, and that within a few years breeding work may largely supplant work on suitability of stock species.

**GRAZING RESEEDED RANGES**

Grazing studies of reseeded range land have revealed highly beneficial results both in volume of forage obtained and in the gains made by livestock. At Benmore, Utah, for example, twenty-four 100-ac pastures of range seeded to crested wheatgrass are being grazed experimentally as joint project of the Utah Experiment Station, the Soil Conservation Service, at the Intermountain Forest and Range Experiment Station. Cattle, grazing at the rate of a cow-month to 1½ to 2 acres, gain an average of 2 pounds a day for 60 to 70 days in the spring. Since the results of the last 4 years have been essentially the same, this high gain is no accident. In the fall when the grass is dry, the gains are about one-half pound a day as an average. Smaller studies have shown similar results near Wells, Nevada, where utilization averaging 60 percent of the herbage gives not only a capacity of a cow-month on acres but leaves a litter cover on the ground.

Small pastures at Ephraim grazed by sheep produced approximately the same amount of forage whether sown to crested wheatgrass or to rye. The rye when close grazed required some seed and annual disking, whereas crested wheatgrass needed attention except to make sure it was not overgrazed. Calculations based on a 1 year period showed rye to cost about twice as much for each sheep month of forage as crested wheatgrass. Also, in some cold dry springs, rye was a highly uncertain producer of forage.

Research studies of the effects of grazing on reseeded ranges have barely begun. About all that has been done is to approximate the grazing capacity and weight gains from a few areas. How intensive they may be grazed without injury and whether to graze them by continuous rotational use are problems now being studied.

**SUMMARY**

There are four generalized planting zones (sagebrush, mountain brush, subalpine, and salt-desert shrub) in the Intermountain Forest and Range Experiment Station. Cattle, grazing at the rate of a cow-month to 1½ to 2 acres, gain an average of 2 pounds a day for 60 to 70 days in the spring. Since the results of the last 4 years have been essentially the same, this high gain is no accident. In the fall when the grass is dry, the gains are about one-half pound a day as an average. Smaller studies have shown similar results near Wells, Nevada, where utilization averaging 60 percent of the herbage gives not only a capacity of a cow-month on acres but leaves a litter cover on the ground.

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mountain region in which reseeding research at various levels has so far been done. Research is most advanced in the sagebrush zone. Species suitability is being tested at four sites in Ephraim Canyon, Utah, comparable in elevation to the four zones. Crested wheatgrass does better in the sagebrush zone than any other species of grass. At the higher sites, intermediate and stiffhair wheatgrasses and smooth brome outrank all other species.

Sagebrush can be eradicated most effectively by burning. Mechanical methods vary in effectiveness, with the wheatland plow (one-way disk), the offset disk, and the brushland plow all giving a 75 percent kill or better. Moldboard and wheatland type plows are highly efficient mechanical means of reducing competition from cheatgrass; early summer burning is also particularly effective. Drilling of seeds is generally more successful than broadcasting. In the valleys and sagebrush foothills, a seeding rate of 6 to 8 pounds of crested wheatgrass to the acre is considered best. Seeding rates for adapted species of 12 to 15 pounds are best in the mountainous zones. The most favorable average time of seeding at the lower elevations has been during October.

The presence of sagebrush on a site indicates that precipitation, temperature, and soil relations are favorable for reseeding and that soil salinity is low. Other simple correlations between site factors on which to base reseeding are being sought. Several superior strains of bromes and wheatgrasses, yielding from 3 to 5 times more herbage than unselected stock, have been developed by controlled pollination. Grazing studies indicate that cattle grazing at the rate of a cow-month to 1½ to 2 acres, gain an average of 2 pounds a day for 60 to 70 days in the spring on range reseeded to crested wheatgrass.