

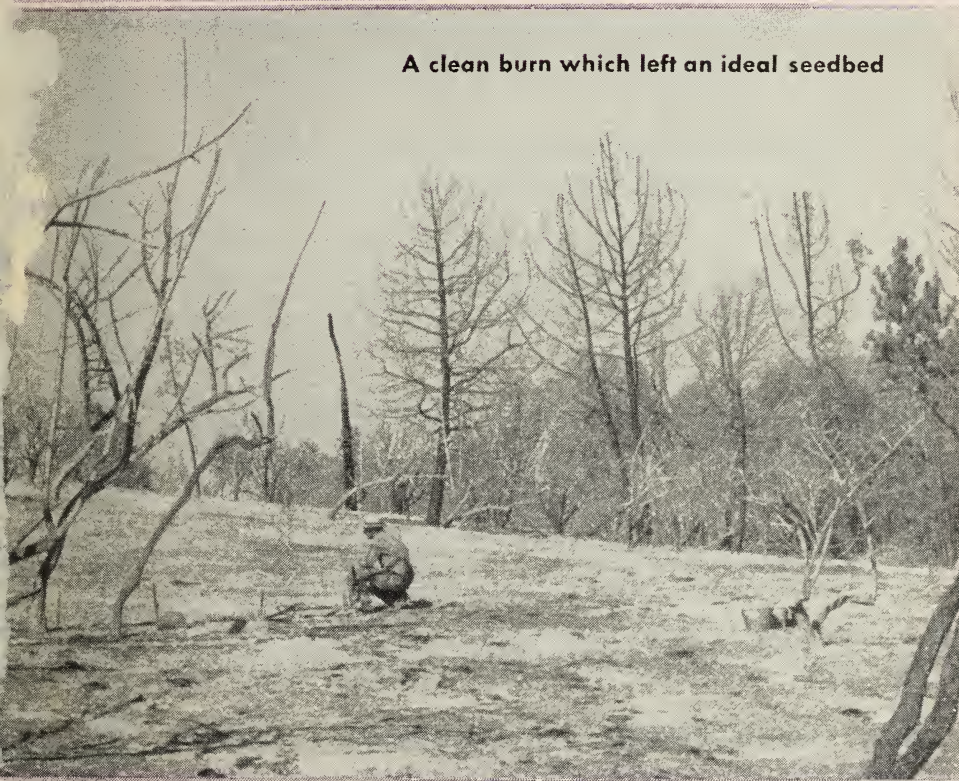
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IMPROVING CALIFORNIA BRUSH RANGES

R. MERTON LOVE and BURLE J. JONES

A clean burn which left an ideal seedbed



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MORE MEAT... MORE WOOL...

can be produced in California if adaptable brushlands are cleared and converted into pasturage for cattle and sheep.

- Many promising areas have, at present, only limited grazing usefulness. For the rancher who wishes to increase production and whose land warrants brush clearing, "Improving California Brush Ranges" presents information on removal of brush; methods of seeding cleared areas; and grazing management practices to improve and maintain feed on newly opened ranges.

MORE GRAZING LAND WILL INCREASE CALIFORNIA'S MEAT AND WOOL CROPS

- There are between ten and twenty million acres of brushland in this state. Not all of this can profitably be cleared, but large areas can be made to support additional stock.

IN 1946, RANCHERS IN 29 COUNTIES CLEARED 60,000 ACRES BY CONTROLLED BURNING OF BRUSH

- Any brush clearance project must be well planned if it is to succeed. The place, the time, the method—all these are important. If fire is used to clear land, the work must be done under permit from the State Division of Forestry.

Seeding cleared areas to forage plants and controlled grazing to establish and protect grasslands are both essential steps in an effective brush-control program.

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IMPROVING CALIFORNIA BRUSH RANGES

R. Merton Love¹ and Burle J. Jones

WELL-PLANNED PROGRAMS of brush removal by individual ranchers can change certain adaptable California brushlands into valuable grasslands that produce greater crops of meat and wool.

The removal of brush is merely the first step in any sound, long-term range-improvement plan. Just as important, if the program is to be worth the stockman's time and money, are seeding of cleared lands with forage grasses and legumes (when natural growth is not enough to provide pasturage) and planned range management, to prevent ill-timed grazing or overgrazing.

Each year between 50,000 and 100,000 acres in California are burned over to destroy the brush. In 1946, brush was burned, under permits from the State Division of Forestry, by individuals or groups of ranchers in 29 counties. These were: Amador, Butte, Calaveras, El Dorado, Humboldt, Lake, Madera, Mariposa, Mendocino, Monterey, Napa, Nevada, Placer, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Siskiyou, Sonoma, Tehama, Trinity, Tulare, and Yuba. The territory included about 60,000 acres with widely varying conditions of elevation, soil, brush species, and rainfall. This indicates the wide interest in this phase of range improvement.

This circular considers the three general steps of a range improvement program: (1) Removal of brush; (2) revegetation of cleared areas; (3) control of grazing.

Step One: REMOVAL OF BRUSH

The first phase in a brush-removal program involves the following:

1. Choice of suitable areas, where soil fertility, topography, and rainfall offer support for forage growth on cleared lands.
2. Proper clearing of the land through fire alone to clear rough, steep slopes; or use of machinery to knock down and pile brush, followed by fire to destroy it, on more level and easily tilled areas.
3. Reburning of cleared lands at intervals to keep the brush from covering the areas again.

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Fig. 1—Attempted burn April 3, 1942, east of Santa Ana, Orange County. Burning at the wrong time of year often results in a very spotty kill of brush. (Photographed April 16, 1942)

Where to Remove Brush

According to Forest Service data,³ California had, in 1946, from ten to twenty million acres of chaparral and wooded grasslands of which large areas were of little or no value for stock grazing. Some of the acreage has already been converted to pasture, but not all brushlands can be profitably cleared. Many areas are too rough and steep to be cleared, or have insufficient fertility and rainfall to support forage crops even if brush were to be removed.

Choosing the Area. Soil and topography are the two most important factors in determining whether to remove brush from a given area. The rancher's decision to clear brush should be based upon a thorough examination of the area.

Dense stands of tall brush usually indicate a moderately fertile soil capable of supporting a grass cover. If pasturable plants are found as remnants in the brush, or if they are growing well in the open spaces, then the entire area is likely to have equal value for producing feed if cleared. (The information in table 5 on the types of forage plants should be helpful to the rancher here.) Perhaps enough seed of perennials is present so that artificial seeding will be unnecessary. If there is little or no feed within the area, natural revegetation

³ Wieslander, A. A., and H. A. Jensen. Forest area, timber volumes, and vegetation types in California. California Forest and Range Experimental Station, Forest Service Survey Release 4. March 1, 1946.

may not be adequate the first winter after the brush is removed, and seeding should therefore be planned.

A given area may include shallow, sterile soils on one slope and deeper, fertile soils on another. Since it is not always economic to clear only the favorable spots, the over-all picture must be considered in choosing lands for clearing—balancing the probable total gain in feed resources against the cost of clearing and the possible damage by soil erosion following brush removal.

How to Remove Brush

Brushland is cleared in two ways: by fire alone, or by a combination of tools and fire.

The use of chemicals is now being investigated as another means of killing brush and controlling sprouts and seedlings. New materials and methods for chemical control are being developed so rapidly that no accurate appraisal of results is yet possible. Current developments will be available from the county farm advisors.

If the land is rough or steep it is usually cleared by the cheaper method of burning. Good soils and arable land justify the costlier method of using tools to uproot the brush before it is destroyed by fire. This is preferable because a more complete destruction of brush by fire is possible where tools are used.

Fig. 2—Grass plots seeded September 27, 1946, in a clean burn near North Fork, Madera County. Same site as cover picture. The white stake marks the third plot from left. Sixty acres of recommended mixture were seeded by owner. (Photographed June 6, 1947)





If the full potential of this project is ever to be realized, it must be raised to a plane of careful, progressive, coöperative planning and execution by which to win public approval and legal and financial support. It is only through community, county, and state coöperation and a demonstration of efficiency and good faith that this problem can be solved with due respect to public safety and property rights.

Use of Fire Alone. When the rancher has determined that fire alone is to be used to clear a chosen area, he must plan the operation carefully. Details should be worked out in accordance with requirements and suggestions from the representatives of the State Division of Forestry.

The first step is to obtain, from the local State Forest Ranger, a permit to burn at a stated time and place.

The second is to cut and clear a firebreak, by removing the brush in a strip around the area to be burned. The ranger must approve this firebreak.

It is customary for the rancher to enlist the help of neighbors, if possible, or to employ other persons, to guard against the spread of flames past the firebreak. There should be plenty of guards at the fire.

Detailed instructions on burning are not included in this circular, as varying conditions must govern the procedure, and directions are set forth by the forest ranger to cover each case.

Usually the local forest ranger, who has had experience in fire fighting, decides when conditions are suitable for burning off the area, and sets the actual date. This does not mean, under the law, that he will assume any responsibility for accidental damage to adjacent property from the fire. *Responsibility rests with the person to whom the permit is issued.*

A period of high temperature and low humidity is the most favorable for



Fig. 3—Brush burning trial in Nevada County. General view showing the distribution of the brush. (Photographed May 15, 1946)

a hot, clean burn, although such weather adds to the chances that the fire may get out of control. With high humidity, on the other hand, the burn may be light, patchy, and unsatisfactory. In dense stands of brush the understory (ground cover) of grass and weeds is usually either scanty or absent, so that the shrubs themselves must be depended on to carry continuous and killing flames. Depending upon local conditions, the burning is done some time during the late summer months.

In some counties, it has been done after the first fall rains or in the early spring, because the fire is less likely to get out of control (fig. 1). This practice has not been satisfactory. The burn is incomplete and the vegetation that later covers the area is often made up of summer weeds, which delay the growth of pasturable plants. In contrast, a burn at the time of year the brush is inflammable consumes most of it and leaves a good ash that is an ideal seedbed (see cover picture).

Mechanical Method, Followed by Fire. An increasing amount of brush clearing is being done by bulldozer; or by a steel rail used to dislodge the standing brush.

The best tool for breaking down brush is the bulldozer, with the blade held 10 to 12 inches above the ground to prevent disturbance of the soil. By first crushing down the brush, so that it is compacted and partially dried, a cleaner burn is secured.

It is necessary to obtain a permit for burning an area cleared in this manner, and to work out details with the forest ranger, just as when fire alone is used. The usual firebreaks also must be provided, although the use of machinery does away with, or at least reduces, the fire danger. The flames from piled or windrowed brush are more easily controlled than those from standing brush.

This dual method has been successfully used in Santa Barbara County. In

an area where chamise⁴ and other sprouting forms of brush predominated, the brush was removed with a bulldozer and pushed into windrows. After these had been burned, the roots were dug up with a machine developed for the purpose. These in turn were pushed into windrows by a bulldozer with heavy teeth, which moved the roots with very little soil disturbance. When the roots had been burned, the land was ready for plowing. After a year in vetch and oats, or Sudan grass, the land was again plowed to destroy brush seedlings and was then in condition for seeding to a permanent pasture of grasses and legumes. The cost per acre for the entire operation, at wartime prices in 1944, was \$25.00. This comparatively high cost was justified, because the soil is productive.

In Monterey, San Bernardino, and some other counties, another combination of tools and fire is used to eliminate crown-sprouting chamise and other brush. Brush on the firebreaks is broken down and burned early in the season, before the standing brush becomes too inflammable. In these counties bulldozers are used to break the standing brush; after this has been burned, the roots are turned up with a heavy disk plow. A heavy rake, similar to a bull rake, is used to pile them together in windrows, where they are burned. The land is then generally seeded to grain. A plowing after the grain is harvested, as grain or as hay, serves to kill out brush seedlings. After one or two crops of grain, the land is seeded down to pasture. The cost of knocking down the brush for burning will run from \$3.00 to \$15.00 per acre. The total cost of one extensive operation in Monterey County was \$15.00 per acre where the cover was practically all brush. With a cover of 35 per cent oaks the cost rose to \$28.50 per acre.

Similar practices were used on a demonstration area in Nevada County, except that range plants were to be seeded in the ash immediately after burning. Figures 3 and 4 illustrate the mechanical operations. When the brush is knocked down in place, the resulting burn, with even distribution of ash, forms an ideal seedbed.

Before starting on a brush-clearing program involving tools, it would be wise to visit ranches where effective equipment and methods have been developed.

Reburning Aids Brush Control

For effective control of sprouting brush, two or more fires appear to be essential unless machinery is used. Some time between three and five years after the first burning for brush removal, the area may require reburning, as brush can become reestablished within such a period.

Method of Reburning. On a repeat burn, most satisfactory results are secured from a continuous ground fire. The area should be left ungrazed the year it is to be reburned, as a good mat of dry grass will carry an effective ground fire and is the best known means of doing a good job. Though such a fire

⁴See appendix for common and scientific names of shrubs, legumes, grasses, and herbs mentioned in this circular.



Fig. 4—Same field as in figure 3. Above, close-up showing the brush knocked down and left in place. The result is an even distribution of the ash after the dried brush is burned. Below, equipment used for knocking down brush. The blade of the bulldozer has been raised in order to turn around. Note the soil has not been disturbed. (Photographed May 15, 1946)



Fig. 5—Regrowth of manzanita five years after burn. Grass is still present in the plots seeded in the ash in the fall of 1937, but the area should have been reburned in 1940 or 1941. Pope Valley, Napa County. (Photographed June 9, 1942)

should be amply protected to keep it from escaping, it is less risky than the original burning of either standing or bulldozed brush. A permit for burning must be obtained from the forest ranger.

Reburning two or three times at three- to five-year intervals will neither greatly reduce the annual plants nor seriously injure perennial grasses and legumes. An area to be reburned in the fall should not be grazed until the following summer, after the perennial grasses have matured their seeds. This results in more total feed, and a thickening of the stand of grasses.

It has been found that if the burned brush is largely of the sprouting type, such as chamise and certain species of manzanita, sprouts will emerge from the crowns the year after the first burning. *Only in a very hot fire will the crowns be entirely killed.* The nonsprouting forms will have cast an abundant crop of seeds and some of these, such as wild lilac (*Ceanothus*) and mountain balm (*Eriodictyon*), will germinate readily after a burn.

The sprouting forms will generally begin to produce seed by the third year, and seedlings from both sprouting and nonsprouting forms will produce seed by the fifth year. A good ground fire in a second burning should destroy the seedlings that have come up since the original fire. It will also kill the crown sprouts and further weaken the roots and crowns of the sprouting shrubs.

Goats have often been used to complete the eradication of brush by browsing upon young sprouts. Even cattle and sheep relish the shoots of many species.

Desirability of Reburning. Failure to reburn may result in economic loss, as a case in Napa County illustrates. In 1937 a small area in that county with a dense cover of manzanita was burned. A trial plot of grasses and legumes was seeded in the ash that same fall. Many of the species did very well. In 1941, however, it was evident that the encroaching manzanita seedlings should be reburned if the seeded plants were to survive. Since this was not done, the benefits of the first burning were lost through regrowth of manzanita (fig. 5).

The value of reburning, on the other hand, was demonstrated on a ranch north of Hopland in Mendocino County. The brush here included chamise, wild lilac, cascara, manzanita, scrub oak, and toyon. There was a sparse cover of pinegrass, purple stipa, and foothill stipa as well as a number of other perennial grasses including certain fescue grasses (*Festuca* spp.), perennial bluegrasses (*Poa* spp.), and melic grasses (*Melica* spp.), and a good population of annuals.

The ranch consists of 3,000 acres, 100 of which were burned in 1937. In 1941 these 100 acres were reburned, with an additional 50 acres of new burn. Figure 6 shows the stand of foothill stipa in this area in 1942. Pinegrass invaded the poorer soil sites. The ranch now grazes 900 to 950 ewes, their lambs, and an undetermined deer population. It must be emphasized that brush burning was only part of the conversion from brush- to grassland. Ten years ago the range was divided into only two fields. Now, in the 3,000 acres, there are seven fields with stock-watering facilities well distributed in each. Grazing management, except for the deer, is well regulated.

Fig. 6—Volunteer recovery of grasses one year after a reburn near Hopland, Mendocino County. A coin envelope is at the base of a foothill stipa plant. (Photographed June 12, 1942)



Fig. 7—Grass plots seeded December, 1944, immediately after a burn near Kelsey, El Dorado County. This hillside was covered with manzanita and poison oak. Plot at left is domestic ryegrass; at right, tall oatgrass. Note the absence of volunteer plants in the strip between plots. (Photographed July 10, 1945)



Step Two: REVEGETATION OF CLEARED AREAS

The second phase of range improvement by brush removal is revegetation. The following considerations largely determine the success of any revegetation plan:

1. Examining the area (before burning) to determine whether artificial seeding will be needed to establish a forage crop. (See table 5.)
2. Choosing the best methods, time of planting, mixture and amount of seed, if artificial seeding is necessary.
3. Selecting the proper species of forage plants for the zone in which the cleared land is located. (Zone map on p. 25.)

Artificial Seeding May Be Necessary

Before an area is burned over, a careful examination should be made to determine whether artificial seeding will be necessary. In many places seed of forage grasses and legumes must be planted to provide pasturage on the burned-over areas.

As stated earlier, dense stands of tall brush usually indicate a moderately fertile soil which can support a grass cover. Where such stands have been removed, remnants of both annual and perennial grasses and of weedy species



are likely to be sparse. During the first year, while seeded plants are establishing themselves in these areas, there is little or no competition (fig. 7) from established growth such as interferes with seeding on open range.

Artificial seeding in burns is best done on a spot basis, not over the entire area. In open spaces where, before the fire, there was no coverage except grass or sparse brush, seeding is not likely to be successful.

In any operation that is not to be continuous over the whole area, best results will come from seeding on the less exposed slopes and the deeper soils.

Natural Seeding. It may well be that sufficient seed of perennials is present in the brush so that artificial seeding is unnecessary.

An example of this condition was observed on a range in Orange County. On this range of 1,000 acres no pasturage was available for cattle, because they would not go through dense brush (fig. 8) to harvest scant feed growing there or even to reach the more liberal feed growing in open spaces. After the brush was burned, in the fall of 1942, recovery of bunch grass was almost immediate. In many places, including hillsides as well as swales, the grass reached a height of 3 feet (fig. 9). There was no evidence of soil erosion, and the 1,000 acres now carry 300 cattle for 7 months of the year.

Low-growing shrubs such as wild buckwheat (*Eriogonum* sp.) usually have a good understory of grasses and herbs, so that these areas may be expected to bear a good natural cover the first year after burning.



Fig. 8—Field on El Toro Ranch, Orange County, indicating density of brush before burning. Such a stand of brush usually indicates a moderately fertile soil which can support a grass cover. There are many stipa plants under the brush but these are not available to livestock. (Photographed April 30, 1943)

An accidental burn of this type of brush near Temecula in Riverside County was observed in 1941, the year after burning, and in subsequent years. An excellent stand of forage came up after the first fall rains. According to conservative estimates, the burned area produced more than twice as much feed as the unburned portions of the range. This grass defended the slopes perfectly against erosion, although the soil there is highly erosible and the first winter after the fire was one of unusually heavy and severe rainfall. The essential point is that in this stand of low shrubs there were ample remnants of annual and perennial forage plants to revegetate the entire area naturally.

Artificial Seeding. There were 600 test plots seeded from 1937 to 1946 in 44 California counties by the Agricultural Extension Service and the Division of Agronomy. A number of these were seeded in the ash of brush burns. In

addition to the test plots, a considerable number of acreage seedings in brush burns were observed.

Judging from the tests and observations in burned areas, the ash of a heavy brush burn is an ideal medium in which to plant seed. Where the annual rainfall is such that the sown plants can survive dry summers, such seeding is successful. The ash of *grass* burns is *useless* as a seedbed.

Some trial plots have been subjected to a series of detailed observations for a period of three or four years. In Mendocino County near Yorkville, a landowner had been seeding a mixture of ryegrass, Harding grass, and orchard grass in brush and timber ash. On October 18, 1943, the writers seeded a test plot of grasses and legumes on the ash on a southerly exposure. The plots were not fenced and received the same grazing treatment as the remainder of the range. Table 1 gives details of the recorded data. Notes were taken the first year after seeding, in February, April, and July of 1944; in June of the second and third years; and in May of the fourth year. The first year results obtained here, as elsewhere, demonstrate the slow initial development of the seeded

Fig. 9—Volunteer recovery of foothill stipa after brush burn on same field as in figure 8. (Photographed April 30, 1943)



Table 1

EXAMPLE OF NOTES TAKEN ON TRIAL PLOTS NEAR YORKVILLE, MENDOCINO COUNTY, SEEDED OCTOBER 18, 1943

Species and key no.	February 25, 1944		April 12, 1944		July 17, 1944		June 10, 1945		June 10, 1946		May 16, 1947	
	Stand*	Height inches	Stand*	Height inches	De- velop- ment†	Height inches	Stand*	Height inches	Stand*	Height inches	Stand*	Height inches
Tall oatgrass, 6.....	FG	1-3	FG	3-7	R, Gn	VG	48	VG	48	VG †	36	Fl
Tall fescue, 8.....	FG	1-3	FG	3-6	R, Gb	G	36	G	24	G	24	H
Annual ryegrass, 13.....	G	2-6	VG	6	R	G	20	G	24	G	20	H
Perennial ryegrass, 14.....	G	2-6	VG	6	R, Gb	G	24	G	18	G	18	H
Birdsfoot trefoil, 16.....	G	1/2-3	G	2-4	Fl	G	8	P	8	FG †	16	Gn
Alfalfa, 17.....	G	1	G	2-3	Gn	F	4	P	6	FG	10	Gn
Bur clover, 20.....	F	1-2	F	2	R, D	P	6	P	6	P	6	Fl
Smilo, 26.....	F	1	F	2-4	Fl	FG	30	G	30	FG	10	Gn
Harding grass, 28.....	G	1-3	G	2-6	R, Gb	FG	24	FG	24	FG	8	Gn
Burnet, 30.....	F	1-3	F	3-5	R, Gb	G	38	G	12	F	6	Fl
Nodding stipa, 34.....	F	1-2	F	6	R, Gb	G	30	G	30	G †	24	Fl
Purple stipa, 35.....	F	1-2	F	6	R, Gb	F	24	F	30	FG	24	H
Subterranean clover, 56.....	G	1-2	G	6	R, D	G	12	G	12	G	15	R, Gb
Sweetclover, 61.....	G	1-2	G	3	Gn	0	..	0	..	0
Orchard grass, 63.....	G	2-5	G	6	R, Gb	G	10	G	10	G	12	Fl

* Stand: VG = very good; G = good; FG = fairly good; F = fair; P = poor; 0 = no plants found.
 † Development: R = ripe; Fl = flowering; H = heading; Gn = green; Gb = green at the base; D = dead or dry.
 ‡ Grazed closely by rabbits.
 § Spreading.

perennial grasses and legumes. In some plots there was a grass burn rather than a brush burn, and significantly, on such sites the stand of seeded species was much poorer than on the brush ash. The plants were not strong and sturdy. This statement applies particularly to smilo, Harding, and the stipas. The plots were four years old at the last reading, and, as will be seen from the last column of table 1, a good mixture of grasses and legumes can be made up of those that succeeded. Subterranean clover was the outstanding legume.

On a more favorable site near Comptche in Mendocino County, a series of similar plots was broadcast in the fresh ash of a brush burn in the fall of 1944, and still another series in the fall of 1945. Notes have been taken each year in June. No field was grazed until the July after seeding. Figure 10 shows the growth of orchard grass and Harding grass in these plots the first June after seeding, just before cattle were turned into the field.

Test plots seeded in December, 1944, on a burn near Kelsey in El Dorado County have been observed for three years. This site has an elevation of about 2,300 feet, and an average annual rainfall of 40 inches. At the last observation in May, 1947, the results indicated that tall oatgrass, smilo, California oatgrass, the ryegrasses, Harding grass, burnet, the stipas, and orchard grass are well adapted to that area. Stands of alfalfa and subterranean clover (now often called "subclover" in the seed trade) were improving.

Methods Used in Artificial Seeding

Planting the Seed. Seed can be broadcast by hand, by the use of a breast seeder, by an endgate seeder (if the topography and brush stumps will permit its use), or by plane. The method chosen will depend on the type of area involved and the complexity of the seed mixture to be planted.

Whichever method is chosen, preliminary tests should be made with a given amount of seed over a measured area, to determine the proper distribution of the seed. Adjustments can then be made so that seeding is done at approximately the desired rate.

Time of Planting. The seed should be sown as soon as the ash has cooled after burning. Otherwise both wind and dew pack the ash so that the seed remains above it instead of being covered by it. Seeding should be done before the first fall rains have compacted the ash. No covering is necessary.

Seed Mixtures. Annuals grow and mature on winter moisture at shallow depths. The roots of perennial grasses and legumes, however, extend more widely and deeply, so that most range areas will support permanently only sparse stands of them. The problem is one of moisture limitation. Probably an ideal average composition of range forage would be made up of sparse stands of perennials, with the spaces filled by desirable annuals.

It is not wise to limit the opportunity of establishing long-lived perennials by mixing the seeds of perennials with heavy seedings of fast-growing annuals

such as ryegrasses or cereal rye, which start early and grow as rapidly as the resident annuals. Seeding these annuals heavily in a mixture with slow-starting perennials should be avoided, since they will provide the same competition for moisture and sunlight as do the resident species on open range. Although cereal rye develops rapidly (fig. 11), it is an annual and does not readily volunteer. When this species disappears, annual grasses and weeds will take over, and the chance to establish perennials is gone. If, on the other hand, the original stand of perennial grasses is not dense enough, seeds of annuals may be broadcast later and will serve to thicken the stand of forage plants. *What constitutes a good stand of annuals would be entirely too thick for perennials.*

Mixing the Seed. It is recommended that seeding in burns should be done on a spot basis rather than over the entire area if much high-priced seed is not to be wasted. The best plan is to buy seed unmixed and prepare the desired

Fig. 10—Orchard grass and Harding grass plots in burn near Comptche, Mendocino County. Seeded November, 1945. Allowing full development before grazing ensures maintenance of the initial stand. (Photographed June 10, 1946)



Table 2

EXAMPLES OF SEED MIXTURES FOR PLANTING IN LOW OR INTERMEDIATE
ELEVATIONS (UP TO 3,000 feet) AND SEEDING RATES PER ACRE

Mixture	Seeds included	Proportions	Approximate rate per acre
Ash mix	Harding grass	1/3	3 pounds
	Smilo	1/3	
	Alfalfa	1/3	
General mix	Annual ryegrass	1/4	4 pounds
	Perennial ryegrass	1/4	
	Burnet	1/4	
	Annual clover	1/4	
Combination mix	Harding grass	2/5	5 pounds
	Alfalfa	1/5	
	Annual ryegrass	1/15	
	Perennial ryegrass	1/15	
	Burnet	2/15	
	Annual clover	2/15	

mixture. A "spot" or "ash mix" is broadcast only where there is a good, white, brush ash. A "general mix" can be widely used. If the total area is to be seeded by plane, a "combination mix" is best.

Examples of these three seed mixtures, for use in low or intermediate elevations (up to 3,000 feet), are given in table 2.

Rate of Seeding. On many burns the brush ash may be so distributed that on several acres of land there is but one acre of good brush ash. Seeding the "ash mix" at the rate of 3 pounds for *every acre of good brush ash* will distribute the seed mixture over several acres of the burn, according to the nature and distribution of the original brush cover. As can readily be determined from table 3, this low rate of seeding will result in placing 18 seeds on each square foot of good ash. In the open (grass burn) area, the "general mix" should be broadcast at 4 pounds per acre. There will then be at least 20 seeds per square foot of these species that are good competitors. When spot seeding is not practical, the "combination mix" can be broadcast over the entire area at the rate of 5 pounds per acre; and there will be at least 30 seeds per square foot. The perennials may not start well on the grass-burn area, but waste of some seed cannot be avoided under the general-broadcast method. The low rate of seeding recommended will keep this waste to a minimum.

One severe handicap in the seeding program is the scarcity of seed of some

of the more promising species, resulting in high cost of seed per pound. Since, however, there are many thousands of grass and legume seeds to a pound (table 3) the expense is reduced by the seeding rate which, although apparently low, is really adequate, especially where there is a good brush burn.

Brush ash (see cover picture) forms an ideal seedbed for such hardy perennials as Harding, smilo, tall fescue, stipas, alfalfa, and birdsfoot trefoil.

Table 3
NUMBER OF SEEDS PER POUND IN RANGE SPECIES

Common name	Key no.	Seed per pound	Seed per square foot broadcast at 1 pound per acre
		thousands	
Grasses:			
Crested wheatgrass	1	193	4.4
Tall oatgrass	6	150	3.4
Mountain bromegrass	7	142	3.2
Prairie brome	25	68	1.6
Smooth brome	64	137	3.0
Harlan brome	100	72	1.7
Rhodes grass	67	1,700*	39.0
Orchard grass	63	590	13.5
California oatgrass	9	145	3.3
Perennial veldtgrass	91	531*	12.3
Tall fescue	8	225	5.1
California ryegrass	12	241	5.4
Annual ryegrass	13	227	5.2
Perennial ryegrass	14	330	7.5
Smilo	26	1,221	28.0
Harding grass	28	350	8.0
Nodding stipa	34	224	5.1
Purple stipa	35	108	2.5
Legumes:			
Birdsfoot trefoil	15, 16	500	11.5
Bur clover	20	209	4.8
Alfalfa, Common	17	220	5.0
Yellow sweetclover	61	250	5.7
Rose clover	102	177	3.9
Subterranean clover	56	140	3.2
Herbs:			
Burnet	30	45†	2.0

* Germination of seed of these species is low. All others usually germinate 80 per cent or better.

† There are usually two seeds in each burnet achene.



Fig. 11—Cereal rye seeded in a burn in Nevada County. This dense stand will soon disappear, as rye does not volunteer well. *In this area the opportunity of establishing perennials was thus lost.* Compare figure 10. (Photographed May 15, 1946)

Choosing the Forage Plants

Species Listed. Since 1937 more than 200 species of forage plants have been tested in trial plots in 44 counties. Each of the species has been assigned a permanent key number, as shown in table 3.

These key numbers are the same as those listed in an earlier publication⁵ but species and varieties that have been added to the trials since 1943 have been given new key numbers. Only those mentioned below are listed in table 3. The importance of these key numbers is illustrated by reference to No. 25. The scientific name of this grass is *Bromus catharticus* Vahl. (*Bromus unioloides* Kunth). This scientific name also applies to the rescue grasses of the southwestern United States, many of which are annuals. No. 25, however, is a perennial strain of *B. catharticus* that was introduced from New Zealand to California. The seed was collected by Wayne H. Fisher on a trip to New

⁵ Jones, B. J., and R. M. Love. Improving California ranges. California Agr. Ext. Cir. 129: 1-48. 1943.

Zones	Counties Included in Zone*	
ZONE 1 (NORTH COAST)	Del Norte	Western portion
	Humboldt	of:
	Marin	Lake
	Mendocino	Napa
	Sonoma	Trinity
ZONE 2 (CENTRAL COAST)	Alameda	Northern portion
	Contra Costa	of:
	San Luis Obispo	Santa Barbara
	San Mateo	Western portion
	Santa Clara	of:
Santa Cruz	San Benito	
Monterey		
ZONE 3 (SOUTH COAST)	Orange	Western portion
	Ventura	of:
	Southern portion	Los Angeles
	of:	Riverside
	Santa Barbara	San Bernardino
		San Diego
ZONES 4, 5 (CENTRAL VALLEY)	<i>Foothill area (up to 3,000 feet) of:</i>	
	Amador	Sacramento
	Butte	San Joaquin
	Calaveras	Shasta
	Colusa	Solano
	El Dorado	Stanislaus
	Fresno	Sutter
	Glenn	Tehama
	Kern	Tuolumne
	Kings	Tulare
	Madera	Yolo
	Mariposa	Yuba
	Merced	Eastern Portion
	Nevada	of:
	Placer	Lake
	Napa	
ZONE 6	Alpine	Shasta
	Lassen	Sierra
	Modoc	Siskiyou
	Plumas	Trinity
	<i>Elevations above 3,000 feet in:</i>	
Amador	Mariposa	
Butte	Nevada	
Calaveras	Placer	
El Dorado	Tehama	
Fresno	Tulare	

TABLE 4
Zones for Planting in California Counties and Recommended Species of Short- and Long-lived Grasses and Legumes

ZONE 1

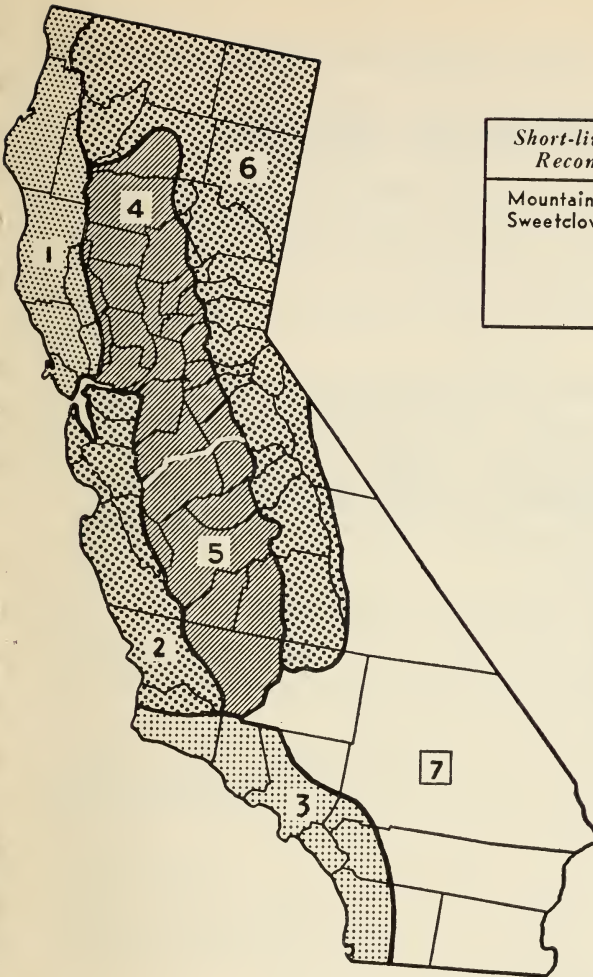
Short-lived Species Recommended	Long-lived species Recommended
Ryegrasses	California oatgrass†
Mountain brome grass†	Harding grass
Prairie brome†	Smilo†
Harlan brome†	Burnet
Bur clover	Tall fescue
Subterranean clover	Tall oatgrass
Rose clover†	Stipast†
	Alfalfa
	Birdsfoot trefoil
	Orchard grass

ZONE 2

Short-lived Species Recommended	Long-lived species Recommended
Domestic ryegrass	California oatgrass†
Mountain brome grass†	Tall oatgrass
Prairie brome†	Harding grass
Harlan brome†	Orchard grass
Bur clover	Smilo†
Subterranean clover	Burnet
Yellow sweetclover	Tall fescue
	Stipast†
	Birdsfoot trefoil
	Alfalfa

ZONE 6	Kern	Tuolumne
	Madera	Yuba
	Western Portion of:	
	Inyo	Mono
ZONE 7** (DESERT)	Imperial	
	Eastern Portion of:	
	Inyo	Riverside
	Kern	San Bernardino
	Los Angeles	San Diego
	Mono	

Zealand, and he gave it to L. G. Goar of the Division of Agronomy, as part of a large collection of grasses and legumes. In New Zealand it is commonly called prairie grass. The writers suggest the common name prairie brome (or brome 25) for this strain, to avoid confusion with the rescue grasses.



ZONE 6

<i>Short-lived Species Recommended</i>	<i>Long-lived species Recommended</i>
Mountain bromegrass† Sweetclover	Crested wheatgrass Tall fescue Orchard grass Smooth brome Tall oatgrass Ladak alfalfa

ZONE 4, 5

<i>Short-lived Species Recommended</i>	<i>Long-lived species Recommended</i>
Ryegrasses Mountain bromegrass† Prairie brome† Harlan brome† Bur clover Subterranean clover Rose clover† Yellow sweetclover	Harding grass Stipas† Smilo† Veldt grass† Burnet Alfalfa

ZONE 3

<i>Short-lived Species Recommended</i>	<i>Long-lived species Recommended</i>
Ryegrasses Mountain bromegrass† Prairie brome† Harlan brome† Bur clover Subterranean clover Yellow sweetclover	Tall fescue Smilo† Harding grass Burnet Stipas† Rhodes grass Veldt grass† Alfalfa

Note: *Counties listed alphabetically for convenience. See your local Farm Advisor for mixture to be used.

† Indicates species not yet available commercially but which are included since they will be on the market shortly.

**There is no discussion of brush removal for Zone 7.

Species Recommended for Certain Zones. Many of the plants are limited in their distribution, others are widely adaptable. Zones have been set up in the state, as a result of the test plots and acreage seedings observed. A map outlining the seven zones into which the state has been divided is included in table 4, which lists short- and long-lived species adapted to each zone.

Step Three: CONTROL OF GRAZING

The third phase of a planned program to change brush-covered areas into productive grasslands—the control of grazing—is of much importance. Without it, both the process of clearing brush from the land and the revegetation of such areas will fail of complete economic success.

To carry out this part of the three-fold plan for improving range lands, the rancher should:

1. **Adjust grazing practices. On any ranch this is usually essential.**
2. **Plan a long-term grazing program. The rotational grazing plan, herein described, calls for dividing the range into fenced or controlled fields.**
3. **Discontinue grazing before burning or reburning an area, to provide a mat of dry grass to carry the ground fire; after seeding, this permits vegetation to become well established.**

Grazing Management Is Important

Adjusted grazing is essential to insure permanent stands of forage. On most ranges, in fact, whether or not they have been burned off and converted to grasslands, planned grazing has been found desirable.

In general, seeded plants adapted to an area will survive and flourish under the same grazing practices that serve to improve the natural vegetation. On the other hand, they will gradually be eliminated by the same practices that tend to destroy the best species of natural forage plants.

When the rancher opens new range areas by the removal of brush, he has both an added responsibility and an improved opportunity to produce more meat and wool: he can make adjustments that will not only increase feed resources but also prolong the season of grazing.

Proper seasonal use of the range should lie somewhere between continuous close cropping, which weakens and gradually removes the better forage plants, and too light grazing, which tends to build up a heavy litter and increase the less palatable weedy plants.

Planning the Long-Term Grazing Program


No fixed rules can be outlined for a range domain such as California, with its wide variations in climate, soil, and elevation. A grazing-management plan must be based on individual ranch conditions; the type and abundance of forage plants and their distribution over the given area; and the practical necessities such as cross-fencing and providing stock-watering facilities.

Obviously, the seasonal green feed produced by winter rains should be converted into meat and wool while at its best. On the other hand, the perennials and better late-maturing annuals (such as bur clover, filaree, and soft chess), should be allowed to set some seed, and thus increase their percentage in the forage. This requires a balanced grazing program.

Outlining the Program. For the most effective over-all operation, the rancher should not burn, in any one season, an area larger than can be placed under controlled grazing so as to assure a permanent revegetation.

To establish growth of forage on burns, there should be no grazing the first spring until the perennials have started to set seed. It has been found that perennials and desirable annuals can better be maintained under a system of seasonal rotational grazing (table 5).

TABLE 5
MAIN TYPES OF RANGE FORAGE PLANTS, THEIR GROWTH CHARACTERISTICS,
AND GRAZING-MANAGEMENT REQUIREMENTS



	<i>Long-lived Perennials</i>	<i>Weedy Annuals</i>	<i>Desirable Annuals or Short-lived Perennials</i>
TYPE:			
Grasses	Harding, stipa, tall fescue, California oatgrass, Smilo	Foxtail Ripgut	Ryegrass Soft chess Mountain brome
Legumes	Alfalfa Birdsfoot trefoil		Bur clover Sweetclover
CHARACTERISTICS:			
Seedling development	Very slow	Rapid	Fairly rapid
Ability to compete first year	Poor	Excellent	Good
Seasonal use	Green early in fall, mature late in spring	Mature early; noxious when ripe	Intermediate
MANAGEMENT REQUIREMENTS:			
To establish on burns	No grazing first spring and summer		As for perennials
To maintain	Seasonal rotation system of grazing (see text)		As for perennials
To reduce		Graze or mow in early spring to prevent seeding	

The best operators who have followed a brush-control program for five years or longer, have made their range subdivisions correspond roughly with the areas to be burned. Topography or watering facilities or north and south slopes may keep this plan from being copied precisely, but a good brush-control program should follow it as closely as possible.



Fig. 12—General view of artificially seeded area in burn near Weed, Siskiyou County. This brush field was burned in the fall of 1939, and the ridgetops were seeded to crested wheatgrass, ryegrass, tall oatgrass, and smooth brome. The latter two are prominent in the picture. (Photographed June 24, 1942)

Seasonal Rotation Grazing. A three-year rotation plan has been found practical to apply and effective to prevent overgrazing.

In carrying out such a plan, the rancher divides his range area into at least three fields, either by actual fencing and cross-fencing, or by herding and drift-fencing to keep stock from certain portions of the range. The plan must also include adequate watering facilities in each field. The plan is:

The first year, the rancher grazes field number 1 early and removes the stock before the surface soil moisture is exhausted in the spring, keeping the animals in the other fields.

The second year, he applies the same treatment to the second field, using the first and third fields for later grazing.

The third year, he applies this practice to the third field, turning the animals then into the first and second fields.

Such a grazing cycle should serve to keep a proper balance of forage species in all three fields, although certain factors complicate a too-rigid application of this scheme. For example: the feed on north slopes is green later in the

spring than that on exposed south slopes; and on swales and seeps the feed remains green much later. Thus, in planning cross-fencing and stock-watering facilities these topographic factors, as well as the varying plant populations peculiar to them, must be taken into account.

A knowledge of range forage plants will aid the operator in managing grazing areas. Table 5 should prove helpful; it lists examples of long-lived perennials, desirable annuals or short-lived perennials, and weedy annuals, as well as their characteristics and management requirements under grazing conditions.

Value of Grazing Periods Shown

To Aid in Elimination of Brush. If fire is to be used to clear brush from the land, the selected area should not be grazed at all during the year it is burned. This treatment (p. 12) will provide an understory of grasses to help carry the flames and make a clean burn. This also applies to reburning.

To Establish Forage. Experience has shown that seeded plants are attractive to range livestock. If grazed as soon as they reach pasturable height, their development will be retarded; many plants will literally be pulled out.







Fig. 13—Same field as in figure 12. The native bunchgrass is western stipa. The plants were not killed by the fire. There is a 6-inch rule at the base of the stipa plant in the left foreground. (Photographed June 24, 1942)



Stock should be kept off freshly seeded areas the first spring until the perennials have set seed; but a light grazing later will serve to trample the new seed crop into the soil and help thicken the stand for the next season.

The value of adjusted grazing in a seeded area was demonstrated north of Weed, Siskiyou County. An area of 3,000 acres there was burned in the fall of 1939; the ridgetops were seeded to crested wheatgrass, perennial ryegrass, tall oatgrass, and smooth brome. This acreage, together with an additional 2,000 acres not burned, has been carrying 700 head of cattle from November 1 to May 1 of each year. Confining the grazing to that period has resulted in an increased stand of seeded species (fig. 12) even in this area of low rainfall (approximately 12.1 inches annually). It was also significant that the fire did not kill the native bunchgrass (fig. 13).

TABLE 6
EXAMPLE OF GRAZING MANAGEMENT FOR AN
AREA TO BE CLEARED OF BRUSH

FIRST YEAR		Keep stock off. Burn in summer. Seed burned area if necessary. (Refer to page 14).
SECOND YEAR		Graze lightly after perennials set seed, say July 15, whether artificially seeded or not. (Refer to page 29).
THIRD YEAR		Graze early. Remove stock before soil moisture is exhausted.
FOURTH YEAR		Keep stock off all year. Reburn in late summer. Reseed certain areas if necessary.
FIFTH YEAR		Treat as in second year.
SIXTH YEAR		Treat as in third year.

To Maintain Forage. An area that is burned or reburned should not be grazed until the next year (June to August, varying with local conditions); then perennials will have a chance to develop and mature seed (table 6).

A seasonal rotation grazing system (see p. 28) will help maintain the forage plants at a maximum level consistent with high returns in meat and wool.

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APPENDIX

Common and scientific names of shrubs, legumes, grasses, and herbs mentioned in this circular, with key numbers of those used for seeding:

Common Name	Scientific Name	Key No.
Alfalfa, Common or Chilean	<i>Medicago sativa</i>	17
Alfalfa, Ladak	<i>M. sativa</i> hort. var. Ladak	18
Birdsfoot trefoil	<i>Lotus corniculatus</i>	15, 16
Brome, Harlan	<i>Bromus stamineus</i>	100
Bromegrass, mountain	<i>Bromus marginatus</i>	7
Brome, prairie	<i>Bromus catharticus</i>	25
Brome, smooth	<i>Bromus inermis</i>	64
Bur clover	<i>Medicago hispida</i>	20
Burnet	<i>Sanguisorba minor</i>	30
Crested wheatgrass	<i>Agropyron cristatum</i>	1
Chamise	<i>Adenostoma fasciculatum</i>	
Cascara	<i>Rhamnus purshiana</i>	
Fescue, tall	<i>Festuca arundinacea</i>	8
Harding grass	<i>Phalaris tuberosa</i>	28
Manzanita	<i>Arctostaphylos</i> spp.	
Mountain balm	<i>Eriodyction</i> sp.	
Oatgrass, California	<i>Danthonia californica</i>	9
Oatgrass, tall	<i>Arrenatherum elatius</i>	6
Orchard grass	<i>Dactylis glomerata</i>	63
Poison oak	<i>Rhus diversiloba</i>	
Rhodes grass	<i>Chloris gayana</i>	67
Rose clover	<i>Trifolium hirtum</i>	102
Ryegrass, annual	<i>Lolium multiflorum</i>	13
Ryegrass, perennial	<i>Lolium perenne</i>	14
Ryegrass, California	<i>Lolium</i> sp.	12
Scrub oak	<i>Quercus dumosa</i>	
Smilo	<i>Oryzopsis miliacea</i>	26
Stipa, foothill	<i>Stipa lepida</i>	33
Stipa, nodding	<i>Stipa cernua</i>	34
Stipa, purple	<i>Stipa pulchra</i>	35
Stipa, western	<i>Stipa occidentalis</i>	
Subterranean clover	<i>Trifolium subterraneum</i>	56, 98
Sudan grass	<i>Sorghum vulgare</i> var. <i>sudanense</i>	
Sweetclover, yellow	<i>Melilotus officinalis</i>	61
Toyon	<i>Photinia arbutifolia</i>	
Vetch	<i>Vicia sativa</i>	
Veldtgrass, perennial	<i>Ehrharta calycina</i>	91
Wild buckwheat	<i>Eriogonum</i> sp.	

