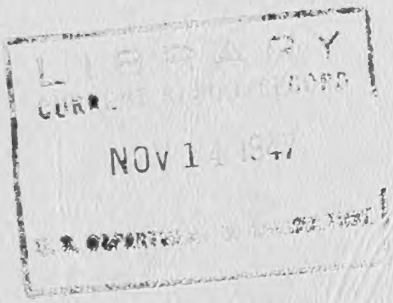
A GUIDE FOR RANGE RESEEDING ON AND NEAR THE NATIONAL FORESTS OF MONTANA

by

C. Allan Friedrich



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Reseeding must play a larger part in the management of western range lands as the need for full production from every acre increases. Fortunately, many of Montana's ranges are in fairly good condition, but there are numerous areas where overgrazing, plowing, fire or other disturbance has resulted in reduced yields and accelerated erosion that can be remedied by reseeding.

Areas in need of reseeding occur on both public and privately-owned ranges throughout the state. This reseeding guide, however, is intended especially for use on national forests and nearby range lands in any ownership. Its purpose is to promote effective reseeding where needed as an aid to full and permanent production.

The suggestions presented are based primarily upon results of research in Montana by the Northern Rocky Mountain Forest and Range Experiment Station during the past 12 to 15 years. The Montana Agricultural Experiment Station has also been carrying on research in range reseeding for many years and their publications, as well as those of other agencies, have been freely drawn upon for ideas adapted for use here.

I. WHY RANGE RESEEDING?

There are two principal reasons for range reseeding: (1) for increasing forage production, and (2) for soil and watershed protection. These benefits of successful reseeding usually come hand in hand and, together, help provide a more stable base for the economic and social structure of the West.

Where portions of the range have deteriorated to such an extent that they cannot recover within a reasonable time under proper or light use, reseeding is needed. Reseeding is also the only practical method of getting plowed and abandoned land back into high forage production short of the twenty or more years usually required for natural revegetation.

No one knows precisely how many acres of range land in Montana are in need of reseeding. It is estimated that more than 20,000 acres of depleted native or unplowed range on the national forests should be so treated. The acreage of similar range outside the national forests is undoubtedly much larger. But in either case most of the acreage of

native range in need of reseeding consists of relatively small "sore spots" with only occasional extensive areas needing treatment.

Currently the big job in the State is to re-establish good forage plants on formerly plowed range land mainly outside the national forests. Already approximately 1½ million acres have been successfully seeded, but the high grain prices of recent years have served to slow the program and to keep considerable submarginal land in crops. With more normal conditions much of this will be dropped from cultivation and, together with that already abandoned, will constitute a 2 to 3 million-acre reseeding job. As will be shown later in this paper, it is very important that land being dropped from cultivation should be seeded promptly in the fall after the last crop is harvested.

Reseeding is not a substitute for good range management, but a part of it. In many cases, as where depletion has been caused by overgrazing or poor distribution of livestock, reseeding will do little good until the basic trouble is corrected. Some have made the mistake of turning to reseeding when reduced stocking, additional water developments, fences, better salting practices, etc., were needed first. Practices, which promote more even distribution and proper season and degree of use, will frequently restore run-down ranges without reseeding.

II. GENERAL GUIDES FOR RANGE RESEEDING

General agronomic principles are the same for seeding grasses on the range as for any other seeding operation. Details differ largely because of the need for keeping costs in proper relation to the low value and productivity of the land, and because of the more varied and difficult operating conditions on the range than on cultivated lands.

VARIABILITY OF CONDITIONS ON THE RANGE CALLS FOR PRELIMINARY ANALYSIS AND PLANNING.

Even within the limited scope of this guide it is necessary to consider an extremely wide variety of conditions that affect plant growth and seeding methods. For example, areas in need of reseeding range in altitude from around 2,000 feet in some of the western valleys to 9,000 or 10,000 feet on some of the mountain summer ranges. Precipitation varies from 10 to 14 inches per year in the valleys and on the low benches, to 16 or 20 inches in the foothills and lower mountains, and up to 50 or 60 inches in some of the high mountain areas. Soil may be deep and fertile or shallow and rocky. Slopes may be exposed in any direction and may vary from nearly level to precipitous. An area in need of treatment may be right in the back yard, or it may be in a high mountain park accessible only on foot or horseback. It may be almost bare of vegetation, or it may be covered by a dense stand of cheatgrass (*Bromus tectorum*) or sagebrush (*Artemisia tridentata*).

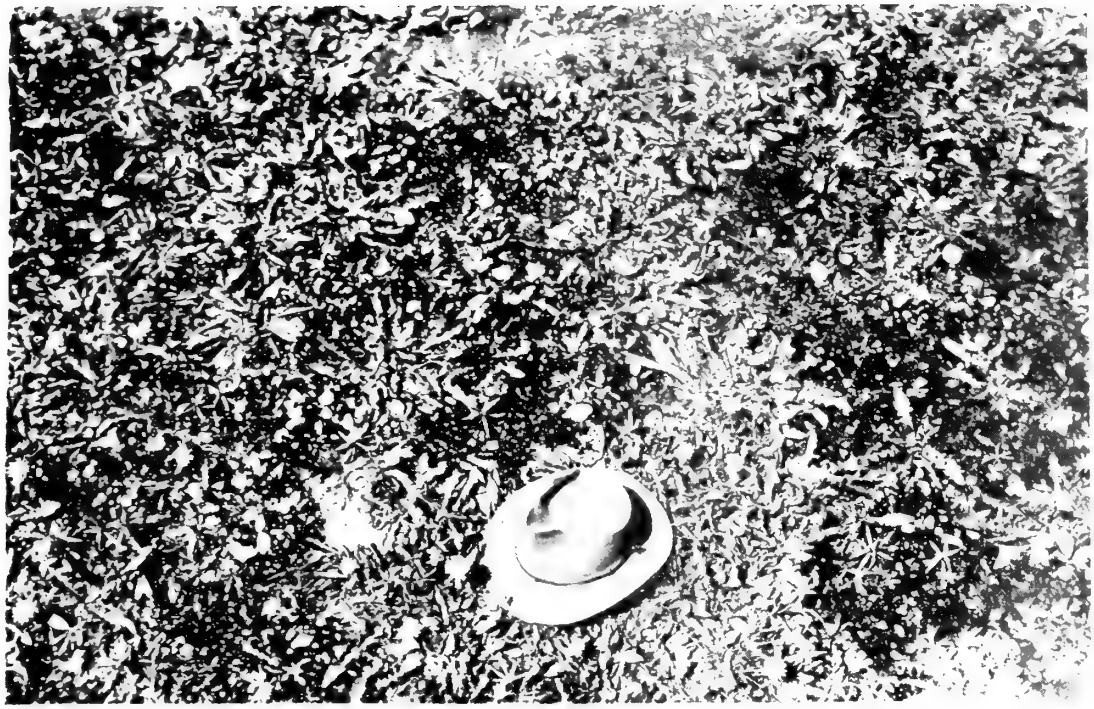


Figure 1. (above) Where conditions like this exist on potentially productive native range land, there is little question but that proper reseeding will be worthwhile.

Figure 2. (below) The areas on both sides of the fence were disked and broadcast seeded. That protection rather than reseeding was needed is demonstrated by recovery of native plants inside the fence (right). Very few reseeded plants became established, largely because of competition from natives. Beaverhead National Forest.

All such factors are important and must be considered in selecting species and determining seeding methods to be used on a reseeding job. Careful planning in the light of all available knowledge of conditions on the ground and species and methods that have been successful in similar situations will avoid many failures and discouragements.

Specific suggestions for seeding under certain typical combination of these factors are given in section III.

AVAILABLE MOISTURE, LARGELY DICTATES WHAT TO SEED.

When planning a reseeding job it is important to select from the numerous hardy forage species that thrive in various parts of Montana only those that are well adapted to the particular situation to be seeded. General requirements of the principal species used in reseeding are fairly well known (see section VI), so the next task is to determine growing conditions on the area.

Several more or less interrelated factors such as precipitation, elevation, direction of slope, soil, and topography must all be considered. The major importance of each, and of the combination of these factors, lies in their effect upon the amount of moisture available for plant growth. For example, certain species which will not thrive on well drained south slopes at 3,000 feet elevation will do well on a similar site at 8,000 feet, largely because the cooler temperatures and more rainfall at the high elevation combine to provide more available moisture. (Other factors such as shortness of growing season, low temperatures, difference in quality of sunlight, etc., limit growth of certain plants at high elevations, but many of the species commonly used in reseeding are fairly adaptable within the elevational range of most of Montana's grazing land.) More moisture is usually available on north and east than on south and west facing slopes because of temperature and evaporation differences. Ridge-tops and steep slopes tend to be dry because much of the precipitation is lost as run-off or as subsurface drainage. Creek bottoms and benchlands frequently benefit from the run-off or seepage from slopes above and lose less of the rain that falls on them. Depth and texture of soil affect its ability to take in and retain water and to make it available to the plants as needed. Most of Montana's range soils, especially on the drier areas, are rich enough in nutrients that forage production is limited mainly by lack of moisture rather than fertility. Therefore, in deciding what to plant, the relative amount of moisture available for plant growth will usually be the deciding factor.

In occasional instances, other single factors such as shade or alkali soil may overshadow the moisture factor and require species especially tolerant to these conditions.

Besides the natural factors which determine the suitability of a site for certain species, it is also necessary to consider value and suitability of the plants for the purpose intended, as well as cost and availability of seed. All of these factors were considered in working out the mixtures suggested in section III.

METHODS OF SEED DISTRIBUTION AND SOIL PREPARATION MUST BE ADAPTED TO PREVAILING CONDITIONS.

Besides selecting the proper species and obtaining good seed, there is the problem of how to plant it. This may be considered in two phases: (1) distributing the seed, and (2) working the soil as needed to provide proper covering and to reduce competition.

Seed is usually distributed either by drilling or by broadcasting. Drilling is restricted mainly to areas where the surface is fairly even and reasonably free from large rocks and other obstructions. On areas too rugged or otherwise unsuited to drilling, seed is usually broadcast either by hand or with various machines.

It is not always necessary to work the soil. Where a drill will provide proper cover as it distributes the seed and competition is not likely to be severe, other soil treatment may not be needed. Where there is little or no competition and the soil surface is fairly loose or surface moisture is dependable, seedbed preparation may not be needed even with broadcasting.

On the other hand, where considerable undesirable vegetation such as cheatgrass or sagebrush is present or where the soil surface is firm so that natural covering would not be expected, it is necessary to work the soil. This is not difficult where conventional farm equipment such as plows, harrows, disks, etc., will operate satisfactorily. But on steep or rocky areas, those supporting considerable sagebrush or other shrubs and trees, and on areas inaccessible to ordinary equipment, ingenuity is needed to devise a practical way to prepare the seedbed. Several useful pieces of specialized equipment, such as rails and self-clearing harrows, have been improvised and in some cases standard machines, such as the wheatland plow, have been adapted for use under these difficult conditions.

For further details concerning the equipment mentioned above and other items useful in range reseeding, please refer to section V.

ADHERENCE TO PROVED PRINCIPLES AND PRACTICES IS THE KEY TO SUCCESSFUL SEEDING

Costs in general must be kept low and in proper relation to probable returns. Frequently, however, a few extra dollars invested in improving the seedbed or in obtaining the best seed will make the difference between success and failure or between a prompt, vigorous stand that will give early returns and a stand that takes years to become established.

The general principles which follow should be considered in connection with every range reseeding job. More specific recommendations of species and methods that have been found effective on typical sites and conditions will be discussed in section III.

Seed only species that are known to be adapted to the particular site to be seeded, and use the best seed available. Mixtures are frequently more desirable than pure stands where more than one species is well adapted. To the extent possible, mixtures should contain both quick-developing and long-lived species, and sod formers as well as bunch-grasses. Legumes are valuable in mixtures because they improve the soil and add extra protein to the forage, but possibility of bloat must be considered. Seed grown under conditions similar to those where it is to be planted should be obtained where practicable. Proven species are listed for specific sites in section III.

Seed at the proper season, that is, either in the fall or very early spring, except for a few species such as grama grass. Fall seeding is favored when seedlings must compete, as on grain stubble, with numerous annual weeds (especially winter growing plants such as cheatgrass); or where frost action is needed to cover the seed; where late snow or other conditions prevent early spring work; or where a seedbed which is weed-free with a loose surface in the fall is likely to be crusted by spring (e.g. burned timberlands, summer-made skid trails, etc.) If stored soil moisture is ample, early fall seeding has an advantage, but if not, late fall (after October 15) may be safer. Early spring is a favorable time for seeding on clean, well prepared seedbeds,especially when a drill is used.

Provide proper covering of seed. Most grasses do best when seed is covered with 1/4 to 1 inch of mineral soil. The smaller seeded species, such as the bluegrasses and timothy, are favored by the shallower, and larger seeded ones like the bromes and wheatgrasses by the deeper covering. Firm seedbeds are desirable if they can be had without sacrificing either proper cover or reduction of competition. One-half to 3/4 of an inch is a good average depth for seeding mixtures of small and large seeds.

Use ample seed and distribute it evenly. Since seed is cheaper and labor more costly than a few years ago, most "reseeders" favor using 50 to 100 percent more seed than used to be recommended to increase the chances for early establishment of full stands. For example, although rates of 4 or 5 pounds per acre of crested wheatgrass have sometimes given excellent stands, rates of around 8 pounds of crested wheatgrass or 12 to 15 pounds of smooth brome are now commonly used when drilling on fair to good seedbeds. Less efficient methods such as broadcasting on poor seedbeds may require 25 to 50 percent more seed.

Avoid or reduce severe competition from cheatgrass, sagebrush or perennial weeds and grasses. Young seedlings of most perennial grasses are rather easily damaged or choked out by established perennials or early growing annuals. Reseeding without reducing competition should probably not be attempted where density of perennial grass exceeds about 10 percent. It is very risky to seed in dense cheatgrass without first destroying most of it. Summer weeds, such as Russian thistle, which do not cause much competition until late spring, are usually less harmful.

Seed first the sites on which the biggest returns in soil conservation, erosion control or forage production can be expected. The extra value of abundant early feed near headquarters for lambing or calving ranges or other special uses should not be overlooked.

Work along the contour wherever practicable with soil working equipment. This practice not only saves water, soil, and power, but also helps to keep the grass seed from being washed away.

Protect reseeded areas from grazing the first growing season if at all practicable. Defer use until midsummer the second season and graze conservatively from then on.

Plan early and adequately for seed, equipment, help, etc., so that the job may be done properly when conditions are most favorable.

OBSERVING CERTAIN PRECAUTIONS MAY PREVENT WASTED EFFORT.

Reseeding is not a cure-all that will build up the range in spite of continued overgrazing. Time and effort will be wasted unless stocking is kept within the grazing capacity.

Don't reseed where it is not needed, i.e. where the range would recover quickly if only given a little protection or lighter use. Numerous cases are on record of seedings which failed when made on overgrazed or drought-damaged range because when protected after seeding, the natives recovered so rapidly that seedlings of the reseeded species never had a chance (see figure 2). Range with a ground cover or density of 10 percent or more of good perennial forage plants will probably recover under light use without reseeding.

Beware of old, poor quality or impure seed. Seed of most grasses weakens rapidly after it is three to five years old. Even new seed will lose its value quickly if it heats or molds in storage. Seed that is very old or has heated in storage seldom has the clean, fresh appearance of new seed. Poorly filled seeds, most frequently found among that collected from native stands, should also be avoided. Avoid buying or reclean seed containing trash that will keep it from feeding well through seeding equipment. Don't take a chance on bringing noxious weeds onto the range.

It is always best to buy seed from dependable dealers. It should be labeled to show kind of seed, where grown, purity and germination in percent, date of test, percentage of weed seeds, name and number per pound of seeds of noxious weeds, and other data required by state law (6).

Actual value for comparison with other prices is the cost per pound of pure live seed. For example, assume that purity is 90 percent, germination is 95 percent, and the price is 20¢ per pound. Then .90 x .95 = 85.5% pure live seed, and cost per pound of pure live seed equals 20¢ ÷ .855 or 23.4¢ per pound.

Figure 3. (above) Reseeding is difficult, success uncertain, and returns low on areas like this. Protection is the primary need, but broadcast seeding on this site did improve the cover on the barest spots. A few too many animals on such slopes usually cause damage that is hard to repair.

Figure 4. (below) Forage production can be increased several-fold at reasonable cost on many cheatgrass fields like this by reseeding to crested wheatgrass. Full production on such land will facilitate protection of sites like that in Figure 3.

Don't cover seed too deeply. On prepared seedbeds more grass seed is wasted by seeding too deeply than too shallowly, especially when drilling on loose soil. Seed can be covered too deeply by broadcasting soon after deep disking or plowing that leaves the soil very loose or rough. Sometimes dragging or allowing time for some settling before broadcasting is advisable. Try not to cover more deeply than 1 inch.

Don't admit failure and plow under or replant too soon. Perennial grasses often don't make much of a showing the first year or two, especially if competition is fairly severe, and it may be the second or third growing season before results are evident.

Don't allow livestock to concentrate unduly on reseeded areas. They frequently tend to do this because of the fact that the grasses used are often more palatable than the natives on surrounding areas. It may be necessary in some cases to take special precautions to keep from killing out the seeding by this type of selective grazing.

Seeding nurse crops with grass is not recommended for dry land, even though this practice is sometimes successful.

III. RECOMMENDATIONS FOR RESEEDING ON TYPICAL SITUATIONS.

It is impractical to give individual instructions for reseeding every variation of site that may need it. Situations on and near the national forests of Montana in need of range reseeding have been divided into a few groups for each of which rather specific practices can be recommended. One or a few important factors, such as available moisture, presence of sagebrush, accessibility, former plowing, etc., dominate each of these groups and tend to determine the methods and species most likely to succeed.

The mixtures suggested in the following recommendations are not inflexible and, especially on the better sites, there is leeway for adjusting proportions or for substituting other proved species as dictated by seed cost and availability. These mixtures are not based on comparative tests, but on adaptation to site, forage value, general availability and cost of seed in recent years, and an effort to get some sod formers, some quick starters, and some long-lived species into each mixture.

HIGH MOUNTAIN GRASSLANDS AND PARKS.

High mountain range lands are characterized by a short growing season and plentiful moisture (20-60 inches), except for about 3 to 6 weeks of dry weather in late summer. They are often remote from headquarters and are frequently inaccessible to wheeled equipment. Soils are extremely variable and patchy. Rocks are common, even on some areas with deep fertile soil. Vegetative types are usually broken and intermingled. Extensive grassland areas are broken by timber along the streams and on northerly facing slopes, while in forested areas the grassy parks occur mainly on ridges and south or west facing slopes. Sagebrush is common, especially on the drier sites. For suggestions on reseeding where sagebrush is a major problem, see page 14.

Figure 5. (above) Reseeding is needed to reduce soil losses and produce forage on denuded high mountain parks such as this, and will yield good returns as shown in Figure 6. Beaverhead N.F.

Figure 6 (left) This is the result of disking and broadcast seeding a depleted high mountain park similar to that shown in Figure 5. Seeding was in fall, 1940; picture in 1946. Beaverhead N.F.

Areas in need of reseeding are frequently small and irregularly shaped. The need usually arises because of too early or too concentrated use, or both. The best grass grows where the soil is deep and fertile and the slopes moderate as in basins, swales, low passes, and open parks, and on the broad ridges and flats These are the kinds of areas on which stock like best to graze and thus are more likely than the steep, rocky slopes to be in need of reseeding.

How to seed: Use a grain drill on accessible areas where it will operate satisfactorily unless cultivation to reduce competition seems necessary. Cover about 1/2 inch deep and seed at 7 to 8 pounds per acre.

Where a drill cannot be used, a disk or springtooth harrow used once or twice over should help to relieve competition and leave the soil open enough for seed to be covered properly if broadcast after the cultivation. The recommended mixtures should be broadcast at a rate of about 8 to 10 pounds per acre.

If only a spiketooth harrow or improvised drag must be used, the soil should be worked both before and after broadcasting the seed.

Although broadcast seeding without soil preparation cannot be recommended as a general practice, it is sometimes the only practicable method for aiding Nature to re-establish a cover on some critical areas too steep or rocky for better methods.

What to seed: Several good grasses have done very well at high elevations, but origin of seed sometimes makes a world of difference. For example, native Idaho fescue is growing all around the 9,300-foot-high nursery on the Beaverhead National Forest, whereas a strain brought from native stands near Missoula started nicely in 1942 but was practically all dead in two years. A strain of sheep fescue and several other grasses from the Soil Conservation Service nurseries at Pullman, Washington has continued to thrive.

The following mixtures are suggested for seeding depleted high mountain areas:

Species	Dry Sites	Moderate to good sites
	lbs. per acre	lbs. per acre
Smooth brome	4	4
Orchardgrass	1	2
Timothy	1	2
Crested wheatgrass	2	
Total:	8	8

When to seed: September and October are probably the most dependable months in which to seed at high elevations, although early spring, before May 15, should be very good where snow and soil conditions allow it.

NATIVE GRASSLAND AT LOWER ELEVATIONS OF THE MOUNTAINS, FOOTHILLS, AND PLAINS.

At the lower elevations a longer growing season prevails, but with less precipitation (only 10 to 25 inches), and a longer, hotter, summer dry spell than on the higher ranges. Soil conditions vary widely. Most of the heavy sagebrush and abandoned farm land occur in this elevational range, but since these each present distinct reseeding problems they are discussed separately on pages 14 and 16 respectively.

Repeated range fires, too early grazing, poor distribution, and just plain overgrazing are all important factors causing depletion of various areas at the medium and lower elevations. Though many of the areas needing seeding are small, occasional extensive ones do occur. Here depletion has extended from the primary concentration areas onto the steep, rocky, hard-to-repair slopes more frequently than is the case in the higher mountains. In selecting places to be seeded remember that methods which are both economical and dependable have not yet been developed for many of the steep, rocky, dry sites. Even though some of them may seem in urgent need of revegetation, it is often logical to seed the better sites first. In this way, large increases in forage on the good sites will make it easier to relieve grazing pressure on the poorer sites, thus giving them a chance to recover by slow natural processes.

How to seed: Because much of the low mountain and foothill range is accessible by truck or wagon, there is better opportunity to use effective equipment and less reason to use spiketooth harrows or improvised drags for seedbed preparation.

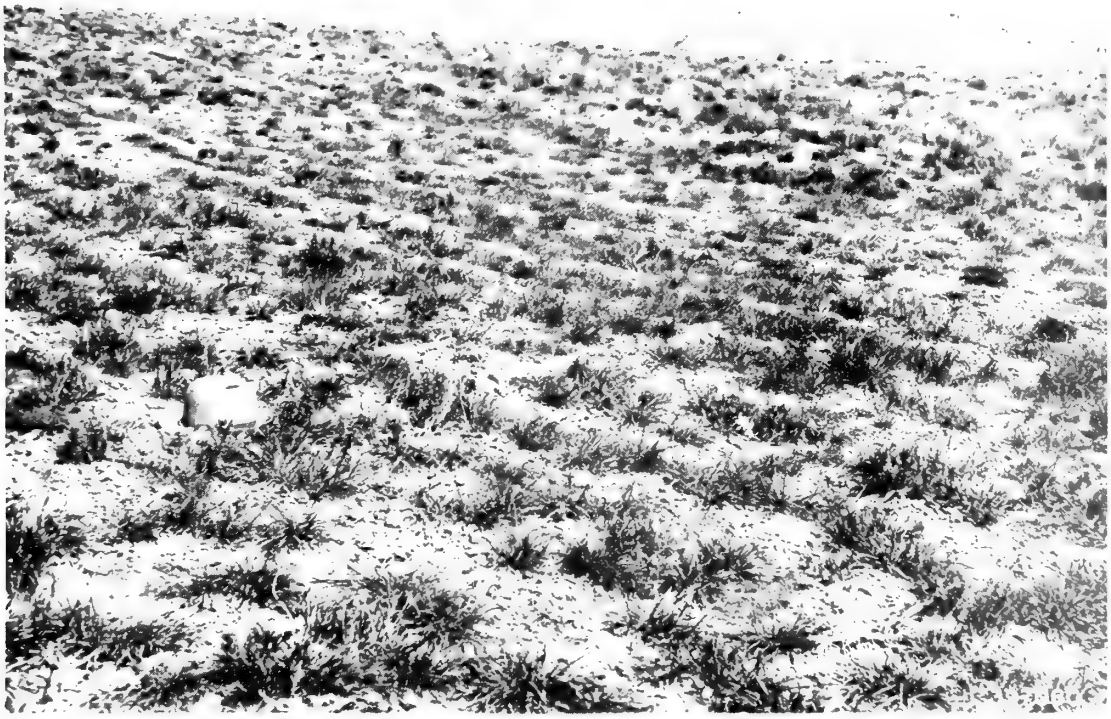
Use a grain drill where it will operate satisfactorily, and where cultivation to reduce competition is not needed. Seed about 8 to 10 pounds per acre and cover 3/4 inch deep.

On productive sites, such as creek bottoms and flats with good soil occupied by undesirable or low value plants, rather thorough seedbed preparation is recommended. Cultivation should be severe enough to kill most of the unwanted vegetation. This may require plowing, wheatland plowing, double disking or some other type of cultivation, as dictated by conditions on the ground. If the seedbed is firm and even enough after cultivation, a drill may be used. Broadcasting is also effective on prepared seedbeds. If rather smooth and firm, harrowing to cover the seed may be necessary, but on rough seedbeds covering may be accomplished by natural soil movement. Harrowing after spring seeding will promote prompt germination and retard drying out.

On certain steep, depleted slopes where soils are unstable and considerable bare ground is exposed, broadcast seeding without seedbed preparation may be justified for soil protection under critical conditions where better seeding practices cannot be used. Repeated seedings in successive seasons may be necessary and high yields are unlikely.

Figure 7. (above) There is too much depleted range like this at the medium and lower elevations. It isn't carrying its share of the load, but can be made to do so by proper reseeding, as shown in Figure 8. Beaverhead N.F.

Figure 8. (below) This area, adjacent to that shown in Figure 7, was disked with a heavy bog disk and broadcast seeded to crested wheatgrass two years before this picture was taken. Given proper management, high forage production can be maintained.



What to seed: Because of the wide range of growing conditions at the medium and lower elevations, rather careful choice of species is necessary.

The following mixtures are suggested for use on various sites, depending upon relative moisture supply (rates given are for drilling):

Species	Dry Sites	Moderate Sites	Moist Sites
	lbs. per acre	lbs. per acre	lbs. per acre
Crested wheatgrass	8	4	
Smooth brome		3	4
Slender wheatgrass		3	2
Timothy			2
Orchardgrass			1
Total:	8	10	9

When to seed: Fall, September through November, is a good time to seed, especially where there will be a ground cover of weeds, grass or brush, and it has some advantages where competition is expected. Early spring seeding is very good on bare or well prepared ground, provided seed is properly covered and soil is firmed after seeding to retard drying.

DENSE STANDS OF BIG SAGEBRUSH (ARTEMISIA TRIDENTATA).

Big sagebrush on the range is, at best, a mixed blessing. When it gets too thick it is a serious pest. It interferes with utilization of forage, and uses water and plant nutrients that could better be used by more valuable plants. In these ways and others it greatly reduces the grazing capacity of the range. This is especially serious because of the fact that dense stands of big sagebrush usually occur on areas with productive soil capable of producing a considerable amount of good forage but with a limited moisture supply.

Many authorities agree that sagebrush is naturally a rather minor part of the range vegetation in most of Montana, but that it tends to take over under prolonged heavy grazing. This it has done on many thousands of acres mainly at medium to low elevations, but also to some extent in the high mountains. Once sagebrush has gained the upper hand, it may hold on for years even under improved management.

Comparatively little sagebrush eradication work has been done in Montana, so most of the following suggestions on methods are based on research work by the Intermountain Forest and Range Experiment Station in Utah, Idaho, and Nevada

Where there is a fair stand of desirable forage under the sagebrush, either railing or controlled burning can be very effective in increasing production without reseeding. Railing is highly effective on large, mature sagebrush, but not on tough, young plants which may be bent over but not broken off or pulled out by it. Burning should not be attempted on national forest lands without prior approval of the regional forester or without careful study of USDA Farmer's Bulletin #1948 (9). Burning on other lands should be attempted only in accordance with the principles set forth therein. Be sure to comply with all local, state or federal fire laws.

When there is so little grass beneath the sagebrush that good recovery cannot be expected following sagebrush destruction alone, reseeding is necessary in order to retard erosion and to prevent sagebrush and other undesirable plants from coming back thicker than ever on the seedbed prepared.

How to seed: Dense stands of sagebrush must be destroyed before grass seeding can be effective. Various methods have been used, four of which will be briefly described. All are adapted mainly to relatively level areas.

Plowing about 2 to 3 inches deep with a wheatland or cylinder plow is the favored method where it can be used. The seed may either be broadcast behind the plow as a separate operation, or a seeder can be attached so that both plowing and seeding can be done in one operation.

Lighter equipment, such as the bog or cut-out disk-harrow, has been used fairly effectively where the sage is not too heavy. They have advantages over the wheatland plows for use on small or rather inaccessible areas.

Railing is best used for killing sagebrush where reseeding is not needed, but it has also been fairly effective in preparing a seedbed under certain conditions. It is sometimes worthwhile to rail in opposite directions. Seed may be broadcast either before or after railing.

The self-clearing or pipe harrow is fairly satisfactory for killing sagebrush and preparing a seedbed where the brush is not too large. It can be used where the soil is too shallow or rocky for wheatland plowing or ripping and on slopes where burning might cause serious erosion. Seed may be broadcast either before or after dragging.

Burning can be used to kill sagebrush on some areas in need of reseeding. It is an extremely dangerous tool, however, and should be used only after all available knowledge has been obtained and full precautions observed. Where conditions permit, burned sagebrush areas should be seeded by drilling 1/2 to 3/4 inches deep, but in some cases broadcasting may be the only method possible. Use of a pipe harrow or other suitable tool to aid in covering broadcast seed will frequently be worthwhile.

What to seed: The amounts suggested in the following mixtures are for broadcasting. About 25 percent less seed may be used for drilling.

Species	Dry Sites	Fair to good soil & moisture
	lbs. per acre	lbs. per acre
Crested wheatgrass	8-6	4
Western wheatgrass	0-4	
Smooth brome		4
Slender wheatgrass	___	2-4
Total:	8-10	10-12

When to seed: Fall, September through November, is the most favorable time for seeding sagebrush areas.

FORMERLY PLOWED RANGE LANDS (ABANDONED FARM LAND).

Fields which were plowed and cropped for a time are common on the plains and foothills and at the lower elevations on the national forests and nearby range lands, but are now in various stages of reverting back to grassland. Some of the oldest have come back to the extent that reseeding is not needed to restore them to satisfactory production. Many fields aggregating many thousand acres are badly infested with cheatgrass, while some others are still in the annual weed stage with a cover of Russian thistle, mustard, etc. In general, these abandoned farm lands occupy the most productive portions of the lower range and are capable of producing an abundance of good forage. Experience has shown that proper reseeding can increase forage production two to many times on much of this land.

How to seed: Drilling is the standard method of seeding on abandoned farm land, but seedbed preparation must be varied depending upon type of vegetation occupying the soil.

Recently abandoned land that is relatively free of cheatgrass does not ordinarily need any preparation before drilling. Russian thistle, lambs quarter, pigweed, etc., do not interfere seriously with establishment of seeded grasses. Heavy stands of mustard are a little worse but not as bad as cheatgrass. For fields without much cheatgrass, drill about 3/4 inch deep in the fall without any previous preparation. Such fields should preferably be seeded during the fall following the last harvest because it has been shown that, other things being equal, chances of success by direct seeding become progressively poorer each year after abandonment.

Cheatgrass-infested abandoned farm land must ordinarily be plowed to reduce the cheatgrass enough to give the reseeded grass a reasonable chance. Cheaper methods of soil preparation have been tried but have not proved dependable for preparing for seeding crested wheatgrass. Plowing is most effective if done in the late fall, winter or early spring after most cheatgrass seed has germinated. A mouldboard plow ordinarily turns the seed-containing litter under more completely than a wheatland or disk plow, and is preferred for that reason, but the other types can be effective if carefully used. Plowing should be deep enough to cover the cheatgrass seed thoroughly. Plowed ground should be worked down with a spiketooth harrow or roller or both before seeding. Grass seed can be drilled about 3/4 inch deep into the plowed ground. There is logic and some experience to indicate that early spring is the best time to seed on clean, well-prepared seedbeds. Plowing and preparing a good seedbed before drilling is rather expensive, however, and the occasional failures that occur represent considerable loss.

A method made cheaper by growing a preparatory crop as a step in getting the land ready to seed has been used successfully both experimentally and on a practical scale for four years, 1943 through 1946, in the Bitterroot Valley. Plowing and soil preparation is done, as described above, but instead of seeding the grass in the plowing a spring cereal crop such as barley, wheat or oats is seeded instead. This crop may be grazed closely, mowed for hay, or in favorable years may produce a crop of grain. The grass seed is then drilled into the stubble in the fall without other preparation, or if the stubble seems too weedy for direct seeding it may be cultivated and drilled to grass early the next spring. The hay or grain produced by the preparatory crop gives a prompt return to help pay the costs of seedbed preparation and seeding.

Haying gives better control of competing cheatgrass than cutting the crop for grain, but gives a lower return in favorable seasons. Haying is recommended especially for dry seasons and situations where the plowing job was none too good.

One progressive Bitterroot rancher, who has used the preparatory crop method for four years, says that each time his grain crop has more than paid all reseeding costs. He has, in this way, established several hundred acres of crested wheatgrass without a failure on land formerly in dense cheatgrass.

Other abandoned farm lands, such as those that may be occupied by mixtures of cheatgrass, sagebrush, and perennial weeds and grasses, may be handled in either of the two methods described for cheatgrass or by wheatland plowing and seeding, as described for sagebrush land.

What to seed: Crested wheatgrass can be recommended for almost any abandoned farm land in Montana, and is the only species that can yet be generally recommended for the poorer grades.

Intermediate wheatgrass, big bluegrass, sheep fescue, meadow brome, Ladak alfalfa, and Russian wildrye are showing considerable promise at several locations in the State, and can be recommended for small scale plantings either in pure stands or in mixtures with crested wheatgrass on average or better sites. When seeded alone, big bluegrass and sheep fescue should be covered less than the 3/4 inch mentioned as a general recommendation. The rates given are suggested for drilling.

Species	Poor to average soil & moisture	Better than av. moisture
	lbs. per acre	lbs. per acre
Crested wheatgrass	8-6	4
Bluestem wheatgrass	0-4	
Smooth bromegrass		6
Total:	8-10	10

When to seed: Seed stubble land or unprepared seedbeds in the fall, September to November, and clean plowed ground or cultivated stubble land in the early spring, preferably before May 1.

BURNED-OVER TIMBERLAND.

In many cases, loss can be reduced and forage production greatly increased by prompt and proper seeding after forest fires. Areas to be seeded must be selected carefully, as not every burn represents a good seeding chance. The best opportunities are on good sites with dense stands of timber where the fire was hot enough to kill practically all vegetation. The ash left from such a burn is usually deep enough to provide good cover for grass seed and a ready supply of plant food to help the seedlings off to a good start.

The 1944 airplane seeding of the Henry Creek burn on the Cabinet National Forest is a good example of a successful low-cost seeding job under the conditions described. Total cost for seed and plane hire for the 225-acre job was a little under $1.50 per acre. Average production in 1946 for the entire area was estimated at 2,620 pounds of green forage per acre (clipped at 1 inch above the ground), while on moderately favorable sites it was up to 3,000 pounds per acre.

It is not known how long the grasses will persist on formerly timbered land or just what effect seeding to grass will have in various situations upon timber reproduction. Studies in eastern Oregon showed that in one case seeding to grass prevented excessively thick stands of lodgepole pine by reducing establishment on the seeded area to 7 percent of the number of trees established on an adjacent unseeded area (10). In some localities this may pose a knotty problem in proper land use, but where there is need for additional forage and where good timber reproduction is unlikely these considerations, added to the erosion control values, may well justify the seeding of grass.

How to seed: Broadcast seeding is usually the only practical method. Seedbed preparation is accomplished by the fire, and ashes provide cover for the seed. Broadcasting may be done by hand or with a cyclone seeder on small areas. For areas of 100 or more acres the job can probably be done most economically by broadcasting from an airplane.

Airplane seeding has not been very widely used, and new developments in techniques, flying speed, height, hopper and feed arrangements, etc., may be expected from time to time. Research Note No. 52 "Seeding grass by airplane on western Montana's burned-over timberland," may be obtained upon request from this station (16).

What to seed: Shade tolerance and ability to become established promptly without much soil covering are characteristics important in selecting grasses for broadcast seeding on burns. The following mixture is suggested for use on most burns under the conditions described as favorable.

Species	Average or better conditions as described above
	lbs. per acre
Timothy	1
Orchardgrass	2
Kentucky bluegrass	1
Bulbous bluegrass	1
Smooth brome	2
Tall oatgrass or Mountain brome	1
Total:	8

Figure 9. (above) Results of airplane seeding at low cost on a properly selected site. Yield in the second growing season was about 3,000 pounds of green forage per acre (clipped at 1 inch) on such sites. Seeded in fall 1944; picture taken in 1946. Cabinet N.F.

Figure 10. (left) This steep west-facing skid trail in the pine-fir type was broadcast seeded about three years before this picture was taken in 1946. It has been grazed each year after about July 1. Forage production is good, and erosion is being checked. Bitterroot N.F.

When to seed: Seeding should be done during the first fall following the fire, before the soil becomes crusted, before the ashes are washed away, and before other plants get a head start on the seeded grasses. This does not mean that worthwhile results cannot be obtained by seeding at a later date, but that conditions ordinarily become less favorable with each passing month.

SKID TRAILS, ETC., ON LOGGED AREAS.

Erosion on areas disturbed during logging operations can be greatly reduced by proper seeding to grass. The effect on timber reproduction has not been fully determined, but seeding skid trails on the Sleeping Child unit of the Bitterroot National Forest in 1940 did not entirely prevent yellow pine from coming back there. In fact, some of the best pine reproduction has developed concurrently with and in the midst of very good stands of reseeded grasses. Several seedings made on the Sula and Darby districts of the Bitterroot forest, starting in 1943, have produced excellent grass stands which have done much to reduce erosion, and have furnished a large amount of urgently needed forage.

Experience in reseeding skid trails in this region has been mainly in the ponderosa pine and Douglas-fir types.

How to seed: Broadcast seeding either with a cyclone seeder or by hand seems to be the only practical method. Hand seeding has some advantages over the cyclone seeder in that width of swath can be varied much more easily by hand. Experience has shown that there is little use in broadcasting seed except where the mineral soil is exposed and native vegetation, such as pinegrass, is disturbed rather severely.

If seeding is done while the surface soil is still loose, special treatment to provide covering apparently is not needed. But when the soil has settled and crusted badly, some soil disturbance to promote covering of the seed is beneficial.

What to seed: A wide variety of site and soil conditions are likely to be disturbed in logging operations, but good success can be expected on many of them if the proper species are used on each site.

Species	Dry ridges and slopes	Fair soil & moisture	Moist north slopes, creek bottoms, etc.
	lbs. per acre	lbs. per acre	lbs. per acre
Crested wheatgrass	6	2	
Sheep fescue	2	1	
Timothy		1	1
Orchardgrass		1	2
Smooth brome		2	3
Tall meadow oatgrass or mountain brome		1	2
Total:	8	8	8

When to seed: In order to take full advantage of the seedbed preparation afforded by skidding, seeding may be done as soon as possible after the soil is disturbed for the last time, except that seeding in midsummer or midwinter is not recommended.

ASPEN AREAS.

Although aspen is not a major type in Montana, it does cover a considerable acreage of grazing land, mainly at medium to high elevations on the national forests. Many of the aspen areas have been rather severely depleted because of stock shading up under them during hot weather, or because of heavy grazing use brought about by nearness to water.

Research in the Intermountain Region has demonstrated that aspen areas can be successfully seeded very easily.

How to seed: Simply broadcast the seed either by hand, with a cyclone seeder, or on extensive areas from an airplane. Many small, depleted aspen areas could be seeded incidental to other fall range work, whereas some few may be large enough to warrant special efforts to seed them.

What to seed: A few good grasses have shown special ability to germinate and to thrive in aspen shade. The following mixture is suggested:

Species	Aspen Type
	lbs. per acre
Orchardgrass	2
Smooth brome	4
Mountain brome	2
Tall oatgrass	1
Timothy	2
Total:	11

When to seed: Seed in the fall just before, during, or soon after leaf fall. Aspen leaves cover the seeds and provide favorable germinating conditions.

MISCELLANEOUS AREAS.

A few other situations deserve mention here, but not in as great detail, either because they are special, rather isolated problems, or because less information is available concerning them.

Big game winter ranges present a challenging problem in management and revegetation. Reseeding is complicated by the fact that these ranges are often so steep and remote that methods used on other ranges may not be usable. Even where seeding could be done with common methods, inability to provide protection from early spring grazing and trampling limits the chances for success.

On winter game ranges where from one to several feet of snow is common, the plants best adapted to range reseeding would be of little value to the game. The need for tall grasses such as giant wildrye, and shrubs such as willow, aspen, serviceberry, and bitterbrush is indicated. Very little progress has been made in developing practical methods of propagating these species under range conditions, although germination and some other initial phases of propagating bitterbrush and other shrubs have been studied by research workers at the California and Intermountain stations.

More experimental work is needed to develop methods of improving big game winter range. But at this time about the only help that can be offered is to suggest that the species and methods mentioned for other range areas be used where they are adapted and where they would be of value either for forage or erosion control.

Gully and erosion control on steep or critical watersheds is a special problem which frequently requires expensive contour trenches or other mechanical structures in combination with reseeding and cannot be discussed adequately in this guide.

Much can be done, however, to prevent more of these critical situations from developing by prompt use of some simple procedures on many of the smaller areas and gullies that are now actively eroding. Seeding on plowed contour furrows has been effective on some steep barren slopes, but these furrows may be dangerous if improperly used.

The best way to treat gullies, where possible, is to revegetate the areas from which the run-off is coming before treating the gully itself. Where this is impossible because of rocks or shallow soil on the source area gully erosion can sometimes be reduced temporarily by direct treatment, such as by dragging poles or brush into the gully and broadcasting seed of adapted species on the gully walls. A brush drag or improvised harrow can sometimes be dragged along the gully sides to help cover the seed. Biennial yellow sweetclover, smooth brome, crested wheatgrass, and tall oatgrass have been used successfully. Effectiveness of this treatment has been demonstrated on Lewis Creek near Vigilante Experimental Range headquarters, Beaverhead National Forest. Generous amounts of seed may well be used and repeated seedings may be necessary in order to establish a stand. Seeding should be done in the fall or very early spring.

Ranger stations and other pastures, because of their location and the special needs they serve, are probably the most valuable portions of the range. Still, frequently they are the most abused and neglected. Many of them could be improved by proper management and reseeding. The methods and species described for use on similar situations on the range may be used on pastures as well, but where the strategic value of the pasture is high, intensive methods of soil preparation, seeding, and management are easily justified.

Recreation areas are usually more valuable and enjoyable when well vegetated. In developing recreation areas and through use of them, many areas of bare soil are exposed. In many cases, the native plants are less able to stand trampling and abuse than are some of the introduced species, such as Kentucky bluegrass and Fairway crested wheatgrass. Much could be done to improve the appearance and wearing qualities of many recreation areas by judicious seeding of freshly disturbed or cleared areas.

In development of winter recreation areas such as ski slopes, it is often necessary to clear trees and brush. Though little use has been made of the practice, there is every reason to believe that the return of trees and brush on such areas could be greatly retarded by promptly seeding the proper species of grass on the cleared and disturbed areas. Since these areas are usually at the higher elevations, with plenty of moisture good results should be possible by broadcasting a mixture of such species as Kentucky bluegrass, timothy, and smooth brome at a rather heavy rate, say, 15 to 20 pounds per acre at any time of the year that the bare soil is exposed.

Other bare and disturbed areas such as new road banks, borrow pits, earth fills on stock water dams, etc., offer countless opportunities to demonstrate good stewardship by seeding them to desirable forage plants. If such areas are not promptly seeded to something useful, they are usually taken over by useless or even noxious weeds, or may be damaged by erosion. Such seeding should be done as soon as practicable before the soil becomes crusted or weed-covered. Crested wheatgrass and yellow sweetclover will frequently make surprisingly good growth on raw subsoils in borrow pits, etc. With fair to good soil and moisture, smooth brome, timothy, orchardgrass, Kentucky bluegrass, etc., are good species to use.

IV. MANAGEMENT OF RESEEDED RANGES.

The same general principles of good range management, i.e. conservative grazing, good distribution, proper season of use, etc., that are recommended for native ranges should be applied on reseeded ranges. There are also some special problems:

1. Protection from grazing throughout the first growing season and until midsummer the second year, or until the first seed crop is produced is very desirable. This practice will promote good vigor and prompt establishment of the reseeded stands. Although good stands have been obtained in spite of grazing the first year, there is little question but that development is retarded and early yields are reduced by this practice. Cost of protection may well be weighed against the damage likely to be caused by continued grazing. Young plants on steep slopes or loose soils are especially likely to be damaged by grazing too soon.

2. Prompt establishment of reseeded stands is especially important in situations where undesirable species are in a position to take over. For example, sagebrush areas prepared by plowing or burning are likely to come back to sagebrush if livestock are allowed to bring in extra sagebrush seed by trailing from untreated onto seeded areas, and to reduce the vigor of the seeded plants by premature grazing.

3. Crested wheatgrass fields can, in many cases, be so managed as to satisfy the widespread need for abundant, nutritious, early spring grazing. It is ready for grazing two to four weeks earlier than most adjacent native range, and will stand up remarkably well under early use. It gets rather tough and unpalatable in midseason, but before that time native ranges are fully ready and crested wheatgrass has served a special purpose. In some localities fall regrowth of crested wheatgrass is fairly dependable, and whenever it occurs has much value for grazing. Crested wheatgrass will probably make its greatest contribution to the forage needs of Montana when used to supplement native range.

Crested wheatgrass that is used too lightly tends to become ungrazable because of the accumulation of dead stems in the clumps. When this condition develops, mowing is recommended where feasible. Mowing for hay at 2 or 3-year intervals will avoid this difficulty.

4. Special management problems sometimes develop when species that are more palatable than the natives are planted in rather small areas or strips interspersed within a larger unseeded area as, for example, on skid trails. Deferring use in the spring until the reseeded grasses have made considerable growth and lost some of their "super palatability" may help discourage such selective grazing.

V. EQUIPMENT USEFUL IN RANGE RESEEDING.

Numerous types of conventional and improvised equipment have been used effectively in reseeding under various range conditions. Real ingenuity is often needed to get proper seed distribution and seedbed preparation at reasonable cost with available or easily made equipment.

A special equipment committee composed of reseeding specialists and equipment engineers at Portland are currently working to perfect, standardize, and promote production of equipment better adapted for range reseeding.

The following brief discussions of some useful implements may be helpful in selecting proper equipment for each job.

GRAIN DRILLS.

Grain drills are very effective where they can be used because they distribute the seed evenly, provide proper covering, and sometimes help to relieve competition all in a single operation. An agitator in the seed box will promote even feeding of grass seeds. Even then, it is necessary for the operator to be alert to keep all spouts feeding properly. Alternate feeds in the bottom of the box may be covered if wider than ordinary spacing is desired, or if the drill cannot be shut down to feed evenly at the desired low rate.

The single disk drill usually cuts through trash or into hard ground rather effectively, and is more widely suitable for range use than the other types. On mellow soil care must be taken to see that it does not plant too deeply.

The double disk drill will, in many cases, serve just as well as the single disk drill. It is sometimes rigged with depth regulators on the disks and is then especially useful on loose seedbeds or where variable firmness makes it desirable to keep considerable pressure on the disks. It does not ordinarily cut through trash as well as the single disk drills, and is not suitable in brush.

The deep furrow disk drill is more heavily constructed than the other disk types, and can be effectively used in light sagebrush or on burned sagebrush and in other places a little too rugged for the other drills. The furrows are effective in trapping water if kept on the contour, but may increase erosion if run up and down the slopes. Care must be taken to prevent too deep covering of the seed because sluffing in of the furrows often adds to the original cover. This drill is more effective than the other disk drills in reducing competition, and will cut through and stay clear of trash better.

BROADCAST SEEDERS.

Broadcast seeders are useful where drills cannot be used, and usually give more even distribution of seed than can be obtained by hand broadcasting.

The cyclone or whirlwind seeder is a small, inexpensive, hand-operated type well adapted for use on inaccessible steep rough areas. It can be used by a man on foot, riding on equipment, or even on horseback.

The endgate seeder is a larger type built to fit into the rear end of a wagon box and is powered by a sprocket and chain from the wagon wheel. Various adaptations have been made to operate seeders of this type from trucks, tractors, disk plows, etc.

Motorized broadcast seeders have been improvised and used very effectively in seeding sagebrush land. They are somewhat like an endgate seeder, but are powered independently by a small gasoline motor and are mounted on a platform for attaching to tractor, plow or truck (11).

Airplanes have also been used very effectively and economically for broadcasting grass seed on burned timberland. Rather simple hoppers and feeds can be improvised to meet the needs of the job (16). This method is adapted for use mainly on fairly large areas. Burns as small as 100 acres can be seeded economically by airplane, provided the plane does not have to be brought too far.

HARROWS.

The spiketooth harrow is not very effective in relieving competition or preparing a seedbed on firm unworked soil, but is better than nothing for providing some cover on areas too inaccessible or otherwise unsuited for use of other soil working tools. At least one of the large implement manufacturers makes a very rugged leverless, spiketooth harrow that can be rolled into a bundle about 1 foot in diameter and $3\frac{1}{2}$ feet long, and readily packed into inaccessible areas such as high mountain parks.

The springtooth harrow is more effective in destroying weeds and in working up the soil, but is harder to transport into inaccessible areas and is a little less rugged than the spiketooth. It clogs badly when used on trashy areas.

Disk harrows or disks are usually more effective in working the soil and in destroying weeds than either the spike or springtooth harrows, and do not clog up as readily with trash. They are not effective enough to be dependable for controlling cheatgrass before seeding, but are useful for working up the soil and reducing competition on many areas too rough, stony or uneven for use of a grain drill. The heavier types of disk harrows are better adapted than some of the light farm models for range use. The heavy bog or cut-out disk has been used effectively in fairly heavy sagebrush.

The self-clearing or pipe harrow can be improvised from steel pipe, chain, and drill steel, and is more rugged and more effective in brush and rocks than the commercial types of harrows. It consists of three or more pipes 4 to 6 inches in diameter and 8 to 12 feet long with 16 to 20-inch spikes of drill or other good quality steel driven through them at about 18 inch intervals in a spiral arrangement, with the ends protruding about 6 inches. The pipes are attached by a heavy swivel or chain at one end to a front cross member to which an ordinary hitch is attached. The pipes with the teeth are thus dragged lengthwise and are free to turn as brush and trash begin to collect under them.

Specifications may be obtained through this station for a large, 12-foot harrow intended for use with a 35 horsepower tractor, and a smaller 6-foot model suitable for a light tractor or horses.

RAILS.

Several types of rail drags have been improvised for breaking off and pulling out sagebrush. They are built of railroad rails in various patterns, but usually either as an "A" pulled from the apex or as one or more parallel beams which are pulled broadside through the brush. Specifications are available at this station for two or three effective models.

PLOWS.

Mouldboard plows are rather slow and expensive for use on range lands but where they will operate satisfactorily are probably the most effective of any implement for destroying cheatgrass, perennial weeds, grasses, and small brush. Their use is recommended especially for spring or late fall plowing of cheatgrass-infested abandoned farm land, which is to be spring seeded either to a preparatory cereal crop or directly to grass.

Disk plows are about as expensive to use as mouldboard plows and may not turn the surface litter under quite as well, but will operate in rocks and brush and on certain floury-textured soils where a mouldboard plow will not.

The wheatland or cylinder plow does not turn the soil as effectively as either the disk or mouldboard plows but can be used much more cheaply, and has proved very effective for killing sagebrush and preparing a seedbed for broadcast seeding in one operation. It seems to be the most promising machine yet tested for sagebrush land that is not too steep or rocky. Research paper No. 13 by Robertson and Plummer of the Intermountain Station gives some helpful hints on use of wheatland plows on sagebrush land (15), and shows how a drill box is sometimes mounted on the plow.

A stump jump plow, at present manufactured only in Australia, has given excellent performance in initial tests in the Intermountain Region on rough, rocky, sagebrush land. It is a very ruggedly constructed disk plow with the disks mounted in pairs on a knee-action arrangement. This allows any pair of disks to ride over a rock without undue strain and without throwing the whole plow out of the ground. It may be several years before these or similar plows are generally available here.

VI. FORAGE SPECIES FOR RANGE RESEEDING IN MONTANA

The following species were specifically suggested for use on certain types of sites. This is not a complete list of species which might have value, but includes most of those that can currently be recommended for large-scale plantings and a few that can be recommended for use only on a limited scale.

It may be noted that most of the species recommended are of foreign rather than native origin. Some were brought over in colonial days and are now so common that many think of them as natives. Several factors have influenced the tendency to use introduced species. Many of them were selected for domestication generations ago because of their superior qualities, and were brought to this country for that reason. They always had or have acquired (through selection and cultivation) good seed habits, seedling vigor, tolerance to grazing, and other characteristics that fit them for reseeding work. On the other hand, many of our valuable native species are still in a wild state.

Plant breeders and seed growers are making real progress in selecting and standardizing top strains of several native species and in developing seed sources for them. For example, certified seed of Sherman big bluegrass, Primar slender wheatgrass, and Bromar mountain brome are now commercially available, and an improved strain of sheep fescue (not yet named) is expected to be in commercial production by about 1948 or '49. These strains were developed through cooperative efforts of federal agencies, state experiment stations, and the Soil Conservation Service nurseries at Pullman, Washington. The same thing is being done with other native and introduced species at several nurseries.

Crested wheatgrass (Agropyron cristatum) is a very hardy, deep-rooted, long-lived, bunchgrass introduced from Russia and Siberia about 1900. It is medium sized and well adapted for either pasture or hay, commonly producing from 1/2 to 1 ton of high quality hay on dry land in Montana. It is our most successful species for reseeding typical abandoned farm land and other dry sites on either heavy or light soil at moderate and low elevations, but is surpassed by some other species at high elevations and under good moisture conditions. Crested wheatgrass provides highly nutritious green forage from early spring through early summer and frequently greens up for fall grazing. It probably has its greatest value when used in connection with native range to furnish early spring grazing before the natives are fully ready, and late fall grazing after they have dried up. The green spring and fall growth is highly palatable to all classes of stock.

Under favorable conditions, crested wheatgrass seeded in early April has produced fine, robust stands with numerous heads in 5 or 6 months, but when seeded in competition with cheatgrass it may be 2 or more years before heads are produced. Once established on dry land and given reasonable grazing management, it will last indefinitely and cheatgrass and most weeds do not have a chance in it. Fields 20 or more years old in Montana have been reported in good thrifty condition.

Crested wheatgrass has very good seed habits, and adequate quantities of seed are available at reasonable prices. It handles well through most seeding equipment if clean and well threshed. There are about 200,000 seeds per pound and, if properly stored, it keeps well for 5 or more years. Both germination and purity of good commercial seed should range above 90 percent.

The Fairway strain, which has had some publicity, is shorter and finer leaved and forms a more solid turf than the standard strain. Fairway seems to be slightly less rugged and, despite appearance, is much less palatable and less desirable for general use than the standard strain.

Intermediate wheatgrass (Agropyron intermedium) is a tall, introduced perennial with short rhizomes that is showing considerable promise on moderately dry to favorable sites. It has done well at Miles City, in Judith Basin County, in the Bitterroot Valley, and at the Vigilante Experimental Range on the Beaverhead National Forest (at 6,200 and 9,300 feet elevation). It starts early in the spring and stays green longer than does crested wheatgrass. It is also more productive where adapted. Limited experience in Montana indicates that it is palatable and probably hardy under grazing. Seed is commercially available in Washington and Oregon. A strain known as Ree wheatgrass, which is apparently a natural mixture of intermediate and stiffhair wheatgrass (A. trichophorum), is being produced in South Dakota.

Bluestem wheatgrass (Agropyron smithii) is a hardy, long-lived, sod-forming native grass of medium height, which is especially important in central and eastern Montana and the Dakotas where it is valuable both for hay and pasture. It is especially adapted to medium and heavy soils under intermediate to light rainfall, and is tolerant of alkali and intermittent flooding. It is moderately resistant to grazing, is very nutritious, moderately palatable, and cures up exceptionally well for winter grazing. It has not been as successful for reseeding as crested wheatgrass, due to the fact that it is slow to germinate, and high quality seed is difficult to obtain. Breeding and selection efforts now under way remove these drawbacks. Thin stands usually thicken up fairly rapidly on adapted sites because the plant has vigorously spreading rhizomes. Seed is harvested in the Northern Great Plains, and is available commercially at reasonable prices. Good seed of bluestem wheatgrass contains about 100,000 seeds per pound, and if stored properly is good for at least four years. It is frequently seeded in mixture with crested wheatgrass on sites adapted to both.

Slender wheatgrass (Agropyron trachycaulum) is our most widely cultivated native wheatgrass. It is a medium-sized, deep-rooted, perennial bunchgrass which is native to many parts of the United States, and is common on western mountain ranges. It is palatable and nutritious and moderately resistant to grazing. Reseeded stands, though readily established, have often proved to be short-lived, especially at the lower elevations. Slender wheatgrass is adapted for range reseeding where annual precipitation is above 16 inches and at the higher elevations. It should seldom be seeded alone on the range, but preferably in mixture with long-lived species such as smooth brome or crested wheatgrass. High quality seed is produced in Oregon and Washington and in the Northern Great Plains area. There are about 160,000 seeds per pound. The seed commonly retains high viability for only 3 or 4 years. Germination and purity both above 90 percent can reasonably be expected of commercial seed.

Primar slender wheatgrass, now being grown in Washington and Oregon, is described by the Soil Conservation Service as a "rapid growing, long-lived, high yielding, early maturing" strain. Though not thoroughly tested in Montana, it should be a better risk than common seed from an unknown source.

Tall oatgrass (Arrhenatherum elatius) is a tall, vigorous, moderately hardy, deep-rooted, perennial bunchgrass, which was introduced from Europe. It is short-lived, but volunteers readily from seed, so under moderate use can be reasonably permanent. It is palatable and on good sites is very productive. It has been one of the more promising species for range reseeding where precipitation is about 15 inches or above, and does rather well on light or gravelly soil. Where adapted, it is quick growing, and stands are obtained readily. It is shade-tolerant and has done well on timbered sites, such as skid trails and burned-over timberland. The seed is difficult to handle in seeding equipment unless processed to remove the awns. This is now being done commercially. Processed seed is desirable, but must be fresh because it loses viability rapidly after about 2 or 3 years. Purity and germination should be above 80 percent. There are about 150,000 unprocessed seeds per pound.

Meadow brome (Bromus erectus), an introduced perennial bunchgrass of medium height, has shown considerable promise at Miles City, in Judith Basin County, at Thompson Falls, in the Bitterroot Valley, and at the Vigilante Experimental Range on the Beaverhead National Forest. At Judith Basin it did better than crested wheatgrass when seeded in cheatgrass. It seems very thrifty at 9,300 feet on the Beaverhead. Leaves of the strain used in our tests are densely hairy and very soft. It is a good seed producer, but seed is not yet generally available.

Smooth brome (Bromus inermis) is a hardy, aggressive, long-lived, deep-rooted, sod-forming grass introduced from Europe in about 1884. It is one of the best all around grasses in the northern states. It favors heavy soils, but also does well on light soils if moisture is adequate. It will not stand drought like crested wheatgrass, and is not adapted to the ordinary run of abandoned farm land in Montana. Where moisture is a little better than average, equal to about 16 inches or more per year, it will usually thrive and produce abundant, highly palatable and nutritious feed. It also ranks high among the grasses adapted to the more favorable sites such as moist mountain parks or meadows at moderate to high elevations. It is an excellent grass either for hay or pasture, and withstands heavy grazing very well. It is best seeded in a mixture with other grasses or legumes, as it is not so likely to become sod bound under these conditions. Smooth brome grass seed will keep satisfactorily for 5 years or longer. There are about 135,000 seeds per pound. Germination and purity should be around 90 percent or better.

Certified seed of several improved strains is now available. Lincoln smooth brome, a southern strain, is being grown in the Central Great Plains, and Manchar smooth brome, a northern strain, in Washington and Oregon. Both are excellent strains with outstanding seedling vigor and both will doubtless have a place in reseeding Montana ranges.

Mountain brome (Bromus marginatus) is a large, vigorous, deep-rooted, native, perennial bunchgrass adapted principally for reseeding under moderately favorable conditions at medium and high elevations. It is rather short-lived, but reseeds itself readily under favorable conditions and ordinarily produces large quantities of palatable forage. Mountain brome seedlings are quick growing, so it is well adapted for use in mixture with slower starting species where a cover crop effect is desirable, as on burned-over timberland.

There are only about 40,000 seeds per pound. The seed ordinarily keeps well for at least 4 or 5 years. Germination and purity above 90 percent are reasonable requirements. Handling of this seed is made easier by processing.

There are many natural geographic strains which vary widely in yield, smut resistance, and length of life. A very leafy, productive, smut-resistant strain has been developed at the Soil Conservation Service nurseries at Pullman, Washington, and is being produced and certified as Bromar mountain brome. Seed is available at several western seed houses.

Orchardgrass (Dactylis glomerata) was introduced from Europe about 1760, and is one of our most important cultivated grasses. It is a vigorous, hardy, deep-rooted, perennial bunchgrass, which is suited for use both as pasture and hay. Where it is adapted it produces an abundance of palatable and nutritious forage. It does well on moderate sites at medium to high elevations, is very shade tolerant, and is especially promising for use on logged or burned-over timberland. Though it is suspected of being moderately short-lived at the higher elevations, it reseeds itself readily. Where adapted, it is one of the easiest species to establish by reseeding, especially when adequate seed covering is difficult. The seed should have a germination and purity of 90 percent or better. It loses viability rapidly after it is more than 3 years old. There are about 520,000 seeds per pound. Because of its ready establishment, it will often make an important contribution to a mixture even when only 1 or 2 pounds of it are used per acre. Seed is available at most seed houses.

Russian wildrye (Elymus junceus) is a large, hardy, deep-rooted, long-lived bunchgrass introduced from Russia. It promises to come close to rivaling crested wheatgrass in ability to withstand drought, but is somewhat more difficult to establish. It tends to stay green longer than crested wheatgrass and, therefore, may be valuable for use in mixtures to furnish green feed longer into the summer. Some investigators report it as being palatable for grazing at all seasons. It is being studied carefully and some improved strains are being selected at Mandan, North Dakota. It has poor seeding habits, and adequate seed supplies may be slow in developing. Some is produced in the Dakotas and Nebraska. Germination and purity of 85 percent or better is a reasonable requirement.

Sheep fescue (Festuca ovina) is a rather well known native bunchgrass. Work at this station has been mainly with a special strain selected and developed by the Soil Conservation Service at Pullman, Washington. This strain is larger than the ordinary sheep fescue, having leaves 6 to 12 inches long and heading up to 2 feet or more. It has been one of the most successful species in experimental plots in Judith Basin County, at Thompson Falls, the Vigilante Experimental Range (both at 6,200 and 9,300 feet elevation), and in the Bitterroot Valley. The strain is being standardized at Pullman in preparation for certification and subsequent release, and it should be in production by 1948 or 1949. Ordinary sheep fescue seed is available from some Washington and Oregon dealers at this time. There are about 565,000 seeds per pound.

Ladak alfalfa (Medicago sativa) is a high yielding, deep-rooted, hardy alfalfa which was introduced from India by the Bureau of Plant Industry and then developed by selection at Redfield, South Dakota. It is more resistant to bacterial wilt than the Grimm variety, but otherwise seems to have much the same adaptation. It has done very well on fairly good abandoned land near Miles City and on average abandoned land in the Judith Basin vicinity where it was seeded with crested wheatgrass. There is still some question as to how well any alfalfa is suited for range reseeding and how well it will stand grazing. There is also some danger of bloat connected with its use for grazing. But if alfalfa is to be used on the range in Montana, Ladak seems to be the most promising. High quality seed is available at reasonable prices. It should always be inoculated before seeding.

Timothy (Phleum pratense), one of the best known grasses in the northern states, is a hardy, vigorous, deep-rooted, long-lived bunchgrass introduced from Europe in colonial times. It is shade tolerant and well adapted for seeding on moderate to good sites on mountain ranges from low to high elevation. It is highly palatable and productive, and withstands moderate grazing well. It reseeds itself readily, and under good conditions the seedlings grow rapidly. Seed is available at low prices, and there are more than 1¼ million seeds per pound. It remains good for 6 years or more if stored properly.

Big bluegrass (Poa ampla) is a native perennial bunchgrass of medium height. It has been given considerable attention at the Soil Conservation Service Nurseries at Pullman, Washington where several strains have been selected. The outstanding strain, Sherman big bluegrass, has been widely and successfully test-planted in the Pacific Northwest, the Intermountain Region, and Montana, but its ability to stand up under grazing is not well established. It has done well on abandoned farm land in western and central Montana and on skid trails in the upper Bitterroot Valley. Investigations at Union, Oregon indicate that big bluegrass may be more suitable as a hay than as a pasture grass (14). It is earlier than crested wheatgrass and compares well in production, but good stands have been harder to obtain. There are about 900,000 seeds per pound.

Germination of 80 percent and purity of 85 percent are reasonable standards. Certified seed of Sherman big bluegrass is available commercially from some Washington and Oregon seed dealers.

Bulbous bluegrass (Poa bulbosa) is an introduced perennial bunchgrass of small to medium size. Although not widely used in Montana, it promises to fill some special needs. It is a peculiar grass in that, instead of producing seed in the regular manner, most of the seeds develop without fertilization to form little bulbils similar to tiny onion sets. It also produces basal bulbs which multiply and serve as a further means of vegetative reproduction. It has a growth habit similar to winter annuals such as cheatgrass and alfilaria, and makes most of its growth during the fall, winter, and spring months. It will grow on an extremely wide variety of sites although there is some evidence that it will not last long where long periods of extreme cold interfere with winter development. Production is low in comparison to many other grasses, but it is very palatable and nutritious and the "seed" heads produce a considerable amount of nutritious grain which is readily taken by stock. Its greatest redeeming feature is the fact that it is one of the easiest of all species to establish on sites where it is adapted. It is one of the few that will come into cheatgrass land unaided. Probably its main use in Montana will be for broadcast seedings in mixtures on skid trails and burned-over timberland. It is especially adapted to such use because of its ability to establish itself without benefit of covering. On moderately favorable conditions it yields fairly well and stays green much later into the summer than on very dry, exposed sites. It has not been a consistent producer under our tests.

Seed of bulbous bluegrass is inexpensive, and is usually available from seed houses in southern Idaho, Washington, and Oregon.

Kentucky bluegrass (Poa pratensis), the common lawn grass for the northern half of the United States, was introduced from Europe in colonial times. It is a very vigorous, long-lived, aggressive, perennial sod former of medium height. The forage is highly nutritious and palatable and, when moisture conditions are favorable, is produced abundantly and continuously from early spring to late fall. It is favored by good moisture and rich soils, is shade and cold tolerant, and seems well adapted for moderate to good sites from low to high elevations. It is one of the most tolerant to grazing and commonly replaces the taller grasses on irrigated pastures and creek bottoms that are overgrazed. Seed is available at moderate prices. There are more than 2 million seeds per pound. Good viability is usually maintained for only 2 or 3 years.

VII. LIST OF RESEEDING PUBLICATIONS OF SPECIAL VALUE FOR MONTANA

All of the following papers and several others have been freely consulted in the preparation of this guide, and all contain valuable additional information. They are listed in chronological order.

(1) Crested Wheatgrass in Montana
by Ralph D. Mercer, Montana Ext. Serv. Circ. No. 92.
Crested wheatgrass is described and its value and culture in Montana are discussed. There are several good pointers on raising and harvesting seed with instructions for adjusting threshing machines to handle crested wheatgrass efficiently.

(2) Reseeding Range Lands of the Intermountain Region
by George Stewart, R.H. Walker, and Raymond Price. Intermountain Forest and Range Exp. Sta., USDA Farmers' Bull. No. 1823, July 1939.
Contains a lot of good sound background material on the why and where of range reseeding. It is written especially for the Intermountain Region, but has many ideas that are also applicable here. Contains a table of pertinent information concerning reseeding value of 18 important forage species.

(3) Grass
by H.L. Walster, et al. Agr. Exp. Sta., North Dakota Agr. College Bull. No. 300. June 1941.
This bulletin contains 111 pages packed with information of interest to range men, particularly in the Northern Great Plains. There is a discussion of the values of grass in general and very fine descriptions of a large number of native and introduced grasses discussing their distribution and ecological adaptations, seed habits, forage value, adaptation for reseeding, etc.

(4) Reseeding to Increase the Yield of Montana Range Lands
by L.R. Short, Northern Rocky Mountain For. & Range Exp. Sta., USDA Farmers' Bull. No. 1924. February 1943.
This bulletin was prepared especially for Montana, with considerable emphasis on plowed and abandoned range lands. It contains a lot of good background information on soil, climate, competition, costs and returns, etc. Also contains a table giving sowing recommendations for 11 important forage species, and discusses the various methods of seeding adapted to different situations.

(5) How to Reseed Southern Idaho Range Lands
by A C. Hull, Jr., and C. Kenneth Pearse. Intermountain For. & Range Exp. Sta., Res. Paper No. 2, June 1943.
This paper contains 22 pages packed with useful information on reseeding, much of which is of value for parts of Region One. It gives general principles for reseeding followed by specific guides for applying these principles to certain sites. It describes 9 recommended forage species and 20 promising, but not so thoroughly tested, species in a manner pertinent to reseeding. It also contains a short section describing equipment with line drawings of the Dixie drag, rail, and wheatland plow.

(6) Montana Seed Law
by Montana State College Agr. Exp. Sta. Circ. No. 176. August 1943.
Rules and regulations and forms of labels are prescribed for Montana.

(7) Good Seed for Range Reseeding
by A.C. Hull, Jr., and C. Kenneth Pearse, Intermountain For. & Range Exp. Sta. Res. Paper No. 5. September 1943.
This brief paper should be very useful in buying seed. It describes the basis of seed quality (germination x purity = percent live seed); suggests ways to recognize good seed, and gives standards of quality, longevity, seed production habits, etc., for 12 species, most of which are also important in Montana.

(8) Reseeding Abandoned Farm Lands to Crested Wheatgrass Will Increase Range Capacity
by C. Allan Friedrich, Northern Rocky Mountain For. & Range Exp. Sta. Res. Note No. 33, July 1944. (Published originally in the Montana Farmer, October 1, 1943).
This is a brief article confined almost entirely to reseeding abandoned farm land, cheatgrass infested and otherwise, to crested wheatgrass with rather specific recommendations.

(9) Sagebrush Burning - Good and Bad
by J. F. Pechanec and George Stewart, Intermountain For. & Range Exp. Sta. USDA Farmers' Bull. No. 1948. January 1944.
The role that carefully planned and controlled burning of sagebrush can play in the range improvement program is described. Clear instructions are given on how, when, and where to burn safely, with precautions to observe, along with suggestions on how to take advantage of accidental burns by proper management or reseeding as needed.

(10) Reseeding Eastern Oregon Summer Ranges
by G.D. Pickford, Pacific NW For. & Range Exp. Sta., and E.R. Jackman, Oregon State College Agr. Exp. Sta. Circ. No. 159. January 1944.
This circular discusses reseeding both by drilling and by broadcasting, showing advantages and disadvantages as well as the "where, how, and when" of each method for denuded summer ranges of eastern Oregon. It also gives a good deal of space to seeding accidentally burned timberlands, especially "lodgepole jungles" and logged-over areas to forage species. This paper should be of special value and interest in western Montana.

(11) An Efficient Method of Broadcasting Range Grass Seed
by J.H Robertson, Intermountain For. & Range Exp. Sta. Res. Paper No. 8. May 1944.
A motorized broadcast seeder that can be mounted on a tractor, plow, truck, trailer, etc., is described along with some specifications and suggestions for construction and use.

(12) Grazing Crested Wheatgrass
by E.P. Orcutt, Montana State College Agr. Ext. Serv. Circ. No. 153. July 1944.
A brief paper citing some of the values and advantages of crested wheatgrass, with some pertinent tips on how to make best use of it.

(13) Seeding Crested Wheatgrass on Cheatgrass Land
by C. Allan Friedrich, Northern Rocky Mtn. For. & Range Exp. Sta., Res. Note No. 38. March 1945. (Published in the Montana Farmer, March 1, 1945.)
A short article giving rather specific suggestions for use of the preparatory crop method for reseeding cheatgrass-infested abandoned land.

(14) Palatability for Sheep and Yield of Hay and Pasture Grasses at Union, Oregon
by D. E. Richards, Oregon State College Agr. Exp. Sta., and Virgil B. Hawke, Soil Conservation Service. Oregon State College Agr. Exp. Sta. Bull. No. 431. October 1945.
Comparisons are made of yield and palatability for hay and pasture of 29 forage species, many of which are important for reseeding Montana ranges. Species are grouped on the basis of best season of use into spring, summer, and fall grasses and on the basis of whether they are best adapted for grazing or for hay. Conclusions are based on controlled tests with sheep at the Eastern Oregon Livestock Branch Sta. at Union, Oregon.

(15) Hints for Use of the Wheatland Type Plows for Brush Eradication in Connection with Range Reseeding
by J.H. Robertson and A. P. Plummer, Intermountain For. & Range Exp. Sta. Res. Paper No. 13. July 1946.
Strong and weak points of wheatland plows are discussed, and instructions are provided as to how to obtain best results in killing sagebrush and preparing a seedbed. There are also several good suggestions on how to avoid breakdowns and lost time.

(16) Seeding Grass by Airplane on Western Montana's Burned-Over Timberlands
by C. A. Friedrich, Northern Rocky Mtn. For. & Range Exp. Sta. Res. Note No. 52. June 1947.
Conditions favorable and unfavorable for successful airplane seeding of burned-over timberland are described both in the text and in pictures. Results of two recent seeding jobs in western Montana are cited along with some details of hopper construction, flight specifications and costs.

LIST OF PREVIOUS PUBLICATIONS IN THIS SERIES

Station Paper No.	
1	°A preliminary study of root diseases in western white pine, by John Ehrlich, October 1939.
2	°Possibilities of partial cutting in young western white pine, by E. F. Rapraeger, January 1940.
3	Blister rust control in the management of western white pine, by Kenneth P. Davis and Virgil D. Moss, June 1940.
4	Possibilities of wood-pulp production in the northern Rocky Mountain region, by E. F. Rapraeger, March 1941.
5	Results to date of studies of the durability of native woods treated and untreated, by C. N. Whitney, revised January 1946.
6	Changes in Benewah County Forest statistics, by Paul D. Kemp, July 1947.

°Out of print. Loan copies may be obtained upon request.