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Some Brush Conversion Costs on Southern California Fuel-Breaks

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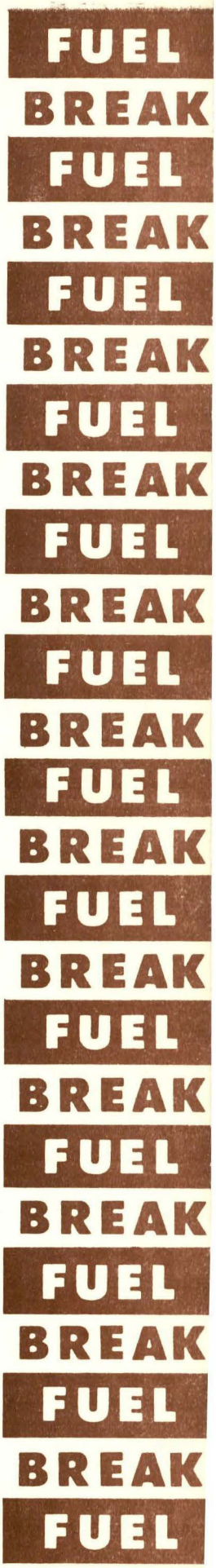

SOME BRUSH CONVERSION COSTS ON SOUTHERN CALIFORNIA FUEL-BREAKS

By

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"How much will it cost?" This question is asked in the planning stage of every brush conversion. "To bulldoze? To spray? To seed?" Frequently there is no experienced person standing by to answer. To provide such information, we have assembled notes and figures from fuel-break studies at the San Dimas Experimental Forest, and from brush conversion projects by the California Division of Forestry, the National Forests in southern California, and the Los Angeles County Fire Department.

Much of the information is summarized in tables which provide estimates for a "typical" fuel-break job of 100 acres--about the size of many 1-year portions of conversion projects. Larger areas may be done more economically, but 100 acres is frequently all that available funds or manpower will allow to be converted at one time. Converting smaller areas will, of course, generally cost more per acre.

The tables present cost data for individual jobs or phases of the brush conversion process. In mature brush these jobs usually include clearing by some method, followed by one or two broadcast sprayings, and then enough hand spraying to complete the shrub kill. Seeding of grass is usually necessary, too. Total cost is the sum of the cost of all necessary operations (fig. 1).

In developing cost tables, we had to make a few assumptions to arrive at representative data. For example, the kind of terrain affects costs directly. Maximum accomplishment is usually on flat or gently sloping sites. But if an adequately powered tractor is used, production decreases are small as gradient increase up to about 40 percent. On steeper terrain, or in rocky areas, operators become more cautious, can sometimes work downhill only, and their accomplishment is greatly reduced. Because many fuel-break jobs are on sites with considerable gradient, we estimated our tractor work-rate for slopes of about 30 percent.

Travel to and from jobs is a big cost item when conversion projects are in remote areas, as many are. For the typical project represented in our tables, we assumed 25 miles of one-way driving, or 50 miles round trip. Many projects are about this far from headquarters.

Equipment and labor costs vary somewhat from place to place. The costs we use are based on an average for southern California in 1962 and 1963. Labor, unless otherwise indicated, is charged to the project at $20 per man day, and supervision $30. Hourly tractor costs, including operators, are:

D-8	$18.00
D-7	16.00
D-6	13.00
D-4	10.00
TD 340	7.50

MECHANICAL CLEARING COSTS

Bulldozer.--The bulldozer is better adapted to working on irregular terrain and in heavy brush then most other equipment. The bulldozer blade or some variation, is generally selected when mechanical clearing operations are needed.

A D-7 tractor is economical for most clearing jobs, but if the brush is large and dense, a larger tractor may be more economical. D-7 or larger tractors equipped with dozer blades will uproot or shear off and push into piles brush of light to moderate density on an acre or more each hour. Large, dense brush will slow any tractor (table 1), but especially small ones. Tractors with less horsepower than a D-6 are useful in light brush, but do not operate efficiently in clearing mature mixed chaparral. Experience of the operator can make considerable difference in the amount of work accomplished.

Crushing mature brush prior to burning and seeding is a recommended step in some brush conversion projects. Crushing is done with the bulldozer blade, or with the tractor and blade followed by a roller or disk. The D-6 or D-7 bulldozers will crush 2 to 3 acres of light to medium brush per hour. Costs will run about $6 per acre--more if slopes are steep and brush is heavy. Pulling a brush roller will add slightly to the cost.

Crushing by pulling an anchor chain or cable between two D-7 tractors has worked well where mature brush grew on uniform terrain. Dodge and Pierce[1/] in San Luis Obispo County reported that two tractors could crush 8 acres per hour on suitable terrain, and about half that under less favorable conditions. Costs would range from about $4 to $8 per acre.

Brushrake.--The brushrake has a moldboard similar to that of the dozer blade, but with teeth extending below and forward. These teeth increase the efficiency of uprooting and piling, and reduce the quantity of earth moved. The brushrake has been used on several jobs in southern California, but only sketchy performance data are available. In one case on the Los Padres Forest, a Fleco brushrake mounted on a D-8 crawler tractor worked in a thick 6- to 8-foot stand of manzanita and oak. The rate of clearing was between 1 and 2 acres per hour. An estimated 50 to 60 percent of shrub root systems were raised to the surface, and the bid price was $24 per acre.

1/ Dodge, Marvin, and Pierce, Cecil. Anchor chain improves brush rangeland. Calif. Div. Forestry. Range Improvement Studies. No. 7, 8 pp., illus. 1962.

Figure 1.--A completed fuel-break may incurr costs for clearing, for one or more broadcast and hand spray treatments, and revegetation.

Table 1.--Estimated rates and costs of mechanically clearing mature brush from southern California fuel-break sites [1/]

Job and equipment	Light brush, <15 tons/A		Medium brush, 15-30 tons/A				Heavy brush, >30 tons/A			
	Chamise, sage chaparral		Chamise chaparral		Mixed chaparral		Mixed chaparral		Woodland chaparral	
Clear and pile:	A./hr.	$/A	A./hr.	$/A	A./hr.	$/A	A./hr.	$/A	A./hr.	$/A
D-8, 12-ft. blade	1.0	18.00	1.0	18.00	0.8	23.00	0.6	30.00	0.4	45.00
D-7, 12-ft. blade	1.0	16.00	1.0	16.00	0.8	20.00	0.5	32.00	0.3	48.00
D-6, 8-ft. blade	0.7	19.00	0.7	19.00	0.5	26.00	0.3	43.00	--	--
D-4, 6-ft. blade	0.5	20.00	0.5	20.00	0.3	33.00	--	--	--	--
Crush brush:										
D-7, 12-ft. blade	3.0	5.30	3.0	5.30	2.5	6.40	2.0	8.00	--	--
D-6, 8-ft. blade	2.0	6.50	2.0	6.50	1.5	8.60	--	--	--	--
D-4, 6-ft. blade	1.5	6.70	1.5	6.70	1.0	10.00	--	--	--	--
D-6, 10-ft. roller	2.5	5.20	2.5	5.20	--	--	--	--	--	--
D-4, 10-ft. roller	2.0	5.00	2.0	5.00	--	--	--	--	--	--
D-8, heavy 10 ft. disk	2.4	7.50	2.4	7.50	2.0	9.00	--	--	--	--
D-7, heavy 10-ft. disk	2.1	7.60	2.1	7.60	1.5	10.60	--	--	--	--

1/ For a 100-acre project on terrain averaging 30 percent slope. Transport, mileage, and swamper charges may add one to several dollars per acre to these costs in heavy brush.

A brushrake equipped with horizontal cutting bars welded between the teeth was used on the Cleveland National Forest. In medium, mixed chamise-chaparral on nearly level, rock-free land it removed almost all brush, including shrub crowns, at a reported rate of 1.4 acres per hour and a cost of about $13 per acre. On rocky terrain the cost was more than $40 per acre.

Some 400 acres of heavy, mixed chaparral on the Sierra National Forest was cleared in 1960-61 with a Ferris brush-grubber attached to a standard bulldozer blade. The tractor, owned by the Forest Service, was an Eimco 105; operation cost $12.50 per hour, including operator. The cost of clearing was $34 per acre on terrain with slopes up to 55 percent.

Many firebreaks have been recleared periodically by bulldozer, but there should be little of this work on fuel-breaks if current recommendations for chemical control work[2/] are followed. But if initial clearing is not followed up by chemical control of brush, regrowth is rapid; once brush sprouts are taller than 2 feet, reclearing is recommended. This can be done with the bulldozer or heavy-duty disk. Costs are estimated in table 2.

Table 2.--Estimated costs of follow-up mechanical brush clearing operations on fuel-breaks 1/

Job and equipment	Follow-up clearing	
	A./hr.	$/A
Clear and pile 1- to 3-year-old regrowth:		
D-7, 12-ft. blade	1.2	$13.30
D-4, 6-ft. blade	0.6	16.60
Crushing after fire:		
D-7, 12-ft. blade	3.0	5.30
D-4, 6-ft. blade	1.5	6.70
Disking 1- to 3-year-old regrowth:		
D-7, heavy 10-ft. disk	2.5	6.40

1/ For a 100-acre project on terrain averaging 30 percent slope. Transport charges may add to these costs.

2/ Plumb, T. R., Bentley, J. R., and White, V. E. Chemical control of brush regrowth on fuel-breaks. Fuel-break Rpt. No. 11. 42 pp., illus. (Address requests for copies to Pacific SW. Forest & Range Expt. Sta., P. O. Box 245, Berkeley, Calif. 94701.)

HAND CLEARING COSTS

Hand Clearing.--Many miles of fuel-break have been cleared in southern California by hand labor (fig. 2). If the work is done by paid labor, the fuel-breaks are very expensive. But it can be justified where fire crews would be otherwise idle, or where conservation camp crews are available.

We have summarized in table 3 some construction rates and cost estimates. We assume that only paid labor is available, that workers will be cutting 6 hours per day, and that their daily pay rate is $15.

Hand-cut brush sprouts quickly on fuel-breaks. Within 1 to several years the sprouts must be recut or otherwise treated if the brush fuel is not to regain its former size and density. We estimate that cutting 2- to 5-year old regrowth will take about half as long as cutting the mature brush, although the time will vary greatly depending on density of the sprouting brush.

Hand grubbing.--Grubbing brush by hand is considerably more time-consuming than cutting alone, but grubbing promises less work in the future. Grubbing goes rapidly in chamise, but very slowly in oak where one or two men may work half a day to remove one root crown. On many jobs the easy-to-remove species are grubbed, but some of the oaks are left for future grubbing or spraying. If the oaks are dug out during a second grubbing, the work will take about the same time as during the first grubbing. But once a fuel-break is thoroughly grubbed, maintenance costs should be small.

HELICOPTER SPRAY COSTS

Helicopter bids for spraying plots, watersheds, and fuel-breaks have varied from about $70 to $245 per flying hour since 1960. Contracts have been signed at from $70 to $120. There is usually a ferrying or transport charge unless the job is large, and then it may be absorbed in the hourly charges. In our estimates we assume $100 per flying hour (not rotor hours) for a G-2 type helicopter, and $1 per acre transport charge.

Most of the helicopters used for spraying herbicides will take off with about 60 gallons of spray solution. At 10 gallons per acre, 6 acres per load will be treated. We averaged slightly less than 8 minutes per flight on the San Dimas Experimental Forest plots and watersheds. On fuel-breaks less time elapsed per load and the over-all spraying rate was 50 acres per hour.

If no research type of spraying is done, and if the helicopter can be serviced close to its spray area, the time per load can be cut to as little as 5 minutes. The rate of spraying then increases to 60 or more acres per hour.

Hours of flying.--For 25 days in June 1962, we had a helicopter working every day but one that weather conditions allowed. Fog prevented any flying on 9 of the 25 days. We averaged about 2-1/2 hours in the air on days we

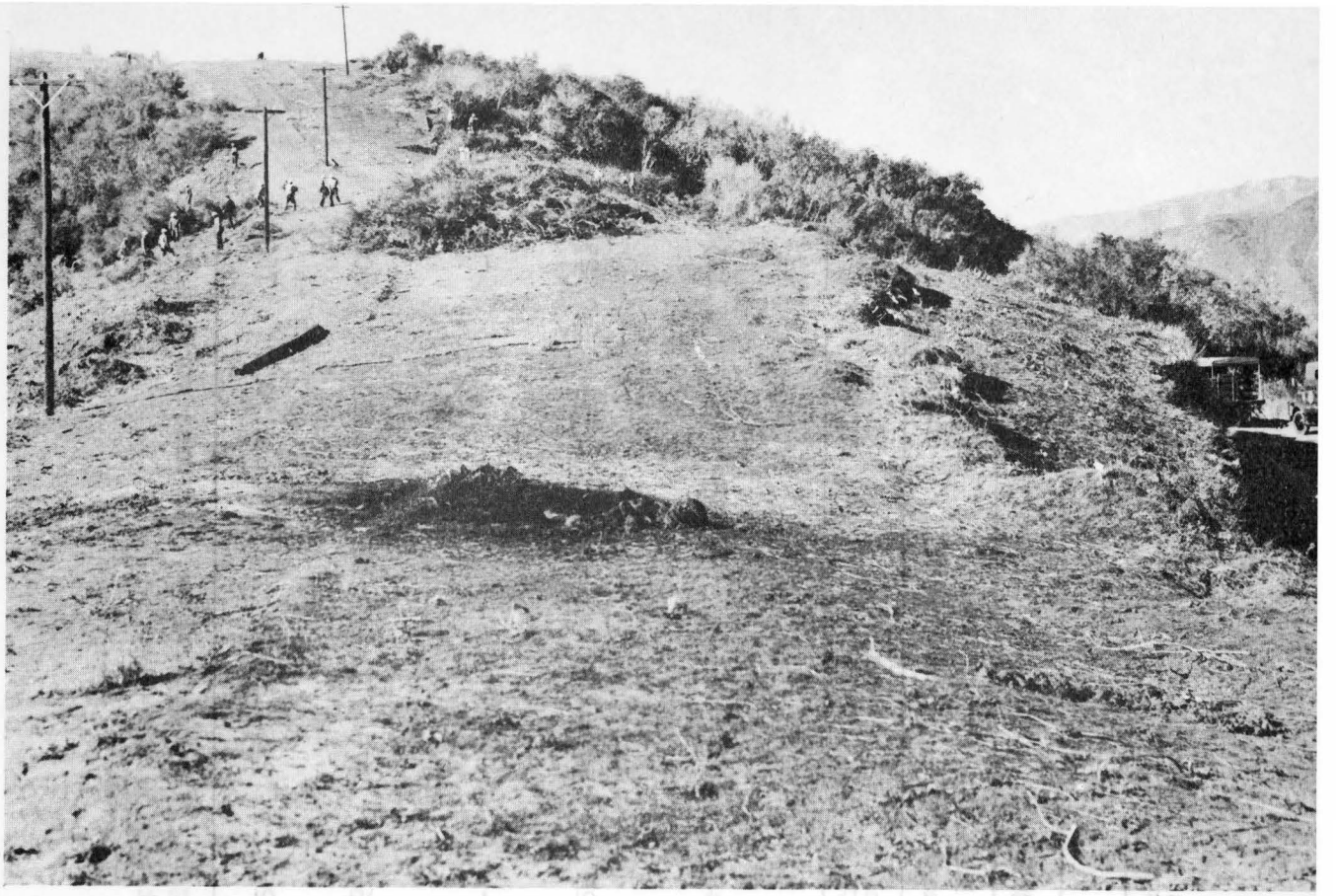

Figure 2.--The availability of conservation-camp labor has made possible hand-clearing of almost 200 miles of fuel-breaks in southern California.

Table 3.--Estimated rates and costs of clearing brush by hand in southern California 1/

Job	Light 15T/A		Medium 15-30T/A				Heavy 30T/A			
	Chamise-sage chaparral		Chamise chaparral		Mixed chaparral		Mixed chaparral		Woodland chaparral	
	Man-days/A.	$/A	Man-days/A.	$/A	Man-days/A.	$/A	Man-days/A.	$/A	Man-days/A.	$/A
Cutting, piling, and burning mature brush	15	225	25	375	45	675	65	975	75	1,125
Cutting, piling, and burning 2 to 5 year old regrowth	10	150	15	225	25	375	35	525	35	525
Cutting unburned stems after fire	-	-	-	-	-	-	15	225	-	-
Grubbing, piling, and burning mature brush	20	300	35	525	65	975	110	1,650	120	1,800
Regrubbing, piling and burning	5	75	10	150	25	375	40	600	50	750

1/ For a 100-acre project on terrain averaging 30 percent slope. Assumes workmen are cutting brush during 6 hours of their working day at $15.00 per day.

could fly. Spraying started about sunup, when down--canyon winds stopped, and usually stopped 2 or 3 hours later when the wind picked up. Spray operations were closed down when wind speed reached about 5 miles per hour. The longest flying time in a single day was 3 hours and 44 minutes.

During a 58-day spray operation in May and June 1961, there were 25 days during which no flying was possible. The average flying time was 2 hours and 6 minutes per day, not including loading time on the ground. The longest time was 4 hours.

The labor cost presented in table 4 is based on a 3-man crew working 8 hours per day at $20. They will normally be busy during non-flying hours accomplishing various service jobs. We assumed there is other work for the men on days when the helicopter does not fly.

Chemical costs are for 6 pounds of 2,4-D, or 3 pounds each of 2,4-D and 2,4,5-T when mixed chaparral is sprayed, in 10 to 15 gallons of solution for single pass and in 20 gallons for double flying.

Mileage costs of about 60 cents per acre on our 100-acre job are based on these assumptions: two vehicles are driven 50 miles per day at 10 cents per mile; water must be hauled 80 miles at 48 cents per mile, and a truck makes one trip to the area. Additional mileage on days when no flying is done will raise this figure.

Reports from other sections of the State indicate that aerial operators will contract to supply all labor and chemicals at per acre rates below those we estimate in table 4. We know of no such jobs in southern California, but recently some persons have favored contracting work "by the acre." There have been too few jobs of this sort to establish a "going" price. We know of two jobs in which the hiring agency supplied the chemical and water, and loaded the helicopter (fig. 3). One of these was a spray job of 800 acres contracted at $3.99 per acre. A nearby job on the San Dimas Experimental Forest, contracted at $102 per flying hour, cost $2.07 per acre.

TRACTOR SPRAY COSTS

A tractor equipped for spraying is less glamorous than aircraft, but even more effective on suitable terrain.3/ Under favorable conditions 6 acres or more per hour can be sprayed, but on most jobs this rate is not achieved. Production decreases as terrain becomes steeper, rockier, or brushier. Although a tractor's spray rate is much less than that of the helicopter, it can operate in wind and fog that stop aerial operations.

3/ See footnote 2.

Table 4.--Some estimated per acre costs of helicopter spray operations by type of chaparral in the original stand 1/

Item	Chamise-sage and chamise	Mixed and woodland
	Dollars	Dollars
Bell G-2 helicopter at $100/hr.	2.00	2.00
Helicopter ferry or transport	1.00	1.00
Labor, 3 men at $20	.60	.60
Supervision, at $30	.30	.30
Mileage	.60	.60
Chemical 2/		
2,4-D	6.00	3.00
2,4,5-T	--	5.60
Miscellaneous	.50	.50
Estimated Total		
Single-flown	11.00	13.60
Double-flown	13.00	15.60 3/

1/ For a 100-acre project on terrain averaging 30 percent slope. About 50 acres per hour will be sprayed.

2/ Six pounds, a.e., of 2,4-D in 10 gallons of water is our recommendation for chamise-sage; for harder to kill species of mixed chaparral, 3 lbs. each of 2,4-D and 2,4,5-T. If the area is double-flown, half the chemical goes on each time.

3/ If the operation requires more than 1 day, labor, supervision, and mileage costs would add $1.50 or more per acre to the costs.

Figure 3.--Costs of a helicopter spray operation include such items as a tanker forhauling water, a canvas water storage tank, portable pump, chemical, and crew.

Our cost estimates for tractor spraying are based mostly on experience with a D-7 tractor and a 300-gallon slip-on spray unit (table 5). Recently a spray unit was mounted on a small tractor, the TD 340. On gently sloping terrain, this combination promises to spray at lower cost than larger tractors. It can be transported on a 1-1/2 ton stakeside truck, and is amply powered for spraying or for such jobs as pulling the rangeland drill on gently sloping terrain.

HAND-SPRAY COSTS

Hand spraying of individual resistant plants is an inevitable part of most conversions. It is usually done with a power sprayer, mounted on a truck or trailer, that pumps the solution through about 200 feet of hose and a hand-held wand. If the area is not accessible to motorized equipment, back pack sprayers must be used. Costs are highly variable, depending on distance for chemical supply, steepness of slopes, and numbers and size of plants.

In table 6 we assume that a man will spray a sprouting shrub 1 to 2 feet tall in 15 to 20 seconds, and that he will spray about 6 hours during a day. Traveling, moving the sprayer, unclogging nozzles, and repairing breakdowns will occupy the remaining time. The spray man is backed up by a service man who helps move the hose, operate the sprayer, and otherwise facilitate the spraying. One man will be in charge, but will also assist the second spray man. If additional spray rigs are used, a man would be needed to haul water.

Length of time required to spray will vary greatly. In one study where plants up to 5 feet tall were being thoroughly hand-sprayed, about 2-1/2 minutes per plant were required. If sprouts are not more than 12 or 14 inches tall and of easy-to-kill species, only a few seconds are needed to spray a plant. Where hard-to-kill species of recommended size for spraying are being thoroughly treated, 15 to 20 seconds are necessary to wet all stems and leaves.

The quantity of spray material used will increase rapidly as numbers of plants and stems per plant increase, as the height of plants increase, and as the proportion of hard-to-kill species becomes greater. For plants 12 to 24 inches tall, we estimate that 100 gallons of solution will thoroughly wet 1,300 plants (table 6, footnote 2).

Handling up to 200 feet of hose as the spray man moves about requires much of one man's time. Otherwise the hose hangs up on rocks, unburned stems, or clumps of sprouts. If there are many unburned stems, smashing with a dozer, or cutting, is necessary before an efficient spray job can be done.

Labor and mileage charges are higher than for tractor or helicopter spraying because fewer acres can be treated per day in hand spraying.

Table 5.--Estimated per acre costs of tractor-boom broadcast spray operations by type of chaparral in original stand [1/]

Item	Chamise-sage and chamise	Mixed and woodland
	Dollars	Dollars
D-7, 300 gal. cap., 25-ft. boom	$3.20[2/]	$3.20[2/]
D-7 transport	1.00	1.00
TD-340, 170 gal. cap., 24-ft. boom	2.70[3/]	2.70[3/]
Labor, 2 men @ $20 for 4 days	1.35	1.35
Supervision, 1 day @ $30	.30	.30
Mileage	.65	.65
Chemical		
2,4-D	4.00	2.00
2,4,5-T	--	3.70
Miscellaneous	.25	.25
Est. total using D-7	$10.75	$12.45

1/ For a 100-acre project on terrain averaging about 30 percent slope.
2/ Assuming an average of 5 acres sprayed per hour.
3/ Assuming an average of 3 acres sprayed per hour.

Table 6.--Some estimated per acre costs of applying herbicides by hand to sprouting shrubs 1 to 2 feet tall

Item	Average distance between plants [1]			
	12 ft.	8 ft.	6 ft.	4 ft.
	Dollars			
Two men spraying from one power sprayer	5.00	10.00	20.00	40.00
Service man to handle hose, etc., for each spray man	5.00	10.00	20.00	40.00
Supervision	.50	1.00	2.00	4.00
Mileage	.75	1.50	3.00	6.00
Stakeside water truck	.75	1.50	3.00	6.00
Chemical [2]	1.45	2.85	5.70	11.40
Miscellaneous	.25	.50	1.00	2.00
Estimated total	13.70	27.35	54.70	109.40

1/ Corresponding numbers of plants per acre are 325, 650, 1300, and 2600. A spray man will spray 4, 2, 1 or 1/2 acres per day at these densities.
2/ 2 lbs. each of 2,4-D and 2,4,5-T in 100 gallons of water. We estimate that 25 gallons will spray 325 plants, 50 gallons, 650 plants, etc.

Back-pack pressure sprayers are used on areas beyond the reach of powered equipment, on small isolated jobs, and to clean up scattered plants after other treatments. Cost will vary widely, depending on density of plants and distance from chemical supply. We estimate that a man will treat about half as many plants during a day as with a powered sprayer. A crew might consist of two men spraying and one man supplying them chemical.

Records covering back-pack spray jobs are limited, but on a 1962 Cleveland National Forest job of 97 acres where considerable hiking was necessary, the approximate per acre costs were:

Labor and supervision	$103.00
Chemical & diesel oil	9.00
Mileage	5.00
	$117.00

Our experience with the back-pack mist-blower has been limited, but it promises to be no more expensive than hand spraying with powered sprayers. The mist-blower appears to be more suited for hand broadcast spraying than for drenching individual plants. A work crew might consist of two men spraying, and one mixing and transporting chemical.

SEEDING COSTS

Perennial grasses are generally recommended for fuel-break conversion projects. Costs are variable, but are usually greater than reported in other areas where larger acreages and more gentle terrain are seeded.

Perennials should be drill-sown, and the rangeland drill is the best equipment for doing this. In fact, the rangeland drill is the most satisfactory piece of planting equipment available for brushland sites. Data in table 7 are based on its use. The drill can be pulled by D-2 to D-6 tractors, depending on terrain. D-7 or larger tractors are generally considered overpowered for this purpose. A D-6 equipped with a 12-foot dozer blade will uproot or crush most unburned plant stems that might otherwise damage the seeding mechanism. Smaller tractors will pull the drill at less cost on cleared, gently sloping terrain.

In many areas, the terrain is too rough for ground equipment and we must resort to either aerial broadcast seeding or hand methods. Aerial methods are usual only in reseeding after wildland fires. Hand-cleared areas are usually allowed to seed naturally to resident annuals. When aerial methods are used, the helicopter is best suited to fuel-break needs. A Bell G-2 helicopter will take off with about 200 pounds of seed which, at 8 pounds per acre, will be broadcasted over 25 acres. With four to five loads, 100

Figure 4.--The rangeland drill is recommended for seeding fuel-break sites.

or more acres will be seeded per hour. If the helicopter cost is $100 per flying hour, the per acre cost is $0.80 to $1. Labor on a 100-acre job might run $1 or more; on a larger area $0.25 should cover this cost. There would likely be a transport charge of $1 or more per acre to move a helicopter into a small job, but none for jobs of several hundred acres.

Fixed-wing aircraft will often broadcast seed at less cost than rotor aircraft if areas to be seeded are large. However, they do a less precise seeding job in rough terrain, and on small jobs may offer no cost advantage.

The cost of perennial grass seed is a large part of seeding expense. Representative prices per pound of some recommended species in 1962-1963 were:

Harding grass	(Phalaris tuberosa stenoptera)	$0.80
Smilo	(Oryzopsis milacea)	1.00
Tall wheatgrass	(Agropyron elongatum)	.40
Intermediate wheatgrass	(Agropyron intermedium)	.60
Pubescent wheatgrass	(Agropyron trichophorum)	.60
Blando brome (annual)	(Bromus mollis)	.50

Thus, a recommended mixture of 2 pounds each of Harding grass and pubescent wheatgrass, 1 of smilo, and 1/2 of blando brome would cost about $4; and 3 pounds each of pubescent and intermediate wheatgrass would cost $3.60.

The annual grass seed generally broadcast on burns is cheaper than most perennial grass seed. Common ryegrass (Lolium multiflorum) seed is $0.05 to $0.07 per pound; the recommended 5/ Wimmera 62 ryegrass (Lolium rigidum) is about $0.07 to $0.10. Blando brome, also recommended for sowing with perennials, has recently sold for $0.40 to $0.60 per pound, one-third to one-half less than it cost in 1960.

4/ Green, L. R., Edmunson, G. C., Cornelius, D. R., and Evanko, A. B. Seeding grasses on southern California fuel-breaks. Fuel-break Rpt. No. 10. 18 pp., illus. 1963 (Address requests for copies to Pacific SW. Forest & Range Expt. Sta., P. O. Box 245, Berkeley, Calif. 94701.)

5/ Edmunson, George C., and Cornelius, Donald R. Ryegrasses for southern California fuel-breaks. U.S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Res. Note 186. 6 pp., illus. 1961.

Table 7.--Some estimated costs of drilling grass seed on fuel-breaks in southern California

Item	Seedbed conditions	
	After wildfire	Cleared
Drill sowing:	- Dollars per acre -	
D-6, 10-ft. drill	6.50 1/	3.50
D-4, 10-ft. drill	5.55	3.00
TD-340, 10-ft. drill	- -	2.70
Equipment transport:		
D-4	1.00	1.00
D-2 or TD-340	.20	.20
Rangeland drill	.60	.60
Mileage	.60	.55
Labor 2/	4.15	1.10
Supervision	.30	.30
Drill maintenance	.50	.25
Perennial grass seed	4.00	4.00
Miscellaneous	.20	.20
Estimated total using D-4 tractor	$16.90	$11.00

1/ We estimate 2 acres per hour on uncleared, and 3.6 acres on cleared land if the D-6 tractor is used, and 1.8 and 3.3 acres if the D-4 is used. The TD-340 should pull the drill over 2.8 acres of cleared land.

2/ Two men are needed to service the drill on brushy sites, but one can do it if brush stems have previously been cleared.