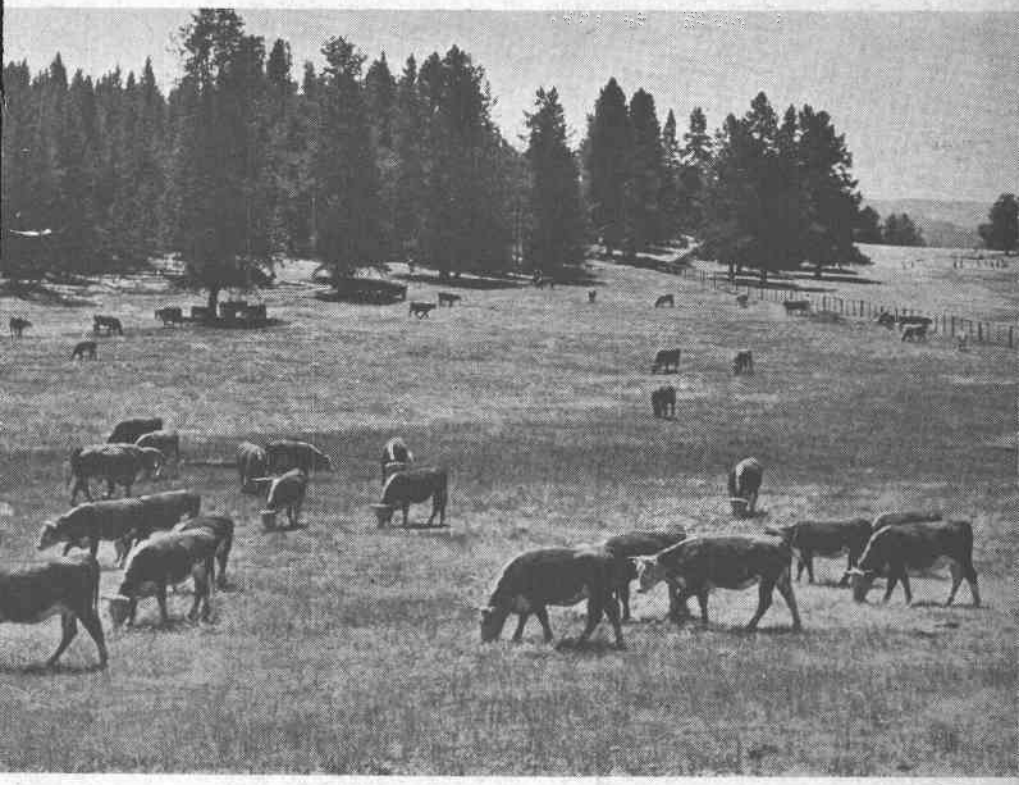
Reseeding

EASTERN OREGON SUMMER RANGES

By G. D. Pickford
and E. R. Jackman



Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis

Station Circular 159 January 1944

TABLE OF CONTENTS

Reseeding Eastern Oregon* Summer Ranges

G. D. PICKFORD† and E. R. JACKMAN‡

NEED FOR RESEEDING

The range country in Oregon, chiefly east of the summit of the Cascade Mountains, totals about 41,800,000 acres when cultivated farm land and waste areas are excluded. Approximately 41 per cent of this grazable land is summer range that is used on the average during 40 per cent of the 10-month period that Oregon livestock usually are grazed on the open range. The remaining 59 per cent of range land is used for spring-fall grazing during the remainder of the grazing season.

Stock need feed in late summer

Offhand it would appear that summer range and spring-fall range are nicely balanced in Oregon with acreage of each proportionate to the length of time it is used. But in many cases the summer range's forage production during the 4-month summer grazing period is inadequate to carry the same number of range livestock that are grazed on the spring-fall range for the remaining 6 months of the grazing season. Estimates of grazing capacity in Oregon generally show that the summer range has only about two-thirds of the forage production required to carry the livestock that can be grazed on spring-fall range. The effect of insufficient summer range on the livestock is loss of weight in the late summer and thin, instead of grass-fat animals. On the range forage, the result is overgrazing, increase of unpalatable vegetation, and decrease of the most valuable forage species. For the livestock owner, the result is a lighter pocketbook.

Livestock like the glades

Lack of balance in forage production between Oregon's spring-fall and summer ranges primarily is due to reduced productivity of the meadows, open bunchgrass range, and alpine grasslands of the summer range. These range types, mostly small areas scattered throughout the

* Too much credit cannot be given to the fieldmen whose interest and activity in artificial reseeding of Oregon summer ranges made this publication possible. The authors gratefully acknowledge the assistance furnished by the following: forest supervisors Carl M. Ewing, James C. Iler, Charles M. Rector, and Charles D. Simpson; Ed E. Birkmaier and Lester Moncrief, who formerly were forest supervisors in Oregon; assistant forest supervisors Chester A. Bennett and Harry W. Elofson; range examiners John G. Clouston and Melvin H. Burke; forest rangers Walter E. Barnett, R. R. Butler, Henry D. Harryman, George M. Palmer, and Willis W. Ward; county agricultural agents Ralph E. Brooke, P. T. Fortner, and Walter Holt; Professor R. G. Johnson, formerly county agent in Grant County; and many other state and federal workers and ranchers who did the seeding reported in this bulletin and made many of the records and observations on costs and methods.

† Senior Forest Ecologist in charge of range research, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

‡ Extension Specialist in Farm Crops, Oregon State College, Corvallis, Oregon.

otherwise timbered Oregon summer range, naturally are more attractive to livestock and to those who handle the livestock than is the range under the timber. Hence, use in the openings has been by far the heaviest and there forage production has suffered.

The aggregate acreage of meadows, alpine grasslands, and bunchgrass types is estimated to be about 15 per cent of the total Oregon summer range. These range types are capable of producing 50 per cent of the total summer range forage. In their present more or less depleted condition, however, it is doubtful whether the average per acre grazing value of these types is much greater than that of the relatively inferior timbered range. It can be assumed, therefore, that if the openings in the otherwise timbered summer range were raised to their former productivity, the balance between Oregon's spring-fall and summer ranges would be restored and the range livestock business in the state would be placed on a much more favorable footing than at present. In addition to livestock considerations, it is desirable to return these untimbered summer ranges to full production as soon as possible because in their present depleted condition many of the areas are losing topsoil from accelerated erosion. The soil loss is undesirable from at least two important angles: it reduces soil fertility and hence reduces forage production; and it reduces the ability of the watersheds to produce a dependable stream flow for irrigation and for domestic use.

When forage goes, erosion comes

Restoration of forage production on the untimbered summer range areas is desirable from a quality as well as a quantity standpoint. The green, lush forage produced on meadows, on alpine grassland, and to a certain extent on bunchgrass summer range, is high in protein, vitamins, and minerals at a season when vegetation of the spring-fall range lacks feed value. Stock cannot maintain weight on dead grass alone, no matter how plentiful. Full production of quality forage on these key summer range areas would make possible a better finish on Oregon's marketed lamb and beef.

Only green grass adds weight

Of the approximately 2,500,000 acres of open summer range in eastern Oregon, probably 2,000,000 acres can best be restored by good range management practices. In many cases restoration is under way. On about a half million acres, however, range depletion has gone so far that restoration by natural increase of existing range plants will take decades. It is on these areas that reseeding offers an opportunity to speed up the restorative process. Reseeding is an expensive undertaking that is warranted by the potential high production from

The good lands justify expense

these sites. Often a small mountain meadow is worth more for grazing than hundreds of acres of rough, heavily timbered land surrounding it.

Other phases of reseeding Oregon summer ranges are the possibilities of revegetating accidental burns in the lodgepole pine type and the seeding of skid trails and other areas denuded as a result of logging ponderosa pine. According to the Forest Resource Survey, there are 1,624,000 acres of lodgepole pine in eastern Oregon.* Most of the lodgepole pine is at high elevations where rainfall is greater, the days cooler, and where the grass is green long after it has turned brown in the low country.

Typical lodgepole pine stands are so dense that little or no forage for livestock grows beneath them. Lodgepole pine is a short-lived tree that grows in even-aged stands and is highly susceptible to insect damage. When a stand starts to die, it becomes an invitation to fire because of the tangled, crisscrossed windfalls. Occasionally forest fires burn a considerable acreage of this type. These fires are usually so hot that nearly all vegetation is destroyed, and two things usually happen: soil erosion is greatly accelerated for several years until vegetation is again reestablished; and after a few years the lodgepole pine that was reseeded from the fire-resistant cones forms a dense stand of reproduction, termed a "jungle," beneath which nothing in the way of forage can grow. If burned lodgepole areas can be seeded to range forage species and a dense grass cover established quickly after the fire, three favorable results may follow: (1) the soil erosion that ordinarily follows a forest fire may be arrested quickly; (2) the establishment of an open, productive forest cover may be secured instead of a dense stand of stagnated lodgepole pine reproduction; and (3) a supply of high quality forage may be added to Oregon's inadequate summer range.

The "jungle" benefits neither man nor beast

Many of Oregon's ponderosa pine stands are being cut at accelerated rates because of the great demand for lumber in the war effort. Logging operations in the pine country are less destructive to vegetation than in the Douglas fir region west of the Cascades. Studies in California,† however, have revealed that the vegetation on 14 per cent of a logged-off ponderosa pine area is seriously disturbed by skid trails. Piles of slash and debris were found to cover 24 per cent of the area. If these piles are burned, an additional amount of forage is destroyed. Much of the cheatgrass brome‡

Logging bares about 40 per cent of the land

* Cowlin, R. W., Briegleb, P. A., and Moravets, F. L. 1943. Forest Resources of the Ponderosa Pine Region of Washington and Oregon. U. S. Department of Agriculture, Miscellaneous Publication 490, 99 pp., illustrated.

†Hormay, A. L. 1940. The Effect of Logging on Forage. Chron. Bot. 6 (1):6-7.

‡Common and botanical names of the species mentioned in this bulletin are listed on page 48.

(bronco grass) infesting eastern Oregon ponderosa pine summer ranges can be traced to the soil disturbance and burning that accompany logging. If skid trails and slash-burned areas can be reseeded successfully following logging, forage is increased, unwanted plants are kept out, and erosion is checked.

The purpose of this bulletin is to record experiences from preliminary reseeding tests on Oregon summer ranges and also to summarize pertinent results of reseeding studies in other similar localities. This is done with the hope that the material presented, while not so complete or in so final a form as could be desired, will be helpful to those who wish to reseed Oregon summer range. It may also point the way for further study. An attempt has been made to organize the bulletin so that one wishing to reseed need refer only to those parts dealing with his conditions.

Reseeding is a postwar job

It is probable that, after the war, far more attention will be directed to restoring and maintaining the nation's natural resources. The western range should receive much consideration in such a postwar program. Reseeding summer ranges in Oregon should be of high priority within the state because such effort will offer a much needed reservoir of employment, will save the fertile topsoil, and will aid to insure the national supply of meat, wool, and hides, as well as a dependable output of water for irrigation, power, and domestic purposes. Every acre of worthless brush, dead timber, or barren eroding land is a waste and a reproach to the nation.

GUIDES TO SELECTING PROPER RESEEDING LOCATIONS

Reseed the bare ranges

Only range virtually denuded of perennial forage plants by overgrazing, plowing, logging, or by fire should be reseeded. Seed scattered on land already covered by native forage plants is largely wasted. Summer range in moderately poor condition usually may be restored far more cheaply by permitting native forage plants to increase naturally through good range management practices. When the native forage species have almost or entirely disappeared, then reseeding offers the only hope of restoring the former productivity of mountain meadows, alpine glades, or bunchgrass hillsides.

Only those areas having the most favorable soil and moisture conditions should be considered for reseeding. Seeding on excessively eroded soil or in very dry locations has a doubtful chance for success with present knowledge of species and methods. Too much expense is involved in reseeding to invite failure by selecting difficult

sites. An exception may be made of lodgepole pine tracts that have burned over and of skid trails and slash-burned areas in logged-off ponderosa pine. The desirability of obtaining grass stands quickly on such areas, in order to prevent excessive erosion or the encroachment of undesirable vegetation, may make seeding feasible when it would not be warranted otherwise. Even in these instances the sites with moist, deep soil return more dollars' worth of forage per dollar spent than do the high, steep rocky ridges.

Reseed only on good locations

Reseeding on gentle terrain usually gives best results. Steep slopes seldom are seeded successfully because of the difficulty in covering the seed sufficiently to insure germination and establishment. An exception is again necessary for burned-over areas in lodgepole pine and for skid trails. These offer a seedbed in which no mechanical process of covering the seed is necessary. Even a minimum of forage establishment on steep, burned-over slopes and in skid trails that traverse steep slopes and gullies is desirable to help prevent excessive soil loss.

Avoid steep slopes

No seeding should be attempted unless there is some provision for controlling grazing on the area. Seedlings should be given at least one year's protection from grazing. Furthermore, grazing practices may need changing because a practice that ruined the original fine grass stand may be expected to ruin the new one. It is rather silly to go to the work and expense of seeding only to kill the hopeful new grass.

Keep stock off reseeded areas for one year

General guides to selection of locations for reseeding are summarized briefly as follows:

1. Choose areas with bare ground or with only annual weeds.
2. Choose areas with good soil and with favorable moisture conditions.
3. Favor gentle slopes or level ground for reseeding unless unusual circumstances make the treatment of steep slopes feasible.
4. Be certain that whatever killed the original grass will not kill the new stand.
5. Reseed after forest fires or after logging.

RESEEDING DENUDED RANGE LANDS BY DRILLING

Where ground conditions permit, a grain drill gives the best results in reseeding. The drill gets the seed into the ground and gets it covered.

WHERE TO DRILL

Drilling requires open, unobstructed ground, and accessibility. Meadows are ideal sites for drilling since they usually are fairly level, free of rocks and logs, and only occasionally support enough brush to hamper the use of a drill. Grassland slopes and benches, if not too steep, can be drilled satisfactorily provided the ground is not rocky or brush covered. If there is sufficient rock, brush, or timber on the area to impede drilling, or if the slopes are too steep, the alternative is broadcasting. If perennial weeds and grass are so thick that drilling is difficult, it is safe to assume that reseeding will fail and is not necessary anyhow. Vegetation that will stop a drill is thick enough to respond to management if it is desirable vegetation. If undesirable, such as sagebrush, then it must be removed before reseeding will accomplish much.

Don't drill where grass is already growing

HOW TO DRILL

A grain drill is satisfactory for reseeding range grasses. For best results the drill should be equipped with an agitator and with single-disk or double-disk furrow openers. Drills with the shoe-type furrow openers tend to catch in brush and are unsatisfactory where the soil is rocky. A regular 6-foot drill works well on level meadowland and on gentle slopes. For steeper slopes, a one-horse, 3-foot drill is best. The Intermountain Forest and Range Experiment Station at Ogden, Utah, has developed an outrigger wheel attachment for a Van Brunt Model V 3-foot drill that is reported to be usable on slopes ranging from 35 to 65 per cent. If the drill is to be pulled with a tractor or truck, it should be equipped with rubber tires because unplowed range land gives hard usage to machinery developed for farm use. Rubber-tired drills have far lower maintenance costs.

Use disk, not hoe drill

Generally speaking, the less seedbed preparation, the better the stand. Grasses prefer a firm seedbed. If the ground is plowed, considerable soil erosion is invited on sloping land and a loose seedbed is created. The plowing, moreover, destroys whatever useful plants are present. If the ground surface is too hard to permit the drill disk to make fairly deep furrows, harrowing or disking to loosen the top few inches of soil may be necessary. The soil should be firm enough, however, so that the V-shaped trenches from the drills will persist until after the seedlings have become well established. These small trenches are important aids in collecting mois-

Seedbed should be too hard to track a mule across it

ture for early seedling growth and in providing some shade while the seedlings are small. No harrowing or disking should be done after drilling.

Depth of these trenches was the subject of a cooperative study made at Logan Valley by the Malheur Forest, the Oregon Agricultural Extension Service, and the Pacific Northwest Forest and Range Experiment Station. Crested wheatgrass was drilled in the fall of 1938 on a hard, unprepared seedbed. The drill was set to trench at ½ inch, 1 inch, and 1½ inch depths and to cover the seed approximately ½ inch. Measurements made in 1942 show that 310.4 pounds of air-dry crested wheatgrass herbage per acre were produced on the 1½ inch depth plots, 231 pounds per acre on the 1 inch depth plots, and only 84.8 pounds per acre where the drill was set at a ½ inch depth (Figure 1). The deeper trenches held moisture for the young seedlings and resulted in better stands and more vigorous plants. Work elsewhere shows that most grass seeds should not be covered more than ½ inch deep. The owner usually can say goodby forever to deeply buried seed.

Trench deeply but cover lightly

When drilling, even on very gentle slopes, it is important to work on a contour. There is abnormal run-off from most areas in need of reseeding. It is important to retain as much of this moisture as possible to provide for good germination and growth conditions. The V-shaped trenches from drilling when they are placed at right angles to the run-off, catch an appreciable amount of water and put it to good use in speeding the growth of the new seedlings. Drilling uphill and down not only allows needed water to run off, but also invites erosion, gullying, seed loss, and the destruction of seedlings by washing.

Always drill on the contour

The quantity of seed to use varies somewhat with the size of seed but generally is less than half of the amount used on tilled land. Stewart and others* recommend drilling from 5 to 10 pounds per acre of the seed of large seeded grasses such as bromes, bluestem wheatgrass (western wheatgrass), and tall oatgrass, and 3 to 6 pounds of seed of small seeded plants such as sheep fescue and slender wheatgrass. Results from extensive tests on the Malheur National Forest indicate that 5 pounds of mixed grass seed per acre is sufficient when drilling on eastern Oregon summer ranges. Many excellent

Five pounds of seed is enough

* Stewart, George, Walker, R. H., and Price, Raymond. 1939. Reseeding Range Lands of the Intermountain Region. U. S. Department of Agriculture, Farmers' Bulletin 1823, 25 pp., illustrated.

stands of crested wheatgrass in eastern Oregon attest that 5 pounds of seed per acre is enough if conditions are right for securing a stand.* If conditions are wrong, results are likely to be poor no matter how much seed is used.

Figure 1. Views that illustrate the effect of depth of planting on crested wheatgrass production. Seeding shown in the upper picture was at 1½ inch depth; production was 310 pounds of air-dry herbage per acre. Seeding in the center picture was planted at 1 inch depth and produced 231 pounds per acre. The seeding in the lower view was planted at ½ inch depth; 85 pounds of air-dry herbage was produced per acre. Seed was covered approximately ½ inch. Areas were seeded side by side in the fall of 1938 at the same rate per acre. Measurements of herbage production were made in August 1942. Pictures were taken in September 1941.

* Jackman, E. R., Stephens, D. E., and Richards, D. E. 1936. Crested Wheatgrass in Eastern Oregon. Oregon State College Extension Bulletin 494, 38 pp., illustrated.

The rate of flow through a drill depends on such things as size of seed, weight of seed, and the amount of chaff and other trash. On the average, with the drill indicator set for wheat at 1 peck per acre, 7 pounds per acre of crested wheatgrass or 6 pounds of slender wheatgrass will be sown.* By stopping up alternate drill openings and by adjusting the drill indicator, almost any desired seeding rate is possible. A good practice is to adjust the drill approximately, put in a measured lot of seed, drill until the seed is completely used and then measure the length and breadth of the drilled strip. Mixing a few pounds of rye or wheat with grass seeds that are awned, such as mountain brome or tall oatgrass, will cause them to flow through the drill more freely.

Check drill for seeding rate

With low rates of seeding it is usually necessary to keep the drill box open, watch the feed closely, and stir occasionally. With most varieties, 10 to 15 seeds per foot in the drill row will give a good stand if other conditions are right.

Keep seed from clogging

From work done in Logan Valley on the Malheur Forest, it is concluded that crested wheatgrass rows should be about 1 foot apart to get the best spacing of plants. A crested wheatgrass seeding made in 1938 in Logan Valley in which the rows were 3 feet apart had failed to spread satisfactorily between the rows by 1942, although the plants in the rows were well established and had matured seed crops for 3 years. With species that spread by underground rootstocks, such as smooth brome, bluestem wheatgrass, and Kentucky bluegrass, the drill rows may be spaced 3 feet apart.

Bunchgrass seedlings between the rows usually die

If the cost of seed is a limiting factor in planting a considerable acreage, it is advisable to drill in parallel strips at right angles to the drainage. Accelerated erosion is thereby prevented to a large extent, and a seed source of good forage plants is provided from which the entire area may eventually become covered. On highly productive sites, such as mountain meadows, however, it is advisable to drill the entire area. The returns from a full stand of grass on all the land, in contrast to part production, for the period of years that parallel seedings require to spread to the unseeded strips, are well worth the additional seed and labor costs.

Drill entire area unless seed is very high priced

* Walker, R. H. and Bracken, A. F. 1938. Seeding Grasses on Utah Dry Farms. Utah Agricultural Experiment Station Circular 111, 10 pp., illustrated.

WHEN TO DRILL

Drilling on Oregon summer ranges ordinarily should be done in the fall either early or very late. The Malheur National Forest seedings that were drilled in September or in late October and in November generally have been more successful than those drilled in early and mid-October. Apparently the midfall seedings make just enough growth so that they are susceptible to damage from heaving while the early fall and late fall seedings escape this hazard. Seeds sown late in the fall do not germinate until the following spring. Seedlings from fall sowings can take full advantage of the ample soil moisture and growing temperatures during the spring season and can develop their root systems to a sufficient depth to escape the effects of the usual summer drought.

Seed in the fall, either very early or very late

Drilling in the spring is not usually successful on Oregon summer range. Conditions generally are such following snow melting that when it is possible to get on the ground with heavy equipment, there is insufficient time for seedling development before the usual summer drought. Seedlings should be 3 to 4 inches high before dry weather. Roots cannot push into dry ground, and if the soil dries ahead of the young roots, the plants are doomed to untimely death.

Spring seeding is usually a failure

LOGAN VALLEY DRILLING EXPERIMENTS

Tests of reseeding various species by drilling have been made from time to time since 1937 in Logan Valley on the Malheur National Forest. The elevation of this mountain valley is approximately 5,000 feet. The soil is badly eroded. Native vegetation has been depleted to such an extent that, over a large portion of the valley, only 3 pounds of air-dry herbage per acre was produced in 1942. The water table is high but the surface soil dries quickly in the spring and becomes extremely hard, indicating the absence of organic matter. The vegetation on reseeded areas has been fully utilized by cattle during the late summer season since 1939. Other high altitude seedings have been made yearly since 1930 in all of the eastern Oregon counties.

Crested wheatgrass was drilled in the fall of 1938 on the poorest sites in Logan Valley. The drill was set to cut trenches 1 to 1½ inches deep in the hard, unprepared seedbed. Drill rows were spaced 3 feet apart with the thought of planting a maximum acreage with a minimum of seed. This seeding produced 271 pounds of air-dry herbage per acre in 1942. The plants averaged about 21 inches high. Good seed crops have occurred since 1940, but an

Crested wheatgrass lived when native forage failed

average of only 6,500 seedlings per acre (one seedling per 7 square feet) has become established between the rows. Many young seedlings come up between the rows each year but die during the summer. Evidently the old plants rob the young ones. The plants are thought to be too thick in the rows and the rows too far apart for the seeding to perpetuate itself to the best advantage. Mice and grasshoppers are beginning to kill the older plants. Only time will tell whether new seedlings will come along fast enough to replace the loss. Nevertheless, the seeding demonstrates that crested wheatgrass can become established at this 5,000 feet elevation and under these extremely adverse soil conditions where native forage is a failure.

Additional plantings of crested wheatgrass were made in the fall of 1941 with the rows 1 foot apart. These seedings are now fairly well established. It remains to be seen, however, whether the close-planted stands of this species are more self-perpetuating than those in which the drill rows are farther apart.

Tall oatgrass planted in the fall of 1940 on a somewhat better site in Logan Valley produced 424 pounds of air-dry herbage per acre in 1942. The plants averaged 36 inches high and were stooling out rapidly into large, vigorous bunches. The species seems admirably suited to areas on which there is some subirrigation. Although no measurements or counts were made, the species is observed to reseed itself and spread to a much greater extent than crested wheatgrass, but more care is needed in pasturing it. Close grazing kills it rather quickly.

A small amount of bluestem wheatgrass was drilled in the fall of 1938. This original seeding is spreading vigorously. More was drilled in the fall of 1941 and is now well established. The seeding is too recent to permit drawing definite conclusions, but the species seems well adapted to the compact clay soil that is found in Logan Valley and in other depleted mountain meadows. Bluestem wheatgrass is a good hay and pasture grass. It spreads by underground runners and closely resembles quackgrass. It also withstands spring flooding.

Smooth brome and bearded bluebunch wheatgrass, both drilled in the fall of 1941, are established and doing well. Bulbous bluegrass, drilled in 1941, has become well established. The use of this species for reseeding Oregon summer ranges is not recommended, however, except in combination with a more productive grass. It dries up extremely early in the summer and produces a very small amount of herbage. The root system of the plant is also limited and is not very effective in stabilizing the soil.

COSTS OF DRILLING

The costs of reseeding range lands by drilling include machinery and labor charges, cost of seed, and in some instances cost of seedbed preparation and cost of fencing to protect the new seeding. Cost accounts for equipment rental and labor kept on the Malheur Forest reseeding project are summarized in Table 1. In computing the costs, labor was charged at $135 per month, truck rental $0.07 per mile, team hire $1 per day, and drill rental $0.03 per acre.

Table 1. GRASS SEEDING COST PER ACRE

(Exclusive of seed)

Type	Area seeded	Labor cost per acre	Equipment charge per acre		Total cost per acre
			Truck or team	Drill	
	Acres				
Drilling with 1½-ton truck and 6-foot grain drill	626	$0.722	$0.085	$0.03	$0.84
Drilling with team and 6-foot grain drill	176	.829	.166	.03	1.03

These compare favorably with figures given in U. S. Department of Agriculture Farmers' Bulletins 1823 and 1924,* which place the cost of drilling from $0.84 to $1.50 per acre.

The cost of seed will vary greatly from year to year and will depend on the mixture used. Crested wheatgrass is usually low in price, about 17¢ per pound (see page 44,) whereas tall oatgrass and meadow foxtail will nearly always be high. In most cases in the past, seed has cost from 90¢ to $2 per acre. Costs for fencing were not computed for eastern Oregon conditions, but in the Intermountain Region fence construction ranges from 3¢ to 10¢ per acre. No seedbed preparation was made in the Malheur tests. Again, in the Intermountain Region these costs are found to amount to from 30¢ to 50¢ per acre. Reseeding Oregon summer ranges by drilling, therefore, may be expected to cost at least $1.75 per acre and possibly more than $3.50 depending on the traction equipment used, the rate of seeding, the seed mixture, and whether or not fencing and seedbed preparation are required.

Labor, machinery, and seed cost $1.75 per acre or more

* Short. L. R. 1943. Reseeding to Increase the Yield of Montana Range Lands. U. S. Department of Agriculture, Farmers' Bulletin 1924. 26 pp., illustrated.

RESEEDING DENUDED SUMMER RANGE LANDS BY BROADCASTING

Broadcasting generally is not so successful as drilling because it is difficult to cover seed properly, but there are circumstances under which drilling is impossible or impracticable, and in these instances broadcasting is the only alternative.

WHERE TO BROADCAST

Broadcasting is necessary to reseed areas that are too brushy, too rocky, too steep, too inaccessible, or too densely timbered to permit the use of a grain drill. Burned-over areas and logged-off lands usually have too much debris to permit use of a drill. Unless special drill attachments are available to permit drilling on steep slopes, broadcasting is necessary on slopes with gradients higher than 25 or 30 per cent. Most of the alpine grasslands must be reseeded by broadcasting because they are remote from roads, prohibiting the use of heavy reseeding equipment. In this connection, Sampson* recommends that reseeding in Oregon be limited to altitudes below 7,800 feet because chances for success were found to be dubious above that altitude. The reseeded species that Sampson observed at or above 7,800 feet in the Wallowa Mountains were unable to produce sufficient viable seed to maintain a stand and, furthermore, were dwarfed and low in vigor when grown at such high altitudes.

Broadcast where a drill won't work

HOW TO BROADCAST

Broadcasting may be done either by hand or with a portable hand seeder (Figure 2). The portable hand seeder requires less skill to obtain a uniform distribution of the seed. The machine covers a swath from 10 feet to a rod wide. One man can seed 25 to 35 acres per day with this type of light, portable seeder.† It is sometimes impossible to handle large, fluffy seeds with this machine.‡ With experience, hand broadcasting will give sufficiently uniform seed distribution, but generally more seed is required than either by drilling or by using the portable hand seeder. With hand spreading, one man can usually seed about 10 acres per day in the rough country where most of this work is done.

One man can broadcast 25 to 35 acres per day with machine

* Samson, A. W. 1913. The Reseeding of Depleted Grazing Lands to Cultivated Forage Plants. U. S. Department of Agriculture, Bulletin 4, 34 pp., illustrated.

† Sampson, A. W. 1913. The Reseeding of Depleted Grazing Lands to Cultivated Forage Plants. U. S. Department of Agriculture, Bulletin 4, 34 pp., illustrated.

‡ Stewart, George, Walker, R. H., and Price, Raymond. 1939. Reseeding Range Lands of the Intermountain Region. U. S. Department of Agriculture, Farmers' Bulletin 1823, 25 pp., illustrated.

Broadcast seeding usually requires some advance ground preparation to insure a good seedbed. In the case of recent burns or of disturbed soil in skid trails, the seedbed is already prepared, but on brushy or weedy areas the advance preparation is important and rather costly. Plowing contour furrows several feet apart in grasslands grown up to sagebrush or to cheatgrass brome in preparation for broadcasting is recommended.* Soil disturbance with a heavy double disk or with a one-way disk plow is also effective. In the case of sagebrush, burning is feasible, as is railing. Harrowing with spike-tooth, wooden peg A, or brush harrows is recommended on alpine grassland where sagebrush is not prevalent.† On dry loose soil common to slopes in the high Wallowas, Sampson† recommends trampling by sheep in advance of seeding to compact the ground.

Broadcast seeding needs seedbed of some kind

Figure 2. Broadcast seeding in a recent burn with the aid of a portable hand seeder. A strip approximately one rod wide is covered. A man can seed about 25 acres per day with this equipment.

* Stewart, George, Walker, R. H., and Price, Raymond. 1939. Reseeding Range Lands of the Intermountain Region. U. S. Department of Agriculture, Farmers' Bulletin 1823, 25 pp., illustrated.

† Sampson, A. W. 1913. The Reseeding of Depleted Grazing Lands to Cultivated Forage Plants. U. S. Department of Agriculture, Bulletin 4, 34 pp., illustrated.

Most authorities recommend seeding at a heavier rate when broadcasting than when drilling because seedling establishment and survival ordinarily are poorer. If drilling is successful with 5 pounds per acre, then broadcasting will require about 10 pounds, except in cases of natural seedbeds. For example, the Malheur National Forest recommends seeding about 4 pounds of grass seed mixture per acre when broadcasting on skid trails with a hand seeder.

Broadcasting requires more seed unless there is good seedbed

It is essential that the broadcast seed be covered for good germination and seedling survival. In some circumstances such as seeding in ashes or in the very loose soil on skid trails, the seeds usually become sufficiently well covered through natural means; in all other cases seed covering is necessary for success.

Seed must be covered

Seed can be covered successfully by disking, harrowing, or trampling with sheep. If the area to be seeded is covered with light brush such as sagebrush, disking is most effective. If the area is relatively free from brush, harrowing with a spike-tooth, brush, or wooden peg A harrow is recommended. On ranges inaccessible to machinery, trampling the seeded areas with sheep will serve, but Sampson* found in reseeding tests in the Wallowa Mountains that this method was less effective than harrowing.

Effective improvised harrows are suggested by Sampson* for use on areas remote from transportation. A wooden peg harrow is made by fitting three logs, 5 to 6 inches in diameter and 5 to 6 feet long, together in the shape of a letter A. Holes 1 inch in diameter and spaced about 5 inches apart are drilled through the logs, and sharpened teeth about 7 inches long are cut from branches driven through the holes. A saddle horse pulls the harrow by a rope attached to the apex. A brush drag is constructed by cutting five saplings, pines or spruces preferred, in lengths of about 6 feet and clamping their butt ends between two 5-foot crosspieces that are wired or roped tightly to hold the brush. The lower crosspiece should be the heavier. This drag also can be pulled by a saddle horse. If a team is available, both of these improvised harrows may be made heavier and wider.

All wood harrows or brush drags can be made on spot

If forage is desperately needed, and any kind of seedbed disturbance or preparation is out of the question, it may be advisable to broadcast without covering the seed. On the Malheur National Forest and in other places in eastern Oregon stands occasionally have

* Sampson, A. W. 1913. The Reseeding of Depleted Grazing Lands to Cultivated Forage Plants. U. S. Department of Agriculture, Bulletin 4, 34 pp., illustrated.

been successfully obtained by scattering seed on steep, rocky, denuded slopes. This is wasteful of seed, but some of it works downhill and lodges in earth behind rocks or logs. At least a part stand has resulted.

WHEN TO BROADCAST

Broadcasting on Oregon summer ranges ordinarily is most effective when done in the late fall, just before winter snows and rains set in. Sampson* suggests the following reasons why late fall seedings are best: (1) under natural conditions seed usually is disseminated in the fall and lies dormant until the following spring; (2) if germination occurs in the fall season, seedlings may be killed by ground heaving; (3) if seeding is done late enough in the fall so that germination is postponed until spring, danger of frost and heaving injury to seedlings is eliminated, and the seedlings can take full advantage of the ample soil moisture that follows snow melting. Early fall or late summer seedings, however, are sometimes advisable if a loose seedbed is available on which no mechanical seed covering is to be done. This gives the seed time to work into the ground sufficiently so that when germination occurs the seed will have been planted to a depth where seedling survival is assured. Occasionally a seeding made in early spring is successful. The melting snow and ground heaving from frosts usually bury part of the seed. In the experience of the writers, late spring broadcasting has never succeeded.

Broadcast in very late fall

At low elevations where dry weather comes early, spring broadcasting is almost certain to fail. No time nor method of broadcasting was found successful in reseeding trials on cheatgrass brome range in Jefferson County. The chances for success with broadcasting increase as rainfall becomes greater and the climate cooler. In eastern Oregon broadcasting should be practiced only at elevations above 4,000 feet or in areas where the rainfall is more than 14 inches.

RESULTS FROM BROADCASTING TRIALS

Some experiences in broadcasting different species on northwest summer ranges follow.

An experimental reseeding plot was established in 1939 near Bear Wallow Guard Station on the Umatilla National Forest. Reseeding work was done cooperatively between the Oregon Agricultural Extension Service and the Umatilla National Forest. The plot is located on a main sheep driveway over which thousands of sheep have been driven spring and fall for many years. Virtually all perennial for-

Sheep driveway was reseeded

* Sampson, A. W. 1913. The Reseeding of Depleted Grazing Lands to Cultivated Forage Plants. U. S. Department of Agriculture, Bulletin 4, 34 pp., illustrated.

age plants were destroyed by such use; only 31 pounds of air-dry herbage was produced per acre in 1942. The soil had become eroded to such an extent that the surface was littered with rock, and organic material was largely removed. The area is typical of "scab ridges" that commonly occur on what once were well-grassed openings throughout Oregon's summer range in the ponderosa pine zone. The elevation is approximately 4,500 feet. The soil is heavy clay that dries and bakes during the summer.

Timothy, crested wheatgrass, and Kentucky bluegrass were seeded in plots within the fenced area in 1939 and 1940. The seeding was raked in by hand. In 1942 the timothy plots produced 1,368 pounds of air-dry herbage and nearly 300,000 seedlings per acre. Kentucky bluegrass produced only 171 pounds of herbage per acre but almost a million and a half seedlings per acre. Kentucky bluegrass was outstanding in arresting soil erosion. Crested wheatgrass was a failure in these trials. The striking feature of these tests is the productiveness of the apparently infertile "scabland" when seeded to suitable forage species and given adequate protection from overgrazing and excessive trampling.

"Scabland" will grow grass

Another example of broadcast seeding is found on Middle Creek Meadows in the Manastash Cattle Allotment of the Wenatchee National Forest (Figure 3). The elevation is approximately 5,000 feet. The soil is a heavy black "gumbo" typical of depleted meadows. It dries with many surface cracks, indicating that most of the fertile, organic top soil has been lost. Smooth brome, Kentucky bluegrass, and crested wheatgrass were seeded on adjacent plots within a fenced enclosure in 1935. The seeding was raked in by hand.

In 1938, the seeding appeared to be a failure; only a little of the reseeded vegetation was showing. By 1942, however, the smooth brome was producing 1,503 pounds of air-dry herbage per acre, the crested wheatgrass 570 pounds, and the Kentucky bluegrass 486 pounds. The smooth brome was most aggressive in occupying the ground as judged by the occurrence of competing native forage plants. In the smooth brome plot, 142 pounds of air-dry herbage per acre of native range plants grew, while 430 and 486 pounds per acre, respectively, grew in the crested wheatgrass and Kentucky bluegrass plots. The smooth brome had invaded the crested wheatgrass seeding to the extent that 94 pounds of air-dry smooth brome herbage was produced in the plot. Although no measurements were taken on the grazed, unseeded meadow it is doubtful whether more than 100 pounds of air-dry

Smooth brome fine for meadows

herbage is produced on the average acre. Thus, the reseeding on Bear Wallow and on Middle Creek Meadows indicates that from 5 to 44 times more herbage can be produced by reseeding depleted "scabland" and meadows. This figure does not take into account the tremendous increase in quality of forage.

COSTS OF BROADCASTING

Costs of distributing seed by broadcasting, according to records from the Malheur National Forest, vary from 56¢ per acre, for seeding skid trails and other scars resulting from logging, to 27¢ per acre for seeding extensive areas of burned-over timberlands. Costs are higher in the case of seeding skid trails because the areas are relatively small and considerable travel is necessary between them. The cost of labor, at a $135 per month wage, is 53¢ per acre; cost of transportation, at 7¢ per mile, is 3¢ per acre. For seeding extensive areas the labor cost is 25.7¢ per acre and transportation 1.5¢. No costs for seedbed preparation or seed covering are available under Oregon summer range conditions. Stewart *et al,** however, quote figures on areas of 5 acres or more varying from 75¢ to $3 per acre. Seed costs for broadcasting usually range from $1.45 to $3.20 per acre depending on the kind and quantity of seed used. Fencing costs given by Stewart range from 3¢ to 10¢ per acre. With these figures as a basis, broadcasting costs can be expected to range from $1 to more than $7 per acre, depending on the seeding rate per acre, cost of seed, and whether or not fencing, seedbed preparation, and seed covering are necessary.

RESEEDING BURNED-OFF TIMBERED RANGE IN THE LODGEPOLE PINE ZONE

The average yearly accidental burn in the 1,624,000 acres of lodgepole pine type in eastern Oregon was only 629 acres during 1924 to 1935.† Occasionally, however, when conditions such as severe drought, strong winds, and the presence of beetle-killed lodgepole pine create an intense fire hazard, large acreages in this type burn over. For example, a fire that started on Big Cow Creek in 1939 burned a total of 31,306 acres on the Malheur and Whitman national forests of which 20,153 acres was the lodgepole pine type

Diseased or overmature lodgepole pine is fire trap

* Stewart, George, Walker, R. H., and Price, Raymond. 1939. Reseeding Range Lands of the Intermountain Region. U. S. Department of Agriculture, Farmers' Bulletin 1823, 25 pp., illustrated.

† Cowlin, R. W., Briegleb, P. A., and Moravets, F. L. 1943. Forest Resources of the Ponderosa Pine Region of Washington and Oregon. U. S. Department of Agriculture, Miscellaneous Publication 490, 99 pp., illustrated.

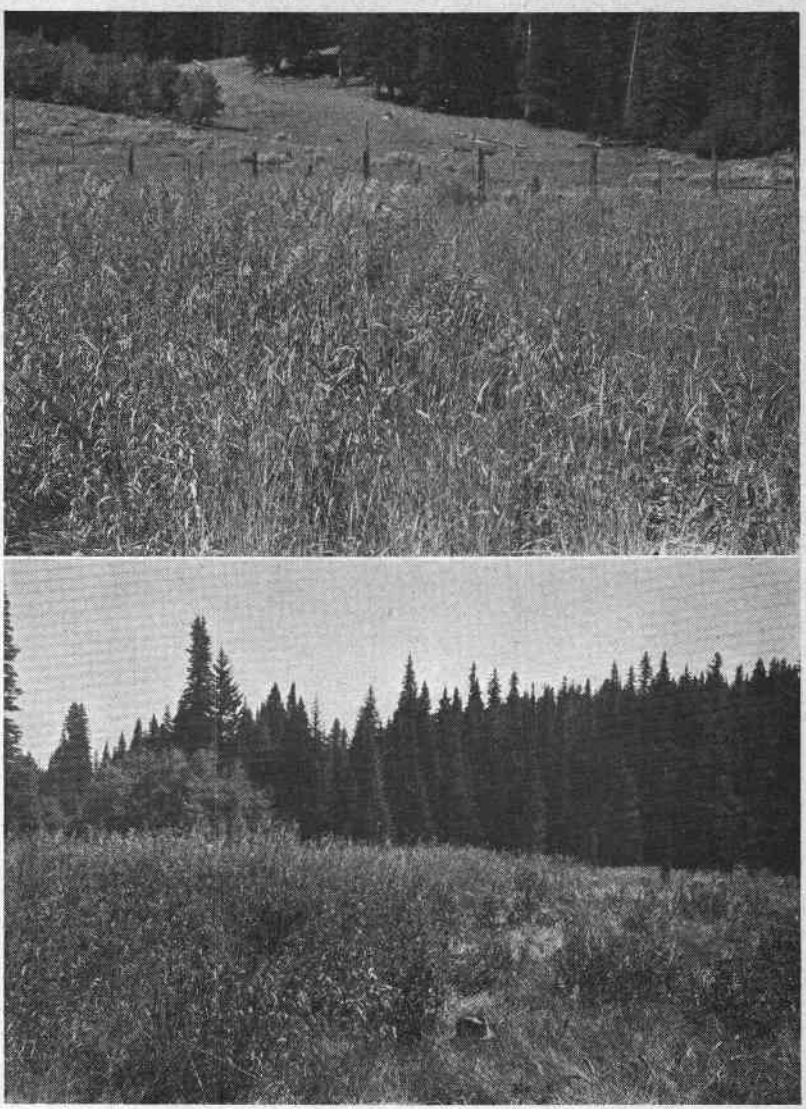


Figure 3. Views of a successful attempt to reseed depleted range by broadcasting on the Wenatchee National Forest. Broadcasting was done in 1935; seed was planted by hand raking. Herbage production measurements were made in August 1942 at the time the pictures were taken. In the upper picture, the tall grass to the left is smooth brome that produced 1,503 pounds of air-dry herbage per acre. The shorter grass to the right is crested wheatgrass, producing 430 pounds per acre. Smooth brome has invaded the crested wheatgrass plot to the extent that its production on the plot amounts to 94 pounds per acre. The lower picture shows the same stand of smooth brome, from the opposite direction, with Kentucky bluegrass on the right. The bluegrass is producing 486 pounds of air-dry herbage per acre. The smooth brome is not invading the bluegrass stand.

and 5,545 acres was a Douglas fir-western larch type with some lodgepole pine in the mixture.

The usual result following a burn in the lodgepole pine type is a period of serious soil erosion prior to the establishment of a new lodgepole pine forest. The new forest ordinarily is a dense stand of poles too crowded to produce an appreciable amount of wood and much too thick to permit the growth of range forage plants. Proper reseeding of these accidental burns to range forage species shows promise of arresting much of the accelerated erosion that usually follows the fire, of holding the reestablishment of lodgepole pine to a reasonable number of trees per acre, and at the same time of adding much needed summer range acreage to Oregon's supply.

Soil erosion is severe following a lodgepole pine burn

Most of the lodgepole pine is at relatively high elevations where rainfall is ample to grow nearly any of the grasses, and where rainfall and elevation combine to keep the grasses green all summer. Location is thus ideal for good summer range for both domestic and game animals. Actually native range forage for either is scanty in a typical lodgepole pine area either before or after a fire.

Lodgepole makes poor grazing

The recommendations that follow do not constitute an endorsement for so-called light burning or controlled burning of lodgepole pine stands in eastern Oregon. The hazards to surrounding timber stands, the costs of controlling the fire to a specified area, the methods of burning, the best season for burning, the most effective intensity of the burn, and the over-all influence of burning on watershed, timber, and forage values of the land need much careful study before definite conclusions regarding controlled burning can be formed. The recommendations in this publication are concerned solely with the salvage of resource values on lodgepole pine tracts that have accidentally burned, so as to prevent excessive soil erosion and dense, stagnated lodgepole pine stands and to produce on the burned area range forage as well as timber.

Deliberate burning is too dangerous

WHEN TO SEED

Lodgepole pine burns should be reseeded in the fall of the year in which the fire occurred. The seeds sink into the fluffy ashes and as soon as rains come conditions for germination are almost ideal. If the burn is not seeded until after much rain has fallen on the ashes, or until several years after the fire, the fluffy seedbed conditions usually are lost and the possibility for self-planting of the seed is reduced. Another reason for seeding soon after the burn is to take

Seed the same year that the fire occurred

full advantage of the mineral plant foods that are liberated in the ashes from burned organic matter. Otherwise these leach rapidly when rains and snow fall on the ashes. Still another reason, perhaps the most important of all, is to obtain germination and establishment of the range forage plants before competing native vegetation, primarily lodgepole pine, snowbrush, ceanothus, manzanita, and pinegrass, can become well established.

Seed early and avoid the brush

Burns in these dense lodgepole pine forests ordinarily are so hot that not only is the vegetation consumed but also the roots in the topsoil. With few roots to hold it, the soil is washed downhill by run-off from rains and melting snow. Erosion may be so serious that in places only bedrock is left and production of either trees or grass is out of the question.

It might be expected that seed sown on the ashes of recent fires would be subject to heavy losses from seed-eating rodents. In 1940 a canvass of the grass seedings in the Big Cow Creek Burn by A. W. Moore, associate biologist of the Fish and Wildlife Service, found no evidence whatever of seed having been disturbed or taken by small rodents. Small unburned islands and marginal areas showed a normal small-rodent population, but these evidently did not penetrate into the burn owing to the lack of protective cover.

HOW TO SEED

Burns must be seeded by broadcasting since there are too many snags and too much debris to permit drilling. Drilling is unnecessary, however, because the broadcast seed buries itself in the light, fluffy ash where it germinates and becomes established when moisture and temperature conditions are favorable. A solid coverage of the area to be seeded is necessary for best results. If strips are left unseeded, the probable result will be alternate belts of lodgepole pine "jungle" and grass. Not only would this be undesirable from a livestock-management standpoint, but the long, narrow belts of grass would be highly susceptible to encroachment from the dense bordering lodgepole pine stands. If insufficient seed is at hand to plant an entire burn, the best course is to block out a favorable site for which enough seed is available and to plant it completely.

Seed burns by broadcasting

Ashes bury the seed and little is lost

The correct amount of seed to use per acre when reseeding burned-over land is not definitely established. Christ,* working in

* Christ, J. H. 1934. Reseeding Burned-over Lands in Northern Idaho. Idaho Agricultural Experiment Station, Bulletin 201, 28 pp., illustrated.

the western pine type in northern Idaho, recommends from 10 to 15 pounds per acre when seeding mixtures of different range forage species to obtain a fair pasturage quickly but states that some persons seed as little as 3 to 4 pounds per acre. A seeding rate of 2½ pounds per acre was found to be sufficiently heavy on one area of 800 acres on the Malheur National Forest. It is probable that with most mixtures a rate of 5 pounds should prove satisfactory on recent burns.

Five pounds of seed per acre enough

A quick-starting, rank-growing grass or cereal should be included in the mixture to provide a nurse crop for the slower developing, more permanent range forage species. The nurse crop is highly important in establishing forage species on burns for several reasons: (1) it starts growth quickly the spring following the burn, thereby stabilizing the soil against severe run-off and excessive erosion; (2) it soon provides shade, thereby decreasing excessive surface temperatures of the black, ashy soil to a point that the slower-developing seedlings of long lived grasses can survive; (3) it produces deep shade and a high degree of root competition to check the establishment of excessive numbers of lodgepole pine seedlings that otherwise would germinate and quickly grow to a height beyond competition with grasses for light; and (4) it produces a quick ground cover that forestalls invasion of the burn by undesirable weedy plants such as cheatgrass brome, groundsmoke, and fireweed.

Mixture should include a quick-growing grass

Observations in June 1940 revealed that winter rye sown in the ashes of a lodgepole pine burn on the Whitman National Forest in the fall of 1939 had produced an abundance of thrifty seedlings averaging 12 inches tall by that date. The elevation of the seeded area was approximately 6,500 feet. Slopes were moderately steep and faced east. Seedlings of range grasses sown at the same time as rye and adjacent to the rye seeding were very spindling in comparison and averaged less than 4 inches tall. Erosion was imperceptible within the rye plantation while soil on the area seeded to grasses had been badly eroded from the spring rains. Grass seedlings in the absence of a nurse crop were found to be thrifty and abundant only in the shade of logs and in depressions deep enough to give part shade to the seedlings growing within them. The lack of seedlings on the areas exposed to full sunlight doubtless was because the surface of the black ash soil became so hot that the young, tender grass seedlings were killed.

Rye stops erosion and grows fast

Although no thermometer readings were taken, the black soil in full sunlight was decidedly hot to the touch while that in the shade of logs and in the stand of rye was cool. It was estimated that the temperatures of the exposed and shaded soils were 130° and 80° F. respectively at the time the observations were made. Studies by Isaac* and Tsi-Tung Li† indicate that surface soil temperatures of unprotected black ash soils are at least 30° higher and much more hazardous for seedling survival than in the part shade of weeds or grass, when maximum air temperatures range from 80° to 90° F.

Black burned exposed surfaces get very hot

Counts of established lodgepole pine seedlings made on areas in the Big Cow Creek Burn where grass mixtures that included a fast growing species had been seeded showed a maximum of 174 lodgepole pine seedlings per acre in 1942. Counts in an unseeded part of the area, in a burn of similar intensity, showed an average of 2,439 lodgepole pine seedlings per acre. Counts made within grass seedings on burns of similar intensity where no nurse crop or quick-growing grass was used in the mixture showed an average of 1,755 lodgepole pine seedlings per acre. Unquestionably, the quick occupation of a seeded area by the nurse crop and the deep shade cast by the abnormal height growth that it made the first year were factors in reducing the stand of lodgepole pine seedlings.

Quick-growing grasses stop the "jungle"

Winter rye can be used as a nurse crop. It is an annual, however, that does not persist in the stand for more than one year. Michels rye is better than other varieties because some of the plants live into the second year. Rye should be seeded very lightly as a nurse crop, not more than 15 pounds per acre. Heavy seedings of rye will result in poor grass stands.

Seed Michels rye at less than 15 pounds per acre

In general, a quick-starting grass is better than rye for these purposes: to insure shade for more than one year; to check lodgepole pine seedlings; and to provide forage for livestock during the period that the slower-growing, long lived grasses are gaining a satisfactory foothold. Tall oatgrass is ideal for this purpose, but seed is not always available. Timothy is fairly satisfactory. Both are better than rye because they are more permanent.

Quick-growing grasses are better than rye

* Isaac, L. A. 1938. Factors Affecting Establishment of Douglas Fir Seedlings. U. S. Department of Agriculture, Circular 486, 45 pp., illustrated.

† Li, Tsi-Tung. 1926. Soil Temperature as Influenced by Forest Cover. Yale University, School Forestry Bulletin 18, 92 pp., illustrated.

COSTS OF SEEDING LODGEPOLE PINE BURNS

Since there is no need for seedbed preparation or for seed covering in reseeding lodgepole pine burns, costs consist of the price paid for seed, labor of sowing, and sometimes for fencing or otherwise protecting the new stand. Fencing is unnecessary on sheep range. On cattle range the most economical way to protect the seeding is by electric fence. Cost records from the Malheur National Forest indicate the labor charge to reseed burns to be 27¢ per acre. Assuming that seeding rates will vary from 3 to 8 pounds per acre and that the cost of the mixed seed per pound will vary from 18¢ to 30¢, the seed costs can be expected to range from $0.54 to $2.40 per acre. Based on these estimates, reseeding lodgepole pine burns may be expected to cost from about $0.80 to $2.65 per acre, exclusive of fencing. Using an ideal mixture described on page 44 the total cost would be about $1.80 per acre.

Lodgepole burns cost $1.80 per acre to seed

EXPERIMENTAL SEEDINGS ON LODGEPOLE BURNS

Determination of the best species to use in reseeding lodgepole pine burns was the object of an investigation conducted jointly by the Agricultural Extension Service of Oregon State College and the Forest Service at two major locations within the Big Cow Creek Burn. Eleven lots of seed were broadcast on 7 experimental areas. Of the lots 4 were mixtures of seed of four or five different species while 7 were trials of single species (Table 2). All seedings were made in October 1939 soon after the Big Cow Creek fire had been extinguished.

Lot 1 was a mixture of timothy, Kentucky bluegrass, and standard crested wheatgrass sown with white clover on a 100-acre tract that is situated on the flood plain and lower, east-facing slope of the North Fork of the Malheur River at an elevation of approximately 5,500 feet. The intensity of burn on this area was classed as moderate. Adjacent to this area and on the slope immediately above it in the same intensity of burn, another 100-acre tract was seeded to lot 2, a mixture containing slender wheatgrass, mountain brome, orchardgrass, and white clover. The soils of both areas are deep and fertile. Deeper soil and better soil moisture, however, exist on the area seeded to lot 1. Slopes are gentle on both areas. The rates of seeding were 8.6 pounds per acre for lot 1 and 13.1 pounds per acre for lot 2. Proportions of seed of different species in the mixtures are listed in Table 2.

Approximately 10 miles due north, at an elevation of about 6,500 feet, on the upper slopes of a ridge that has a general east-facing slope, two areas of approximately 75 acres each, and one

Table 2. Acreage, Species, Amounts Sown, Grass Herbage and Seedling Production, and Number of Lodgepole Pine Seedlings in Big Cow Creek Burn Reseeding Trials
(Malheur and Whitman National Forests)

Species	Seed sown (1939)	Seed sown per acre	1942 air-dry herbage produced per acre	Number grass seedlings present in 1942 (thousands per acre)	Number lodgepole pine seedlings present in 1942 (per acre)
	Pounds	*Pounds*	*Pounds*		
Lot 1—Moderate burn, 100 acres, elevation 5,500 feet					
Standard crested wheatgrass	375.0	3.7	44.2	35	.....
Kentucky bluegrass	150.0	1.5	128.4	344	.....
Timothy	300.0	3.0	804.5	279	.....
White clover	37.5	0.4	0.0	0	.....
Total	862.5	8.6	977.1	658	0
Lot 2—Moderate burn, 100 acres, elevation 5,500 feet					
Slender wheatgrass	375.0	3.7	28.0	3.5	.....
Mountain brome	450.0	4.5	75.9	87	.....
Orchardgrass	450.0	4.5	520.3	1,080	.....
White clover	37.5	0.4	0.0	0	.....
Total	1,312.5	13.1	624.2	1,170.5	174
Lot 3—Heavy burn, 75 acres, elevation 6,500 feet					
Meadow fescue	600.0	8.0	29.4	No data	.....
Chewings fescue	150.0	2.0	14.8	No data	.....
Highland bentgrass	75.0	1.0	28.7	No data	.....
White clover	37.5	0.5	0.0	No data	.....
Total	862.5	11.5	72.9	No data	174
Lot 4—Heavy burn, 75 acres, elevation 6,500 feet					
Slender wheatgrass	125.0	1.6+	35.5	No data	.....
Standard crested wheatgrass	125.0	1.6+	2.0	No data	.....
Smooth brome	225.0	3.0	51.7	No data	.....
Alta fescue	300.0	4.0	100.3	No data	.....
White clover	37.5	0.5	Trace	No data	.....
Total	812.5	10.8	189.5	No data	131
Lot 5—Heavy burn, 20 acres, elevation 6,500 feet					
Fairway crested wheatgrass	300	15.0	Not measured	No data	No data
Lot 6—Heavy burn, 0.6 acre, elevation 6,500 feet					
Beardless bluebunch wheatgrass	10	16.7	5.4	No data	291
Lot 7—Light burn, 0.6 acre, elevation 6,500 feet					
Beardless bluebunch wheatgrass	10	16.7	8.9	No data	1,416
Lot 8—Heavy burn, 0.6 acre, elevation 6,500 feet					
Smooth brome	10	16.7	62.6	No data	36
Lot 9—Light burn, 0.6 acre, elevation 6,500 feet					
Smooth brome	10	16.7	88.9	No data	2,251
Lot 10—Heavy burn, 0.6 acre, elevation 6,500 feet					
Mountain brome	10	16.7	45.3	No data	109
Lot 11—Light burn, 0.6 acre, elevation 6,500 feet					
Mountain brome	10	16.7	85.2	No data	1,597
Check—Moderate burn, elevation 5,500 feet					
Unseeded burn	.....	.....	36.9	No data	2,439
Check—Heavy burn, 0.6 acre, elevation 6,500 feet					
Unseeded burn	.....	.....	84.6	No data	145
Check—Light burn, 0.6 acre, elevation 6,500 feet					
Unseeded burn	.....	.....	85.3	No data	2,795

20-acre area were seeded. On these areas slopes are moderately steep. Soils are relatively thin and very dry. The intensity of burn on these three areas was classed as heavy. Lot 3, consisting of a mixture of meadow fescue, Chewings fescue, highland bentgrass, and white clover, was seeded on one of the 75-acre tracts that lay on a slope facing nearly due east. Lot 4, a mixture of standard crested wheatgrass, slender wheatgrass, alta fescue, smooth brome, and white clover, was seeded on the second 75-acre area, which lay on a slope facing north of east. The 20-acre tract facing slightly south of east was seeded to lot 5, Fairway crested wheatgrass. Seeding rates for lots 3, 4, and 5 were 11.5, 10.8, and 15.0 pounds per acre respectively (Table 2).

Just below these three seedings on a bench that faces southeast with a slope of 5 to 10 per cent and on which burns both of light and of heavy intensity (Figure 4) had occurred, 8 plots were laid out, each 0.6 acre with 4 plots in each burn intensity. Three plots in each burn intensity were seeded to beardless bluebunch wheatgrass, smooth brome, and mountain brome. Each plot was sown to a single species at the rate of 16.7 pounds per acre. Two plots in each burn intensity were left unseeded for checks.

At approximately the juncture of the two intensities of burn a nursery was laid out and planted to 52 species and strains to test their suitability for reseeding under these conditions. The species were sown in rows, each species replicated three times (Figure 5).

Lot 1 germinated and became well established in 1940 except in small areas near down logs and pitchy stumps where the fire had burned most intensely. Timothy was by far the most abundant species. White clover failed completely. In 1941 the stand made extraordinary growth, averaging approximately 3½ feet high. Observers estimated that it would have produced 2 tons per acre if cut for hay. Timothy was exceptionally vigorous, some of the heads measuring 8 inches long. Kentucky bluegrass, while a thin stand and quite short, had thickened perceptibly. Crested wheatgrass was beginning to appear in the stand. Here, as in other experimental plantings, the ashes evidently provided more plant food than was available in later years. In 1942, measurements were made of the volume of herbage produced, the number of grass seedlings present, and the number of tree seedlings (Table 2). Timothy produced an average of 804.5 pounds of herbage per acre, Kentucky bluegrass 128.4 pounds, and crested wheatgrass 44.2 pounds, all weights given on an air-dry basis. A total of 977.1 pounds per acre was produced by the species seeded in this mixture (Figure 6). Native forage plants produced 29.2 pounds per acre. No

Timothy did well in good location

Dense grass growth kept out lodgepole

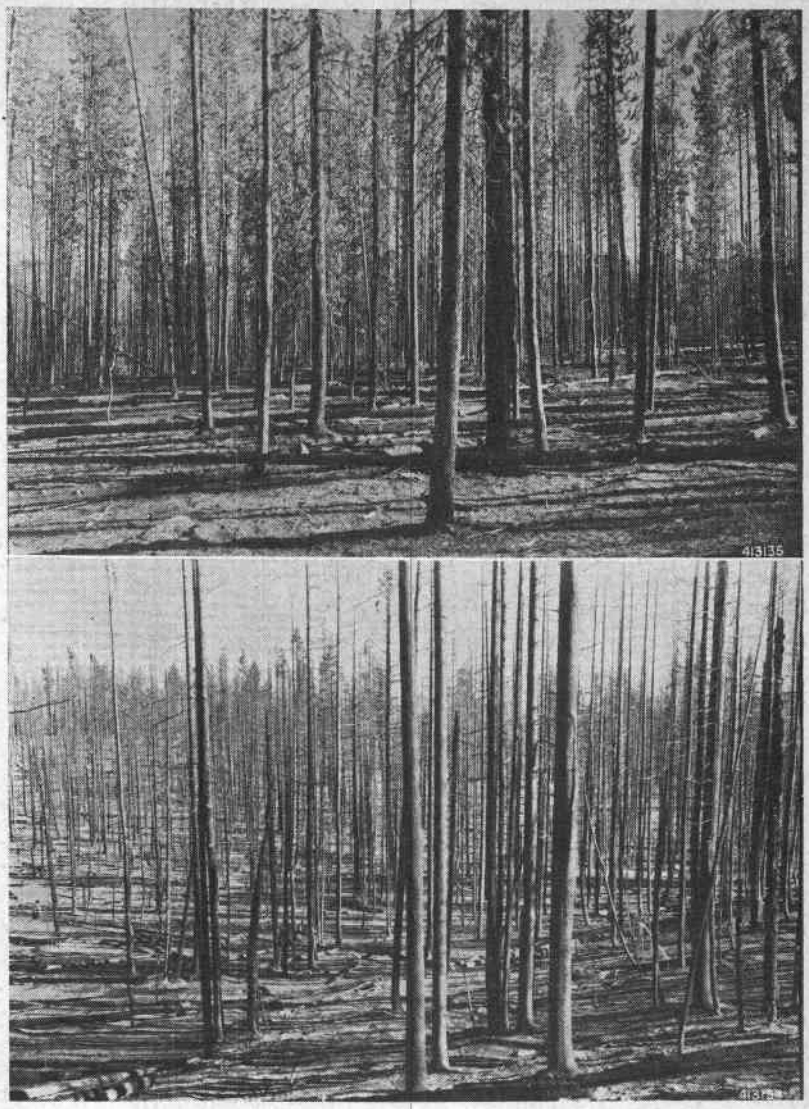


Figure 4. Views illustrating the light and heavy burn intensities that occurred in the Big Cow Creek fire that burned over an extensive acreage of lodgepole pine on the Malheur and Whitman National Forests in 1939. In the upper picture the ground vegetation has been consumed but the needles of the lodgepole pine trees have only been scorched. The trees were exposed to such a hot ground fire, however, that virtually all of those shown in the picture were killed. The lower picture illustrates an extremely heavy burn with parts or all of the lighter branches consumed and virtually all of the seed cones burned. The heavy burned plot was located in the foreground; the light burned was installed in the background where the unburned crowns of trees are showing. The nursery is located midway between the two reseeding plots. Pictures taken in October 1939.

lodgepole pine seedlings were found in the plots on which measurements were made although an occasional seedling may be found growing in small areas where the grass did not become well established in 1941. An average of 279,000 timothy seedlings, 344,000 Kentucky bluegrass seedlings, and 35,000 crested wheatgrass seedlings was found per acre, based on counts made on plots 2 feet square taken at random within the area.

Figure 5. Mr. Jackman and crew seeding the grass nursery. Note the loose, fluffy ash that forms the seedbed for broadcasting or other seeding in a recent lodgepole pine burn. Picture taken in October 1939.

Lot 2 also germinated well and became established quickly in 1940 although not in so even nor so dense a stand as lot 1. Mountain brome with an average height growth of about 18 inches was most conspicuous in the stand although considerable orchardgrass was evident. In 1941 the seeding presented a totally different picture. The orchardgrass had thickened tremendously and averaged between 3 and 3½ feet high. The mountain brome had lost vigor and had thinned its stand. Slender wheatgrass was more in evidence than in 1940 but was greatly overshadowed by orchardgrass. The stand was estimated to produce about 1½ tons per acre in 1941, despite the fact that it was rather spotty. In 1942 measurements of air-

Mountain brome not persistent

Orchardgrass supplanted mountain brome

dry herbage production showed that orchardgrass averaged 520.3 pounds per acre, mountain brome 75.9, and slender wheatgrass 28.0 (Figure 7). White clover was a complete failure. An average of 1,080,000 orchardgrass seedlings, 87,000 mountain brome seedlings, and 3,500 slender wheatgrass seedlings per acre was estimated on the basis of counts made on sample plots (Table 2). The count of lodgepole pine seedlings averaged 174 per acre. The greater abundance of lodgepole pine seedlings than in lot 1 is probably because the establishment of the lot 2 seeding was uneven in 1940 and 1941. The lodgepole pine seedlings were encountered only in places where it was evident that orchardgrass had seeded in naturally after 1940. Within lot 2, 108 pounds of herbage per acre was produced by native range plants.

Thinner grass stands allowed more lodgepole

Figure 6. Stand of timothy, Kentucky bluegrass, and crested wheatgrass seeded on the Big Cow Creek Burn, Malheur National Forest, at an elevation of 5,500 feet. Seeding was done in October of 1939; picture taken August 1942. Supervisor Iler at left, Ranger Harryman at right. The air-dry herbage production of this seeding in 1942 was 977 pounds per acre. Only a few lodgepole pine seedlings have become established, compared with 2,439 established lodgepole seedlings per acre on the burn adjacent to the seeded area. Kentucky bluegrass produced 344 thousand seedlings per acre compared with timothy's 279 thousand. The bluegrass, not very conspicuous, may be the ultimate species dominating the vegetation of this area.

Unseeded range immediately adjacent to lot 2 and resembling it and lot 1 in its burn intensity produced only 36.9 pounds of rather poor quality native forage per acre (Table 2). Lodgepole pine seedlings on the unseeded burn at this location averaged 2,439 per acre. Forty-four seedlings per acre each of white fir and western larch were also found growing with the lodgepole pine. The tree seedlings were thrifty and well established, averaging about 10 inches high, with long terminal shoots. It is evident that the mixtures seeded in lots 1 and 2 reduced the lodgepole pine stand to 7 per cent of what it would have been had the seeding not been made. At the same time, forage produced in 1942 was 26.5 times as much in lot 1 and 17.5 times as much in lot 2 as was produced on the unseeded burn.

Unseeded portion nearly bare of forage for 3 years

Young lodgepole thick on unseeded burn

Both of the foregoing seedings were protected from livestock in 1940. The seedings have been grazed moderately by sheep in the late summers since 1940. Considerable season-long grazing by elk and deer has occurred since the seedlings first became established.

Lot 3 germinated well, but in the absence of a quick-growing species in the mixture, the seedling loss from high soil temperatures and from washing was so great in June 1940 that it was feared the seeding was a complete failure. Only a few fescue and highland bentgrass seedlings could be found in the shade of down logs, in elk tracks, and in other depressions. In 1941, with highly favorable moisture conditions, the seeding had not thickened perceptibly but a rather remarkable stand of seedlings, evidently established from seed carried over two winters in the soil, was noticed.

Slow-growing grasses are heat scalded

In 1942 production in the area was measured. The air-dry herbage production per acre for highland bentgrass was 28.7 pounds, for meadow fescue 29.4 pounds, and for Chewings fescue 14.8 pounds, a total of 72.9 pounds of air-dry herbage from reseeded species per acre (Table 2). This sparse stand of reseeded plants may or may not spread sufficiently to dominate the native vegetation on the seeded area (Figure 8). In 1942 within the seeding 120 pounds per acre of native forage were produced, most of which was pinegrass, a very aggressive plant. The seeding did not affect the reestablishment of lodgepole pine since there was an average of 174 thrifty 2- and 3-year-old lodgepole pine seedlings on the area compared with 145 on a neighboring unseeded, heavy burned plot.

The primary reason for the poor production of reseeded forage is that slow-growing grasses were sown without the protection of a

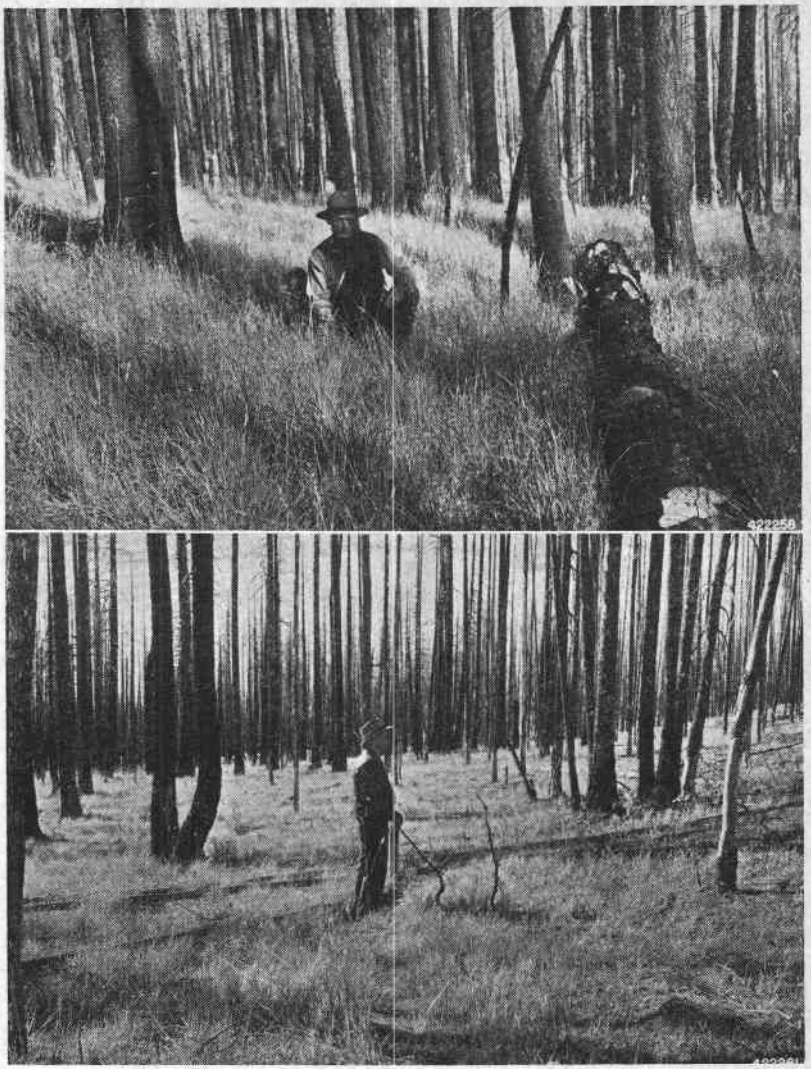


Figure 7. Views taken in August 1942 of orchardgrass, slender wheatgrass, and mountain brome seeded on the Big Cow Creek Burn, Malheur National Forest in October 1939 at an elevation of 5,500 feet. Upper picture shows Ranger Harryman in a typical portion of the seeding. Herbage produced by the seeding in 1942 amounted to 624 pounds per acre (air dry). Orchardgrass produced five times as much as did mountain brome and slender wheatgrass combined. Lower view shows Supervisor Iler standing on the upper boundary of the 1939 seeding. The orchardgrass, which produced 1,080,000 seedlings per acre in 1942, has spread uphill more than a rod from the original seeding. There are 174 lodgepole pine seedlings per acre in the seeding behind Mr. Iler. The unseeded area that he is facing supports 2,439 lodgepole pine seedlings per acre.

faster growing species. If a grass such as tall oatgrass had been included in the mixture, the heavy mortality of fescue and highland bentgrass seedlings from high soil temperature that occurred in the spring of 1940 doubtless would have been avoided, and much harmful erosion would have been prevented. As it is, the fescues and highland bentgrass are showing remarkable qualities of establishment, having spread downhill over an area fully as large as the one on which they were sown. In 1942 erosion on the steep seeded portions had been virtually stopped, while it was still severe on adjacent unseeded hillsides.

Growth poor but erosion stopped

Experience was the same with lot 4 as with lot 3. Although slightly better moisture conditions resulting from the northeast exposure and a generally taller growth habit of the seeded species resulted in a production of 189.5 pounds of air-dry herbage per acre, this area is producing only a fraction of what it should (Table 2). The loss of grass seedlings in June 1940 because of the absence of a quick-growing nurse crop is considered the chief reason for this low production. Traces of highland bentgrass were found in this seeding, evidently from an impure seed mixture. There was also 5.3 pounds per acre of orchardgrass produced, the seed of which may have been included as an impurity or may have been carried into the area on clothing or equipment. Native species produced 52.6 pounds per acre of air-dry herbage.

Bromegrass and fescues need faster company

This seeding may become a successful forage stand. Smooth brome is a tall, rank-growing species and spreads readily by seed and by rootstalks. Alta fescue seems well suited to the site and slender wheatgrass is growing vigorously. Standard crested wheatgrass apparently is the least aggressive of the grasses seeded in lot 4. The low count of 131 lodgepole pine seedlings per acre, evidently because such a severe burn occurred in this particular area, gives the grass a chance to compete with both the native range and tree species. For some reason that can be only conjectural, pinegrass is more plentiful and vigorous within the seeded areas of lots 3 and 4 than on the unseeded areas surrounding them.

Pinegrass likes companionship of other grasses

Lot 5, in which Fairway crested wheatgrass was seeded in a pure stand, was a complete failure. Evidently this grass will not grow at 6,500 feet elevation, for it failed also in the nursery.

Fairway crested wheatgrass hasn't the heart for high altitudes

Lots 6 to 11 were seeded to beardless bluebunch wheatgrass, smooth brome, and mountain brome in pure stands on pairs of small plots, one plot of

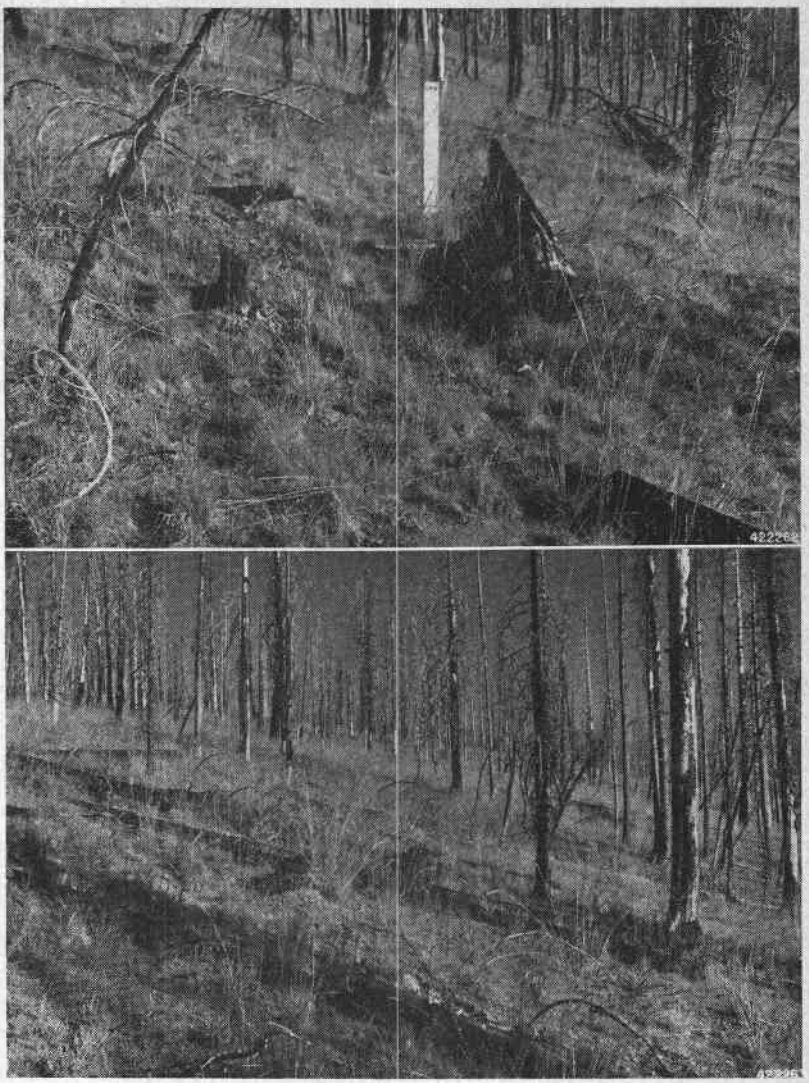


Figure 8. Two views showing the establishment of a mixture containing Chewings fescue, meadow fescue, and highland bentgrass sown on the Big Cow Creek Burn in October 1939 at an elevation of 6,500 feet on the Whitman National Forest. Picture was taken in August 1942. Until 1941 the seeding was thought to be a failure. Now the plants are well established and are growing vigorously, although still in a thin stand. The herbage production from this seeding in 1942 averaged 73 pounds per acre (air dry). Native forage plants produced 120 pounds per acre. There were 174 lodgepole pine seedlings per acre within the seeding, a low number influenced by the severe intensity of the burn, not by the establishment of the grasses.

each pair located in heavy burn and the other in a neighboring light burn. Slope was gentle; direction of slope was uniform on all plots. Because of heavy seedling loss in June 1940, none of the three species resulted in a successful stand. There are several things of interest, however, to note in the results of these seedings (Table 2): (1) beardless bluebunch wheatgrass, like crested wheatgrass, evidently is not suited to the high elevation, since it produced less than one-fifth as much herbage as the two bromes; (2) growing conditions are measurably better for forage plants on light burns than on heavy burns since the species produced from 42 per cent to 88 per cent more herbage on the light burns; (3) conditions on light or moderate burns likewise are better for lodgepole pine reestablishment; the check plots unseeded to grasses produced 145, 2,439, and 2,795 lodgepole pine seedlings per acre respectively on burns of heavy, moderate, and light intensities; (4) highland bentgrass had invaded all of the 0.6-acre plots, meadow fescue had invaded 5 out of 8 of them, orchardgrass 3, and Chewings fescue 2, which gives some indication of the relative aggressiveness of these species (Figure 9).

Native bunchgrass not at home on this range

Highland bentgrass spreads rapidly

Based on these seedings, tentative recommendations can be made for the species to use in seeding recent lodgepole pine burns:

(1) Always include a quick-growing, tall species. Timothy is recommended because of its low seed cost and its vigorous growth performance on these experimental plots. Tall oatgrass is recommended if seed is available.

(2) Do not seed crested wheatgrass or beardless bluebunch wheatgrass at elevations above 5,500 feet. Few of the wheatgrasses do well at high altitudes.

(3) Always include one or several aggressive, long lived grasses in the mixture. Species recommended for the more moist sites are Kentucky bluegrass, smooth brome, orchardgrass, meadow fescue, alta fescue, and highland or Astoria bentgrass. For the drier sites, Chewings fescue, smooth brome (Figure 10), slender wheatgrass, highland or Astoria bentgrass, and orchardgrass are apparently well suited.

(4) Mountain brome is not aggressive enough to include in the mixture, nor is it long lived, although it has some value as a nurse crop.

(5) On the basis of results of the experiment white clover is not recommended for fall seedings on recent lodgepole pine burns, although permanent grass stands will be better yielding if grown with a legume. It is possible that the clover would have succeeded had the

seed been inoculated. White clover is easily killed by shade, and it is doubtful whether it would persist under the conditions of this trial.

Timothy requires a fair amount of moisture to make the best growth, and on very dry sites may fail to provide the most desirable nurse crop for the slower, longer lived grasses. Michels rye is fairly well suited for use as a nurse crop since it germinates readily, stools out rapidly, and quickly attains heights of 3 feet and more in the spring after fall seeding on the ashes of recent burns.* Furthermore, it is reported to withstand grazing better and to maintain its stand longer than other winter rye varieties. In seeding Michels

Use tall grass or Michels rye for nurse crop

Figure 9. Orchardgrass that was an "escape" in the Whitman National Forest reseeding study on the Big Cow Creek Burn. Elevation is 6,500 feet; area was seeded in October 1939; picture taken August 1942. The orchardgrass seed may have been brought into the area in the clothing of range inspectors who had been visiting the seedings on the Malheur Forest 10 miles to the south, as that is the closest point where any orchardgrass was intentionally sown on the burn. On some of the Whitman plots, the escaped orchardgrass averaged as much as 59 pounds of air-dry herbage per acre in 1942. This species is well suited to reseeding lodgepole pine burns. The fine-leaved grass in the left foreground is Chewings fescue, another plant that shows aggressive spreading qualities.

* Young, V. A. 1941. A Promising New Hybrid Grass for Certain Burned-over Forest Lands. Journal Forestry 39: 930:934, illustrated.

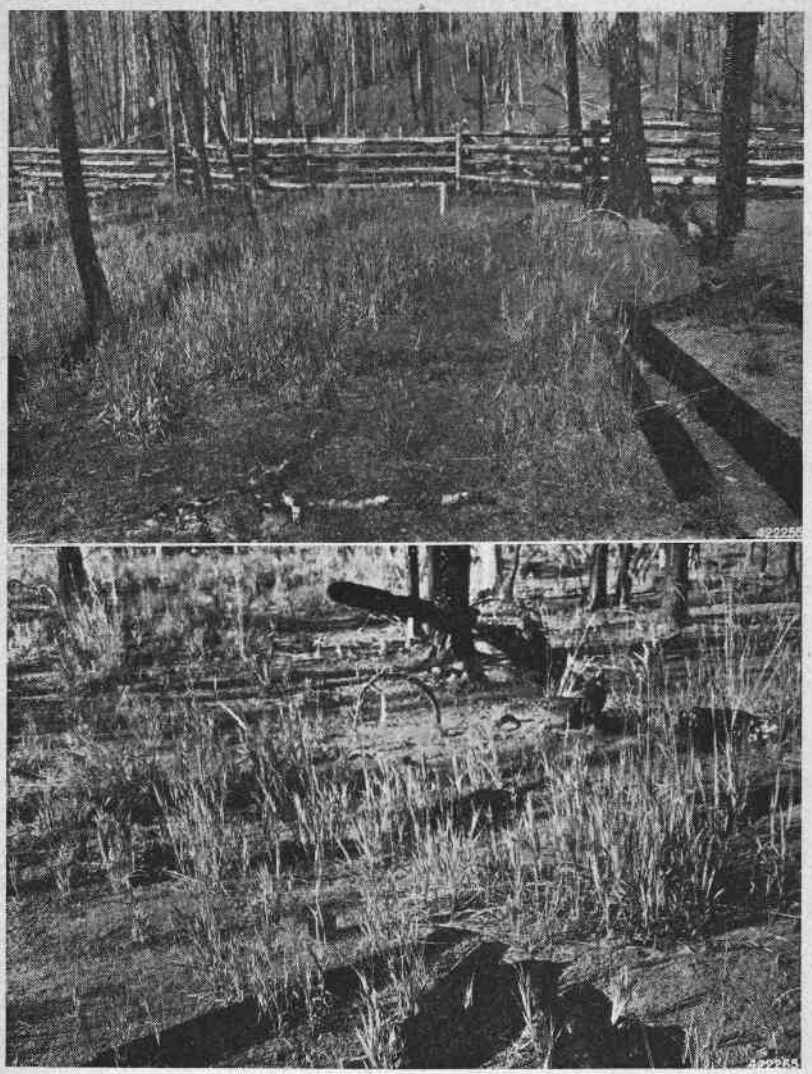


Figure 10. Two views of smooth brome seeded at an elevation of 6,500 feet in the Big Cow Creek Burn on the Whitman National Forest. Seeding was made in October 1939; picture was taken in August 1942. This grass shows promise for reseeding lodgepole pine burns even under dry conditions. The species apparently requires a nurse crop to avoid seedling loss from sun scald the first year. The herbage production from smooth brome grass on the light burn shown in the upper picture averaged 89 pounds per acre air dry. The production on the heavy burn (lower picture) averaged 63 pounds.

rye under these conditions, 8 to 15 pounds of seed per acre is recommended.

Orchardgrass will serve as a nurse crop if seeded rather heavily in the mixture and on a favorable site, but the seed cost is high. Tall oatgrass is ideal as a nurse crop but seed is high priced and not always obtainable.

Undoubtedly better species and more suitable mixtures will be developed for reseeding lodgepole pine burns. The success that was attained in the Big Cow Creek area, however, was enough so that it is safe to say that timely reseeding of burns with proper forage species will check erosion, prevent quick development of the jungle type of lodgepole pine reestablishment, reduce fire hazards, and at the same time provide needed forage for domestic and game animals.

NURSERY TRIALS IN THE BIG COW CREEK BURN

A grass nursery, located on a fairly level bench at an elevation of about 6,500 feet, was planted at the same time that the larger seedings were made. The nursery was near the areas seeded to lots 3 to 11. Purposes of the nursery were:

(1) To try out at this elevation all of the grasses that seemed to offer hope and for which seed was available. Numerous nurseries had already given information about adaptation of species at lower elevations.

(2) To try out new strains of grasses.

(3) To have all of the grasses at one location so that comparative growth and aggressiveness could be checked.

(4) To provide an accessible meeting place where all species could be seen at one time by interested livestock men or others.

(5) To have all species within an area fenced from livestock and big game in order to check length of life, seeding habits, etc., without interference by grazing animals.

Fifty grass species or varieties and two legumes were planted in the nursery in October 1939. Each species or variety was planted in three adjacent rows that were 3 rods in length. Width between rows was 3 feet with a space 3½ feet between species or varieties. Seed was planted by hand in shallow furrows. The seed was furnished by the Bureau of Plant Industry, either from the Pullman Nursery or from Corvallis. Dr. D. C. Smith and H. A. Schoth, both of the Bureau of Plant Industry, aided by furnishing seed. The area was enclosed in 1940 with a log fence approximately 9 feet high. Deer and elk so far have not disturbed the plantings, and there has been no evidence of rodent damage.

In 1940 the nursery appeared to be a failure. The young seedlings came up very thickly in most rows but were largely killed by excessive ground temperatures in June and July. It was not until 1942 that any worth-while results could be reported. By that time practically all of the grasses were either established or else it was evident that they were unadapted. It is very noticeable, however, that most grasses seeded outside of the nursery are more vigorous than those within it. This is probably due to seeding the nursery rows too heavily.

Based on observation 3 years after seeding, the 12 best adapted grasses in order of preference were listed. Preference was based on:

1. Total growth
2. Ability to reseed
3. Ability to spread to other plots
4. Length of pasture season

It is probable that in later years a different alignment could be made with perhaps some species dropped entirely from this list and others added. To date, the species apparently best adapted are listed in order with brief comments as follows:

1. Orchardgrass. Standard market strain.
2. Astoria bentgrass. Runners 2 feet long; filling in between rows.
3. Orchardgrass S-37. A leafy, early growing strain developed in Wales.
4. Chewings fescue. Vigorous; spreading to adjoining areas.
5. Timothy. Vigorous and spreading.
6. Creeping red fescue. Rapidly filling the spaces between the rows.
7. Tall oatgrass. Tallest plants in nursery; beginning to spread to adjacent rows.
8. Mountain brome. One selection reseeding well.
9. Alta fescue. Long pasture season; not so vigorous as at lower elevations.
10. Redtop. Reseeding well; growth short.
11. Blue wildrye. A native grass found at both high and low elevations all over eastern Oregon. Long pasture season; vigorous, but very little seed.
12. Meadow foxtail. Poor stand but excellent vigor; spreading; long pasture season; seeding plentifully.

The conclusions drawn from the nursery trials to date are as follows:

1. Wheatgrasses are not adapted to the elevation of 6,500 feet.

2. As a group, the fescues are outstanding.
3. Orchardgrass is well adapted.
4. Several domestic grasses appear better than the native species.
5. Most bromes are not well adapted to the elevation.
6. None of the common bluegrasses is adapted.
7. A good mixture for burns at high elevations might include:
   a. Orchardgrass
   b. Timothy
   c. Chewings fescue
   d. Astoria bentgrass
   e. Tall oatgrass
   f. Meadow foxtail

Such a mixture would have a quick-growing tall grass of rather short life (tall oatgrass); a quick-growing grass with cheap seed (timothy); a spreading, sod-forming grass (Astoria bentgrass); two grasses adapted to shade (orchardgrass and Chewings fescue); and an extremely early, palatable grass with a very long pasture season and ability to spread (meadow foxtail).

RESEEDING FROM THE AIR

In eastern Oregon there has been some experience in airplane seeding, and a 12,000-acre seeding in Coos County in 1936 showed that the method is practicable for seeding large areas of burned-over land. It is not suitable for meadows, and in most cases it would be too wasteful of seed for use on logged areas.

In Coos County airplane seeding cost 21¢ per acre for the use of the plane, the ground crew, travel, and all expenses except seed. This compares favorably with costs of drilling and broadcasting (pages 14 and 20). It is successful only on clear days with very little wind. When conditions are right, the method is inexpensive, exceedingly fast, and results in uniform spreading of the seed.

The plane used flew at a height of about 500 feet and spread seed in a strip 150 feet wide. It seeded 15 acres per minute at a rate of 8 pounds per acre. As its load was 1,200 pounds of seed, it was necessary to refill the hoppers after seeding for 10 minutes.

To date, most commercial flyers have charged 50¢ or more per acre, but when large acreages are available for reseeding, and when more planes are adapted to this work, it is likely that the cost will be lower than for drill or broadcast seeding. In all cases of large burns, this method should be investigated.

Probably average costs (exclusive of seed) in a normal peacetime year would compare as follows:

Method	*Cost per acre aside from seed*
Drilling	$1.00
Broadcasting	.50
Airplane	.25

It is necessary for a ground crew to mark the line of flight in order to avoid skips. Frequent refilling of the hopper requires the attendance of at least one man at the runway. In times of high labor costs airplane seeding would be far more economical than the other methods because of the enormous acreage seeded per hour.

GRASS SPECIES FOR RESEEDING

So far this bulletin has dealt mainly with where, when, and how to seed. In some respects, however, the most important factor of all is the kind of grass or legume to use. It is certain that time, money, and valuable seed have been wasted in the past by individuals and public agencies through the use of unadapted varieties. The choice of species should be governed by some of the following factors:

1. Elevation
2. Rainfall
3. Depth of soil
4. Kind of soil
5. Shade
6. Competition of other plants
7. Water table
8. Cost of seed
9. Availability of seed
10. Kind of seedbed

Ordinarily, a mixture of species should be used in seeding because the chances of a complete failure are less and also because stock seem to prefer mixed forage rather than a single species. In general the mixtures used should be rather simple. In the case of a uniform site where smooth bromegrass does well, for example, there is no point in spending money for half a dozen other grasses. In cases where shade is a factor, one should use only the shade-tolerant plants, such as orchardgrass and Chewings fescue. At high elevations, naturally only those species should be chosen that do well in short seasons. For each soil, moisture, or other conditions, there are usually several grasses that are suitable.

Use simple mixtures

The moisture supply is the largest single factor to watch in choosing varieties. In eastern Oregon elevation is also important and as a rule the moisture supply increases with the elevation. Crested wheatgrass tends to be supplanted by other higher yielding grasses when the rainfall exceeds 16 inches. Also, crested wheatgrass does not perform so well at elevations above 5,000 feet. Most of our country more than a mile high has more than 16 inches of rainfall. Some of the common grasses are listed below approximately in the order of decreasing drought resistance.

Variety	*Normal price of seed per pound**
1. Crested wheatgrass	$0.17
2. Bearded and beardless bluebunch wheatgrasses	.35
3. Idaho fescue	----
4. Big bluegrass	.50
5. Blue wildrye	----
6. Smooth brome	.20
7. Slender wheatgrass	.15
8. Bluestem wheatgrass	.15
9. Alta fescue	.30
10. Tall oatgrass	.35
11. Mountain brome	.20
12. Chewings fescue	.45
13. Sheep fescue	----
14. Creeping red fescue	.50
15. Highland and Astoria bentgrasses	.55
16. Orchardgrass	.30
17. Timothy	.10
18. Meadow fescue	.14
19. Redtop	.20
20. Kentucky bluegrass	.25
21. Meadow foxtail	.75
22. Seaside bentgrass	.55
23. Reed canarygrass	.30

For dry sites, several of the species at or near the top of the foregoing list can be chosen. For wet sites, species may be selected that are near the bottom. The last three on the list may be seeded in semiswampy land.

Other factors may influence choice of species to reseed. For example, no matter what the moisture supply, crested wheatgrass and bearded bluebunch wheatgrass do not do well at high elevations.

Do not seed crested wheatgrass at elevations higher than 5,000 feet

The fescues, bentgrasses, redtop, orchardgrass, timothy, blue wildrye, and meadow foxtail are all better adapted to high areas because of the heavy snows, short seasons, and frequent frosts. The fescues are especially good for clay soils. The wheatgrasses can be

* Price of seed will vary with temporary scarcities or surpluses. These prices are listed only to show the relative normal differences between the varieties.

expected to thrive on all of the natural bunchgrass lands. The cultivated meadow grasses, such as timothy, Kentucky blue, and orchardgrass, do well on moist, rich meadow soils.

Below are a few suggested mixtures for various summer range locations. In most cases, one or more other adapted grasses can be substituted for any of those listed or can be added to the mixture. One or more of the grasses might also be dropped from the mixture.

	Pounds of seed per acre
1. Sagebrush hillsides or dry meadows	
Crested wheatgrass	2
Big bluegrass	1
Bluebunch wheatgrass	1
Tall oatgrass	1
Normal cost of seed per acre—$1.55	
2. Ponderosa pine logged-off land, low rainfall	
Crested wheatgrass	2
Idaho fescue	1
Chewings fescue	1
Mountain brome	2
Normal cost of seed per acre—$2.00	
3. Yellow pine, logged-off land, good rainfall	
Orchardgrass	2
Tall oatgrass	2
Chewings fescue	1
Kentucky bluegrass	1
Timothy	1
White sweet clover	2
Normal cost of seed per acre—$2.40	
4. Good meadows with deep soil, well drained	
Tall oatgrass	2
Smooth brome	2
Alta fescue	2
Timothy	1
Ladak alfalfa	1
Normal cost of seed per acre—$2.25	
5. Meadows wet in spring	
Bluestem wheatgrass	4
Meadow foxtail	1
Redtop	1
Alsike clover	1
Normal cost of seed per acre—$1.75	
6. High elevation, burned-over land	
Timothy	2
Orchardgrass	2
Chewings fescue	.5
Tall oatgrass	.5
Meadow foxtail	.25
Astoria bentgrass	.25
Normal cost of seed per acre—$1.55	

It is unfortunate that so far we have no suitable legume for large areas of eastern Oregon. A legume ordinarily will double the total forage produced. Because legumes are easily killed by frost heaving, it is unsafe at the elevations of these summer ranges to seed legumes in the early fall. Spring seedings are usually failures because summer drought kills the seedlings before they become established. White Dutch clover sometimes is successful on the better sites. White sweet clover is successful on most of the forest soils if seeded very late in the fall, but it is not a perennial. It did very well on a seeding made on a burn in southern Umatilla County in 1939. Ladak alfalfa will grow with very little moisture, but it is not adapted to meadows that may have a high water table part of the year, and close grazing kills it. Work is now under way with native clovers, new alfalfas, and other legumes, such as lotus, in the hope of developing a legume that is suited to reseeding eastern Oregon summer range lands. All legume seed should be inoculated, especially when seeding burned-over lands where heat may have killed the soil bacteria.

Yes, we have no legumes suitable for wide use

SUMMARY

Summer range in eastern Oregon produces only about two-thirds enough forage to carry the number of livestock during a 4-month summer period that can be grazed on the spring-fall range during the remaining 6 months of the 10-month grazing season. This low-producing summer range results in loss of weight in livestock in the late summer on many of the ranges.

Mountain meadows, alpine grassland, and bunchgrass land that occur in the otherwise timbered Oregon summer range represent only about 15 per cent of the total acreage but potentially could produce nearly half of the summer range forage.

If these forest openings can be brought back to their potential forage production, the grazing capacity of eastern Oregon's spring-fall and summer range can be balanced, to the great benefit of the range livestock industry.

About 500,000 acres of the open summer range types in eastern Oregon can best be restored to their former productiveness by reseeding.

Reseeding seems practicable on the following types of range:

1. Mountain meadows or other grasslands where perennial forage plants have been almost completely killed.
2. Skid roads and slash burnings on logged-off pine lands.
3. Recent burns in lodgepole pine areas.

Reseeding by use of a grain drill is the most effective method when ground conditions and accessibility will permit. The seedbed should be firm for drilling. The V-trenches cut by the drill should be 1 to 1½ inches deep with the seed covered about ½ inch. Drilling, even on gentle slopes, should be at right angles to the drainage. Drill rows should be relatively close together for bunchgrasses, wider for species that spread by underground rootstocks. Drilling should be done in the fall preferably just before late fall rains begin. Drilling is successful with 5 pounds of seed per acre. Costs of drilling including seed, labor, equipment, and ground preparation, and fencing if required, range approximately from $1.75 to $3.50 per acre.

Broadcasting is necessary on areas too steep, rocky, or brushy to drill successfully. Broadcasting requires some ground preparation to insure planting seed properly except in the case of seeding soon after lodgepole pine burns or on disturbed soil, such as skid trails, where the seedbed preparation already is adequate. From 8 to 16 pounds per acre should be broadcast except when seedbed and germination conditions are ideal, as in the case of skidded or burned areas. Here the quantity of seed sown may be reduced to 3 to 5 pounds. Except on burns and skidded areas, the seed that is broadcast should be covered. Covering may be done by trampling with livestock or by harrowing or disking. Costs of broadcasting, depending on quantity of seed used and the extent of ground preparation and seed covering practiced, can be expected to vary from $1 to more than $7 per acre. Best results are obtained by broadcast seeding in the fall before the late fall rains.

Drilled crested wheatgrass on a dry meadow in Logan Valley produced 70 times more herbage per acre than the native plants that were present before the seeding. Broadcast Kentucky bluegrass and timothy on a severely depleted bunchgrass range at Bear Wallow produced from 5 to 44 times more herbage per acre than the native plants. Broadcast smooth brome, crested wheatgrass, and Kentucky bluegrass on Middle Creek Meadows were from 5 to 15 times more productive than was the native vegetation.

Reseeding lodgepole pine burns to forage species should be done soon after the fire has been extinguished to take advantage of the optimum seedbed condition and plant food supply. From 3 to 5 pounds of mixed seed per acre should be broadcast on burns. Solid coverage always should be made when seeding burns in order to avoid alternate strips of grass and lodgepole pine "jungle" when the seeding is established. A quick-starting, tall growing grass or cereal should be included with the seed mixture to keep the slower-developing, longer lived grasses from being killed in the seedling stage by

excessive surface soil temperature and soil erosion. The quick-starting species is the chief agent to control the establishment of lodgepole pine seedlings. Reseeding lodgepole pine burns can be expected to cost from about $0.80 to $2.65 per acre. Cost should average about $1.80 per acre.

Species that were found to be well adapted to reseeding lodgepole pine burns are: timothy, orchardgrass, Kentucky bluegrass, alta fescue, meadow fescue, Chewings fescue, highland bentgrass, smooth brome, and slender wheatgrass. In addition, nursery trials indicated that Astoria bentgrass, creeping red fescue, tall oatgrass, redtop, blue wildrye, and meadow foxtail are also well adapted to seeding lodgepole pine burns at high elevations. The Standard and the Fairway varieties of crested wheatgrass do not seem to be well adapted to this type of reseeding. Mountain brome is not aggressive enough to hold its place in the established stand. White clover is not recommended for fall seeding on lodgepole pine burns.

Broadcasting mixtures of Kentucky bluegrass, crested wheatgrass, and timothy, and of orchardgrass, mountain brome, and slender wheatgrass on a lodgepole pine burn on the North Fork of the Malheur River produced from 17.5 to 26.5 times more herbage and reduced the number of lodgepole seedlings 93 per cent in comparison with the surrounding unseeded burn.

Mixtures of Chewings fescue, meadow fescue, and highland bentgrass, and of alta fescue, smooth brome, and slender wheatgrass broadcast on an area at a higher elevation in a heavy burn and without a nurse crop failed to establish soon enough to prevent lodgepole seedling encroachment or to arrest harmful erosion. By the end of the third year, however, stands were fair and erosion had stopped on the seeded portion while it was still severe on adjacent, unseeded hillsides.

Intensity of the burn greatly affects lodgepole pine seedling establishment. Counts on unseeded areas revealed an average of 2,795 lodgepole pine seedlings per acre on light burns, 2,439 per acre on moderate burns, and only 145 per acre on burns of heavy intensity.

Growing conditions for grasses are indicated to be better on light than on heavy burns. Beardless bluebunch wheatgrass, mountain brome, and smooth brome on heavy burns produced only from 45 per cent to 71 per cent as much herbage per acre as they did on light burns.

Species well adapted to reseeding Oregon summer ranges include: crested wheatgrass, slender wheatgrass, bluestem wheatgrass, bearded and beardless bluebunch wheatgrass, smooth brome, moun-

tain brome, tall oatgrass, big bluegrass, Kentucky bluegrass, timothy, orchardgrass, alta fescue, meadow fescue, meadow foxtail, Chewings fescue, creeping red fescue, highland bentgrass, and Astoria bentgrass. Mixtures of seed of several species ordinarily should be sown for best results either in drilling or broadcasting.

COMMON AND BOTANICAL NAMES OF SPECIES DISCUSSED

Alta fescue	*Festuca elatior arundinacea*
Astoria bentgrass	*Agrostis tenuis*—var. *astoriana*
Bearded bluebunch wheatgrass	*Agropyron spicatum*
Beardless bluebunch wheatgrass	*Agropyron inerme*
Big bluegrass	*Poa ampla*
Bluegrass	*Poa* spp.
Bluestem wheatgrass	*Agropyron smithi*
Blue wildrye	*Elymus glaucus*
Bulbous bluegrass	*Poa bulbosa*
Cheatgrass brome	*Bromus tectorum*
Chewings fescue	*Festuca rubra commutata*
Creeping red fescue	*Festuca rubra*
Crested wheatgrass	*Agropyron cristatum*
Douglas fir	*Pseudotsuga taxifolia*
Fireweed	*Epilobium angustifolium*
Groundsmoke	*Gayophytum* spp.
Highland bentgrass	*Agrostis tenuis oregonensis*
Kentucky bluegrass	*Poa pratensis*
Lodgepole pine	*Pinus contorta latifolia*
Manzanita	*Arctostaphylos* spp.
Meadow fescue	*Festuca elatior*
Meadow foxtail	*Alopecurus pratensis*
Mountain brome	*Bromus carinatus*
Orchardgrass	*Dactylis glomerata*
Pinegrass	*Calamgrostis rubescens*
Ponderosa pine	*Pinus ponderosa*
Red clover	*Trifolium pratense*
Redtop	*Agrostis alba*
Reed canarygrass	*Phalaris arundinacea*
Sagebrush	*Artemisia* spp.
Seaside bentgrass	*Agrostis palustris*
Sheep fescue	*Festuca ovina*
Slender wheatgrass	*Agropyron trachycaulum*
Smooth brome	*Bromus inermis*
Snowbrush ceanothus	*Ceanothus velutinus*
Tall oatgrass	*Arrhenatherum elatius*
Timothy	*Phleum pratense*
Western larch	*Larix occidentalis*
Western white pine	*Pinus monticola*
White clover	*Trifolium repens*
White fir	*Abies concolor*
White sweetclover	*Melilotus alba*
Winter rye	*Secale cereale*