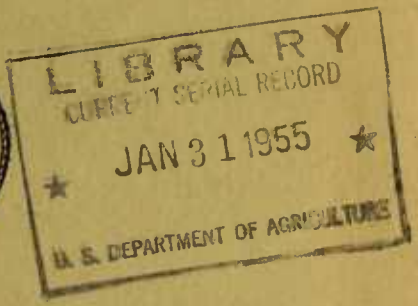
Seeding Rangelands in

Utah, Nevada
Southern Idaho
and Western Wyoming



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Seeding Rangelands in Utah, Nevada, Southern Idaho, and Western Wyoming[1]

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INTRODUCTION

Artificial seeding of immense areas of deteriorated rangeland in the Intermountain region (Utah, Nevada, southern Idaho, and western Wyoming) now offers a major and direct means of vastly increasing forage production and controlling erosion. This is possible because of up-to-date information developed by more than 20 years of experimental planting. In this period nearly 1,000 species and species variants from all parts of the globe have been tested. Trials with these have been conducted on the most important problem areas by many field methods.

It is conservatively estimated that a total area of approximately 20 million acres of deteriorated rangeland in the Intermountain region should be revegetated, either for forage production or for watershed protection and soil stabilization. Increased forage production on this seedable area will help to obtain the lighter use necessary for improving an additional 100 million acres of damaged range which can be rehabilitated more economically through proper management.

Advantages from successfully seeded ranges are immediate and direct to livestock operators. More forage is made available at seasons when it is most needed, and livestock gains are greater and quicker as the forage is improved. The increased forage production on many large areas established from 8 to 20 years ago in different parts of the region, has run between 300 and 3,000 pounds of air-dry herbage an acre. The general average for successful planting has been 900 pounds. Before seeding, only a few of the sites were producing more than 50 pounds per acre. In terms of the average, if the seeded stands are utilized 50 percent, 450 pounds of air-dry forage is available. This is enough so that 1⅓ to 2 acres will support a cow or 5 sheep for 1 month, where before seeding 10 to 25 acres were necessary to supply this amount of forage.

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[1] This handbook supersedes Farmers' Bulletin 1823, Reseeding Rangelands of the Intermountain Region.

[2] The authors thank the Soil Conservation Service and the Agricultural Research Service for supplying seed of hard-to-get species for seeding; and these same agencies, together with the Bureau of Land Management, Forest Service, State Agricultural Experiment Stations and Extension Services, and numerous ranchers who cooperated in making the seedings to supply information for this handbook.

To illustrate, a mountain area in central Utah invaded by big sagebrush [3] and of little value for grazing was burned and drilled to a mixture of palatable grasses in 1944 (fig. 1). Between 1945 and 1951 this area annually produced an average of two cow-months' grazing per acre. As another example, a big sagebrush area in southern Idaho producing 50 pounds of native forage per acre was burned and drilled to crested wheatgrass in 1943. Two years later it was producing 1,785 pounds (dry weight) of grass per acre, or the equivalent of 1½ cow-months' forage. Again, in Ruby Valley, Nev., a large acreage of big sagebrush range requiring 16 acres per cow-month was seeded to crested wheatgrass in 1944. Between 1946 and 1951 this area has produced spring grazing at the rate of 2½ acres per cow-month.

Although more forage is often needed on all ranges, early spring and fall forage on our lowland ranges are in greatest demand in the Intermountain area. Seeding them to crested wheatgrass makes these ranges ready for grazing 10 to 20 days earlier than is possible with cheatgrass or with native perennial grass or brush ranges. It is thus possible to turn livestock out to graze 2 weeks sooner in the spring (fig. 2). This ordinarily saves 300 pounds of hay per cow and provides green feed when most needed. It also means lower feeding costs, less labor, and better gains on livestock. Lambs have been found to make gains of over ½ pound per day on such range through the spring. Calves will make 1¾ pounds gain per day per head, and cows will make 1½ to 3 pounds gain per day.

Seeding has the added value of reducing and controlling poisonous or undesirable plants such as halogeton, tarweed, low larkspur, and Barbey (or tall) larkspur. In many instances seeding can build high grazing capacity range on lands supporting such undesirable weeds. Near Wells, Nev., poisonous halogeton is unable to gain a foothold in a good stand of seeded crested wheatgrass, although it has become abundant on all sides in annual cheatgrass and Russian-thistle. In areas in Utah, planted grasses have completely suppressed cluster tarweed. Replacing Russian-thistle and tumblemustard with perennial grasses in Idaho decreases these weed hosts of beet leafhopper, which causes immense damage through curly top to beets, beans, and tomatoes.

Present seeding costs are high, often $5 to $15 per acre, but if seeding will result in an increase of 1 cow-month's grazing, or 30 to 50 pounds of lamb or beef per acre each year. the amount of money spent for seeding is usually a good investment.

Seeding will pay biggest dividends on sites where the plants valuable for grazing have largely been killed and where recovery of valuable forage plants would be very slow by natural means. Where the desired improvement in plant cover can be attained through good range management practices within a reasonable period of time, seeding is not advisable. On a range where a good forage cover is present but weakened by overuse, it may require only a year of no grazing in spring and a period of years of light grazing to bring about substantial improvement.

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[3] A list of common and botanical names of species mentioned appears on page 71.

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FIGURE 1.—*A*, Mountain brush range in central Utah burned and seeded in September 1944. Prior to seeding, this was dense brush which livestock could not use. *B*, Stand of mixed grasses produced in 1945 on the same area. Between 1945 and 1951, this formerly valueless brush site produced the equivalent of 2 cow-months' forage per acre for use during June, July, and August.

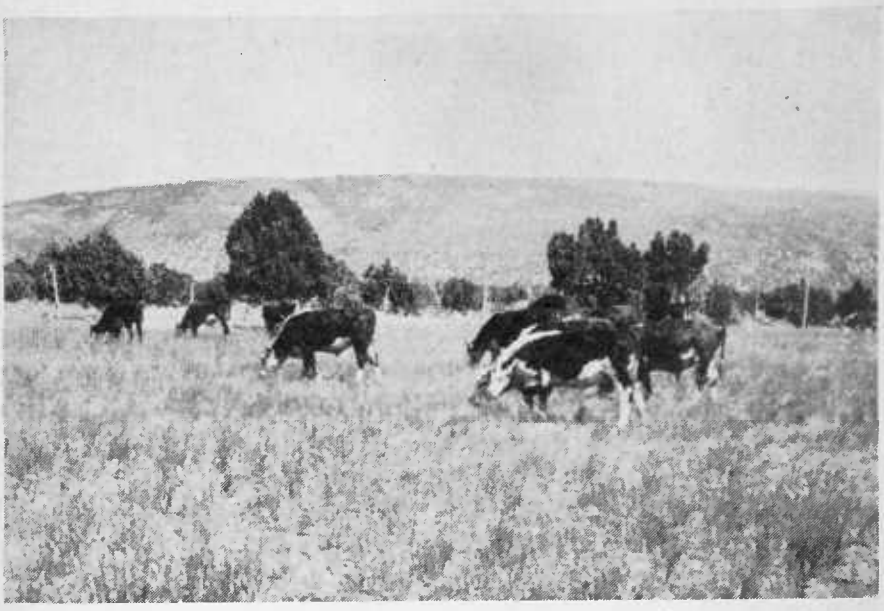

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FIGURE 2.—Cattle grazing crested wheatgrass on a lowland area in Utah with an average annual precipitation of 10½ inches. Adjoining cheatgrass and Russian-thistle range is usually not ready to graze for at least 2 weeks after crested wheatgrass.

In any program of range seeding there is a logical procedure to be followed. It involves: (1) Choosing the correct places to seed; (2) using the right methods and equipment; (3) sowing at the best time of year; (4) using adapted species that will give greatest returns; and (5) managing the seeded range. Each of these steps is described in separate sections in the following pages. While this handbook is primarily for seeding ranges in the Intermountain region, it is also applicable to comparable areas in other parts of the West.

WHERE TO SEED

In deciding where to seed there are some factors which must be carefully considered. The most important of these are terrain (evenness of the land surface and degree of slope), competing vegetation, soil, and available moisture. Terrain and competing vegetation figure importantly in the ease and cost of seeding, whereas soil and moisture are the two factors which affect production most. There are wide variations between sites suitable for seeding in the Intermountain region. They vary from the dry lowlands, where low precipation is the major limiting factor, to mountains, where precipitation is usually adequate but terrain and short growing season are the major limiting factors.

Terrain

Preferred for seeding are level to gently sloping lands where ground preparation can be done with machinery at reasonable cost. Except for watershed protection, it may not be economically feasible to treat and plant slopes in excess of 30 percent (a 30-foot rise for every 100 feet on the horizontal). Even on grades above 20 percent the cost is much greater than on level lands, because large equipment cannot be used and small machinery or horse-drawn equipment must be resorted to. Gullies, ditches, and steep ravines also hinder use of heavy equipment and increase costs (fig. 3).

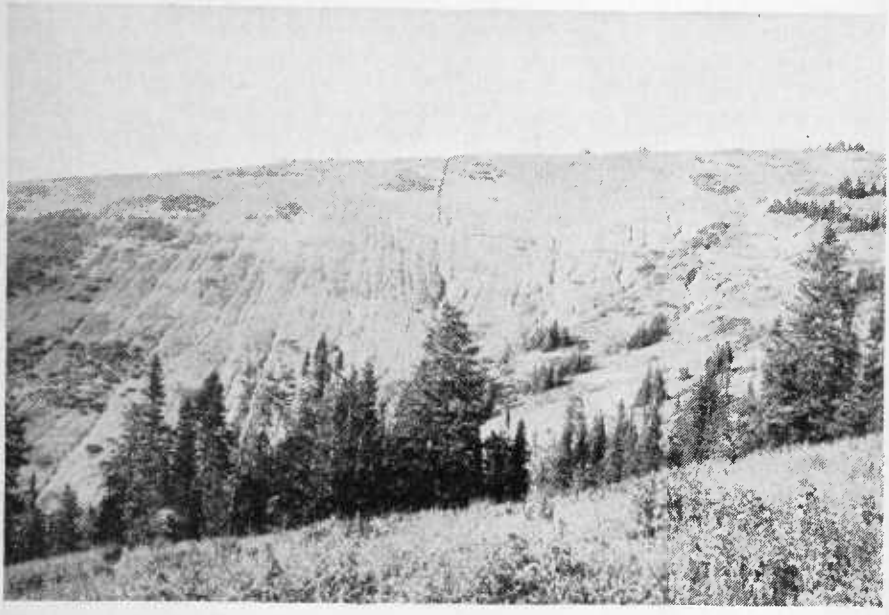

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Figure 3.—Because of deep gullies and steep slopes, this is not a suitable place to seed for forage production. However, it is often necessary to plant such slopes for watershed protection.

Soil

Deep, fertile soils, well supplied with organic matter, are more productive than thin soils. Heavy soils with good moisture-holding capacity require less moisture than gravelly or light sandy soils to make the same production. Soils with good moisture-holding qualities will frequently give similar or greater yields of seeded grasses than lighter soils where considerably more precipitation occurs. If salts are suspected of being excessive, soil samples should be sent to a soil-testing laboratory to determine suitability of the soil for seeding.

Vegetation

Thick, vigorous stands of sagebrush, cheatgrass, or Russian-thistle indicate a site that will produce high-yielding stands of better forage plants (fig. 4). Greasewood or saltgrass indicate that salt-tolerant plants, such as tall wheatgrass and Russian wildrye, should be used. Remnants of bluebunch wheatgrass generally show that crested wheatgrass or other drought-enduring species will grow well. Mountain brush, such as snowberry and serviceberry, indicates that mixtures of the less drought-enduring grasses—tall oatgrass, bearded wheatgrass, and smooth brome—will succeed. Winterfat (or whitesage) and shadscale saltbush are evidence that the site may be too dry for successful seeding.

Close inspection should be made of lands being considered for seeding to be certain that desirable native plants are not present in sufficient number to recover merely by eliminating brush or improving the management. A fair rule of thumb is to seed where there is less than one desirable bunchgrass or broadleaf herb to every 10 square feet or one stem of bluestem wheatgrass or other sod-forming plant to every 15 square feet.

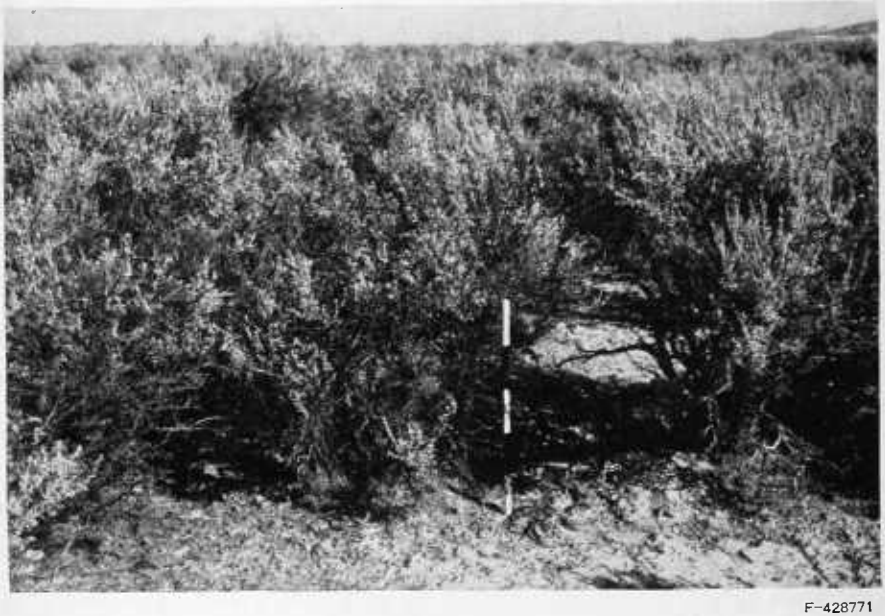

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Figure 4.—Areas supporting heavy sagebrush stands with little undercover of grasses are excellent prospects for seeding. A heavy cover of brush and weeds is evidence of a productive planting site.

Precipitation and Available Moisture

As a general rule, seedings in the Intermountain region can be successfully made where average annual precipitation is greater than 10 inches. With careful planting in soil having good moisture-holding qualities, successful stands have been attained where annual precipita-

tion is as low as 8 inches. A few successful stands of crested wheatgrass have been obtained on desert ranges where annual precipitation is below 8 inches, but here stand establishment is always uncertain.

In some places it is possible to get new plantings established readily by spreading the surplus water of early spring runoff. Water-spreading is particularly helpful on dry ranges where stand establishment is normally slow. In Idaho, yields of forage on a high mountain meadow were increased from ½ to 4 cow-months per acre by spreading water following the planting of grasses and alsike clover. In Utah, spreading of surplus high water and seeding on dry sagebrush benches increased the grazing capacity from virtually nothing to from 2 to 5 cow-months per acre (fig. 5). Wherever there is opportunity for distributing surplus water on a seeded range, there is opportunity for increasing the available forage and obtaining returns which will usually greatly exceed the expense.

Lowland Sites

Lowland valleys, benches, and adjoining foothills suitable for seeding vary in elevation from 2,500 to 7,000 feet. The average annual precipitation varies from 8 inches to nearly 17 inches. The major portion of the lowlands suitable for seeding is in a belt where precipitation varies between 9 and 14 inches. While these lowlands are predominantly used for spring-fall range, some of the higher valleys and some of the alkaline valley bottoms with a high water table provide good summer range for cattle, particularly after seeding to improved forage species. Certain of these lowlands which remain fairly free of snow are used also as winter range.

Because of the large and level tracts of lowland range, opportunities for seeding are much greater than in the mountains. In total, there are estimated to be at least 15 million acres of lowland range in the Intermountain region where seeding to improved forage plants will be worth while.

The major range areas where seeding can be successfully carried out on lowland range include: (1) Recently abandoned dry farmlands, (2) big sagebrush and associated brush species, (3) cheatgrass, (4) Russian-thistle, (5) saltgrass and greasewood, and (6) juniper-pinyon.

During the past emergency period many thousand acres of the best sagebrush range were plowed and sown to dryland grain to meet the demand for wheat. As demand and price decline to where wheat is no longer profitable, most of these dry farmlands can be converted to productive range by planting adapted grasses.

Land covered with thrifty big sagebrush is fertile. Where depleted of valuable perennials, it makes highly desirable range for seeding, but some expense is required to eliminate the brush competition (fig. 4). Small and widely spaced bushes, however, usually indicate poor soil or moisture.

Sagebrush should not be eliminated where it is important forage for big game. On winter range both black sagebrush and big sagebrush are valuable browse and should not be eradicated.

Black sagebrush, which is normally smaller than big sagebrush, often predominates on large areas with less than 8 inches annual preci-

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FIGURE 5.—Spreading of surplus high water in the spring months on this rocky foothill land has added to the 10 inches of average annual precipitation and made possible a high-yielding stand of timothy, smooth brome, and yellow sweetclover. This procedure also makes it possible to establish seeded stands quickly.

pitation. Except on winter ranges, black sagebrush is of little value for livestock grazing. The better sites supporting it are suitable for seeding if the terrain permits. In Nevada and central Utah, crested wheatgrass on adjoining big sagebrush and black sagebrush range yielded similar amounts of forage. Because the soil under black sagebrush is usually thinner and rockier than under big sagebrush, black sagebrush is usually more costly to eradicate.

Rabbitbrush is often mixed with big sagebrush, but also may occur in pure stands. Such sites, in either instance, generally have a potential production equal to that of pure stands of big sagebrush but are always more expensive to treat. To eliminate rabbitbrush, horsebrush, and other sprouting shrubs, their roots must be cut deep enough below the crown to prevent sprouting. Successful plantings have been established by drilling directly into thin stands of rabbitbrush. However, the brush persists, and usually eliminating it pays, unless it is valuable for browse.

Some successful seedings have been made on depleted shadscale saltbush and winterfat types on the better sites. Generally, however, the hazards in these types are too great to warrant large-scale seedings, especially where the average annual precipitation is less than 8 inches.

Because these shrubs do not offer as severe competition as does sagebrush, it is possible to drill directly into shadscale and winterfat without seedbed preparation. One rancher in Millard County, Utah, obtained excellent stands of crested wheatgrass by drilling directly into shadscale where the average annual precipitation was approximately 9 inches. Good stands have been obtained in other places in shadscale where average annual precipitation exceeded 10 inches. If shadscale occurs as a pure stand one should suspect high salinity which in effect accentuates the aridity of the site. Many seedings of crested wheatgrass in these relatively dry and often saline types have looked successful the first 2 to 5 years, then later dwindled away.

Vigorous stands of annual cheatgrass, growing as pure stands or as an understory in sagebrush in a year of normal or less than normal precipitation, are indicative of productive sites which can be successfully seeded. However, where cheatgrass is small and spindly in years of normal precipitation, only poor stands of perennials can be grown. As cheatgrass grows in the fall and early spring, it competes with seeded species and must be eradicated for successful seeding.

Lands supporting Russian-thistle within the sagebrush zone are some of the best for seeding, because they can be seeded without seedbed preparation. Since Russian-thistle makes most of its growth in summer after seeded species are well established, it furnishes but slight competition to seeded grasses. Dry Russian-thistles help protect the small grass seedlings from wind and sun in summer and from winterkilling and frost-heaving in winter. All Russian-thistle areas should be sown before they are occupied by more competitive plants such as big sagebrush and cheatgrass. The same also applies to areas dominated by other summer-growing annuals, such as the poisonous halogeton, tumbleweed amaranth, and lambsquarters goosefoot.

Saltgrass and greasewood types, having a high water table, can be converted into more productive ranges by seeding adapted salt-tolerant grasses. For successful seeding, the soluble salt content should not exceed 1 percent, and the ground should be moist to the surface, at least in spring. If there is a prevalence of sodium carbonate, often called "black alkali," seeding probably should not be undertaken.

Juniper and pinyon trees occupy large areas of formerly good forage-producing range. For the most part these areas are suitable for seeding. The best sites in this type are the swales and benches with deep soils. The rocky ridgetops and hillsides are usually not suitable, being sites where the trees have always been dominant and grass production low.

Mountain Sites

There are at least 5 million acres of mountain land within the Intermountain region where increased production will make seeding a paying investment. Elevations suitable for seeding vary from 4,500 feet in the lower mountain brush to over 11,000 in the subalpine zone. Precipitation varies from 14 inches at low elevations to as much as 50 inches at high elevations. While the mountains usually have more favorable moisture and more fertile soil than the lowlands, their slop-

ing and rougher terrain, as well as smaller areas available, make seeding more costly. Planting can be carried out successfully within the major mountain range types, including mountain brush, aspen, open weedy parks in timber, and high subalpine weedy ranges. Artificial rehabilitation is also necessary on certain watersheds for soil protection alone.

The extent and depletion of many mountain brush areas, as well as need for forage on these ranges, make them some of the most important for seeding. They may be characterized by either short brush or tall brush. Big sagebrush and mountain snowberry are the most common short-brush plants. Gambel oak (or shrubby oak), bigtooth maple, serviceberry, and true mountain cercocarpus are the most characteristic shrubs of the tall brush, and in places some of these may actually take the form of small trees. Althongh highly variable with exposure, the soils within this zone are usually fertile and will support high yields of seeded forage plants. Areas to be selected are those where the herbaceous plants are mostly gone.

Experience has shown that growing conditions in openings in the ponderosa pine zone are similar to those on mountain brush lands and the same species may be used.

Short brush areas can be successfully treated and sown by conventional procedures described in the following methods section. Tall-brush types are usually too expensive to seed by these methods, but fortunately good stands can often be obtained merely by broadcasting the seed before or during leaf fall, particularly in areas where Gambel oak and bigtooth maple predominate.

Aspen, depleted of herbaceous undercover, also provides some of the best and easiest range for seeding. Here, too, merely broadcasting the seed just prior to or during leaf fall gives excellent results. Douglas-fir and spruce timber openings resemble aspen openings and may be seeded with the same forage plants.

Open subalpine ranges and parklike openings in timber, supporting only low-value weeds, are excellent seeding sites. Tarweed, knotweed, and sweet sagebrush are examples of low-value weeds now dominating these areas. Many of these lands are important watersheds where seeding is essential to restore a plant cover.

HOW TO SEED

The first essential for successful planting is a method which eliminates competing plants to permit establishment of seeded species. As far as possible this method should also furnish a suitable seedbed. Secondly, a planting procedure must be used which will place the proper amount of seed in the soil near the optimum depth for good seedling emergence.

Removing Competition

Undesirable plants with growth periods similar to seeded species rob the soil of moisture, causing poor seedling establishment and low production. Sagebrush, rabbitbrush, cheatgrass, cluster tarweed, common dandelion, and mules-ears wyethia are examples of such

competing plants. Poor elimination of such competition may completely prevent young seedlings from becoming established. Normally the greater the kill of competing plants the more quickly a productive stand will be established and the less the chance will be for reoccupancy by undesirable competitors. On the Snake River Plains, in southern Idaho, for example, killing 92 percent of the big sagebrush and seeding crested wheatgrass resulted in 1,785 pounds of air-dry crested wheatgrass per acre 2 years later. In contrast, 53-percent kill resulted in only 529 pounds of crested wheatgrass per acre. Again, complete elimination of cluster tarweed in an aspen opening during early spring and seeding to a mixture of adapted grasses in Utah, resulted 2 years later in a full stand of grass and production of 3,000 pounds of air-dry forage per acre, whereas 50-percent elimination resulted in a very poor stand of grass and a production of less than 90 pounds of forage per acre.

Summer-growing annuals, such as Russian-thistle, make their growth after seeded species are fairly well established, and so do not need to be eliminated. Aspen and tall mountain brush, such as bigtooth maple, depleted of herbaceous understory, are also exceptions. In these types there is sufficient moisture, beyond what the trees and brush use, for establishment of seeded forage plants. After establishment, seeded species develop at the expense of the trees and brush, and eventually the suppressed browse and grass make high-yielding range (fig. 6).

The two general methods of removing plant competition are planned burning and mechanical procedures.[4] Use of chemical sprays is now gaining considerable prominence, and, as more is learned, spraying probably will be more widely used.

Burning

Planned burning is the most economical and successful procedure for eradicating the nonsprouting big sagebrush, and can often be successfully used on juniper. Although it kills only a low percentage of sprouting brush species, it reduces their vigor and helps herbaceous plants to suppress them. Burning is an effective method for thinning cheatgrass competition, if done before the seeds fall in the summer. At this time cheatgrass will burn readily, so that very little live seed remains.

Where big sagebrush comprises a substantial part of the brush cover, complete burns can be attained and a good firm seedbed is provided for direct planting. Of course, the total brush cover must be thick enough or with sufficient undercover to carry fire well. With establishment of good stands of adapted grasses, followed by proper grazing, brush may be suppressed, and in this form becomes a valuable component of the cover, adding greatly to the nutritive value of the total forage, particularly in late summer and fall. Rabbitbrush and sagebrush, however, sometimes increase despite proper use of the grass. To minimize this, it is important to burn before these two brush species mature seed.

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[4] Details on methods of controlling sagebrush are available in U. S. Dept. Agr. Farmers' Bul. 2072, Sagebrush Control.

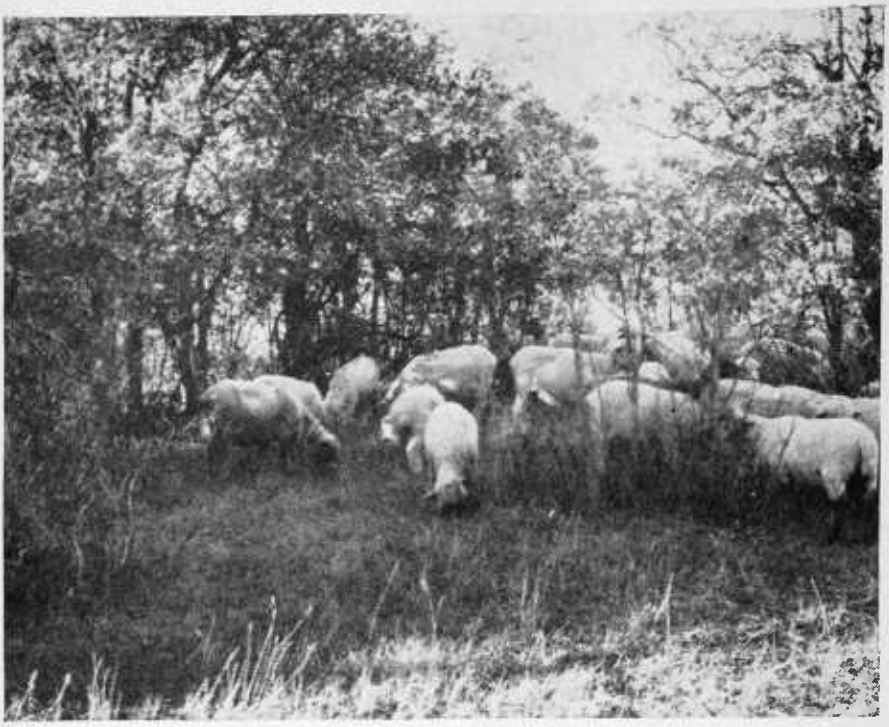

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FIGURE 6.—Broadcasting just prior to leaf fall results in good stands of forage in oak patches. Smooth brome sown in 1930 has suppressed much of the oak and opened it up so sheep can graze through the thickets.

Burning kills a very low percentage of the free sprouting brush associated with sagebrush, such as rabbitbrush, horsebrush, saskatoon serviceberry, mountain snowberry, Gambel oak, true mountain cercocarpus, and common chokecherry. Antelope bitterbrush, a valuable browse commonly associated with sagebrush, shows a high percentage of sprouting from the crown in some places, and in others is totally killed as a result of burning. Mortality of this species varies with geographical area and growth form, as well as with intensity of fire and soil moisture. Its survival after burning in Nevada and southwestern Idaho is practically nil, whereas in southeastern Idaho and Utah survival may be fairly high. Mortality of bitterbrush tends to be high among upright forms and low among low-growing forms having branches which lie along the ground and root at occasional points where they contact the soil. If it is known that burning kills bitterbrush in an area where it provides an important amount of forage, methods that do less damage to this shrub should be used.

Burning of Gambel oak or other tall mountain brush is risky. Furthermore, the large trunks that may be left are such obstacles that ground treatment to cover the seed is impossible, unless heavy equipment is available to push through them (fig. 7). While good forage stands will frequently result from merely broadcasting into the ash following burning, too often the ash litter is washed or blown

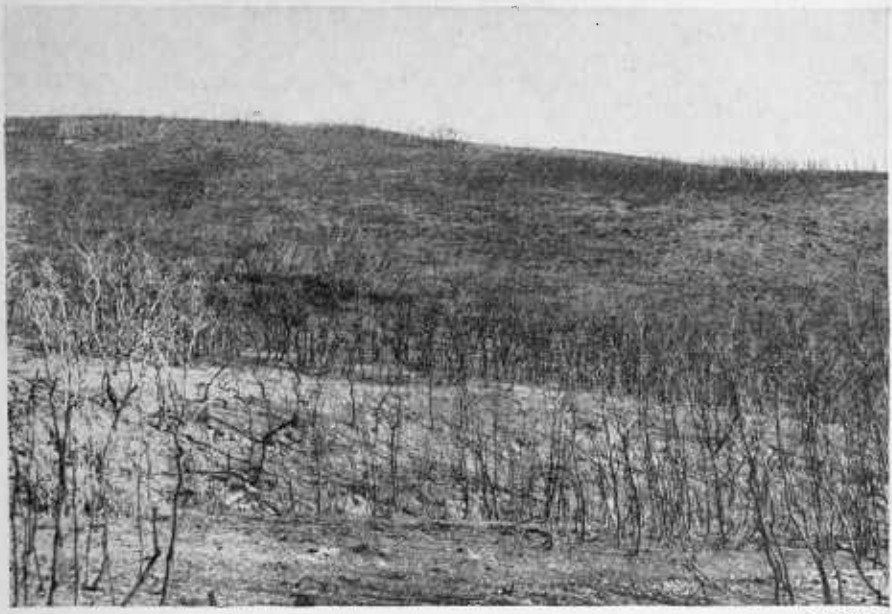

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FIGURE 7.—Burns in tall mountain brush (here Gambel oak) are not reliable places for broadcasting if the ash blows away. For good seedling establishment, heavy equipment is required to push the trunks over and cover the seed.

away, leaving a hard surface on which very few seedlings become established. With no competing herbaceous cover, the brush becomes a dense thicket and sometimes a greater problem than before burning. Usually equally good or better stands of forage would eventually have followed broadcasting before leaf-fall.

Fire is also one of the most effective and least expensive means of eliminating juniper and pinyon, particularly where there may be an understory of cheatgrass to carry fire. Where trees are not close enough together to carry fire, they can be pushed into continuous windrows with a bulldozer. Windrows may be spaced at intervals of 100 to 200 feet apart, and greater if the fire will carry through the interspaces. Setting the trees on fire after they have dried 2 or 3 weeks builds up a wall of flame which carries across the interspaces. Even if some trees do not burn, the heat kills them.

Back-pack burners, which throw a flame 25 to 30 feet long, readily scorch the foliage, killing most of the standing scattered trees (fig. 8, A). If humidity is low and wind is about right, the fire will spread rapidly over a large area, even among trees quite widely spaced.

Burning Cautions

Fire on the range is always dangerous. When burning is used as a method of eliminating competition, it necessarily has to be done in late summer, when fire-hazard conditions are high and there is a sustained wind. Therefore, precautions should be taken to keep the fire under control. Burning should be carefully planned and all fire-warden

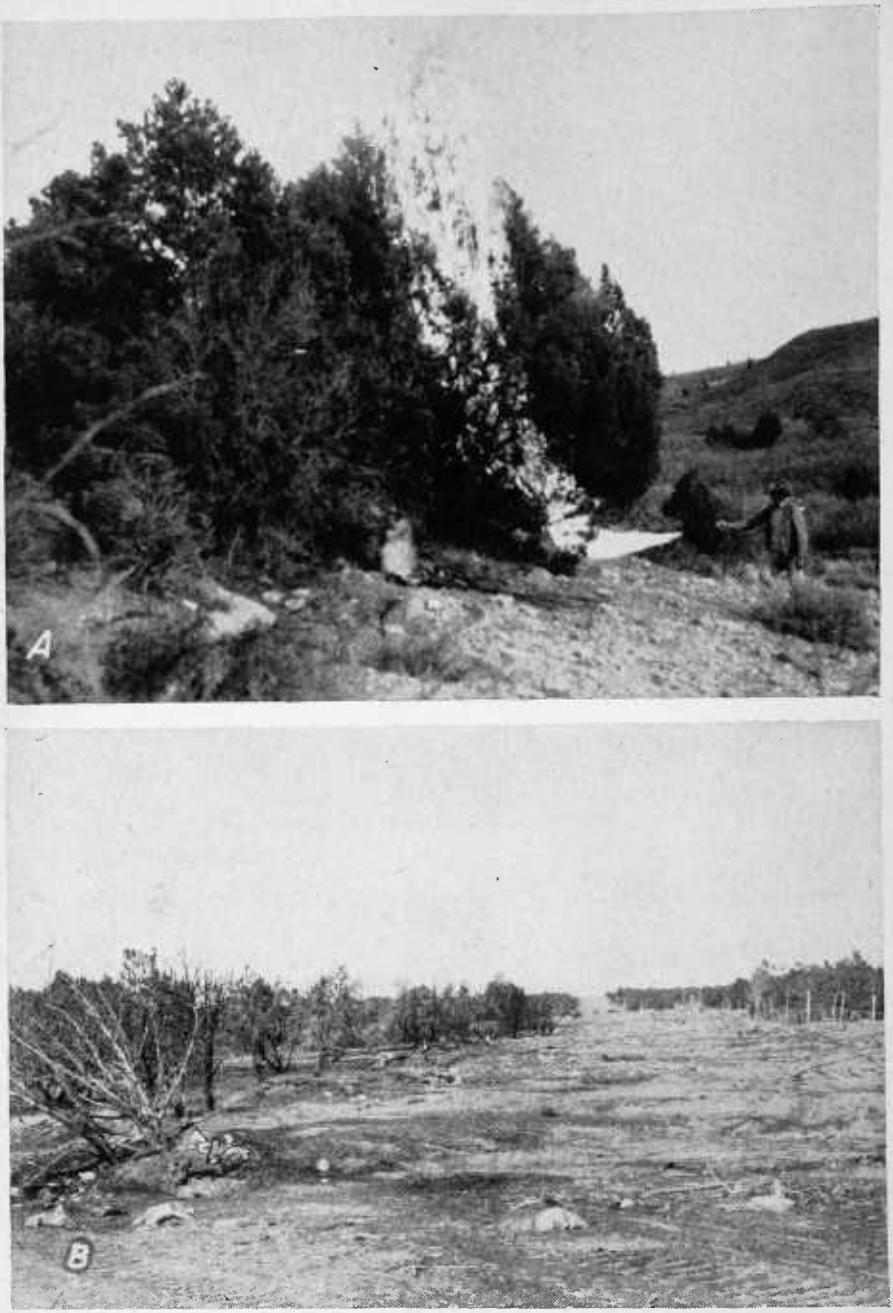

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FIGURE 8.—*A*, Back-pack flamethrowers which use fuel oil are useful for killing juniper and pinyon, as well as for starting fires. If the foliage is scorched, the tree will die. *B*, Fireline to leeward of fire should be a minimum of 200 feet wide. Here the 30-foot dozed out line was made wide enough by backfiring into junipers on left.

officials informed of the burning plans. An experienced crew should do the burning and a standby crew should be on the alert.

Greater caution is needed when burning mountain rangeland, because of the hazard to timber and watershed values. Fire should never be used where land is highly susceptible to wind or water erosion. The planting of fast-growing grasses in mixture with the slower-growing but more persistent ones may permit the burning of slopes up to 30 percent. Fire is not advised where slopes exceed 30 percent, because of danger of erosion afterward. Controlling fire on slopes is always more expensive and dangerous than on level and gently rolling areas in the lowlands.

Advice of local people who have had direct experience is helpful in deciding how to make the firelines. When burning brush or cheatgrass, a fireline, usually not less than 200 feet wide, should be provided on the leeward side (side toward which the wind will carry the fire). This normally consists of two strips, cleared by bulldozer or power grader, separated by a 200-foot uncleared strip. This strip is then burned out in a calm period when there is no likelihood of a brisk breeze. The outer cleared strip should be 12 to 16 feet wide, which is usually twice the width of the dozer blade, and the inner strip, next to the main area to be burned, 6 to 8 feet wide. On the windward side of the fire (side from which the fire is started), a 6- to 8-foot cleared strip is usually adequate. These widths should be doubled in juniper or brush over 5 feet high (fig. 8, *B*). Also, if there is above-normal risk that live sparks may jump across firelines, their widths should be increased to eliminate the hazard. Duff from all lines should be scraped off clean to the mineral soil. Natural barriers, such as barren ridgetops, roads, and wide streams can often be used as part of the fireline to reduce costs.

Accidental Burns

Many accidental burns are excellent seeding sites. When seeding is needed, they should be sown the year of burning and before the ground becomes overgrown with competing vegetation. Accidental burns in sagebrush and cheatgrass on lowland ranges can be seeded readily by drilling. Excellent stands of grass have resulted from broadcasting on a number of accidental burns in mountain brush, pinyon-juniper, lodgepole pine, and ponderosa pine, when a heavy mantle of ash is deep enough to cover the seed (fig. 9).

Mechanical Methods

The choice of mechanical implements to be used for eliminating competition depends on the terrain and vegetation to be dealt with. While usually more expensive than burning, mechanical methods have a much wider area of application. Plowing, with such disk-type plows as heavy offset, wheatland, or the newly developed brushland, is the most widely used mechanical procedure. But on certain areas railing, pipe-harrowing, beating, grubbing, moldboard-plowing, cabling, and bulldozing are highly satisfactory. In some places lighter farm equipment can be used to good advantage. For instance, with annual weeds, surface cultivation with light disks, duckfoot weeders, and

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FIGURE 9.—Accidental burns in timber often produce a good forage cover after broadcast seeding in the heavy ash mantle. The seed should be broadcast the same year as the burn.

spring-tooth harrows is adequate. However, on most rangeland, more sturdy equipment than ordinary farm machinery is required.

Where two or more plant types occur on a general site, more than one kind of equipment or methods may be needed to effectively eliminate the competition.

Plowing

Of mechanical methods, probably plowing can be employed more effectively and on a larger area than all other methods. It is feasible in sagebrush, rabbitbrush, greasewood, low mountain brush, cheatgrass, saltgrass, and annual and perennial weed areas which are relatively rock-free and not excessively cut up by gullies. Plowing has several advantages over burning: The mulch provided by the cut-up plants usually helps to keep moisture in the soil and makes a better environment for seedling establishment; a residue is left on the soil which is helpful in erosion control; and the mulch helps to build up fertility although slight nitrogen depletion may result the first year.

The most widely used and available procedure is disk-plowing, with the heavy offset disk and wheatland type plows (1-way disk plows) (figs. 10 and 11, *A*). Both should be equipped with 26- or 28-inch disks for treating rangeland. If properly adjusted, under ordinary

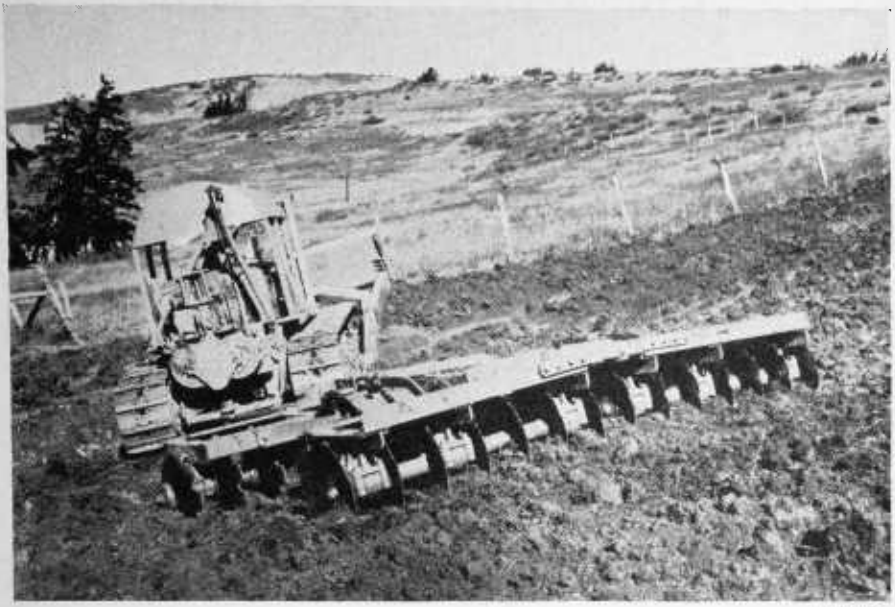

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FIGURE 10.—The heavy offset disk is useful for eliminating a variety of competition. While not quite so effective in sagebrush as the wheatland plow, it is easier to operate and more effective on weedy range.

conditions, either should give better than 85 percent kill of the competing plants. Offsets give better kills of herbaceous vegetation, particularly in heavy, tight soils, and wheatlands give somewhat better kills on level sagebrush areas. The heavy offsets require less adjustment than the wheatlands and are usually not as expensive to operate because of less breakage; but on loose, soft land they plow deeper than necessary and consequently require more power.

The new brushland plow, patterned by the Forest Service after an Australian model stump-jump plow, is the best machine on rough and uneven land (fig. 11, *B*). With the brushland, kills of over 90 percent have been obtained on the same ground where the wheatland and offset gave kills of less than 75 percent. The brushland can be used on land too rocky for other types of plows, because the paired disks work on separate spring levers, which permit each pair to rise independently over rocks or other obstructions. Cost of repair per acre of rough and uneven land is much less for the brushland plow than for the offset or wheatland.

In some places the ordinary disk plow mounted on wheels does an excellent job of eliminating competition. With larger plows and sufficient horsepower, comparable acreages can be done as with other plows.

Moldboard plows can be used to good advantage on limited rock-free areas of very dense cover with tight soils, where disk-type plows may be inadequate. Because they are slower, and because of the greater power required for pulling, moldboard plowing is usually overly expensive.

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FIGURE 11.—*A*, The wheatland is one of the best all-around implements for eradicating sagebrush on level land, but some skill is required to keep it in proper adjustment. *B*, The brushland plow is the most efficient machine on uneven or somewhat rocky land.

Plowing to a depth of 2 to 4 inches will give satisfactory kills on most nonsprouting plants like sagebrush. Sprouting species like rubber rabbitbrush and horsebrush, however, require plowing 5 to 7 inches deep to cut the root below the crown. This deeper plowing takes more power and time and will often be doubly expensive. Deep plowing often turns sterile subsoil to the surface in thin soils. This is often undesirable, because this soil tends to crust, thereby hindering good seedling emergence.

Perennials which spread by underground rootstocks or from the crown, such as sweet sagebrush, desert saltgrass, or mules-ears wyethia, should be completely turned over so the roots are exposed to the sun. This requires plowing to a depth of 4 to 6 inches. For control of saltgrass, two plowings at a 1- to 2-year interval are required.

Hitches can be purchased or readily made so that two or three plows, and sometimes other implements, can be pulled simultaneously. Where a tractor has enough power and the land surface permits, it usually pays to pull more than one plow.

Other Mechanical Methods

Brush-beaters, or rotary cutters, with revolving hammers or beaters (fig. 12, *A*) on a rotating axis, or cutting knives on a vertical shaft, are particularly useful for eliminating sagebrush from either seeded or natural grass stands. These machines are most valuable on rocky lands, but where the rocks do not stick up from the ground more than 3 to 4 inches. Brush-beating retains the native herbaceous perennials and the fine shredded brush is left as a surface mulch. The mulch conserves moisture and protects the soil against erosion. An important limitation of beaters is that they will not kill low-growing timber or sprouting brush.

Rail drags of various designs (fig. 12, *B*) have proved useful and economical for eliminating large mature sagebrush on large expanses of level or rolling land. The most common are heavy rails pulled by a cable or chain at right angles to the direction of travel. Rails have the advantage of preserving the herbaceous understory, which is often desirable. Rails do not effectively cover broadcast seed.

Self-clearing pipe harrows are well adapted for eliminating brittle sagebrush on rocky and rough ground, but make low kills on willowy brush or perennial weeds. They give higher brush kills on rocky than on rock-free areas. On range with a shallowly embedded rock layer and high-projecting surface boulders, they loosen the ground surface and make a seedbed where practically no other machinery can be used (fig. 13). Pipe harrows can be readily constructed in any machine shop. They consist of a series of 4-inch pipes 10 feet long, with teeth 4 inches long and 1 inch in diameter. Pipes are attached to a spreader by swivels so the pipes can turn and clear themselves of brush. Troughs inserted on the front end of the pipes keep them from jumping across one another on sloping ground.

The log harrow can be used in a similar manner. It can be constructed of green logs 6 to 8 inches in diameter and 10 feet long, and assembled in the same manner as the pipes in the pipe harrow. Drill steel or similar irons, 1 inch in diameter and 12 inches long, are driven

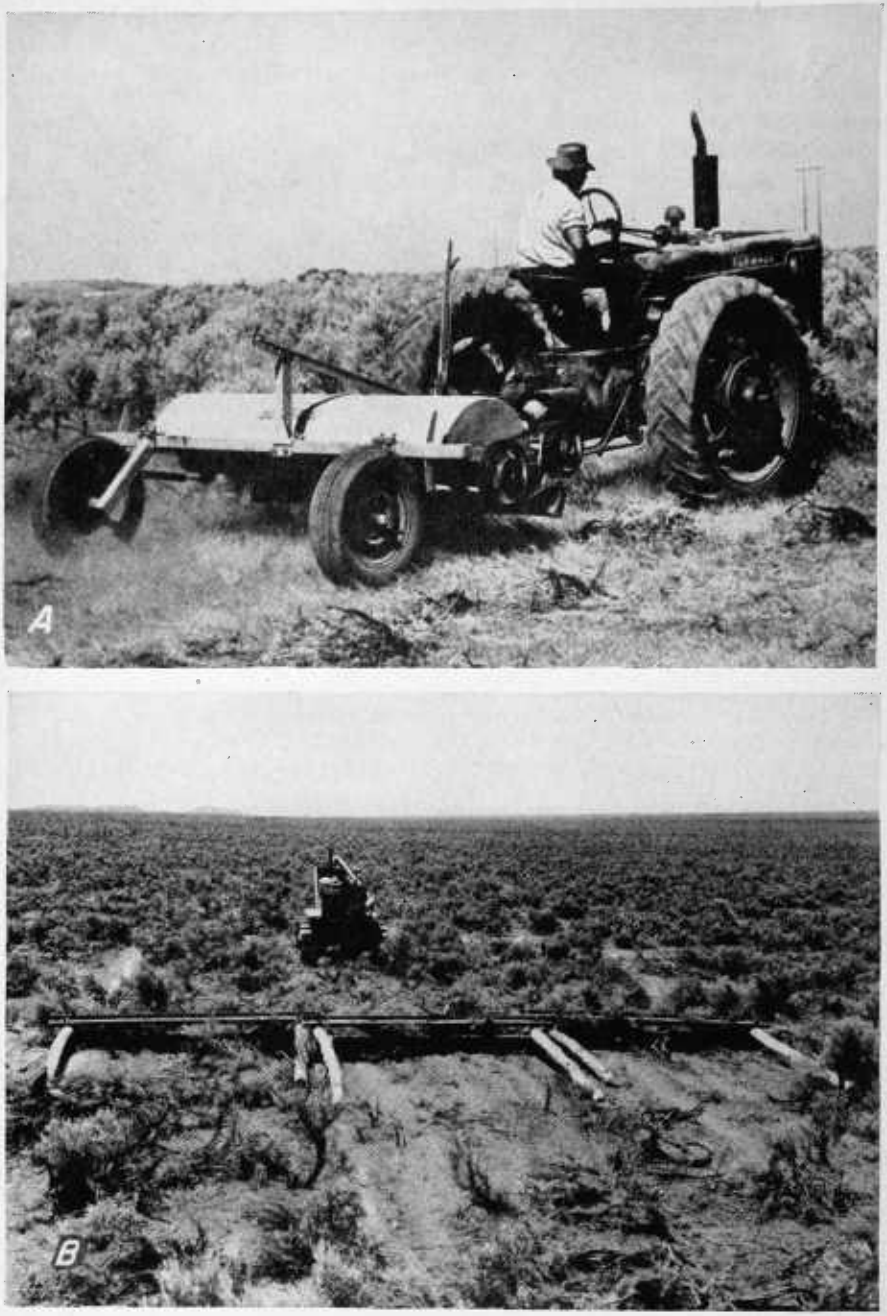

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FIGURE 12.—*A*, "Beaters" with revolving hammers or chains on a rotating axis are excellent for killing mature sagebrush, and are valuable on land too rocky to treat with disk plows. *B*, The Supp rail is the most economical and effective of the rails for eradicating mature sagebrush on level areas.

F-475374

FIGURE 13.—Self-clearing pipe harrows are useful for eradicating brittle sagebrush on ranges too uneven and rocky to plow or rail, and for covering broadcast seed. (Photo courtesy of Oregon Extension Service.)

through the logs at staggered intervals. Both pipe and log harrows can be made up to fit the power available.

Grubbers and root planes with single or multiple duckfeet or blades, which cut 4 to 8 inches under the surface of the ground (fig. 14, *A*), are particularly effective in killing sprouting brush such as rabbitbrush and horsebrush. For this reason, they are excellent accessory equipment to heavy disk plows. They are useful only on relatively level and rock-free areas.

Road rippers of various designs have been used to open up tight soils which are too hard to plow. However, the high cost of power to pull road rippers limits their usefulness.

Light offset disks (fig. 14, *B*), duckfoot weeders, and spring-tooth harrows are good for eliminating competition of annual weeds on small areas where large equipment is cumbersome. When using this lighter farm equipment, the land should be treated when the soil is moist; otherwise the ground may be too hard for good seedbed preparation.

On level or moderately sloping land, excellent eradication of juniper and pinyon trees results from cabling. In this method a 150- to 300-foot, 1½-inch cable is pulled in a U-shape behind two large crawler-type tractors (fig. 15, *A*). From 30 to 100 acres per day can be cabled, depending on the horsepower of the tractors and the size and density of the trees. Usually tractors with a capability of 70 horsepower or more are needed. Where equipment is available and

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FIGURE 14.—*A*, A heavy duckfoot grubber is useful for killing sprouting brush. Here two grubbers are to be pulled side by side. Together they eliminate the brush over a 12-foot swath. *B*, Small disks pulled by wheel tractors are useful for eliminating competition in small openings where it is difficult to maneuver large equipment.

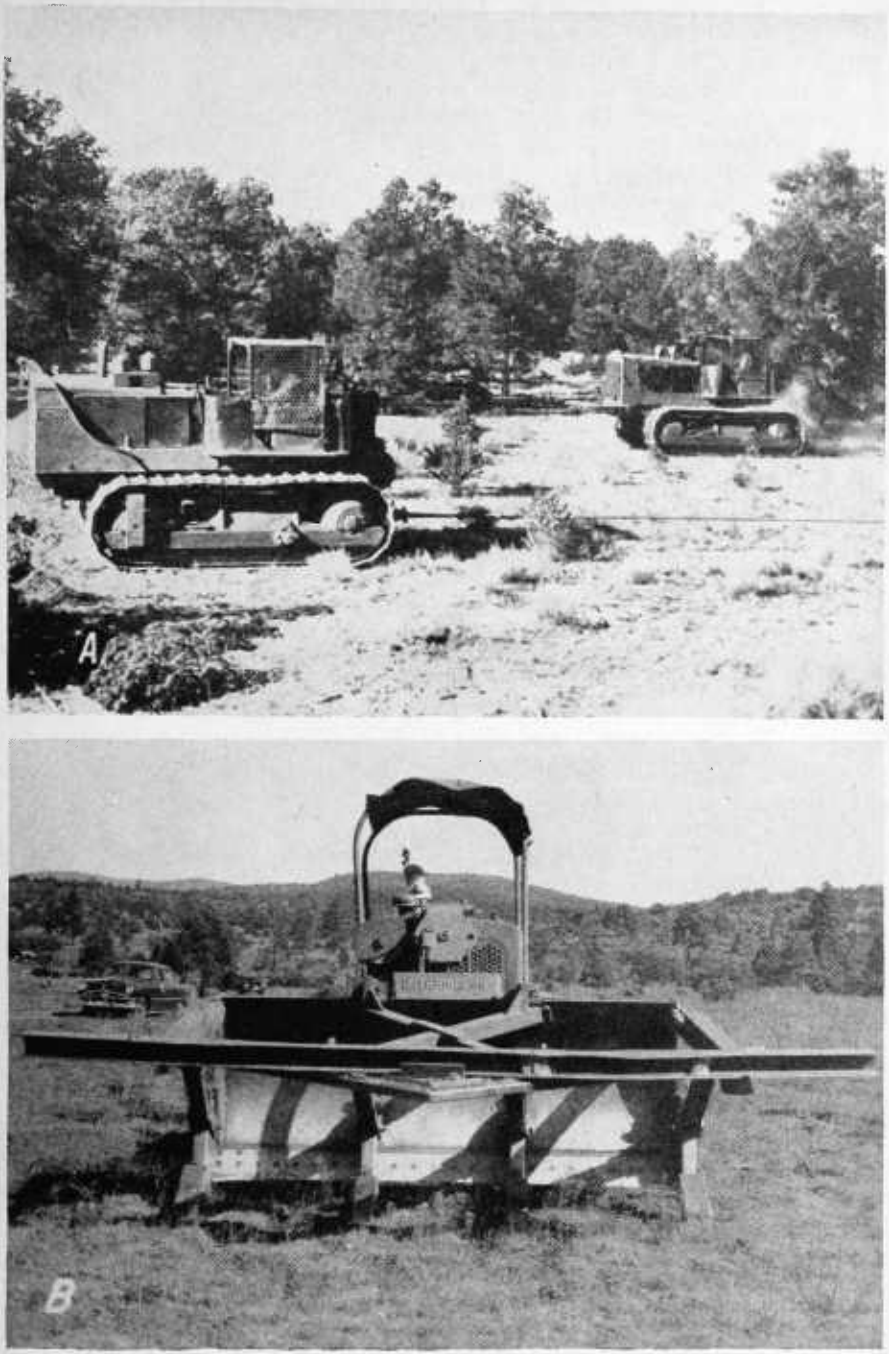

FIGURE 15.—*A*, Cabling is an economical method of eliminating juniper and pinyon trees. *B*, The push bar and catclaw assembly on a dozer blade aids in pushing the trees out.

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cabling will effectively kill trees, cabling is usually as economical as burning and is usually preferred.

Young willowy trees not killed by cabling can be chopped out readily with an ax, but cabling may not be worthwhile if large numbers of trees are young and flexible. Cabling is not usually practicable on slopes greater than 10 percent. Where trees occur on sidehills too steep for cabling or safe burning, they can often be pushed out with a dozer. Use of a push bar and catclaw assembly helps materially (fig. 15, *B*) because trees can be taken out in a single push with a minimum of topsoil disturbance.

Flooding with surplus high water will kill either big or black sagebrush (see footnote 4, p. 11). Soil saturation for a week or so in two successive years will usually give a fairly complete kill (fig. 5). Where this method can be employed, broadcasting seed prior to flooding, or as the surface water subsides, will generally result in good stands of forage. The additional moisture makes it possible for the small seedlings of perennial grasses to become established successfully in annuals, such as cluster tarweed and cheatgrass. Gradually the seeded perennials crowd out the annuals.

Chemicals

Chemical sprays, chiefly 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), have been found useful for killing brush and weeds, to release the existing suppressed forage plants. The ester base type is regarded as somewhat more deadly, but amine salt bases have often produced similar kills. Much is yet to be learned relative to concentration and how and when to apply these chemicals.

Properly applied solutions kill 60 to 90 percent of the big sagebrush. Present information indicates that for best kill of big sagebrush, solutions containing 1 to 2 pounds per acre of 2,4–D (acid equivalent) mixed with one-third as much 2,4,5–T should be used between mid-May and mid-June when the brush is actively growing. In some instances good kills have been obtained with only 2,4–D. It has been found elsewhere that mixing diesel oil in the ratio of 1 gallon to 5 gallons of water increases the percent kill. When this is done, a small amount of detergent should be used to get proper mixing of the oil and water. Enough solution should be used to wet all parts of the brush. Where brush is thick, as much as 30 gallons of water an acre may be required. When more water is added, the same amount of chemical is used, but the solution is sprayed on the plants more heavily to maintain the desired rate.

Many broadleaf annual weeds, including cluster tarweed and knotweed, can be completely killed with as little as one-half to three-fourths pound of 2,4-D to an acre. Both the amine salt and ester bases are effective on such annuals. Spraying should be done when the annual weeds are young, generally before they have more than four leaves, and preferably when they are still in the two-leaf stage. Good kills of common dandelion can be achieved with similar amounts of chemical. High kills of mules-ears wyethia result from application of 2 pounds of ester base 2,4-D per acre during the early blooming period.

The spray can be applied by ground equipment or from an airplane, with very similar kills. Small areas are most economically treated by ground procedures (fig. 16) and large areas by airplane. Special precaution should be taken so there is no harmful drift of chemicals to nearby susceptible timber or field crops. Because of the greater speed of an airplane, a large spray output per minute is required. Ten gallons of total solution per acre is about the maximum possible from a plane.

Seeding areas of chemically killed annuals can usually be accomplished in the spring, soon after spraying. Killed wyethia patches are usually best seeded the fall following spraying, and often seeding is unnecessary because recovery of suppressed grasses gives the desired forage.

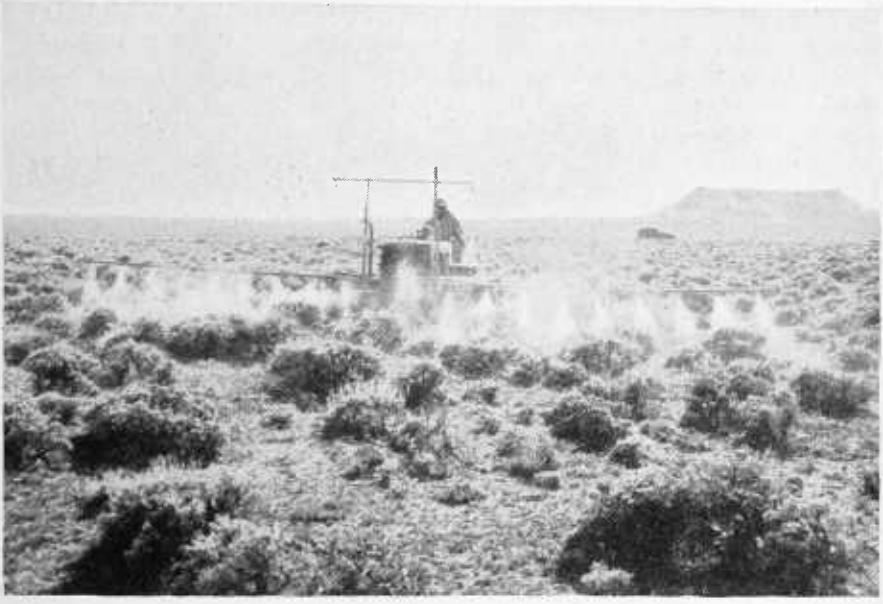

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FIGURE 16.—Spraying by ground procedures is most satisfactory for eradicating competition on small areas. On large areas airplanes can be used to advantage.

Season for Eliminating Competition

Eradicating competing plants before they mature seed greatly reduces the hazard of their reinvasion. This is particularly true for sagebrush, rabbitbrush, cheatgrass, and cluster tarweed. This general rule holds despite some known instances in which but few brush seedlings became established following eradication of sagebrush and rabbitbrush plowed after seed maturity. Eradication of sagebrush and rabbitbrush by mechanical means can generally proceed from spring until mid-September. If annuals such as tarweed and cheatgrass are not eliminated before they mature seed, their competition

may be more severe than previously. Ordinarily the ground is most easily treated in spring while it is still moist.

Herbaceous perennials with rootstocks, such as desert saltgrass and sweet sagebrush, can most readily be eliminated by plowing in late summer after the ground has become dry, whereas perennials with deep taproots, like mules-ears wyethia and common dandelion, are more easily killed in early season. Usually plowing for two successive seasons is required to kill desert saltgrass.

Planting Procedures

To do the best planting job, seeding implements and procedures must be adapted to local conditions of soil, topography, and vegetation. Drilling is preferable to broadcasting wherever land surface conditions permit because less seed is needed and because the seed is more evenly distributed and more adequately and evenly covered.

To obtain good stands seed must be covered. Seeds of most species suited for range seeding produce the best stands when covered to a depth of about one-half inch, unless the soil is sandy and tends to dry rapidly, in which event it pays to plant slightly deeper. Species with unusually small seeds, such as timothy, Kentucky bluegrass, and meadow foxtail, should be planted about one-fourth inch. Planting deeper than 1 inch greatly reduces seedling stands of most species except those with the largest seeds, such as mountain brome, tall wheatgrass, and intermediate wheatgrass.

Drilling

Ordinary grain drills (fig. 17, *A*) provide an excellent means of distributing seeds, and depth can be quite satisfactorily regulated. They can be used with good results wherever the land is not unduly rough or rocky. They work best on a firm seedbed, but are also satisfactory on a loose seedbed if care is taken to avoid planting too deeply. Best seedbeds for drilling after plowing or similar treatment often result from allowing the soil to settle a few weeks.

Use of a cultipacker or a drag will firm loose soil and make for better stands. Packing, however, increases costs and on rangeland packers are easily broken. Press wheels on drills will usually serve the same purpose and their use on loose soils is recommended. Should they plug with brush, short lengths of heavy drag chains may be substituted.

To insure against drilling too deeply in loose soil, depth regulators (fig. 17, *B*) consisting of a band of metal 1 inch wide can be bolted to the disk 1 inch from the outside edge. Burned areas, Russian-thistle stands, and stubble land provide excellent seedbeds for direct drilling because the ground is firm.

For grazing, spacings of 6 to 8 inches will result in smaller but more closely spaced plants the first 3 to 5 years than is provided by plants at wider spacings. This is often needed to quickly overcome competition from weeds and brush and to provide more soil protection. In dry sites where there is a premium on moisture for plant

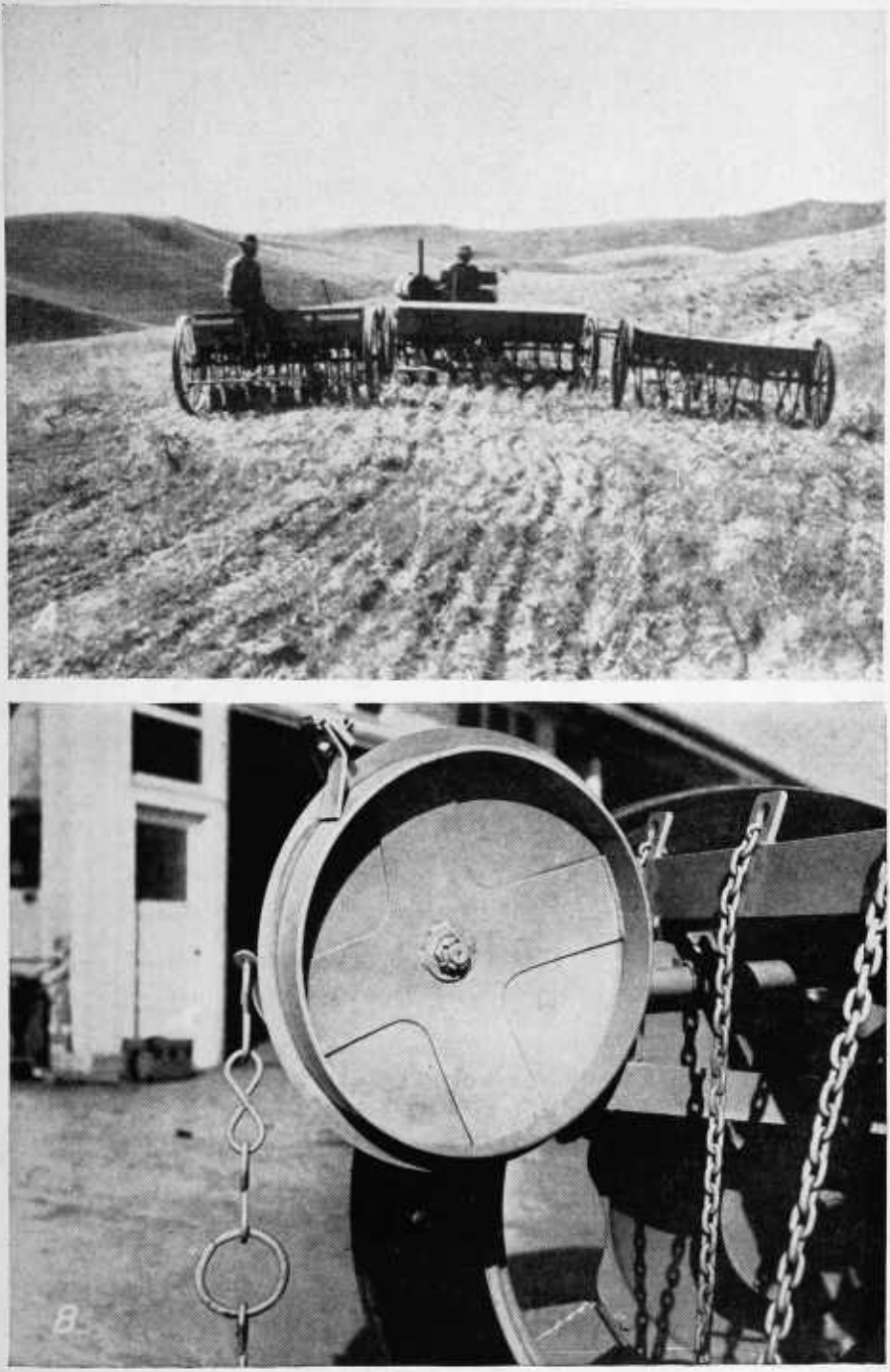

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FIGURE 17.—*A*, Ordinary grain drills are the best equipment for seeding rangelands where they can be used. *B*, Depth rings or regulators bolted to the disks insure that drills do not plant too deeply on loose seedbeds.

survival, row spacings of 10 to 14 inches are best. Even wider spacings are desirable if hay or seed is to be harvested, because plants will be taller and seed yields higher. Removal of every other disk assembly from drills with 6- or 7-inch spacing is desirable if clods, brush, and trashy material clog up the drills. The unused feed cups should be covered with snug-fitting pieces of tin or pasteboard.

Four general types of disk openers are used for range seeding (fig. 18, *A*). These are the ordinary single, semideep, deep, and double-disk types of furrow openers. All are interchangeable on recent model drills, and sometimes it pays to have more than one type available. The shovel or lister, hoe and shoe types have but limited use for range plantings.

Drills equipped with semideep disk openers are generally the most satisfactory for all-around range seeding. They are slightly larger than the ordinary single disks, have more concavity, and leave a small furrow. The small furrow helps protect seedlings from frost damage and also traps snow and rain which is often a great aid in getting good seedling establishment. Where moisture is not limiting, ordinary single-disk furrow openers give as good stands as semideep types.

On dry ranges where moisture is marginal for successful establishment, or where competitive annuals such as cheatgrass prevail, deep-furrow openers give the best stands and should be used except where soil conditions allow blowing or sloughing into the furrows and covering the seed too deeply. The deep-furrow openers penetrate dry ground and place the seed in the bottom of a 2- to 3-inch furrow in a good position to use the deeper moisture (fig. 18, *B*). Ranchers in central Utah have had successful plantings of crested wheatgrass and winter rye in dry years with deep-disk openers whereas stands from other disk openers failed completely. Similar results were secured in Idaho in cheatgrass after fall germination. The deep-disk opener kills the young plants in a broad furrow so there is little direct competition with the seedlings of drilled forage plants.

The double-disk opener is primarily for well-packed, nontrashy seedbeds. It has been successfully used on large range areas, but it is not as trouble-free as the single-disk types. In rough trashy or cloddy ground the double disks occasionally pick up sticks and clods which block the feed outlets, and there is considerably more breakage than with single-disk types.

Recently drills with heavy disk furrow openers have been developed which are particularly suited to irregular land.

Lister or shovel model drills are specially designed to make furrows 2 to 4 inches deep and are somewhat more effective for seeding in newly germinated cheatgrass and in hard ground than the ordinary grain drill with deep-furrow disk openers. Seeds are left in a wide-bottom furrow and press wheels follow back of each opener to firm the soil over the seed. However, this type drill has the handicap of being limited to rock-free, fairly level land. Also more power is required to pull it than to pull disk drills.

Seed boxes and tubes are available for mounting on wheatland plows so seed can be sown directly when plowing out brush. The plowing must be done in a season suitable for planting, and care must be taken not to cover the seed too deeply.

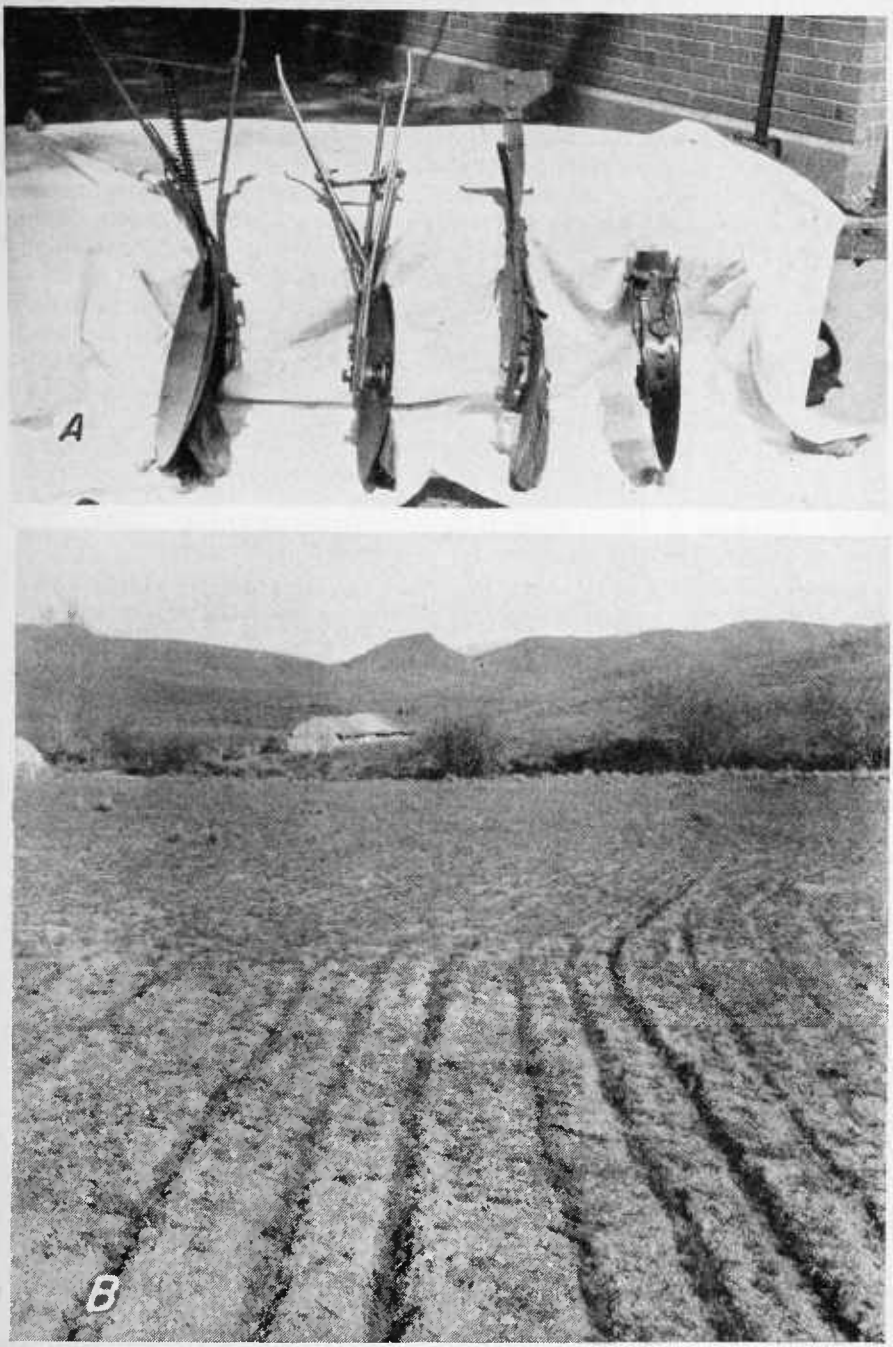

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FIGURE 18.—*A*, The four disk types of furrow openers right to left are: Double, ordinary single, semideep, and deep furrow. *B*, Deep-furrow openers leave small furrows 2 to 3 inches deep so that seed is placed nearer to the deeper moisture.

Most seeds for range planting, particularly those of grasses, are best sown directly from the grain box. A preliminary drill box setting or calibration may be obtained by raising the drill wheels off the ground and rotating them the number of times necessary to cover a calculated portion of an acre, considering the width of the drill and the circumference of the wheel. Seed can be caught in pans or sacks and weighed. A preliminary setting established in this manner will usually require further adjustment under actual field operation. At a given setting less seed will usually feed through when the wheels are turned by hand than when the drill is bouncing along in the field. To check in the field, fill the seed cups to a level where they will feed and then weigh the amount of seed desired into the drill and do an acre or some portion thereof, repeat and adjust until the desired rate is obtained. Continue checking throughout the seeding operation because rates may vary with different batches of seed and with the terrain. Clover, timothy, and similar seeds may be sown from the smaller seed box, which can be more easily regulated for these small, heavy seeds. This attachment is readily obtainable if not already on the drill.

By plugging alternating seed cups in the two boxes, legumes and grasses can be drilled in alternate rows and better establishment of legumes usually results. Planting grass and browse in alternate rows has been found a desirable way to reduce competitive effects of grass on the browse. As most browse seeds feed only through the main grain box, it is usually necessary to make separate compartments in the box so that alternate cups contain the browse seed.

Seeds of different sizes used in mixtures can be sown together from the main grain box by mixing 8 to 16 pounds of rice hulls to the acre. Where rice hulls are used a higher setting on the drill is necessary. Cracked grain can be used to serve the same purpose.

Fluted force feeds, with projections or flutes of at least ½ inch, are superior to gravity feeds and are much preferred when seeding grasses. To facilitate cleaning out trash which may clog, the bottom of the feeds should be equipped with gates.

Although clean, well-filled, heavy seed flows readily, much grass seed tends to be fluffy or chaffy, so that most drills for seeding rangelands should have agitators. These help to maintain a continuous flow of light grass seeds into the feeds and prevent pockets from forming above the seed cups.

Broadcasting

Broadcasting provides the only means of seeding rough terrain where rocks, steep slopes, trees, or other obstacles make drilling impracticable. This method requires one-third to one-half more seed to compensate for uneven distribution and depth of planting. Broadcasting may be done by hand or mechanically. In the common mechanized broadcasters, seed is thrown out by a cyclone-type disk or by a blast of air. Broadcasters powered by the tractor power take-off or by a small motor can be attached to the tractor frame so that seed is broadcast ahead of or behind eradication equipment (fig. 19). Two-wheeled fertilizer spreaders or ordinary grain drills with the

disks and seed tubes removed are also efficient seed broadcasters. They are particularly good because they provide more positive and uniform seed distribution and broadcast the seed close to the ground surface where wind drift of seed is at a minimum.

Where large areas are to be broadcast, an airplane is rapid and inexpensive. Its use on rangelands has been limited mainly to aspen, tall mountain brush, and burned timber where a leaf litter or heavy ash provides natural covering for the seed. In rough and brushy terrain it is superior to hand broadcasting from a horse or on foot because areas are sown more uniformily.

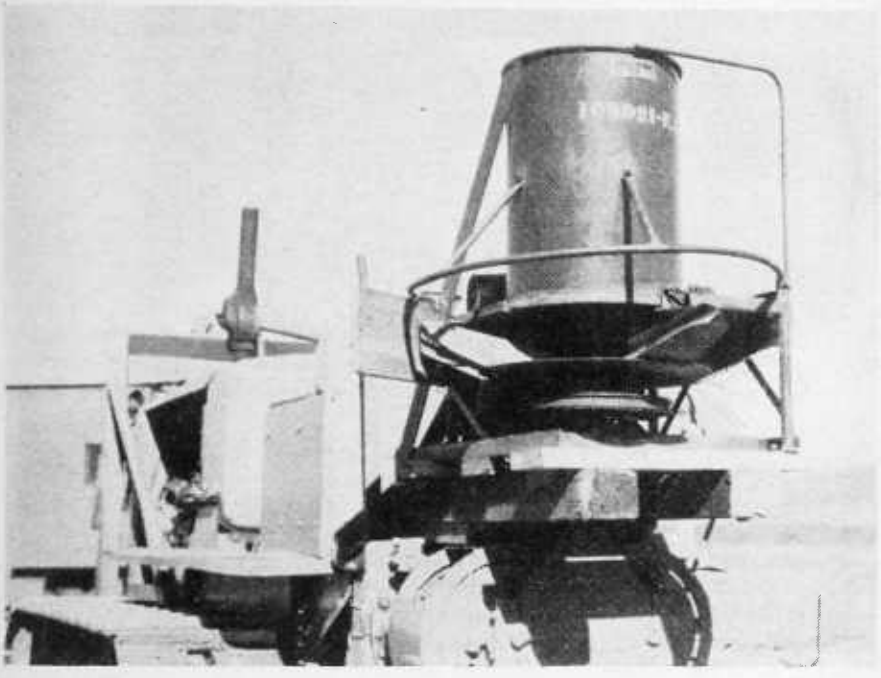

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FIGURE 19.—Small motor broadcasters can be attached to tractor frame so that seed can be broadcast at the same time brush is eradicated.

Airplane broadcasting is as effective as other broadcast methods of scattering seed on large, previously prepared seedbeds where the soil is loose and sloughing will cover the seed. It can also be employed where implements such as the self-clearing pipe harrow are used afterward to eliminate brush and cover the seed.

Scattering seeds compressed in pellets of soil or other material has attracted much attention. In none of the many areas where it has been tried has this procedure been found satisfactory.

Without assurance that seed will be covered, broadcasting is never recommended. Broadcasting on snow is not successful because seeds are not covered with soil.

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Seeding Rates

Adequate seed should be used to ensure stands. For the majority of species and mixtures with a high standard of germination and purity, drilling at a rate of 4 to 8 pounds per acre, or broadcasting at 8 to 14 pounds, has in practice been satisfactory for Intermountain rangelands. Double these amounts are justified if there is danger of invasion by noxious weeds such as halogeton, or on watersheds, where it is essential to establish a cover quickly. Forage species with small seeds, such as timothy, should be sown at the lower rates, and species with large seeds, such a mountain brome and intermediate wheatgrass, at the higher rates. Seeds of intermediate size, such as crested wheatgrass and smooth brome, should be sown at intermediate rates. Where frost and drought may be a major problem in the young seedling stage, species with small- and intermediate-sized seeds should be sown at heavier rates because of the likelihood of excessive mortality. Recommended seeding rates for species and mixtures are given on pages 64–71.

Appropriate increases in seeding rates should be made for low germination and purity. Germination of seed older than 3 years should always be checked. For commercial seed used in the Intermountain region germination should usually be at least 85 percent and purity 90 percent with a live pure seed index (lps) above 75. Live pure seed index is determined by multiplying the germination and purity together and dividing by 100. For example with a purity of 90 percent and a germination of 85 percent, we would have a live pure seed index of 76.5.

$$\frac{90 \times 85}{100} = 76.5$$

Where seed falls below a live pure seed index of 75, enough additional seed should be planted so there are ample good seeds being sown to meet this standard. Thus when crested wheatgrass seed has a purity of 50 percent and germination of 90 percent, the rate should be increased to equal 6 pounds of good seed per acre. In this example the live pure seed index is 45. Dividing 75 (minimum standard) by 45 and multiplying by 6 (the normal seeding rate per acre) we find that approximately 10 pounds of seed per acre is required. This procedure should be used whenever germination or purity is below standard.

Seeding Steep Slopes

Broadcast methods must largely be used on steep, eroding slopes where contour terraces or similar structures are made to stop erosion and floods. The seed is usually broadcast on the loose soil by hand or hand machines. On large areas an airplane can be used. On moderate slopes (up to 30 percent) plowing with a heavy offset disk prior to making the terraces provides a good surface on which to broadcast seed between terraces (fig. 20).

F–464812

FIGURE 20.—Here the ground was treated with a heavy offset disk prior to making the terraces. Seeds were broadcast into the loose soil immediately after terracing was completed.

Terraces are often used as temporary measures to prevent erosion and hold water on the area to allow herbaceous vegetation to become established. They must be spaced closely enough to stop any runoff between them. Distance between terraces may vary from 25 to 100 feet depending on slope and size of terrace. Check dams should be built at intervals within the terrace to prevent lateral flow of water in case of occasional terrace breaks.

Heavily built farm tillers or furrowers (fig. 21, *A*), which make small furrows 20 to 30 inches apart and 3 to 5 inches deep, break up small gullies and provide an excellent surface on which to broadcast seed. Slightly larger furrows made at slope intervals of 3 to 5 feet with a horse-drawn reversible sidehill plow are also effective. Care should be taken to place all furrows on the contour.

While drills in general are not well adapted for seeding steep sloping land or lands with a rough surface, small 1-horse disk drills can be equipped with outrider wheels so they will not tip over and can be effectively used on slopes up to 45 percent (fig. 21, *B*). Such a drill can be used to good advantage for planting between terraces.

On sidehills with loose soil, broadcast seeds occasionally are adequately covered by natural soil movement (fig. 22). On slopes too steep or rough for heavy machines, light offsets or single disks (fig. 23, *A*) pulled by horses can be used to cover broadcast seed. Where machinery cannot be used trampling with livestock often helps to cover seed and results in better seedling stands (fig. 23, *B*) than depending entirely on natural soil movement.

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FIGURE 21.—*A*, Tillers or heavy farm furrowers are good equipment for breaking up gullies on sloping lands. *B*, A 1-horse drill converted into a sidehill drill by the addition of outrider wheels is useful on slopes not too greatly cut up with deep gullies.

F-472877

FIGURE 22.—Hand broadcasting is the best method for spot seeding. Men can broadcast those areas in need of seeding and skip vegetated areas.

WHEN TO SEED

Seeding should be done at the time that will allow the slowly developing seedlings to have the longest possible period of good growing conditions. The larger the seedlings become before droughts, frost, or other adversities hit them, the better chance they have to survive. The top 3 to 4 inches of soil should remain reasonably moist for at least 30 days after seed germination, and preferably 40 to 60 days.

LOWLAND SITES

Late fall, early spring, and early fall, in the order stated, have been found, on the average, to be the most satisfactory times for seeding. The spring period, from the time snow melts until the onset of summer drought, is the longest and most reliable for seedling establishment and growth. When good seeds are already in the ground from late fall planting, the moisture left from winter snow gets the plants started with earliest favorable weather, and spring rains stimulate growth. Also winter cold breaks seed dormancy, so that seedlings emerge more uniformly and develop faster. Seeds of some native grasses and of most broadleaf herbs and shrubs must be subjected to cold, artificially or by being in the ground over winter, to germinate and emerge well. Another advantage of late fall seeding is that there is a longer period for seeding and labor and machinery are much more likely to be available then than at other times of the year.

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FIGURE 23.—*A*, Single disks are useful for covering broadcast seed in small rocky openings among juniper on hillsides where heavy machinery cannot be used. *B*, Trampling with livestock helps cover the broadcast seed with soil which aids in stand establishment.

Late fall seeding should start after temperatures become low enough so that seeds will not germinate. Suitable time for planting in late fall may last as long as 4 to 12 weeks and sometimes even longer. Occasionally there is some mortality in spring when frosts interrupt the early growing season, but grasses generally withstand such freezes fairly well. In some years there may be very high mortality of broadleaf herbs and browse.

Early fall seeding is successful in places where early fall rains result in fall germination and seedling establishment. If rain is scanty or intermittent, however, the seed may germinate and then die. Seedling stands may occasionally be killed by severe freezes. Where there is a continuous snow cover during the winter, this danger is greatly lessened.

Early spring (late February to mid-April) planting has been successful on many lowland sites, but must be done within a few days after it is possible to get on the ground in order to take advantage of the moisture in the soil. In many localities this suitable period is so short that spring seeding is impracticable, except where small areas need planting. Seedlings from early spring plantings are not so readily set back or killed by frost or soil crusting as fall plantings, and early weeds are usually eradicated by spring tillage prior to seeding. These factors often more than make up for the other disadvantages of spring seeding. On wet low-lying lands spring planting is best because most seeds deteriorate if there is free water around them.

Legumes are best sown in the spring since their seedlings can tolerate much less frost than grass seedlings. Fall-seeded legume seeds will often germinate within one or two warm days, only to have the small seedlings freeze with the next night of very low temperatures. However, if seeds have a high percentage of dormancy due to hard seed coats fall seeding is sometimes better than spring seeding. When seeding legumes in the fall it is best to use the current year's seed crop because these seeds usually have a higher percentage dormancy and do not germinate so readily in the fall.

Mountain Sites

In Utah, southeastern Idaho, and western Wyoming, planting may be done with good chance of success in spring or fall throughout the mountain brush zone and in openings among aspen and coniferous timber. Frost damage to seedlings in mountain brush and openings in the timber zones is usually slight except where snow melts off at intervals, as on south-facing slopes. Here seedlings will often frost-heave out of the ground. These slopes should therefore be seeded in late fall or early spring.

In southwestern Idaho and in Nevada, fall is the only season presently recommended for seeding mountain rangelands. Lack of rain during the summer in these areas makes spring planting risky.

Broadcasting seed in depleted aspen and in tall mountain brush such as Gambel oak, bigtooth maple, and serviceberry just before or during leaf fall generally provides good stands of grass. The leaves supply some covering for the seed and help hold winter moisture in

the surface soil so that seedlings can become well established before the shrubs leaf out and begin to provide competition. Trailing livestock through the brush and trees helps work the seed into the mineral soil and results in somewhat better stands.

Late fall plantings have proved generally most successful over the region in subalpine areas. At these high elevations it is important that planting be delayed until the soil is too cold for germination. If seeds germinate the young seedlings are likely to be killed by later fall frosts before the ground is insulated by a snow mantle. Planting after October 1 is usually safe. Early snowfall may make late fall seeding at high elevations impossible in some years.

In central and southern Utah's high subalpine parks and aspen openings, where there is good summer rainfall, plantings are most successful between early spring and midsummer on a seedbed prepared the fall before. Intervening snowdrifts, however, often make early seeding of large areas impracticable.

WHAT TO SEED

Whether seeded ranges will thrive and continue to produce depends in large measure on what species are planted. Species should, of course, be adapted to the site and easily established. They should be palatable, productive, and able to withstand invasion by undesirable plants; able to maintain themselves and prevent erosion under moderate grazing, particularly on sloping lands. Seed should be available at a reasonable price. More than 450 species of grasses, broadleaf herbs, and woody plants, and hundreds of strains, have so far been test-planted in the Intermountain region by the Forest Service Branch of Research on problem types of lowlands and mountains. Of these, 56 have shown that they are well suited for seeding on various kinds of sites. Their characteristics and adaptation are described briefly below. Seed of some are not readily available, but within a short time it is believed that seed of most will be on the market. Seeds of a sufficient variety are available, so that seeding programs need not be delayed.

The Soil Conservation Service nurseries and the Bureau of Plant Industry, now part of the Agricultural Research Service, have given excellent assistance in supplying seed of new species and strains which were not otherwise available. This aided immensely in determining the areas of use for the various species. Also, these agencies are aiding farmers in commercial production of seed from species not now readily available.

Use the Best Plants Adapted to the Site

Recent research has demonstrated wide differences in adaptation between geographical strains of a single species, as well as in other qualities, such as palatability, yield, longevity, seed production, and resistance to disease and drought. This is particularly true of native species. The improvement of various species, through selection and hybridization, is under way by the Agricultural Research Service

and State experiment stations. Many superior strains are already in use. This is a continuing study, where great progress can be expected in future years. Where superior strains are on the market, they are noted in the following descriptions of species to use.

It is important to use the best adapted species or strains available for each locality. If native species are used, seed produced from native stands in the same locality, or an area with a similar climate, is most reliable. Seed of most native species recommended here can be easily harvested with equipment which is readily available. Some seeds may need special cleaning and debearding treatment, so they can be handled and planted conveniently. Most seed companies have such equipment, and a great many farmers have the necessary machinery to do a good job.[5]

Mixtures or Single Species

On most mountain lands in the Intermountain region, the use of mixtures of two or more adapted species is advisable. Soil and moisture conditions often change so markedly within short distances that there may be great variation in the success and productivity of a single species within the seeded area. If one species does poorly because of an unfavorable site condition, or is killed by rodents, insects, disease, or frost, one or more of the others may take its place. Another advantage of mixtures is that some species develop stands quickly and can supply forage while others that develop more slowly are becoming established. Mixtures also produce vegetation with a more varied and often a higher feed value. Mixtures have certain disadvantages as well. They are often hard to seed evenly, especially through a drill. Because of differences in palatability, the different species may be more difficult to manage than single species plantings.

On lowlands where terrain and growing conditions are uniform, pure stands of single species are often preferred. Species that differ markedly in their season of usefulness or in palatability should be sown in separate grazing units. Then grazing can be alternated so as to take advantage of the growth characteristics of each species. As an illustration, crested wheatgrass usually can be grazed 2 weeks sooner than tall wheatgrass. On the other hand, tall wheatgrass remains green from 4 to 6 weeks later than crested wheatgrass. When the two species are sown in separate units, both can be grazed when they are most nutritious, and the total grazing period is extended considerably. Plants should be chosen which will best supplement the native range.

If adapted legumes are available, their use with grasses usually increases total production and improves the nutritive value of the forage. They also help to build up soil nitrogen through the action of associated nodule bacteria that convert free nitrogen from the air into available soil nitrogen.

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[5] Description of procedures for collecting and cleaning seed is available in U. S. Dept. Agr. Handb. 24, Procedure for Harvesting and Cleaning Grass and Legume Seed in the Western Gulf Region; and U. S. Dept. Agr. Cir. 558, Processing Seed of Grasses and Other Plants to Remove Awns and Appendages.

Legume seed should always be inoculated with its specific culture of nodule-forming bacteria. Cultures are available from most seed companies. Directions for use accompany each culture, and are easy to follow.

Species for Seeding

The adaptation and relative value of the 56 most promising species for seeding lowland ranges with annual precipitation below 8, 8 to 12, and above 12 inches; salty lowlands; and mountain brush, aspen, and subalpine zones, are shown in table 1. Further recommendations regarding species and mixtures are included in the section on pages 64–71. Detailed information on the adaptability and usefulness of individual species is found below, under the headings of Grasses, Legumes, Other Broadleaf Herbs, and Shrubs. Within these categories, species are discussed in the order listed in table 1, which is a grouping in the order of decreasing drought tolerance.

Grasses

Sand dropseed and *bottlebrush squirreltail* are bunchgrasses, native to dry sites but also occurring within the better precipitation belts. Sand dropseed is characteristically found on sandy and gravelly sites and grows best in openings. Squirreltail is found on a wide range of sites and in all vegetative zones. It shows good ability to grow under and with shrubs, such as shadscale, greasewood, and rabbitbrush. Once established, both sand dropseed and bottlebrush squirreltail are good natural spreaders. Although both may produce good stands, they are low in yield. Their greatest value for seeding is on dry lowlands with less than 9 inches of precipitation, where higher yielding species are difficult to establish or may not be adapted. Seed of squirreltail is seldom commercially available. Seed of both species can be collected from native stands, although squirreltail seed is expensive to harvest and must be debearded before seeding.

Indian ricegrass (fig. 24) is a drought-enduring, native bunchgrass which has shown promise for seeding in dry and infertile soils, such as in the juniper-pinyon belt where it is difficult to get anything else to grow. It grows well on dry sites on mountain brushlands but it is not shade tolerant. As seeds are slow to germinate, getting initial stands has been a major difficulty. This can be overcome to a large extent by bleaching the hard seed coats with sulfuric acid. Thin stands will spread by seed and thicken quite rapidly. Because of wide variation in adaptability between the many geographical variations, the most reliable seed is that from places similar to the site being seeded.

Russian wildrye (fig. 25, *A*), a hardy bunchgrass introduced from Asia,[6] is useful for seeding lowlands and dry sites in the mountain brush zone. It is not shade-tolerant and does best on sunny sites. It grows well on lime-bearing soils, or at least those which are basic in reaction rather than neutral or acid. It is adapted to both light and heavy soils, especially those with moderate to high available nitrogen. Small seedlings are sensitive to frost and drought, and for this reason

[6] A brief summary on the origin, adaptation and use of introduced grasses is available in U. S. Dept. Agr. Handb. 58, Grasses Introduced into the United States.

TABLE 1.—*Adaptation and recommended use*[1] *of species for seeding in various precipitation and vegetation zones on lowland and mountain areas in the Intermountain region*

GRASSES

Species	Lowlands				Mountain lands		
	Below 8 inches precipitation	8–12 inches precipitation	Above 12 inches precipitation	Salty soils	Mountain brush[2]	Aspen[3]	Subalpine
Sand dropseed	C	C					
Bottlebrush squirreltail	C	C					
Indian ricegrass	C	C	C		C		
Russian wildrye	C	B	B	B	C		
Crested wheatgrass (Standard)	B	A	A		B		
Crested wheatgrass (Fairway)	B	A	A		A	C	
Bulbous bluegrass		X	X		X		
Bluebunch wheatgrass		B	B		B	C	
Beardless wheatgrass		B	B		B	C	
Pubescent wheatgrass		C[4]	A		A	B	
Intermediate wheatgrass		C[4]	A		A	B	
Western wheatgrass		C[4]	B		C	C	
Beardless wildrye		C[4]	B	C	C	C	
Big bluegrass		C[4]	C		C		
Mountain rye			X		X		
Great Basin wildrye			B		B	C	
Tall wheatgrass			B	A	B	C	
Tall fescue				B[4]		C	
Bulbous barley					B	C	
Blue wildrye					B	B	
Bearded wheatgrass					B	B	
Smooth brome (southern strain)			C[4]		A	A	B
Smooth brome (northern strain)					C	A	A
Slender wheatgrass					B	B	C
Mountain brome					B	B	C
Meadow brome					B	B	B
Kentucky bluegrass					X	X	X
Tall oatgrass					A	A	A
Orchardgrass					B	A	C
Reed canarygrass					B[4]	B	B[4]
Timothy					B[4]	A	B
Meadow foxtail					B[4]	A	B
Sheep fescue (Sulcata)						C	C
Red fescue (sod-forming)						C	C
Subalpine brome							B
Winter rye		X	X		X		

See footnotes at end of table.

TABLE 1.—*Adaptation and recommended use*[1] *of species for seeding in various precipitation and vegetation zones on lowland and mountain areas in the Intermountain region*—Continued

Species	Lowlands				Mountain lands		
	Below 8 inches precipitation	8–12 inches precipitation	Above 12 inches precipitation	Salty soils	Mountain brush[2]	Aspen[3]	Subalpine
LEGUMES							
Alfalfa	----	C[4]	B	----	B	C	----
Sicklepod milkvetch	----	C[4]	B	----	B	C	----
Chickpea milkvetch	----	C[4]	B	----	B	B	C
Yellow sweetclover	----	----	X[4]	B[4]	X	C	----
Strawberry clover	----	----	----	X[4]	----	----	----
Birdsfoot trefoil	----	----	----	----	C	C	----
Mountain lupine	----	----	----	----	----	C	B
Alsike clover	----	----	----	----	----	C[4]	C[4]
OTHER BROADLEAF HERBS							
Summercypress	----	----	----	X	----	----	----
Fivehook bassia	----	----	----	X	----	----	----
Palmer penstemon	----	X	X	----	X	----	----
Wasatch penstemon	----	----	----	----	X	X	----
Showy goldeneye	----	----	----	----	X	X	X
Common cowparsnip	----	----	----	----	C	C	C
Sweetanise	----	----	----	----	C[4]	C	C
SHRUBS							
Winterfat	C	C	C	----	C	----	----
Fourwing saltbush	C[4]	C	C	----	C	----	----
Antelope bitterbrush	----	C	C	----	C	C	----
Oldman wormwood	----	----	X	----	X	X	----
Blueberry elder	----	----	X	----	C	C	----

[1] A—Proved to be productive and widely adapted for seeding throughout the zone or type.
B—Valuable over much of the zone or type, but value or adaptation either more restricted or not as well determined as species designated A.
C—Value or adaptation more restricted than those species designated B, but useful in some situations.
X—Recommended for special uses or conditions, usually as pure stands.
[2] Applicable also for seeding openings in the ponderosa pine zone.
[3] Applicable also for seeding openings in Douglas-fir and spruce timber.
[4] Adapted only to better than average sites in the zone or type.

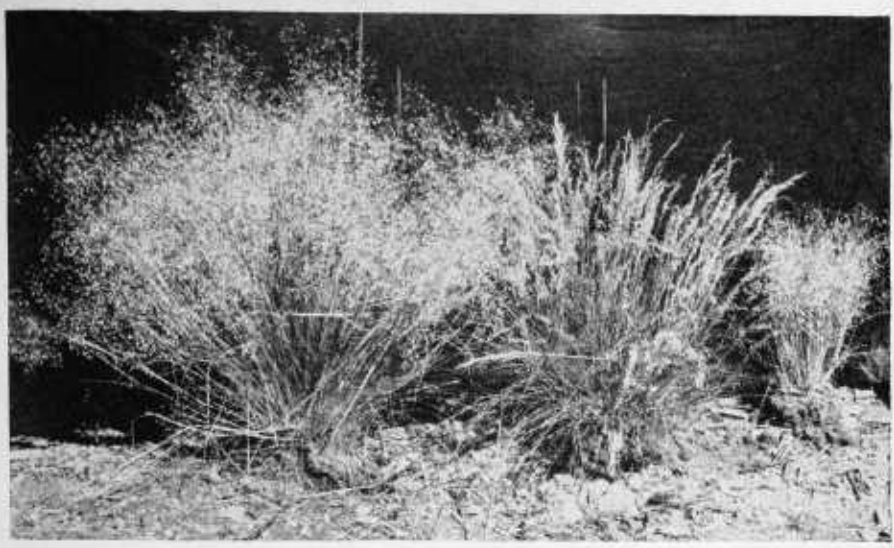

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FIGURE 24.—Indian ricegrass shows wide variation between geographical strains. Strain on left is twice as productive as next best one and is much more persistent among juniper trees.

stand establishment is often erratic. Planting in furrows aids in getting good stand establishment. Once started, it is only slightly less drought-enduring than crested wheatgrass. Generally, on most lowland sites Russian wildrye is somewhat less productive than crested wheatgrass, but on alkaline sites it is more productive than crested wheatgrass. Russian wildrye is well adapted to salty lands. On moist salty soils it is not nearly so productive as tall wheatgrass, but on dry soils it develops a more finely branched root system than tall wheatgrass and withstands more drought. It is especially valuable on dry, salt-bearing lands where the water table is out of range of tall wheatgrass roots.

Russian wildrye tends to stay green and palatable throughout the growing season, and then with appreciable rainfall it makes new growth quickly, even in the hot summer and early fall when the wheatgrasses tend to remain dormant. It has a tremendous root system and withstands heavy grazing. It has the excellent attribute of being a good natural spreader even though it is a poor seed producer. Russian wildrye usually grows earlier in the spring than any other grass, with the possible exception of bulbous bluegrass. It produces an abundance of basal leaves and is highly preferred by both deer and livestock.

Crested wheatgrass is adapted and useful throughout the lowlands and on the drier sites in openings in the mountain brush zone and up through the middle of the aspen zone. Two varieties, Fairway and Standard (fig. 25, *B*), are available, and for many conditions are regarded as about equally good. Both are vigorous, drought-enduring bunchgrasses, introduced from Asia. These are now considered as separate species, Standard being called "desert wheatgrass" (*Agropyron desertorum*). Fairway is smaller than Standard, with a denser,

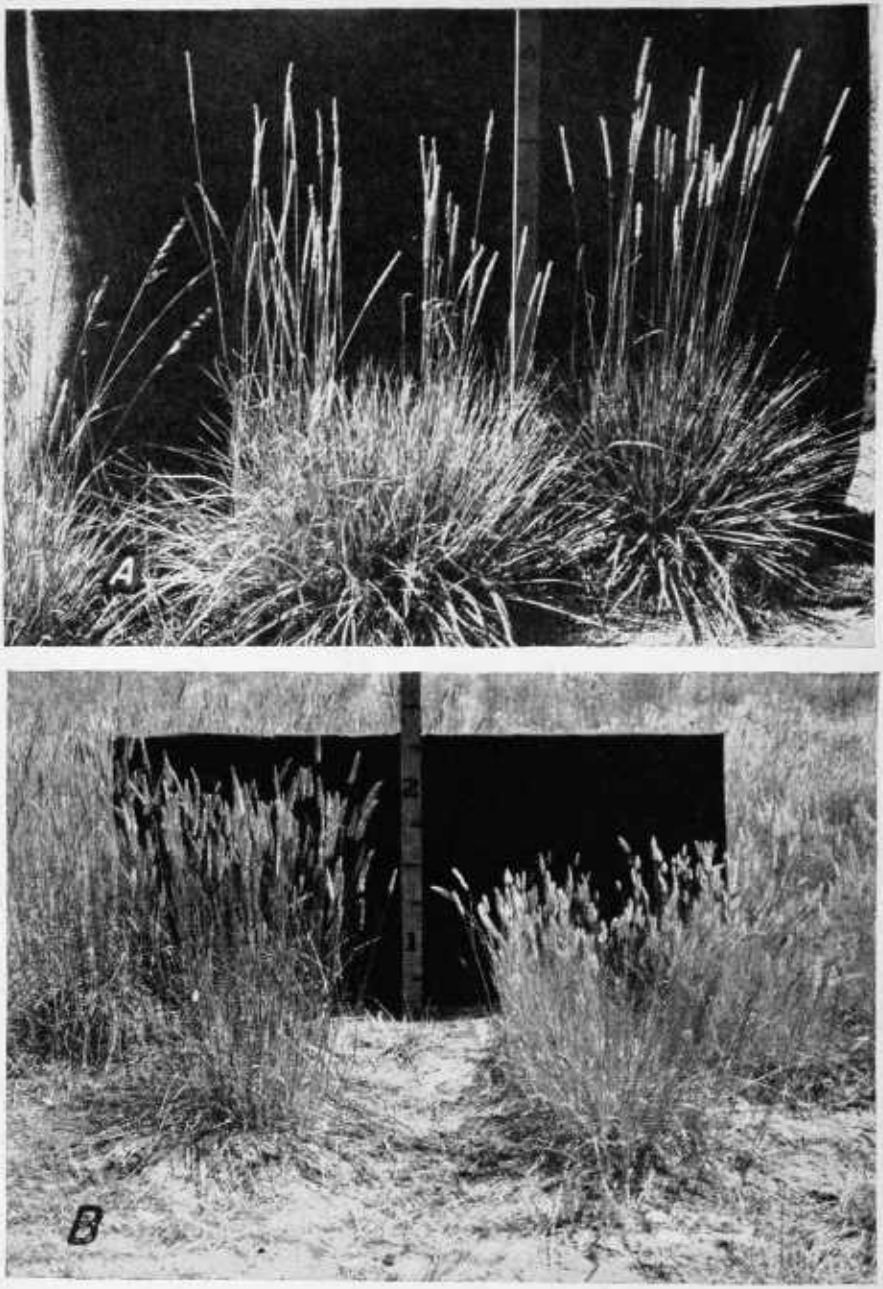

FIGURE 25.—*A*, Russian wildrye is one of the most palatable range grasses. It is adapted at low and intermediate elevations, and is particularly well suited to dry, salty areas where tall wheatgrass will not grow. *B*, Crested wheatgrass strains: Standard, left, Fairway, right. Both are well adapted to dry lowland ranges. The finer stemmed Fairway is grazed more uniformly and is more persistent at high elevations.

leafier basal growth, shorter and wider seed heads, and smaller seeds. Both grow early in the spring, have similar drought-enduring qualities and produce similar amounts of forage. Because of its finer stems and leafier base, Fairway is grazed more uniformly than Standard and there is much less tendency toward large ungrazed "wolf" plants. Fairway often spreads slightly by short rootstocks and, because of this, makes a greater crown spread than Standard. The ability to spread vegetatively probably accounts for the greater persistence of the Fairway type, particularly at high elevations, where seed is frequently not matured. Fairway will usually maintain stands 1,000 to 1,500 feet higher than Standard. In the aspen zone Standard tends to die out within a period of 6 years, whereas, after 16 years, Fairway is still maintaining good stands. While Fairway tolerates more shade than Standard, neither form is very productive in the shade of aspen or tall mountain brush.

Bulbous bluegrass, a small introduced bunchgrass with a bulbous base, is well adapted to areas with a cool, moist spring season. It has done well on many sites on lowlands and in the mountain brush and ponderosa pine zones of southwestern Idaho and southern Utah. Although forage production is very low, it is the earliest grass to green up in spring and provides very early spring grazing. Total production is so low and growing period so short that it is best used where it is difficult or impossible to get more productive species started. The bulbils produced in place of seed are eagerly eaten, particularly by sheep. It also increases by bulbs at the base. Bulbous bluegrass has the unique attribute of establishing itself well from broadcast planting, and so can be successfully seeded on rough, rocky and eroding areas where seedbed preparation and seed covering are not feasible. Where well adapted, it can be broadcast into annual vegetation such as cheatgrass, and it will eventually occupy the site. In southwestern Idaho it has helped reduce the fire hazard by replacing cheatgrass.

Beardless and *bluebunch wheatgrasses* are two very similar native bunchgrasses suitable for seeding through the same general area as crested wheatgrass. Although they will grow at high elevations, forage production is very low above the aspen zone. They prefer well-drained soils and are but slightly shade-tolerant. Trials indicate them to be more productive than crested wheatgrass on poor sites. Where precipitation is over 10 inches, these grasses have given yields which are comparable to, but which fluctuate less between years than, yields of crested wheatgrass. Considerable variation exists between strains of these species. Whitmar, a beardless strain, developed by the Soil Conservation Service at Pullman, Wash., is proving to be productive and widely adaptable, and seed is now commercially available. Seeds of bluebunch wheatgrass must be debearded for drilling. Because of the low preference sometimes shown by livestock for beardless and bluebunch wheatgrasses in mixtures with other adapted grasses on lowlands, as well as their inability to stand as heavy a degree of grazing as other adapted grasses, they are suggested primarily for planting in pure stands which can be grazed separately.

Intermediate and *pubescent wheatgrasses* (fig. 26, *A*), two vigorously growing and similar sod-forming grasses from eastern Europe and Asia, are valuable for range reseeding on the better lowland sites. Although not too well adapted to shade, they are also two of the high-

est forage producers throughout the mountain brush zone and in aspen and timber openings. Above the aspen zone both lack vigor and neither produces seed. They have periods of growth similar to crested wheatgrass but are not so drought tolerant. On deep soil with good moisture-holding qualities, such as a clay loam, they have done well and are good in pure stands for alternating grazing with crested wheatgrass. They mature seed about 2 to 3 weeks later in the season, stay green longer, and are more palatable after heading than crested wheatgrass. In the better rainfall zones they have produced well and persisted in mixture with crested wheatgrass. Their persistence under close grazing is attributed to their sod-forming habit. On low-fertility lands, they may become sodbound after 4 or 5 years, a condition attended by greatly reduced production.

Because pubescent wheatgrass is readily infected with leaf blight in some sections, causing the foliage to dry and become unpalatable, intermediate wheatgrass is generally more preferred for seeding. However, on granitic and basaltic soils in southeastern Idaho and Nevada, pubescent wheatgrass is definitely superior. Among seeded grasses in Nevada, it alone has aggressively invaded a stand of big sagebrush and cheatgrass from old plantings.

Western wheatgrass (fig. 26, *B*), or bluestem wheatgrass, is a vigorous, native, sod-forming grass, best suited for seeding on heavy soils on lowland areas. It withstands considerable flooding and silt deposition, and is productive in swales where moisture tends to accumulate. If there is considerable heavy soil in an area, western wheatgrass can be used to advantage in mixtures, even where the average annual precipitation may be somewhat below 12 inches. It is also well adapted to areas in the mountain brush, as well as openings in aspen and timber. It is not highly shade-tolerant, but does maintain itself well in open brush. After 14 years it was the highest yielder and provided the best cover in a ponderosa pine opening in southern Utah. Its tough sod and ability to spread vegetatively make it good for holding the soil. While it is best adapted for heavy soils, it does grow on lighter soils of the benchlands. Because of low production, it is not recommended for such sites.

Western wheatgrass greens up and grows 1 to 2 weeks later than crested wheatgrass in spring. While not quite so palatable as crested wheatgrass in the spring, it is a preferred fall forage. It has the disadvantage of having a root system that develops slowly in the seedling stage, and seedling mortality is frequently very high, if dry periods occur soon after germination. Once established, its vigorous, spreading root system is extremely competitive and restricts invasion of other species, including sagebrush. On heavier soils, it will invade good crested wheatgrass stands, and sometimes will eventually become dominant.

Beardless wildrye, an aggressive sod-former, is native to moist valley bottoms, especially in Nevada. On mountain lands it has approximately the same range of adaptability as intermediate and pubescent wheatgrasses. Although generally less valuable than the wheatgrasses, in some places it has shown more tolerance to drought and low fertility, and after 5 years has been one of the highest producing grasses in ponderosa pine openings in southern Utah. It is slow in establishing initial stands, but, once started, it spreads vigorously by

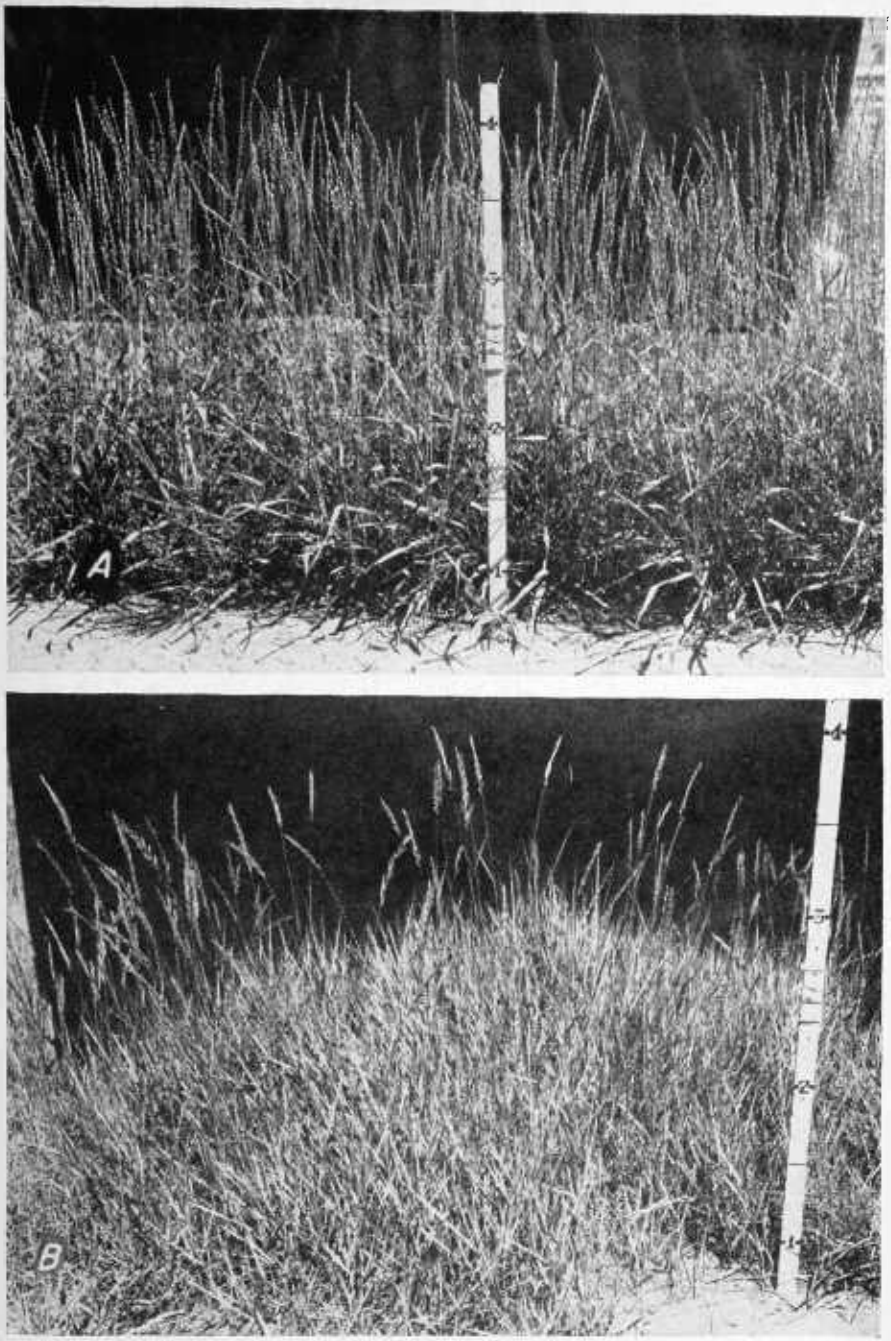

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FIGURE 26.—Sod-forming wheatgrasses: *A*, Pubescent wheatgrass is well adapted to lowland ranges where soil is good. It is a superior grass on granitic and basaltic soils in Idaho and Nevada. *B*, Western wheatgrass is best adapted for seeding heavy soils. It does particularly well in swales where moisture accumulates.

vegetative means. Natural areas indicate that it will be a valuable grass for seeding moist areas in salt-bearing lowlands. Fall seeding is necessary for good seedling emergence. Seed is not commercially available but can be readily harvested from native stands.

Big bluegrass, a thrifty native bunchgrass, recommended for the better lowland sites, is also a valuable forage within the mountain brush zone, particularly on south exposures. The exceptionally early spring growth is relished by all grazing animals, including game. Young plants are easily pulled out of the ground, so should not be grazed until well established. Initial stand establishment has often been disappointing. This is chiefly attributable to the fact that fall-seeded plants sprout in very early spring, and while small and fragile are killed by occasional frosts. This is a problem with several species of bluegrass.

Mountain rye, a short-lived, introduced bunchgrass, is useful in the higher precipitation belts in the lowlands and on open mountain brush ranges. It develops rapidly, and can be used to good advantage with the slower developing perennials while they are becoming established. It is not nearly so competitive as winter rye. When allowed to mature seed, it will reseed itself well in disturbed areas. While seed is not commonly available, it can be readily grown.

Great Basin wildrye, sometimes called giant wildrye, is a tall, robust, native bunchgrass. It is native in a wide range of site conditions, from river bottoms to hillsides. It is probably the highest yielding grass on moist lowlands and in mountain brush and shade-free openings in aspen sites. It is rather difficult to establish and stands are slow to reach full production. Young growth is highly palatable. While older growth is less palatable, on lowland ranges it is especially vauable as roughage for livestock during the winter and fall periods. It starts growth early, and can be grazed to best advantage in the spring period. Fall seeding is required to get good emergence. Although not commercially available, seed can be harvested readily from native stands.

Tall wheatgrass (fig. 27), a tall, vigorous introduced bunchgrass, is one of the highest producers on good sites on lowland and mountain brush areas. It seldom produces seed above the middle of the mountain brush zone and is weak and spindly when growing on shady areas. Within its range of adaptability, however, its yield of forage is consistently higher than yields of other grasses with the exception of Great Basin wildrye. It is vigorous in the seedling stage. Growth starts later in the spring than for crested wheatgrass, but it matures seed late and remains green late in the summer. It is not as tolerant of heavy grazing as most introduced wheatgrasses, and use in the growing stage should not exceed 60 percent. It is not generally as palatable as many other species, and in mixtures livestock are inclined to leave it. However, in pure stands it makes exceptionally high grazing capacity range and in late summer and fall it is frequently preferred over other grasses because its stems and leaves remain green.

One of the greatest uses of tall wheatgrass in the Intermountain region is on salt-bearing lowlands. It grows successfully where as much as 1 percent soluble salts occurs in the soil. It has done well in

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FIGURE 27.—Tall wheatgrass is a high yielder on sites bearing soil salts. It is also one of the more productive grasses on valley and foothill land where the annual precipitation is greater than 12 inches.

places where the water table rises to within a few inches of the surface, as well as under conditions where the water table is barely within the root zone. Its roots have been found to extend as much as 10 feet below the ground surface in some of the deeper soils. Where water tables exist above this depth, as they frequently do on saltgrass and greasewood lands in valley bottoms, roots extend well into them. Consequently plants continue to grow vigorously after the more shallow-rooted native saltgrass dries up.

Tall fescue, a selection from introduced meadow fescue, is a rapidly growing bunchgrass. It is widely used in irrigated and humid pastures and has been found useful on moist salty lands and in shade-free aspen openings on range areas. It does not endure long periods of drought. On salty lands where moisture is ample for continuous growth, it has outproduced tall wheatgrass and can tolerate heavier grazing under season-long use. This is attributed to its better regrowth qualities. It starts growth very early in the spring and basal leaves remain green until covered with snow. These qualities also make it superior to tall wheatgrass early and late in the season.

Bulbous barley (fig. 28), a robust bunchgrass introduced from eastern Europe and growing from a cluster of bulbs, is well suited to mountain brush ranges and aspen openings. Though seed stocks are stemmy and coarse, this species produces a large amount of early spring forage for which livestock and game show a high preference. Seed shatters unevenly but spreads widely. An unusually high num-

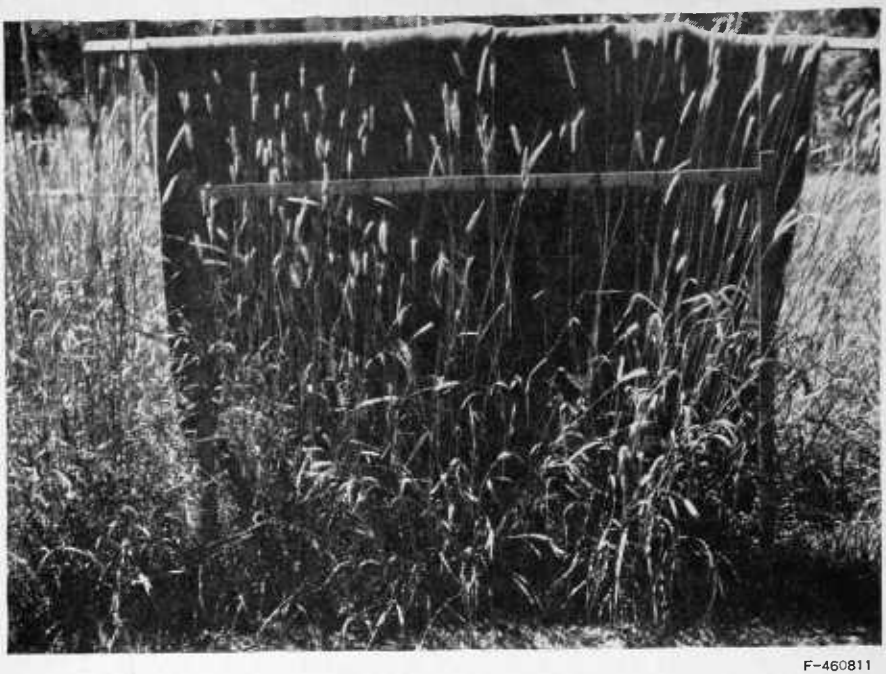

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FIGURE 28.—Bulbous barley, a robust and early grower, is suited to mountain brush openings, where it produces an abundance of early spring forage.

ber of new plants become established, even among other vegetation. The large seeds produce vigorous and rapidly developing plants, which withstand heavy use. Seed is difficult to harvest and requires debearding for drilling. Basal bulbs are readily eaten by pocket gophers and squirrels so that stands are often severely thinned.

Bearded wheatgrass and *blue wildrye* are short-lived native bunchgrasses but strong reseeders. They are productive and aggressive throughout the mountain brush and aspen zones, but are not suited to high subalpine ranges. Both are shade tolerant. Strains adapted to the mountains are not commercially available, but they can be readily harvested from native stands. Seeds are bearded and must be debearded before drilling.

Smooth brome (fig. 29), a long-used introduced sod-former, is the most widely adapted and valuable grass for seeding mountain rangelands and should always be a major component in mixtures. It grows well in shade or sun, from the better lowland sites and the mountain brush through the subalpine zone. Dry, south exposures with poor soil are the only places where its adaptability is doubtful. Even here the southern strains have ranked with the better adapted grasses. It produces a large volume of forage if the level of available soil nitrogen is high. Smooth brome has the ability to persist and spread under severe grazing and competition, a quality possessed by very few species. It even will suppress some brush species. Scattered plants of smooth brome, once well established, will spread vegetatively to make a full cover. Its greatest shortcoming is its slow rate of initial stand develop-

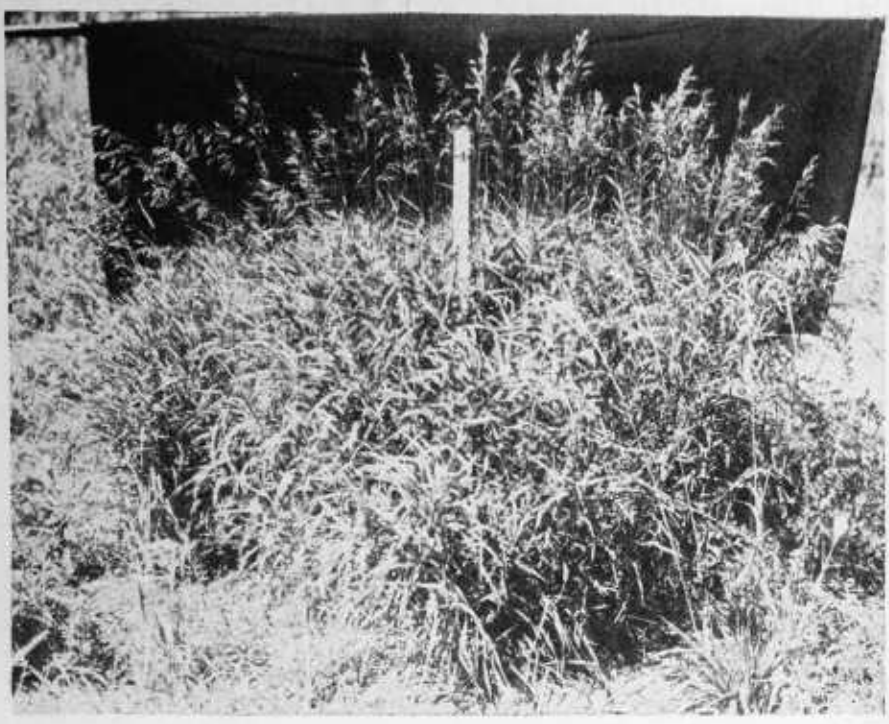

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FIGURE 29.—Smooth brome is the most important grass for seeding mountain rangelands. It is excellent for controlling erosion and grows well from low to high elevations.

ment. Faster developing grasses, such as mountain brome, orchardgrass, tall oatgrass, timothy, meadow brome or subalpine brome, planted with smooth brome, produce forage while it is becoming established.

The southern strains of smooth brome, such as Lincoln, Achenbach, and Fisher, are more productive than northern strains in mountain brush types, whereas in the subalpine zone the northern strains, such as Manchar and Canadian, are usually more productive. At middle elevations in the aspen zone, northern and southern strains appear equally good. The southern strains have stronger seedlings, give better initial stands, and are more vigorous sod-formers than the northern. So where erosion is a problem it may be wise to use them or to plant a southern and a northern strain mixed. Manchar has generally demonstrated better seedling vigor than other northern strains and compares favorably with southern strains in this respect.

Mountain brome (fig. 30) and *slender wheatgrass*, two native bunchgrasses, are adapted to most mountain sites except dry southerly exposures in the mountain brush zone. Both produce an abundance of seed, have vigorous seedlings, and spread rapidly. When used with the slower developing grasses, such as smooth brome, they are at first more prominent, but eventually become secondary, except in spots where the sod is opened by rodent activity or other disturbance. The

FIGURE 30.—Mountain brome is one of the best grasses for raw slopes. It is a fast grower, reseeds itself aggressively, and is useful for seeding under aspen.

high forage production they make in the first 4 to 5 years, as well as the stability they give to disturbed sites, makes them valuable. There is great variation in growth characteristics in both species. Seed should come from sources known to be adapted to the planting area, and it is often wise to harvest seed from native stands having the characteristics desired. The Primar strain of slender wheatgrass, now in commercial production, shows high adaptability to mountain rangelands.

Meadow and *subalpine bromes* are two introduced bunchgrasses which are well adapted to mountain rangelands. Subalpine brome finds its best use on subalpine ranges, where it matures seed early but remains green and succulent throughout the growing season. Meadow brome is more shade-tolerant and can be used on all mountain lands. Both produce an abundance of palatable herbage and seed and are aggressive spreaders. Seed is available in only limited amounts commercially but can be readily grown.

Kentucky bluegrass, an introduced sod-former, grows well in a variety of sites throughout mountain lands, but its production, except on moist areas, is low. It is primarily useful for seeding camp and picnic areas or other sites where short foliage and a tough sod are desired. It is an excellent grass for controlling erosion. Often it is very slow to develop a stand, but sparse stands gradually thicken vegetatively. Because of a shallow root system, it dries up quickly in dry weather. *Canada bluegrass* is a similar type grass, but it makes a more open sod. Once established, it is better for stabilizing raw, eroding sites. It is adapted to a similar elevational range as Kentucky bluegrass but is not as shade-tolerant.

Tall oatgrass (fig. 31, *A*) and *orchardgrass* (fig. 31, *B*) are introduced bunchgrasses with similarly wide areas of use in the mountains. Both are highly useful in mixtures with smooth brome for seeding in tall mountain brush and aspen. They are highly shade-tolerant, especially orchardgrass, and particularly good in seeding aspen areas. Plants grow early in the spring and continue to grow throughout the season. Both are highly palatable. They spread rapidly from seed. The Tualatin strain of tall oatgrass, a type which holds the seed well for higher seed production, is a recommended strain.

Reed canarygrass (fig. 32, *A*), a tall vigorous grass with heavy root stocks, is probably the most productive species on wet sites from mountains to lowlands, especially where soil is rich in organic matter. It spreads rapidly on moist fertile sites and also endures drought, but makes poor growth on dry or infertile soils. Poor stands often result from tardy germination and from weak seedlings which are subject to damage by frost or drying winds. Planting the seed in furrows aids in getting stands established. Good stands of this grass are readily obtained on small wet places by pressing pieces of sod into holes punched in the wet soil with the heel or a stick. From these vegetative plantings reed canarygrass will often suppress inferior plants such as wire rush.

Timothy, a bunchgrass, and *meadow foxtail* (fig. 32, *B*), a mild sod-former with a bunch habit, are two introduced cultivated grasses which are also valuable for range seeding. Both grow under a wide range of soil and moisture from mountain tops to valley bottoms, but are most productive on good soils in moist to wet sites. On such areas they grow throughout the summer season and produce a large volume of palatable forage. Both are shade-tolerant and well suited to seeding under trees. Their ability to establish full stands quickly makes them valuable in mixtures with slower growing species. Timothy seedlings are strong and vigorous, and although meadow foxtail seedlings are weaker, both plants spread aggressively from seed. The small seeds need but little covering to germinate and produce new plants.

Red fescue, a sod-former, and the Sulcata strain of *sheep fescue*, a bunchgrass, are two fine-leaved introduced grasses showing particular promise on aspen openings and high mountain ranges. Both have deep roots, make a heavy litter and are good soil builders. A mixture of the two appears to be most satisfactory. They are only moderately palatable during the summer, but because they maintain a good amount of green leaves, even after frost, they are preferred grasses in the fall period.

Winter rye (fig. 33), a hardy, fast-growing cereal, can furnish good early spring grazing on lowland and mountain brush areas where precipitation exceeds 8 inches. It is excellent for supplementary forage while perennial grasses are becoming established and provides quick green forage for lambing and calving. Young lambs gain over ½ pound per day in the early spring and feeder cattle gain 2 pounds per day or more in the spring, as well as in the summer between the period of soft dough and seed shattering. It is the equivalent of crested wheatgrass in grazing capacity, and it reaches full production the spring after seeding. Although it equals perennial grasses in

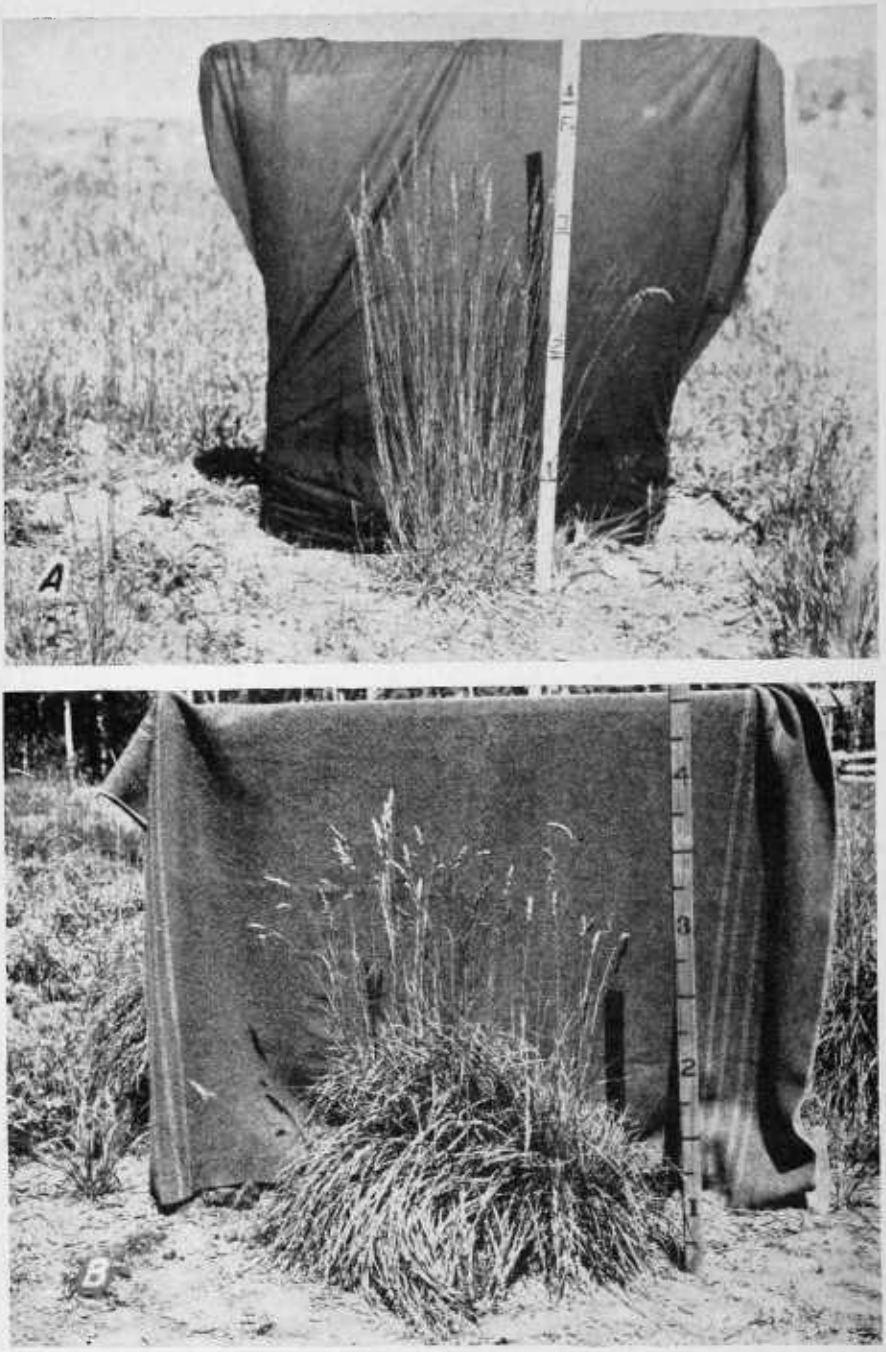

FIGURE 31.—Two important grasses for seeding mountain lands. *A*, Tall oatgrass is widely adapted, is suited either to shade or sunlight, and spreads rapidly from seed. *B*, Orchardgrass becomes established quickly in aspen and mountain brush, and withstands extended periods of drought.

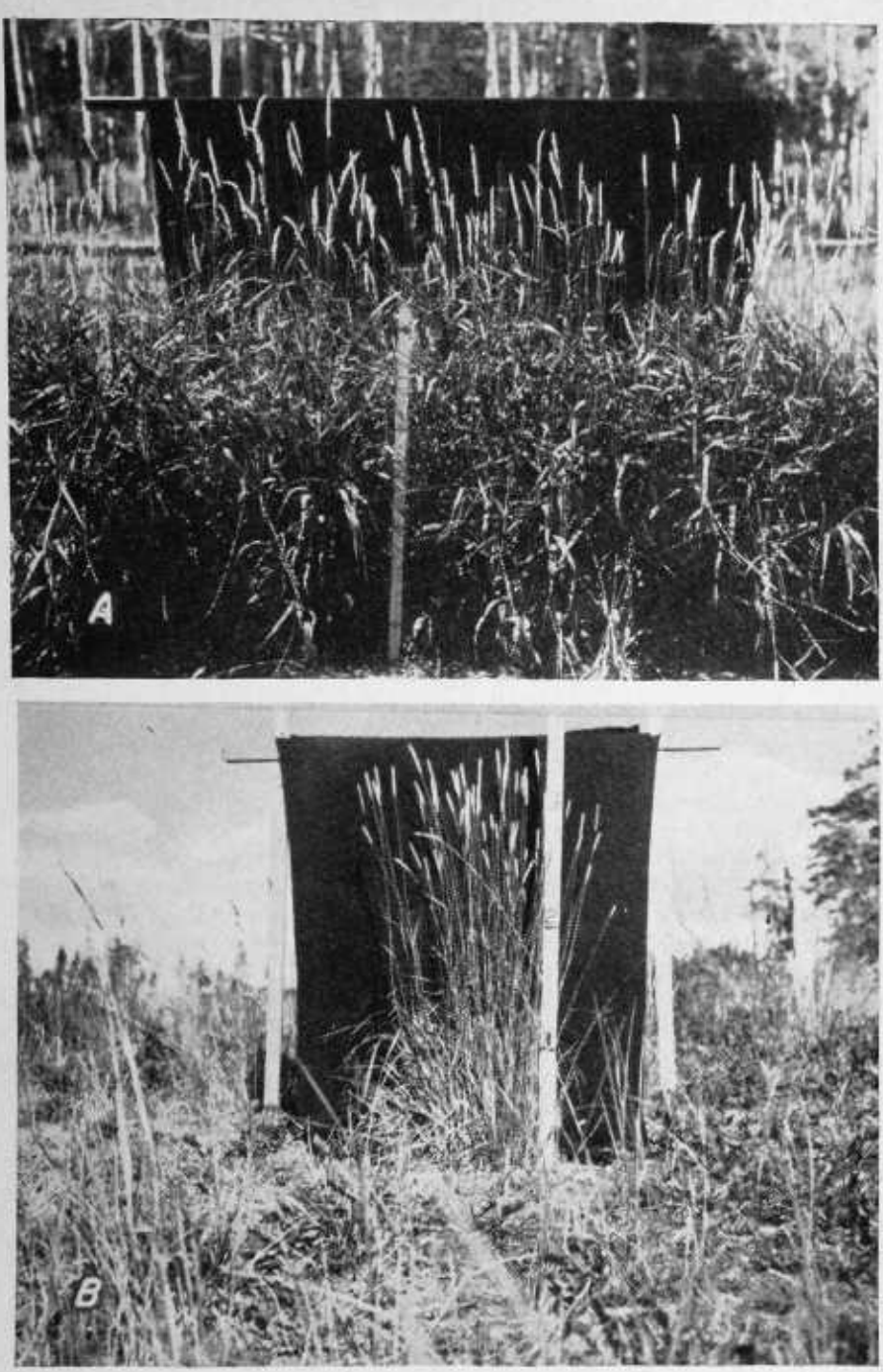

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FIGURE 32.—Two grasses for use on mountain rangelands: *A*, Reed canarygrass is an exceptionally high yielder on moist and wet areas with high organic matter in all zones. *B*, Meadow foxtail, an aggressive seeder on subalpine lands, is also useful for seeding in moist areas in the lower zone.

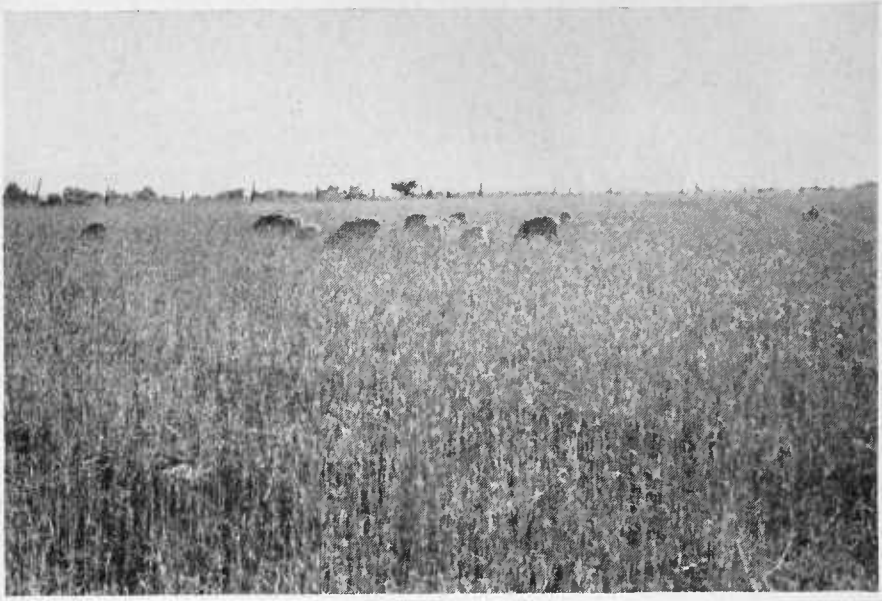

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FIGURE 33.—Winter rye furnishes quick forage and provides temporary pasturage while perennial grasses are becoming established on other areas. Livestock make excellent gains on this annual, but the necessity of replanting at intervals makes it more costly over a period of years than perennial grasses.

productivity and forage quality, it is more costly in the long run because some reseeding and disking are necessary at intervals to keep it productive.

Ground treatment and planting methods are the same as for seeding perennial grasses. Drilling at 40 to 45 pounds per acre or broadcasting at 50 to 60 pounds per acre should be done in the fall. With 12 inches or more of annual precipitation, rye will generally reproduce itself for several years. To do this, however, grazing must be discontinued in late spring, so that heads will develop, or the grazing must be light enough so that about one-fourth of the seed heads mature and shatter. Disking the seed into the ground each year will usually maintain rye with as little as 9 inches of precipitation. In most cases rye should not be sown in mixture with perennials, because with its rapid growth so much moisture is used that the slower-growing perennials are suppressed.

Legumes

Little success has been had with starting legumes on the dry lowlands in the Intermountain region. Where the average annual precipitation is above 12 inches, and the soil has good moisture-holding qualities, certain species show some promise for planting with grass. As previously pointed out, all legumes should be inoculated with their specific nodule-forming bacteria.

Alfalfa, an introduced and highly important hay plant, has proved highly successful on many of the better lowland sites and on mountain

brush areas and shade-free openings in aspen. Because hay strains of alfalfa have a single taproot, rodents will usually reduce stands. The pocket gopher has been the major culprit, although kangaroo rats and mice do considerable damage. Alfalfa is also more subject to overgrazing than grasses, and is thus rendered more susceptible to drought and winter injury. The Ladak strain has been the most successful of the popular types. Crown-spreading or creeping alfalfas are apparently more persistent and, once established, are not injured so readily by rodents. Nomad, Rhizoma, and Sevelra are three strains now on the market. From limited trials they appear well adapted to the general area where alfalfa grows.

Sicklepod and *chickpea milkvetches* are two Siberian legumes adapted to seeding the better lowland sites and mountain rangelands. Some difficulty is encountered in getting stands established, but once established they are both high producers. Sicklepod milkvetch (fig. 34, *A*), is not shade-tolerant and does not grow well above the aspen zone. Chickpea milkvetch is slightly shade-tolerant and more widely adapted, growing well on most mountain rangelands. Because it propagates vegetatively, as well as by seed, it is not readily killed by rodents, and it maintains itself well in grass. Seed sources of these valuable legumes are being developed and soon should be more generally available.

Yellow sweetclover, an introduced but widely naturalized biennial, is useful on the better lowland sites, on mountain brush and aspen lands, and on moist, moderately salty areas. If supplemental water can be applied once or twice during the growing season, yellow sweetclover can be grown on naturally dry, salt-bearing tracts. The first 2 years the clover is the heavy yielding component in mixtures, but later it produces less and becomes secondary to grasses. On the more favorable lowland sites and in mountain brush and aspen openings, yellow sweetclover reseeds itself under moderate grazing and builds up a supply of seed in the soil. Here it becomes an important and lasting constituent of the forage.

Strawberry clover, an introduced low-growing perennial legume, spreading vegetatively by runners, is useful in increasing the quantity and quality of forage on wet, salty lands. It will withstand considerable flooding and is recommended only on permanently wet sites.

Birdsfoot trefoil or birdsfoot deervetch is an introduced fine-stemmed perennial legume widely used in cool humid regions. The broadleaf upright form has been found adapted in mountain brush areas and openings in the aspen. It is not very shade-tolerant, but if seed is allowed to mature this legume is a good natural spreader.

Mountain lupine (fig. 34, *B*) provides protective cover on badly eroded sites in the highest mountains. Being very tolerant of shade, it is also well adapted to aspen. It has remarkably strong seedlings, which enable it to establish itself readily. It spreads rapidly from seed and grows and reproduces well in stands of grass. Seed can be collected from native stands. While it is regarded as somewhat poisonous to livestock in some areas, in Utah it provides good late summer forage, particularly where it occurs with other forage plants.

Alsike clover is well suited to high mountain land having above-average moisture, particularly the wetter mountain parks in Idaho.

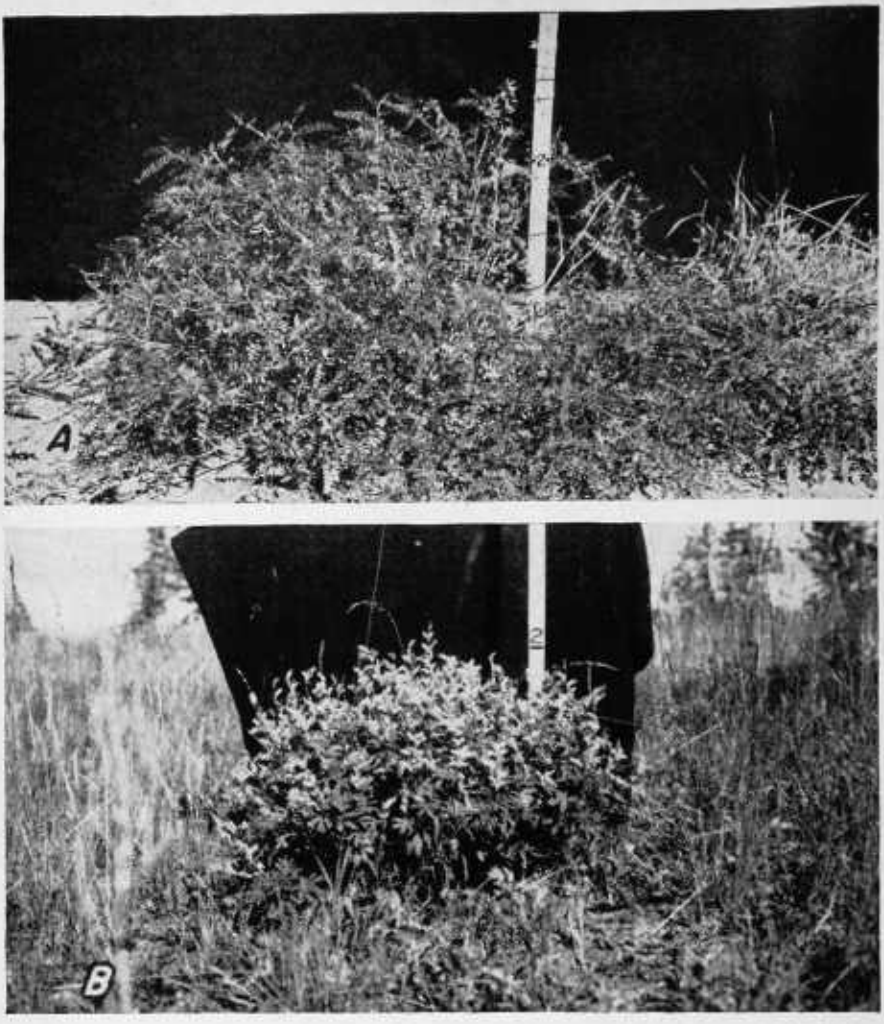

FIGURE 34.—Adapted legumes: *A*, Sicklepod milkvetch is a high producing species in the mountain brush zone. *B*, Mountain lupine is good for seeding in the subalpine zone.

Other Broadleaf Herbs

Seed of most broadleaf plants mentioned here must be harvested from native sources, as there is little or none available commercially. For the most part they are best suited for special use purposes.

Belvedere summercypress and *fivehook bassia*, two introduced and widely dispersed summer annuals, are useful for increasing forage on many moist, salty areas. Belvedere summercypress (fig. 35) often reaches a height of 5 feet and makes good hay when cut in the bloom stage. Fivehook bassia has also been successfully cut for hay but is difficult to mow and rake because of its spreading habit. It is an

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FIGURE 35.—Belvedere summercypress is a palatable annual that provides abundant, high-protein forage on sites with salt content too high for most range forage plants.

aggressive reseeder which will actually germinate and establish under brackish water. After the water dries up, fivehook bassia develops rapidly and makes a luxuriant growth. Seed of summercypress is now available commercially; seed of fivehook bassia can be collected from naturalized wild stands, and is sometimes available from alfalfa screenings in central Utah.

From early growth to rather late maturity, these two annuals retain high nutritive values somewhat comparable to those of alfalfa. They provide palatable, succulent, high-protein forage when the native grasses are dry and low in protein. The plants make a good first-year pasture or hay crop following the plowing up of saltgrass or greasewood, and thus aid in offsetting high costs of plowing. Because replowing is usually necessary to eradicate saltgrass, which tends to become reestablished under these annuals, and also under perennial grasses, generally the land should be replowed after 1 or 2 years and planted to adapted perennials, such as tall wheatgrass and Russian wildrye. If alkali is present in only moderate amounts and considerable moisture occurs, tall fescue and yellow sweetclover may also be used. It may be desirable to retain some areas in these annuals to provide a protein supplement to the grass in late summer.

Palmer penstemon is a vigorous native plant which grows well on disturbed and eroding areas throughout the lower mountain brush zone, as well as in the adjoining juniper-pinyon belt. Although it is a short-lived perennial, it reseeds itself aggressively and at the same time provides an environment in which other plants can become established. Because the basal leaves remain green and succulent

through much of the winter, it is liked by both deer and sheep in this season. *Wasatch penstemon* serves a similar purpose within the mountain brush and aspen zones.

Showy goldeneye, *cowparsnip*, and *sweetanise* are native perennial plants which are well adapted for seeding on mountain lands. All grow well in the shade. Showy goldeneye (fig. 36) has demonstrated exceptional promise as a pioneer species on infertile soils from the mountain brush to the subalpine zone. It is easily established and spreads rapidly from seed. Cowparsnip has shown particular usefulness for seeding moist mountain brush and subalpine ranges and especially beneath aspen. Although this productive broadleaf herb is sometimes slow to establish, it is a good reseeder. It is most easily established where there is an overstory such as aspen or a brush mulch to protect seedlings from frost or rapid drying. Sweetanise is best suited to the aspen and subalpine zones. It is a vigorous grower on raw soils, where it produces well and spreads rapidly where seed is allowed to mature. All three species are excellent game and livestock forage. Cattle show a particular foudness for cowparsnip and sweetanise.

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FIGURE 36.—Showy goldeneye is good for planting on raw or eroding sites.

Shrubs

Several shrubs show real promise for revegetating some lowland and mountain areas where there may be a need for browse and, in some instances, erosion control. Seed of all shrubs must be harvested from native stands as it is seldom commercially available.

Winterfat, a native shrub generally not over 2 feet in height, is a preferred browse for livestock and game. It is well suited for seeding

on lime-bearing soils on south and west exposures throughout the mountain brush zone as well as on most lowlands. Stand establishment, particularly on lowlands, is erratic because seed will germinate with only 1 day of warm temperatures, then freeze with the next cold night. Such losses are less in the mountain brush zone, because the ground is better insulated with snow until later in the spring when there are but few nights with killing temperatures. Where once established, it has been noted in Utah to be a natural spreader. While some seed is available commercially, most of it must be collected from native stands. Seeds lose viability rapidly and should be used within 2 years after collection.

Fourwing saltbush is a palatable and nutritious native shrub suited particularly to south and west exposure where the soil contains lime. It will grow on fairly salty soils and grows well on lowland ranges and in the mountain brush zone. Initial establishment has been difficult, especially where precipitation is less than 12 inches. Hammer milling to remove the wings makes drilling much easier, and permits placing the seed in much closer contact with the soil. With this shrub it is particularly important to use seed from areas where the climate is as severe as that on the area being planted.

Antelope bitterbrush is a highly palatable shrub that is native on the better lowland sites and throughout the mountain brush and aspen zones. It is useful for seeding in these areas and can be started from direct seeding, although establishment is erratic. Seedlings are difficult to establish in cheatgrass or similar competition. Therefore, elimination of competing vegetation is especially important when seeding bitterbrush. For this purpose scalping off the surface inch or so of soil has proved to be an effective procedure where annual weeds such as cheatgrass are troublesome. Bitterbrush seedlings should be protected from grazing, especially in summer, for at least 2 or 3 years. Some bitterbrush plantings have been successfully extended into lowlands where the precipitation has been as little as 10 inches. A low-growing strain, with spreading branches, which roots at points where they are in contact with the soil is especially useful on bare, eroding areas. Such lower growing forms survive fire better than tall-growing types. Tall-growing types are most useful on areas where browse is needed in the winter. Bitterbrush can grow where there is considerable shade as well as on exposed sunny areas.

Oldman wormwood (fig. 37, *A*), an introduced woody plant, becomes established quickly on raw and eroding sites, such as road cuts and gullies, throughout mountain brush areas and on the moister lowlands. It is started in the early spring by thrusting a 12- to 18-inch stem cutting into the soil to a depth of 4 to 6 inches as soon as the ground thaws. It grows rapidly and is fair browse for livestock and big game. Once the wormwood stabilizes the soil, herbaceous vegetation comes in.

Blueberry elder (fig. 37, *B*) is a tall native shrub adapted for seeding mountain lands and favorable lowland sites. Establishment is erratic, but once established it grows rapidly and produces a large volume of palatable browse. It is slightly shade-tolerant.

All grasses, broadleaf herbs, and shrubs discussed above are listed for quick reference in the guide section, which summarizes recommended procedures and species for specific sites and conditions.

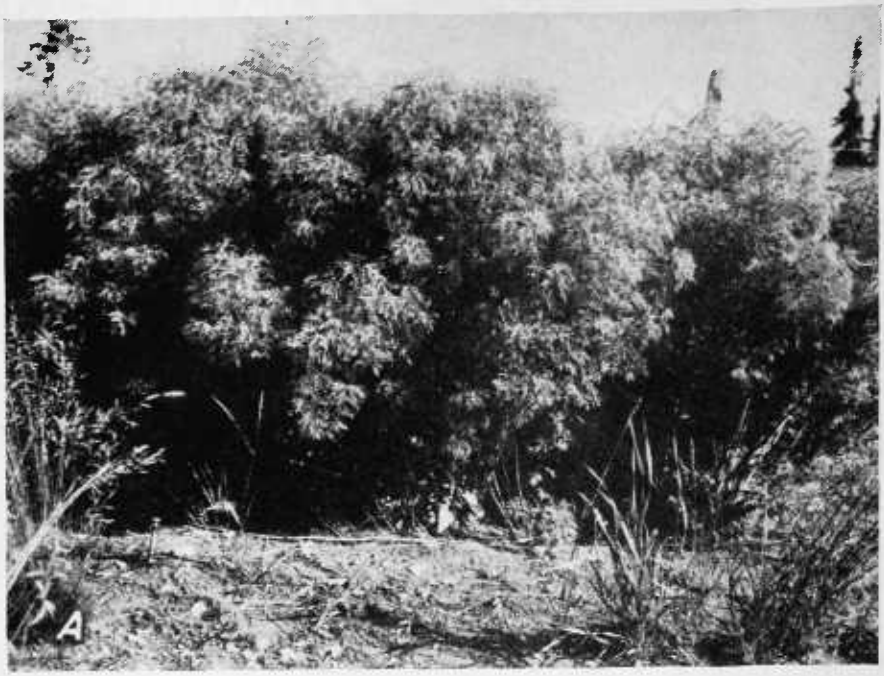

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FIGURE 37.—*A*, Oldman wormwood becomes established readily on roadbanks or other eroded sites. *B*, Blueberry elder can be seeded successfully on lower mountain ranges where browse is needed. Once seedlings are established, the shrubs attain full size in 3 to 4 years.

MANAGING SEEDED RANGES

Seeding should be undertaken only where grazing can be restricted long enough to permit plants to become well established. Thereafter use should be regulated in such a way that a vigorous stand can be maintained. Disregard for protection at the beginning, or improper grazing after the stand is established can defeat the purpose of the work.

In general seeded stands should not be grazed, or if so, only lightly, until a seed crop has been produced. Usually the grazing obtained before the first seed crop does not warrant the risk involved. During the first season, seedlings produce little forage and severe injury is likely to occur from grazing or trampling. With good moisture and good growth, grazing is often feasible in the second year, but it is a good plan to defer use until late in the season or until seed heads are well developed. On dry ranges 2 years of complete protection is usually necessary; and if the plants are small and poorly rooted because of unfavorable growing conditions, a third year of protection may be necessary.

The requirements for maintaining high production from seeded stands after they are well established are the same as for native ranges. These include such fundamental practices as: (1) Stocking the range within the limits of its grazing capacity; (2) delaying use of the range in spring until the soil is firm and the volume of herbage will sustain grazing; (3) using a system of management, such as deferred and rotation grazing or moderate continuous grazing, which will permit the plants to maintain their vigor and allow them to mature some seed for reproduction; and (4) salting and herding to insure proper distribution of livestock. Provision in grazing plans for these important features will make possible successful establishment of seeded plants and their maintenance at a high level of production.

On level areas, it has been found that 30 to 40 percent of the herbage produced by crested wheatgrass should be left to maintain vigor and productivity of the stand. Where soil protection is needed on sloping lands, 40 to 60 percent or more of the herbage should be left. Presumably these standards also apply to other recommended grasses.

Seedling stands should also be protected from excessive utilization by rodents and insects. Poisoning may be necessary to control such pests.

Electric fences offer an economical means for temporarily excluding livestock from newly seeded areas, and for dividing large seeded areas into management units (fig. 38). If land becomes too dry for electric fences to be effective, or there is frequent trouble with electric fences grounding out, a good permanent fence of barb, net wire, or log and block may be needed. Even though it is occasionally necessary to protect considerable unseeded range along with the seeded area, the temporary loss of forage is usually repaid through increased production from the native plants, as well as the seeded stands in following years.

Seeded grasses fit well into various systems of grazing. On lowlands, grasses which make early spring growth may be grazed prior

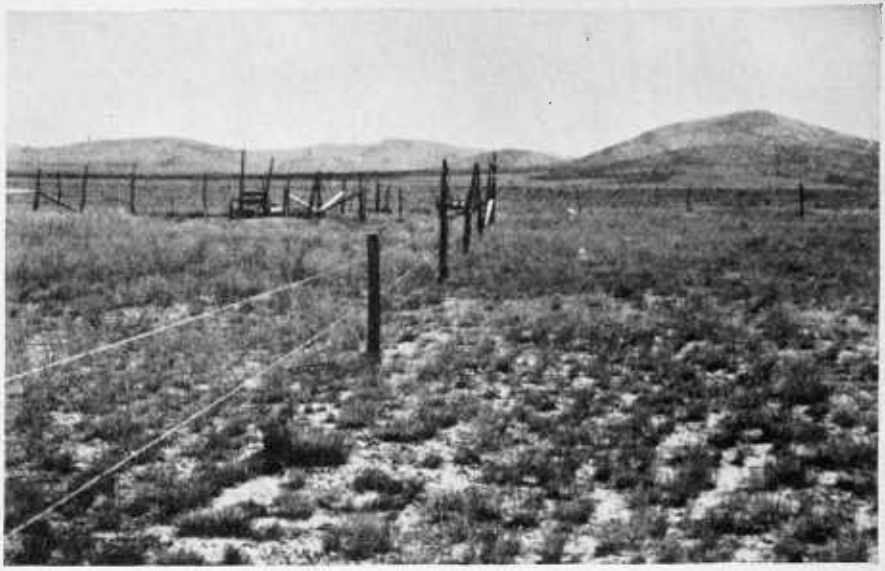

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FIGURE 38.—Electric fences are an economical means of keeping livestock off newly seeded areas, as well as an effective means for dividing a large seeded area into management units.

to the time native ranges are ready for grazing. This saves feeding costs and also avoids too early grazing of native ranges and permits them to improve. A better possibility for extending green nutritious forage over a longer period of time is to seed in separate range units several species having different growth habits and grazing them alternately so as to take advantage of differences in their growth periods. Species such as crested, tall, and intermediate wheatgrasses and Russian wildrye could be used in this manner on lowland ranges. Where adapted, a legume such as alfalfa, sicklepod or chickpea milkvetch, or yellow sweetclover may be seeded with the grasses. An alternate plan for heterogeneous sites is to use a mixture of two or more species which are similar in palatability, but differ in growth periods or site adaptations, and graze moderately so that neither species is overutilized. This is the practice to follow if site characteristics vary greatly within the area being sown.

SEEDING GUIDE FOR SPECIFIC SITES

Procedures and species for seeding various sites are given below in condensed form for quick reference. More detailed discussion of methods and species may be found in earlier sections of this handbook.

LOWLANDS

Sagebrush and Rabbitbrush Areas

Treatment before planting.—Planned burning is inexpensive and effective where sagebrush will carry fire. With an abundance of

sprouting species such as rabbitbrush or horsebrush, mechanical methods are more satisfactory. Disk plowing 2 to 3 inches deep is adequate for sagebrush, but a 4- to 6-inch plowing depth, sometimes in opposite directions, is necessary to kill sprouting brush. On level land without rocks, "grubbers" and root planes also eliminate sprouting brush. Brush "beaters" give good kills if rocks do not stick up above the surface more than 4 inches. Railing is economical and effective on level, rock-free lands where sagebrush is even-aged and brittle. Self-clearing harrows are most effective for brittle sagebrush on rocky areas.

Planting season.—Late fall seeding is generally best. Early fall planting in September and early October is successful where there are fall rains. Early spring is best if the soil surface crusts badly following snowmelt; it also gives better establishment of legumes.

Planting methods.—Drill, if feasible; otherwise, broadcast and cover by means of a disk harrow, self-clearing pipe harrow, or any equipment which will produce similar results.

Recommended species or mixtures.—Crested wheatgrass is best for general use. Antelope bitterbrush, fourwing saltbush, or winterfat are useful where browse is needed. Use species such as Palmer penstemon or oldman wormwood for vegetating raw or eroding areas such as road cuts or gullies.

1. With less than 8 inches of precipitation—most trials have failed and seedings are recommended only on a trial basis, using such species as crested wheatgrass, Russian wildrye, Indian ricegrass, bottlebrush squirreltail, sand dropseed, winterfat, and fourwing saltbush. The latter is best suited to sites with above-average soil moisture.

2. With 8 to 12 inches of precipitation—the above species and beardless and bluebunch wheatgrasses are adapted. Bulbous bluegrass and winter rye are adapted for special uses. Soils with good moisture-holding qualities often make up for deficiencies in precipitation. With favorable moisture, intermediate, pubescent, and western wheatgrasses, beardless wildrye, big bluegrass, and antelope bitterbrush are usually adapted.

3. With more than 12 inches of precipitation—several additional species are adapted. Two successful mixtures, and other species suitable for substitutes or additional components, are listed below.

	Seeding rate per acre in mixture			
	Light soils		*Heavy soils*	
	Drilled (pounds)	*Broadcast (pounds)*	*Drilled (pounds)*	*Broadcast (pounds)*
Crested wheatgrass [1]	3	4	2	2
Intermediate or pubescent wheatgrass [1]	3	4	2	3
Western wheatgrass	------	------	2	3
Alfalfa (creeping forms or Ladak) or chickpea milkvetch	1	2	1	2
Totals	7	10	7	10

[1] Should always be included.

Substitute or additions, and special use plants

General use	*Special use*
Indian ricegrass	Bulbous bluegrass
Russian wildrye	Winter rye
Bluebunch wheatgrass	Mountain rye
Beardless wheatgrass	Yellow sweetclover
Beardless wildrye	Palmers penstemon
Big bluegrass	Winterfat
Great Basin wildrye	Fourwing saltbush
Tall wheatgrass	Antelope bitterbrush
Sicklepod milkvetch	Oldman wormwood (cuttings)
Smooth brome	Blueberry elder

Where lowlands are relatively uniform, it may be desirable to seed single grasses, possibly with an adapted legume, on separate range units. Wheatgrasses and Russian wildrye are suitable for such seedings.

Cheatgrass Stands

Treatment before planting.—Burning before the seed shatters is economical and effective. Plowing is also effective if done in the spring before cheatgrass heads. A less effective but practical method is plowing in the fall after seeds germinate. Offset disks or disk harrows are sometimes satisfactory treatment on light or loose soil.

Direct drilling with deep-furrow type drills often eliminate enough cheatgrass for stand establishment.

Season, methods, and species.—The same as for sagebrush areas. Where seedbed preparation and seed covering are not feasible, bulbous bluegrass can be broadcast seeded in areas where it is adapted.

Sites With Summer-Growing Annuals

No treatment is needed before planting. Otherwise recommendations are the same as for cheatgrass or sagebrush areas.

Abandoned Wheatland and Accidentally Burned Areas

Recommended methods and species are similar to those outlined for sagebrush areas.

Juniper-Pinyon Stands

Treatment before planting.—Burning is effective and economical where trees or understory will carry fire. Pushing trees into continuous windrows at intervals of 100 to 200 feet and firing is effective in burning otherwise thin strands. Scorching individual trees with a flamethrower or burner is successful.

Cabling is effective and economical on slopes up to 10 percent. Bulldozing, a third method, is useful on sparse stands and steep slopes. Push-bar and catclaw assembly on the dozer blades reduces soil disturbance and speeds up the operation.

Small juniper trees in sagebrush can be plowed out along with the sagebrush, particularly with a brushland plow.

Planting season.—Same as for sagebrush areas.

Planting method.—Broadcast and cover seed with a single-disk harrow, self-clearing harrow, or similar equipment on burned areas. Broadcast ahead of cabling and bulldozing, and then afterwards in pits left where the trees were pulled out.

Recommended species mixture.—Use species suggested for sagebrush areas having more than 12 inches of annual precipitation and light soil. If Indian ricegrass is available, include in the mixture up to 3 pounds per acre.

Salty Lands With Saltgrass or Greasewood

Treatment before planting.—Moldboard plowing in late summer or fall to a depth of 4 to 6 inches, soil moisture permitting, effectively reduces saltgrass. Greasewood can be satisfactorily reduced with a heavy disk-type plow. Complete control of either usually requires plowing a second time. Belvedere summercypress or fivehook bassia can be drilled at 4 pounds per acre, or broadcast at 6 pounds per acre, to provide summer forage for 2 or 3 years before the final plowing and seeding to perennial grasses.

Planting season.—Early spring planting is usually best on wet lands, late fall planting is best on dry soils.

Planting methods.—A deep-furrow type drill with furrows spaced 12 to 18 inches apart gives best stands.

	For wet, salty lands with a high water table		*For dry, salty lands with a low water table*	
	Drilled (pounds)	*Broadcast (pounds)*	*Drilled (pounds)*	*Broadcast (pounds)*
Recommended species mixture:				
Tall wheatgrass	4	5	3	4
Tall fescue	3	4	------	-------
Russian wildrye	------	------	5	5
Yellow sweetclover	2	3	------	-------
Total	9	12	8	9

If water table is more than 5 feet below the surface, use only Russian wildrye. Strawberry clover is useful on lands which remain wet to moist during the summer.

Mountain Lands

Mountain Brush

Treatment before planting.—1. Short brush (level areas and moderate slopes)—Planned burning, plowing, or railing, sometimes in combination, may be applicable here. Burning should not be attempted where the erosion hazard is high. Burning of slopes up to 30 percent may be permissible if rapidly growing grasses are used in mixture with the slower growing but more persistent species.

2. Tall brush (Gambel oak, maple, and serviceberry)—No treatment needed.

3. Bare slopes with active erosion—Make contour furrows or terraces to stop runoff. Small furrows about 30 inches apart made with heavy farm furrowers are adequate for breaking up small gullies and providing a seedbed. On slopes up to 40 percent, a crawler tractor can be used. For steeper slopes, horse-drawn equipment is necessary.

Planting season.—1. Short brush and bare slopes requiring seedbed preparation—Late fall, early fall, or early spring in Utah, southeastern Idaho, and western Wyoming. Fall planting only is advised in northern Nevada and southwestern Idaho.

2. Tall brush—Fall (see planting method).

Planting method.—1. Short brush—Use the same planting procedures as for sagebrush and rabbitbrush.

2. Tall brush—Broadcast seed prior to or during leaf fall. Trampling by livestock after broadcasting improves the seeded stand.

3. Bare slopes furrowed or terraced—Broadcast on freshly worked ground and furrows. Trampling by sheep aids in covering the seed.

Recommended species mixture.—A larger number of species are adapted to mountain brush conditions than to other zones. Mixtures for the most important conditions are given below. If more than one condition is to be seeded with a single mixture, the number of species included and the total seeding rate should be increased accordingly. Where seed of a preferred species is not available, some of the listed substitutes may be used. Others are suggested for special uses or conditions, such as for browse forage, or for stabilizing eroding sites. Species for seeding mountain brush lands may also be used for seeding ponderosa pine openings.

Brush eradicated—unshaded

	Seeding rate per acre in mixture			
	Dry to average sites		Above average sites	
	Drilled (pounds)	Broadcast (pounds)	Drilled (pounds)	Broadcast (pounds)
Crested wheatgrass (Fairway strain) [1]	1	2	------	------
Beardless wheatgrass (Whitmar strain)	1	2	------	------
Intermediate or pubescent wheatgrass [1]	2	3	2	3
Smooth brome (southern strain) [1]	2	3	2	3
Tall oatgrass [1]	------	------	2	3
Alfalfa (creeping strain or Ladak)	1	2	1	2
Chickpea milkvetch	1	2	1	2
Total	8	14	8	13

Tall brush—shaded sites

	Seeding rate per acre in mixture (pounds)
Smooth brome (southern strain) [1]	4
Orchardgrass [1]	3
Tall oatgrass [1]	4
Mountain brome	4
Total	15

[1] These species should always be included, if available.

Substitute or additions, and special use plants

	General use	*Special use*
Dry to average sites—unshaded	Indian ricegrass Russian wildrye Bluebunch wheatgrass Western wheatgrass Beardless wildrye Big bluegrass Mountain rye Great Basin wildrye Tall wheatgrass Sicklepod milkvetch	Bulbous bluegrass Winter rye Palmer penstemon Wasatch penstemon Showy goldeneye Winterfat (calcareous soils) Fourwing saltbush (calcareous soils) Antelope bitterbrush Oldman wormwood (cuttings) Blueberry elder
Above average sites—unshaded	Bluebunch wheatgrass Russian wildrye Western wheatgrass Beardless wildrye Great Basin wildrye Tall wheatgrass Bulbous barley Blue wildrye Bearded wheatgrass Slender wheatgrass Meadow brome Reed canarygrass (moist sites) Timothy (moist sites) Meadow foxtail (moist sites) Sicklepod milkvetch	Bulbous bluegrass Kentucky bluegrass Yellow sweetclover Birdsfoot deervetch Palmer penstemon Wasatch penstemon Showy goldeneye Winterfat (calcareous soils) Fourwing saltbush (calcareous soils) Antelope bitterbrush Oldman wormwood (cuttings) Blueberry elder
Tall brush—shaded sites	Blue wildrye Bearded wheatgrass Slender wheatgrass Timothy Meadow foxtail Showy goldeneye Common cowparsnip Sweetanise	

Aspen

For seeding openings in aspen or Douglas-fir and spruce timber, use procedures suggested for low mountain brush or for open subalpine sites, depending on whether mountain brush or subalpine weeds predominate. The following procedures apply to seeding among trees.

Treatment before planting.—No treatment needed in aspen stands.

Planting season.—Broadcast seed among stands of trees, in August to early October, prior to or during leaf fall.

Planting method.—Airplane broadcasting is best for large areas. Small areas are best sown by hand.

Recommended species mixture.—Species for seeding among trees should grow well in the shade. Large sunny openings should be seeded separately. Mixtures below are satisfactory for a wide range of conditions. Additional or substitute species can often be used to good advantage.

	Seeding rate per acre in mixture		
	Large, sunny openings		In shade and small openings, broadcast (pounds)
	Broadcast (pounds)	Drilled (pounds)	
Smooth brome (equal parts northern and southern strain) [1]	5	4	7
Mountain brome	2	1	3
Orchardgrass [1]	1	½	2
Tall oatgrass [1]	2	1	2
Timothy	1	½	1
Meadow foxtail [1]	1	½	1
Intermediate wheatgrass	3	2	-------
Chickpea milkvetch or Ladak or creeping alfalfa	2	1½	-------
Total	17	11	16

[1] These species should always be included, if available.

Substitute or additions, and special use plants

Timber openings		
Among trees—general use [1]	*General use*	*Special use*
Blue wildrye	Crested wheatgrass (Fairway)	Sicklepod milkvetch
Bearded wheatgrass	Bluebunch wheatgrass	Yellow sweetclover
Slender wheatgrass	Beardless wheatgrass	Birdsfoot trefoil
Kentucky bluegrass	Pubescent wheatgrass	Alsike clover
Mountain lupine	Bluestem wheatgrass	Wasatch penstemon
Showy goldeneye	Creeping wildrye	Antelope bitterbrush
Common cowparsnip	Great Basin wildrye	Oldman wormwood (cuttings)
Sweetanise	Tall wheatgrass	Blueberry elder
	Tall fescue	
	Bulbous barley	
	Meadow brome	
	Reed canarygrass	
	Sheep fescue (Sulcata)	
	Red fescue (sod-forming)	

[1] Special use—Kentucky bluegrass.

Open Subalpine

Treatment before planting.—Eliminate weedy competition.

1. Perennial weeds—Plow to a depth of 4 to 6 inches in spring or summer, and let the land lie fallow till late fall or the next spring. Or common dandelion may be eliminated by spraying with 2, 4–D, ester base, at the rate of ¾ to 1 pound per acre, and mules-ears wyethia with 2 pounds per acre, in the early to mid-bloom stage.

2. Annual weeds—Cultivate the soil surface thoroughly to a depth of 1 to 2 inches with a duck-foot weeder, spring-tooth harrow, disk harrow, or similar implement, in early spring. Any abundance of perennial weeds requires procedures suggested for perennials. Spraying with ¾ to 1 pound of 2, 4–D eliminates annual weeds in the 2-leaf stage.

3. Steep eroding slopes—Make contour terraces or furrows to break up gullies and stop runoff. Small furrows 30 inches apart are adequate for small gullies. On slopes up to 40 percent, a crawler tractor with dozer can be used. On steeper slopes, horse-drawn equipment is necessary.

Planting season.—Early summer (late May to early July) and late fall (October and November) are satisfactory in Utah, eastern Idaho, and southwestern Wyoming. Late fall is best in northern Nevada and southwestern Idaho. Late fall planting is recommended on all unprepared seedbeds.

Planting method.—Drill where possible. Broadcasting ahead of surface soil treatment is effective where drills cannot be used. Broadcasting following ground treatment is successful only where seed is covered by natural or artificial means. Seeds planted in the fall on loose, freshly worked soil are often covered by soil sloughing. Trampling by sheep on loose soil on steep slopes helps to cover the seed.

Recommended species mixture.—A shorter growing season reduces the number of species adapted for high elevations. The following mixtures are suited over broad areas in subalpine or in aspen and timber openings immediately below.

	Seeding rate per acre in mixture			
	Well-drained soil		*Moist soil*	
	Drilled (pounds)	*Broadcast (pounds)*	*Drilled (pounds)*	*Broadcast (pounds)*
Smooth brome (northern strain) [1]	2	3	5	8
Smooth brome (southern strain) [1]	2	3	------	-------
Mountain brome	2	3	------	-------
Tall oatgrass	1	2	------	-------
Orchardgrass	1	2	1	2
Reed canarygrass	------	------	1	2
Timothy [1]	------	------	1	2
Meadow foxtail [1]	1	2	1	2
Chickpea milkvetch	2	3	1	2
Mountain lupine	1	2	------	-------
Alsike clover	------	------	1	2
Total	12	20	11	20

[1] These species should generally be present in the mixture.

Substitute or additional plants

Well-drained soils	*Moist soils*
Slender wheatgrass	Slender wheatgrass
Meadow brome	Meadow brome
Sheep fescue (Sulcata)	Kentucky bluegrass
Red fescue (sod-forming)	Subalpine brome
Subalpine brome	Common cowparsnip
Showy goldeneye	
Common cowparsnip	
Sweetanise	

COMMON AND BOTANICAL NAMES OF SPECIES MENTIONED

Common Name	*Botanical Name*
Alfalfa	*Medicago sativa*
Amaranth, tumbleweed	*Amaranthus graecizans*
Aspen, quaking	*Populus tremuloides*
Barley, bulbous	*Hordeum bulbosum*
Bassia, fivehook ("alkali weed," "Piute weed," "ragweed," "smotherweed").	*Bassia hyssopifolia*
Bitterbrush, antelope	*Purshia tridentata*

Common Name	*Botanical Name*
Bluegrass, big	*Poa ampla*
Bluegrass, bulbous	*P. bulbosa*
Bluegrass, Canada	*P. compressa*
Bluegrass, Kentucky	*P. pratensis*
Brome, cheatgrass. See Cheatgrass.	
Brome, meadow	*Bromus erectus*
Brome, mountain	*B. carinatus*
Brome, smooth	*B. inermis*
Brome, subalpine	*B. tomentellus*
Canarygrass, reed	*Phalaris arundinacea*
Ceanothus, snowbrush ("snowbrush")	*Ceanothus velutinus*
Cercocarpus, mountain	*Cercocarpus montanus*
Cheatgrass ("bronco grass," "cheatgrass brome," "downy brome," "dowuy chess," "junegrass").	*Bromus tectorum*
Chokecherry, common	*Prunus virginiana*
Clover, alsike	*Trifolium hybridum*
Clover, strawberry	*T. fragiferum*
Clover, yellow sweet. See Sweetclover, yellow.	
Cowparsnip, common	*Heracleum lanatum*
Dandelion, common	*Taraxacum officinale*
Deervetch, birdsfoot. See Trefoil, birdsfoot.	
Douglas-fir	*Pseudotsuga menziesii*
Dropseed, sand	*Sporobolus cryptandrus*
Elder, blueberry	*Sambucus glauca*
Fescue, meadow ("tall fescue")	*Festuca elatior*
Fescue, red (sod-forming)	*F. rubra*
Fescue, reed (includes the Alta strain and Kentucky 31 selection).	*F. arundinacea*
Fescue, sheep (includes the Sulcata strain).	*F. ovina*
Foxtail, meadow	*Alopecurus pratensis*
Geranium, sticky	*Geranium viscossimum*
Gilia, slenderleaf	*Gilia linearis*
Goldeneye, showy	*Viguiera multiflora*
Goosefoot, lambsquarters	*Chenopodium album*
Greasewood, black	*Sarcobatus vermiculatus*
Halogeton	*Halogeton glomeratus*
Horsebrush	*Tetradymia* spp.
Juniper, Utah	*Juniperus osteosperma*
Knotweed, Douglas	*Polygonum douglasii*
Larkspur, Barbey (one of the numerous "tall larkspurs").	*Delphinium barbeyi*
Larkspur, low (one of the numerous "low larkspurs").	*D. menziesii*
Lupine, mountaiu	*Lupinus alpestris*
Mahonia, creeping	*Mahonia repens*
Maple, bigtooth	*Acer grandidentatum*
Milkvetch, chickpea ("cicer milkvetch")	*Astragalus cicer*
Milkvetch, sicklepod	*A. falcatus*
Mountain-mahogany. See Cercocarpus.	
Oak, Gambel ("shrubby oak")	*Quercus gambelii*
Oatgrass, tall	*Arrhenatherum elatius*
Orchardgrass	*Dactylis glomerata*
Penstemon, Palmer	*Penstemon palmeri*
Penstemon, Wasatch	*P. cyanthus*
Pinyon	*Pinus edulis*
Pinyon, singleaf	*P. monophylla*
Rabbitbrush, rubber	*Chrysothamnus nauseosus*
Ricegrass, Indian	*Oryzopsis hymenoides*
Rush, wire ("wiregrass")	*Juncus balticus* var. *montanus*

Common Name	*Botanical Name*
Russian-thistle, tumbling	*Salsola kali* var. *tenuifolia*
Rye, winter	*Secale cereale*
Rye, mountain	*S. montanum*
Sagebrush, big	*Artemisia tridentata*
Sagebrush, black	*A. nova*
Sagebrush, sweet	*A. discolor*
Saltbush, fourwing ("boxbrush," "chamisa," "white greasewood").	*Atriplex canescens*
Saltbush, shadscale	*A. confertifolia*
Saltgrass, desert ("inland saltgrass")	*Distichlis stricta*
Serviceberry, saskatoon	*Amelanchier alnifolia*
Shadscale. See Saltbush, shadscale.	
Sneezeweed, orange	*Helenium hoopesii*
Snowberry, mountain	*Symphoricarpus oreophilus*
Squirreltail, bottlebrush	*Sitanion hystrix*
Summercypress, belvedere	*Kochia scoparia*
Sweetanise	*Osmorhiza occidentalis*
Sweetclover, yellow	*Melilotus officinalis*
Tarweed, cluster	*Madia glomerata*
Timothy	*Phleum pratense*
Trefoil, birdsfoot ("birdsfoot deervetch")	*Lotus corniculatus*
Tumblemustard	*Sisymbrium altissimum*
Wheatgrass, bearded	*Agropyron subsecundum*
Wheatgrass, beardless	*A. inerme*
Wheatgrass, bluebunch	*A. spicatum*
Wheatgrass ("western wheatgrass")	*A. smithii*
Wheatgrass, crested (includes the Fairway strain).	*A. cristatum*
Wheatgrass, desert (includes the Standard strain of "crested wheatgrass").	*A. desertorum*
Wheatgrass, intermediate	*A. intermedium*
Wheatgrass, pubescent	*A. trichophorum*
Wheatgrass, slender	*A. trachycaulum*
Wheatgrass, tall	*A. elongatum*
Wildrye, beardless ("creeping wildrye")	*Elymus triticoides*
Wildrye, blue	*E. glaucus*
Wildrye, Great Basin	*E. cinereus*
Wildrye, Russian	*E. junceus*
Winterfat, common ("white-sage")	*Eurotia lanata*
Wormwood, oldman	*Artemisia abrotanum*
Wyethia, mules-ears	*Wyethia amplexicaulis*

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