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FUEL-BREAK REPORT NO. 10

SEEDING FUEL-BREAK AREAS IN SOUTHERN CALIFORNIA

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A fuel-break is a wide strip or block of land on which native brush fuels have been reduced or eliminated to facilitate fire control. Brush removal creates a plant vacuum which should be filled rapidly with plants that will protect the soil against erosion, produce lower fuel volume than native chaparral, and possibly provide grazing for wild or domesticated animals.

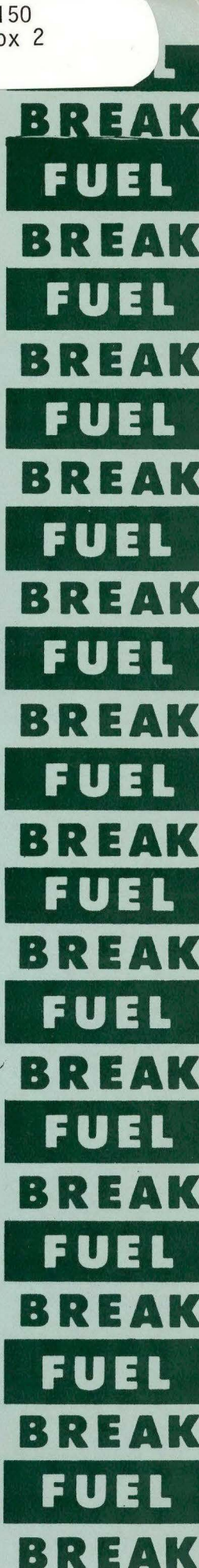
Fuel-breaks are usually constructed along ridge tops, but also along mountain roads, and valley or canyon bottoms. Topography may be steep and irregular, soils shallow and course; rocks, brush, and stumps may cover much of the soil surface. Where site conditions are otherwise good, competition from weedy plants may be excessive.

The special problems are adverse conditions associated with brush-to-grass conversion require strict attention to practices that contribute to revegetation success. The objective of this paper is to summarize the experience and recommend the practices that favor establishment of grasses on cleared chaparral land in southern California.

SPECIES AND RATES TO USE

Grasses are presently preferred over other plants for fuel-break planting. Grass seed is commercially available, and grasses are not affected by the hormone sprays commonly used for shrub control. Grass cover produces a relatively low volume of fuel and is useful as live-stock and wildlife forage.

Perennial grasses, generally recommended where adapted, produce more consistently and stay green later in the summer than annuals. A good stand of perennials or of perennials and annuals, gives good protection to soil.



Perennial grass mixtures recommended for sowing in the different southern California climatic zones are presented in Table 1.

Harding grass and smilo have long been favorites for planting on suitable sites below 4,000 feet elevation.

As experience with the wheatgrasses accumulates, tall and pubescent show considerable promise as companion species with Harding and smilo. At higher elevations the same two wheatgrasses plus intermediate form the basis of most recommended mixtures (Table 1).

Under favorable soil-moisture conditions, 5 to 6 pounds of drilled perennial grass seed will produce a good stand (Bentley, et. al. 1956). Higher drilling rates may produce excessive plant competition, and will not guarantee a stand, especially during adverse moisture years.

If seed must be broadcast, up to double the drilling rate is recommended. This gives greater assurance of seed being available during periods of favorable moisture.

SITE CONSIDERATIONS

A cardinal rule in seeding is to select the best sites. But fire-control considerations frequently determine the fuel-break areas to be revegetated. For most of these areas, the only option is to select plant species and seeding methods best adapted to existing conditions.

Medium- to fine-textured soils are best for grasses, but these soils occur infrequently in southern California brush areas. Soils of sandy loam texture are much more abundant, and most fuel-break seedings have been on this soil type.

Soils should be 2 feet or more in depth for perennial grasses, and deeper if soil is coarse. Adequate depth and fine texture mean high water-storage capacity in the soil--essential for perennial grasses in a droughty climate. Medium- to fine-textured soils will store about 2 inches of available water per foot of depth. Sandy loam will store about 1.4 inches (Anon. 1955). Storage in stony soils will be less. Soils storing less than 3 inches of usable water are poor risks for perennial grasses in our droughty climate.

Average annual precipitation is our best guide to selection of grass species. Drought years, or drought periods within a year may adversely affect the outcome of a seeding operation, but these cannot be predicted. Once established, grasses can tolerate considerable drought.

Table 1.--Grass species and rates recommended for seeding under various climatic zones in southern California.

Species	Coastal and inland mt. zone		Inland mountain zone			Desert-side, mountain zone
	Below 3,500 ft.		3,500-5,000 ft.	3,500-6,500 ft.	5,000-8,000 ft.	3,000-9,000 ft.
	1/ 15 - 25	25 - 30	1/ 25 - 30	1/ 15 - 25	1/ 25 - 45	1/ 15 - 25
	Pounds per acre (drilled) 2/					
Harding Grass	2	2				
Tall Wheatgrass	1	1-2	2	2	1-2	1-2
Intermediate Wheatgrass	(3/)	(3/)	2	1	2	1-2
Pubescent Wheatgrass	1	1	(4/)	1	1	1-2
Crested Wheatgrass			1	2	1	1
Smilo	1	1				
Veldt Grass	(5/)	(5/)				
Goars tall Fescue			(4/)	(4/)		
Orchard Grass					1/2	
Sherman Big Blue			(4/)		(4/)	(4/)
Blando Brome	$\frac{1}{4}$-$\frac{1}{2}$	$\frac{1}{4}$-$\frac{1}{2}$	$\frac{1}{4}$-$\frac{1}{2}$			
Total	$5\frac{1}{4}$-$6\frac{1}{2}$	5-$6\frac{1}{2}$	5-6	6	$5\frac{1}{2}$-$6\frac{1}{2}$	5-6

1/ Annual precipitation.
2/ Rates should be increased 50 to 100 percent for broadcasting.
3/ If livestock grazing is important, intermediate may be preferred over the less palatable tall wheatgrass, although the latter has usually grown somewhat better.
4/ One pound per acre can be added.
5/ Add one pound on sandy or sandy loam soils.

SOURCE: Edmunson and Cornelius 1961 and recent observations by Bentley, Cornelius, and Green.

Perennial grasses are not recommended for use in southern California where annual precipitation is less than about 12 inches. Good results have been obtained near the coast with 15 to 20 inches of rainfall and deep, fine textured soils. Inland, an average of 20 inches is minimum for much assurance of success, particularly on sandy loam soils.

The exposure of a low rainfall site has much to do with survival of seeded species. Best results generally occur on north and east-facing exposures, which receive least direct heat from the sun. Because evaporation is less from these exposures, greater numbers of grass seedlings survive than on south slopes. Then too, south exposures usually support thinner stands of chaparral. Greater erosion has taken place, soils are shallower, and there is less available water for grasses.

Sites which slope excessively should not be seeded (fig. 1). Steep slopes are erodible and difficult to work and revegetate. The rangeland drill, for example, cannot operate economically on slopes steeper than about 40 percent. Furthermore, runoff water and wind remove more seed from these steep slopes than from those of lesser gradient.

SEEDBED PREPARATION

A good seedbed, above all else, should be free of competing vegetation. It should be firm, but not too hard for drilling. Disked or bulldozed areas, or recent burns where loose soil and ash has been firmed by rain or soil-firming equipment, make good seedbeds.

Broadcasting should be done only on loose, easily crumbled, surface soil. Recent burns with their mixture of soft earth, ash, and charred material offer good chances. Loose, disked or bulldozed seedbeds are also favorable for broadcasting. However, if such soils remain loose, they may dry out rapidly and the seeding may be a failure.

Wildfire in dense chaparral will prepare a satisfactory seedbed if the fire burns hot enough to consume at least all small stems and ground litter. Such fires leave "white ash." But additional clearing of larger unburned shrub and tree stems may be necessary before drilling is possible. Fires in open brush or grass may leave the ground surface blackened, but they seldom destroy any great proportion of weed seeds lying close to mineral soil.

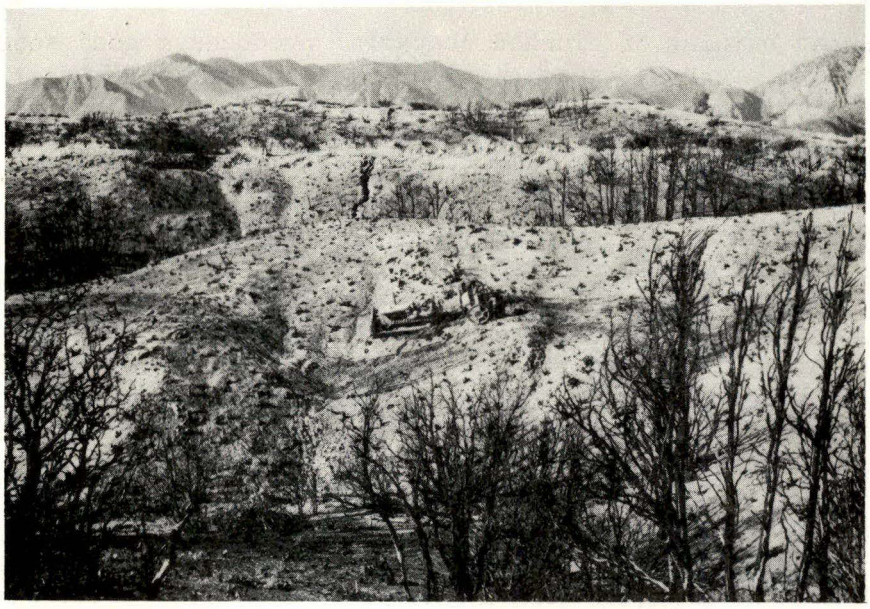


Figure 1.--Terrain such as this is the upper limit for drilling. Only a small proportion of such a burn can be drilled and care is required lest the drill suffer structural damage.

Figure 2.--Chaparral, after being smashed and burned, leaves a good seedbed for drilling. However, when brush is light, as in this case, additional cultural treatment is needed to destroy germinated seedlings of weedy herbaceous vegetation.

Broadcast burning of crushed chaparral produces a good seedbed if the brush has sufficient volume and continuity to burn under moderate and safe burning conditions. Burning a light stand of crushed brush will leave a patchy seedbed containing weed seeds in all the lightly burned spots (fig. 2). This is little better than the seedbed which results if crushed brush is piled and burned. Weed seeds are destroyed where brush piles burn, but nowhere else.

Broadcast burning of crushed chaparral also increases the supply of available nutrients (Vlamis et. al., 1956), in the form of a relatively uniform ash layer, provides a seedbed free of stems that restrict drilling, and leaves fewer brush sprouts (Blanford, 1962).

The naturally occurring grass and forbs growing after most hand or mechanical clearing and light burning will choke out or reduce seeded perennials (fig. 3). To prevent this, disking or other farming operation is necessary before perennials are sown. If timing is right, the germinated crop of annuals can be disked during a late fall or early winter dry spell, thus creating a seedbed with weeds greatly reduced. The alternative is to disk during early spring before native seed is produced, and drill seed of perennials the following fall.

It is important that seedbed preparation and seeding be completed during the year after brush clearing. Weed seeds will never be fewer than at this time. If one or more crops of weedy plants mature seed, preparing a clean seedbed is difficult and expensive.

PLANTING METHODS

Drilling

Drilling has been the only consistently effective method of obtaining a satisfactory stand of grasses on cleared chaparral sites in southern California. It gives better stands of annuals, and is almost essential for perennial grasses. Drilling has always produced first-year stand averaging from one to several perennial seedlings per square foot (Table 2). Broadcasting has failed or has produced very sparse stands in over 70 percent of the attempts (fig. 4). These are results from two consecutive dry years with 50 percent or less of average rainfall and one year of almost normal rainfall.

Figure 3.--This hand-cleared fuel-break was allowed to reseed with resident annuals; but if these were controlled, perennial grasses could be drilled.

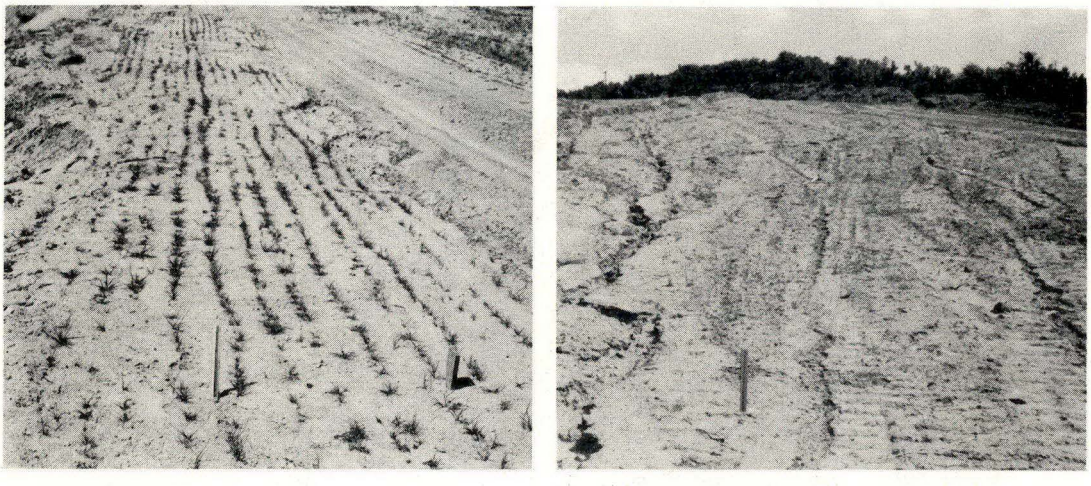


Figure 4.--Drilling intermediate and tall wheatgrass on the Reservoir Summit area, Angeles National Forest, resulted in twenty-eight times more seedling plants (left) than broadcasting (right). 1959.

Table 2.--First year seeding establishment results from drilling and broadcasting grasses on southern California fuel-breaks [1/]

Name of area	Average number of plants per square foot				Plant frequency (percent of sq. ft. quadrats occupied)			
	Drilled		Broadcast		Drilled		Broadcast	
	Perennial	Annual	Perennial	Annual	Perennial	Annual	Perennial	Annual
Reservoir Summit	5.13	8.67	.18	.61	74	100	15	44
Paradise	6.64	9.33	1.95	6.59	97	100	68	100
El Carriso	3.31	7.00	.44	.83	95	100	31	50
Little Pine Flat	1.81	1.63	.05	.17	53	67	4	13
Lukens Truck Trail	3.31	5.04	1.48	2.67	82	100	55	88
Oak Flats	1.17	2.04	.38	.71	46	63	24	42
Red Box Gap	3.28	4.08	.94	.79	71	96	33	37
Average	3.52	5.40	.77	1.77	74	89	33	53

[1/] These data were taken during 1959 and 1960, two dry years.

About 5 times as many perennial grass plants resulted from drilling as from broadcasting (Table 2). In some tests drilling held a 3 to 1 advantage and in one, it was 30 to 1. Drilling annual grasses resulted in establishment of $1\frac{1}{2}$ to 14 times as many plants.

Frequency of plant occurrence is another measure of seeding success. A high frequency of occurrence indicates a uniform stand, a low frequency indicates large bare areas. In our experience three-fourths of all the square-foot quadrats observed on drilled areas contained perennial plants as compared to one-third on broadcast areas. Comparable figures for annuals were 89 percent and 53 percent.

Slopes up to 40 percent can usually be safely and effectively drilled. Gentle slopes, unbroken by gullies, rock outcrops, or trees are most easily drilled. Here up to 3 acres per hour can be seeded when pulling the rangeland drill with a D-4 or comparable tractor.

Steep or irregular terrain will greatly reduce the drilling rate, especially if rocks or other obstacles are abundant. Under such conditions a D-7 or equivalent tractor with a 12-foot bulldozer blade is required to remove the obstacles that would damage the drill. Small, unburned stems that remain following fire in a chamise stand, will not damage the rangeland drill (fig. 5).

The rugged rangeland drill is the only one recommended for use on most fuel breaks. Experience on wildlands administered by Federal agencies indicated that commercially available grain drills were inadequate for conditions encountered. The original model was designed and constructed on the Fremont National Forest in 1950 and 1951. Basically, it was a standard grain drill with reinforced frame, larger wheels, and modified disk arm assemblies. In 1952, the Range Seeding Equipment Committee assumed the responsibility for further development of the drill and other specialized equipment. The Committee consists of representatives of several Federal agencies (BLM, BIA, SCS, FS) who plan and finance development work at the Forest Service Equipment Development Center in Arcadia, California. The drill is not commercially available. Purchases for Federal agencies are processed by the California Region of the Forest Service under contract procedures.

Optimum seeding depth for most species is about 1/2 to 3/4 inch. Larger seeds, such as the wheatgrasses, will send up seedlings from depths of 1 inch. Small seed such as big

Figure 5.--The rangeland drill is not damaged by small brittle stems such as chamise. The dozer blade is needed, however, to remove tough stems such as the oak in front of the blade.

bluegrass and smilo should not be planted deeper than 1/2 inch. Depth bands on disks aid in planting at proper depths, especially on loose sandy soils.

Broadcast Seeding

Broadcasting is the only practical means of seeding terrain on which tractors and drills cannot operate efficiently and safely. Aerial seeding is generally the most efficient method of broadcast sowing large areas.

Broadcast seeding usually produces fewer established plants than drilling, which covers the seed. Therefore it is usually desirable to cover the seed by some method. At the San Dimas Experimental Forest, rolling with a heavy flexible roller (fig. 6) produced stands of perennial grass when broadcasting alone did not. This roller can be used on terrain that cannot be drilled without excessive damage to equipment. Other rollers, the farm cultipacker, for example, can be used; or drags can be made from brush or other material for covering seed and firming the seedbed.

Figure 6.--This experimental brushland roller was pulled over the broadcasted seed. It broke off most unburned brush stems and covered seed so that two years later, in 1962, the area supported a good stand of perennial grasses.

WHEN TO SEED

The degree of first-year success from seeding is largely determined by the rainfall pattern after drilling or broadcasting. Once seed starts to germinate, roots must remain in contact with moist soil, or the seedlings die. A one or two-week period of cloudy rainy weather after seeding is ideal and general germination usually results. Frequent rains and cool weather thereafter aid seedling establishment. Seeding should be done just before such weather is expected.

The best time to seed in southern California is probably through-out the second half of October and November. Some good stands have resulted from drilling in mid-winter, but the chances of receiving adequate rainfall to establish the stand diminish as the planting date is delayed. No seeding date is safe from hot weather or wind, but fall offers the best chance of favorable moisture and temperature.

THE USE OF FERTILIZER

Plant growth responses to nitrogen, phosphorus, and sulfur have been observed at many locations on California rangelands. These elements, as ammonium phosphate-sulfate (16-20-0), were applied to several fuel-break plot locations to observe their effect on growth and survival of grasses. The fertilizer was either drilled in with the seed or broadcast on the soil surface at 300 pounds per acre.

In our tests fertilization had no effect on numbers of grass seedlings established, but did stimulate somewhat greater growth and ground cover. Greatest response resulted from drilling. Little or no response was observed after broadcasting the fertilizer on the soil surface. Fertilizer effects were greater on bulldozed than on burned seedbeds with heavy ash.

Fertilizer cost about $14.00 per acre at the rates used. Insufficient time has elapsed to determine whether fertilizing will improve the mature stand enough to warrant this cost.

COSTS OF SEEDING OPERATIONS

Seeding costs on fuel-breaks vary widely. Size and shape of area, terrain, remoteness or accessibility of site, method of seeding, experience of seeding crews, and job planning--all these affect costs.

A large area will generally be seeded at a lower cost per acre than smaller projects. If the area is in one large block rather than several smaller irregular areas, efficiency of seeding is greater, for there is less turning, nonseeding travel time, or double seeding. Drilling is more expensive than broadcasting, and as topographic conditions become less favorable, the cost spread becomes greater.

On the average, and assuming 100 acres will be seeded, drilling perennial grasses will cost $13.25 per acre (Table 3). Site preparation, where necessary, is additional. With nearly ideal conditions, the cost might be about $10.00. If conditions are unfavorable throughout the operation, drilling costs might increase to $20.00 per acre, or more. Broadcasting by helicopter, using double the basic perennial mixture, will cost $10.45 on the average.

Greatest costs of drilling seed were for tractor, seed, and labor--in descending order. In broadcasting from a helicopter, perennial grass seed was by far the greatest cost because of the greater seeding rate and high cost of seed.

Experience of the supervisor, the tractor operator or the helicopter pilot, and the crew makes a big difference in the job costs. An experienced supervisor will have his men trained, the job well planned in advance, and, except for breakdown periods, equipment and crew are kept busy.

ANNUAL GRASSES ON FUEL-BREAK CONVERSION AREAS

Seeding annual grasses without perennials is not a common practice in southern California brush conversion projects. Annuals are frequently sown where emergency ground cover is needed and control of sprouting brush will not be attempted. Also, they should be sown after chaparral removal on sites not suitable for perennials if there are no resident annual grasses to occupy the space. Sowing is seldom done on hand cleared fuel-breaks because resident annuals usually occupy the site quickly. Where perennials are seeded, resident or seeded annuals will occupy spaces between perennial plants.

Blando brome is recommended in small amounts for seeding with perennials at elevations below 4,000 feet to provide ground cover as soon as possible, and to fill in between perennial plants. It is less competitive than ryegrasses.

Ryegrasses have been widely planted after chaparral burns, but do not do well on poor sites. Wimmera 62 ryegrass has grown somewhat better than common ryegrass during low rain-

Table 3.--Some fuel-break seeding costs per acre, based on 100 acre seedings.

Cost Item	Drilled		Broadcast	
	Range	Average	Range	Average
	Dollars			
Grass seed				
Annuals only *	0.60-2.50	1.40	1.20-5.00	2.80
Basic perennial *	3.50-5.00	4.00	7.00-10.00	8.00
Tractor				
Pulling drill (D-4, D-6)	3.00-6.50	4.50	--	--
Transport to area	.50-1.25	.75	--	--
Drill				
Transport and load	.35-1.25	.50	--	--
Maintenance and repair	.25-1.00	.50	--	--
Helicopter				
Seeding			0.60-1.25	0.85
Transport			0.25-1.80	.50
Labor	1.25-4.00	2.00	0.25-0.50	0.35
Supervision	.25-1.50	.50	0.10-1.95	.50
Mileage	.30-1.00	.50	0.15- .50	.25

* Double seeding rate and cost for helicopter broadcasting is assumed.

fall years (Edmunson and Cornelius, 1961).

Blando brome, Wimmera 62 ryegrass, or a mixture at 5 pounds per acre is our usual recommendation for cleared areas where perennials will not be sown. Blando seed is more expensive, but it can be expected to last longer on poor sites. The light, fluffy blando seed alone does not flow as readily through seeding equipment as when mixed with ryegrass.

Most rules for establishing perennial grasses apply to annuals, but annuals are less demanding. They can be planted on poorer sites, and are more apt to grow after broadcasting than are perennials. The extra costs necessary to prepare a clean seedbed and to cover seed are not justified for annual species except on critical sites.

SUMMARY

Brush is removed from fuel-break areas in southern California and plants substituted that have lower fuel volume, protect the soil, and usually provide better forage. Perennial grasses are more useful in brush conversion than other kinds of vegetation.

Harding grass and smilo with some wheatgrasses are best for seeding below 3,500 feet elevation. The same wheatgrasses--intermediate, pubescent, and tall--are the basis of any seed mixture for elevations above 3,500 feet.

A good site for seeding perennial grasses will have these characteristics: soil medium- to fine-textured and deeper than 2 feet; precipitation greater than 15 inches under the coastal climatic influence and 20 inches inland; and north or east exposure.

A good seedbed for drilling perennials is firm and free of competing vegetation. When seed must be broadcast, the seedbed surface should be loose. Disked or bull-dozed areas and recent burns are suitable seedbeds.

Drilling has produced an average of one or more perennial grass plants per square foot, even in a very dry year, but broadcasting averaged this number on only 40 percent of the areas. Annuals responded similarly, but numbers were usually greater. Rolling with a ring roller after broadcast seeding improved the stand. Drilling is recommended for establishment of perennial grasses.

The best seeding season is usually in the second half of October and November, just before expected winter rains. Fertilizer increased plant size when placed in the drill furrow with the seed, but had no visible effect when broadcast on the soil surface.

Estimated average cost of drilling with the rangeland drill, assuming a 100-acre area and using perennial species is $13.25 per acre. Broadcasting perennial grass seed with the helicopter should average about $10.45.

Annual grasses, chiefly Blando brome and Wimmera 62 ryegrass, are not used where permanent conversion to grass is desired. But they are broadcast seeded, where temporary emergency cover is needed or where site conditions are not suited to perennials.

The Fuel-Break Program is conducted cooperatively by the California Division of Forestry, the Los Angeles County Fire Department, and the U. S. Forest Service.

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Common and Botanical Names of Grass Species Mentioned

Blando brome	*Bromus mollis*
Downy bromegrass	*Bromus tectorum*
Goars tall fescue	*Festuca arundinacea*
Harding grass	*Phalaris tuberosa* var. *stenoptera*
Orchard grass	*Dactylis glomerata*
Red brome	*Bromus rubens*
Rye grass	
Common	*Lolium multiflorum*
Wimmera 62	*Lolium rigidum*
Sherman big blue	*Poa ampla*
Smilo	*Oryzopsis miliacea*
Wheatgrass	
Crested	*Agropyron desertorum*
Intermediate	*A. intermedium*
Pubescent	*A. trichophorum*
Tall	*A. elongatum*
Veldtgrass	*Ehrharta calycina*

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