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USE OF HERBICIDES ON FOREST LANDS IN SOUTHWESTERN OREGON[1/]

by

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A substantial portion of the commercial forest land in southwestern Oregon is occupied by dense stands of brush species or by understocked stands of conifers with a dense understory of brush. Individual brushfields range in size from small patches a few acres in extent to large, continuous areas covering more than 10,000 acres. Climatically, the area is warmer and drier than the northern portion of the Douglas-fir region; and these conditions are reflected in the character of the shrubby vegetation. Sclerophyllous species with dense, stiff branches and thick, evergreen leaves are far more abundant than in northwestern Oregon and western Washington.

BACKGROUND INFORMATION

Southwestern Oregon offers an unusually large variety of topographic, geologic, and climatic conditions; and this great diversity of environmental conditions is reflected in the complex vegetation of the region. As a result, seven geographic areas with different brush growth

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[1/] A condensation of a paper, "Use of Herbicides on Forest Lands in Eastern and Southwestern Oregon," presented September 9, 1961, at a symposium, "Herbicides and Their Use in Forestry," sponsored by Oregon State University, Corvallis, Oreg.

conditions are recognized (10): Northern Coast, Southern Coast, Coast Range, Cascade Range, Siskiyou Uplands, Umpqua Valley, and Rogue River Valley. Each area has its own distinctive combination of environmental conditions and brush species. Deciduous brush species typical of areas farther north extend southward in the cooler and wetter habitats of the Cascade Range and as far south as the Coquille River in the Coast Ranges. Evergreen brush species are more abundant in the southern end of the Cascade Range and are predominant in the extensive broad-sclerophyll forest and chaparral of the Siskiyou Mountains. Since activity of herbicides varies from species to species and is largely dependent upon environmental conditions, foresters must recognize these brush species and different environments in order to use herbicides successfully in silviculture on forest lands in southwestern Oregon.

Brush control and brushfield reclamation problems exist on approximately one-fourth of the 6-1/2 million acres of commercial forest land in the five counties of southwestern Oregon. These consist of nonstocked old burns and cutovers occupied by dense stands of brush, burns and cuttings stocked with young conifers that need release from an overstory of brush, and understocked stands of pole-sized and larger timber with a dense understory.

Foresters over the past half century have been troubled by the need for brush control and brushfield reclamation on forest lands in southwestern Oregon (8, 10, 12), and during this period many efforts were made to reforest brushfields. Almost without exception these efforts were unsuccessful. But the development of 2, 4-D, 2, 4, 5-T, and related herbicides during the past 15 years has at long last given foresters an effective tool for brush control and brushfield reclamation work on commercial forest lands. In view of existing problems as well as the unquestionable need for brush control in the future, all foresters should learn to use this new tool wisely and effectively.

Aerial spraying is generally considered the most practical and economical method for application of herbicides on brushfields in this area, where most brushfields are in rough, mountainous terrain and ground spray equipment would have access to only limited areas. Therefore, most herbicides used and tested to date have been applied as foliage sprays.

In one experiment, six herbicides were evaluated as foliage sprays on thirteen of the most abundant brush species on forest lands

in southwestern Oregon (9). Included were low-volatile esters of 2, 4-D, 2, 4, 5-T, silvex, and 2-(2, 4-DP); a sodium salt of 2, 3, 6-TBA; and amitrole. Low-volatile esters of 2, 4-D and 2, 4, 5-T proved to be the most effective of these herbicides on all brush species, but the best carriers varied from species to species (table 1). Later, repeated applications of the most effective formulations showed that most of these species can be satisfactorily controlled with one, two, or three successive sprayings.

The silvicultural objective of any brush control program on forest land is simply to eliminate undesirable tree and brush species that compete with preferred species for light, soil moisture, and nutrients. Individual projects may be designed to: prepare brushfields for reforestation, release trees from an overstory of undesirable trees or shrubs, or to kill understory brush competing with overstory trees and retarding their growth. To date, use of herbicides on commercial forest lands in southwestern Oregon has largely been confined to projects in the first two categories--brushfield reclamation and release of conifers from brush competition.

BRUSHFIELD RECLAMATION

Aerial application of herbicides alone is generally not an effective method for preparing southwestern Oregon brushfields for reforestation. Even when composed of susceptible species, the dense, interwoven stems of chemically killed brush usually make it impossible for areas to be planted at reasonable cost. Herbicides alone are an effective method of site preparation only when the brush species are very susceptible to herbicides, and when litter is light enough to allow a reasonable chance of success for direct seeding or the stand is sparse enough to permit planting at reasonable cost. But even then, seeds and young trees are jeopardized by rabbits, mice, and other tree- and seed-eating animals that move about freely under the standing dead brush.

On favorable terrain, clearing dense brushfields with mechanical equipment may prove to be more effective and economical. Tractors equipped with bulldozer blades or with toothed brush blades have been used successfully on some sites in southwestern Oregon. Clearing with widely spaced windrows is preferred over clearing alternate lanes, for trees in the narrow lanes are browsed by rabbits and by deer that use the lanes as passageways through the brush. Costs of mechanical clearing are largely dependent upon the species, size, and density of brush to be cleared, and upon the presence of logs and

Table 1.--Suggested solutions of herbicides for foliage application on some common brush species in southwestern Oregon

Brush species	Herbicide	Pounds acid equivalent per 100 gallons	Carrier[1/]	Comments[2/]
Manzanita, hairy	2,4-D	2	Emulsion	Good control with one treatment.
Manzanita, hoary	2,4-D	2	Water	Good control with one treatment.
Manzanita, Howell	2,4-D	2	Emulsion	Good control with one treatment.
Manzanita, greenleaf	2,4-D	2	Emulsion	Good control after three treatments.
Ceanothus, deerbrush	2,4-D	2	Water	Good control with one treatment.
Ceanothus, snowbrush	2,4,5-T	2	Emulsion	Good control after two treatments.
Ceanothus, varnishleaf	2,4,5-T	4	Emulsion	Good control with one treatment.
Ceanothus, mountain whitethorn	2,4,5-T	2	Water	Good control after three treatments.
Chinkapin, golden	2,4,5-T	2	Emulsion	Fair control after three treatments.
Evergreenchinkapin, golden	2,4,5-T	2	Emulsion	Fair control after three treatments.
Tanoak, scrub	2,4-D	2	Emulsion	Fair control after three treatments.
Serviceberry, saskatoon	2,4-D	1	Water	Fair control after three treatments.
Oak, canyon live	2,4-D	2	Emulsion	Poor control after three treatments; aerial parts almost all dead; limited sprouting.

[1/] Emulsions suggested are oil in water, containing 5 percent black diesel oil by volume.

[2/] "Good control" indicates 80 percent or more of the shrubs dead and the remaining shrubs killed back. "Fair control" indicates 50 to 80 percent dead and the remaining shrubs killed back. "Poor control" indicates less than 50 percent of the shrubs dead after high-volume foliage spraying with ground spray equipment.

stumps or topographic hindrances. Costs are high--clearing by this method has cost from $28 to $75 per acre in southwestern Oregon--but this cost may be justified if this is the only method for regenerating productive sites that might otherwise remain nonstocked for an entire rotation or longer.

Controlled burning has also been used to clear dense stands of brush and to prepare sites for seeding and planting in California (2) and in southwestern Oregon. In at least one instance, herbicides have been used to prepare a brushfield for controlled burning; but caution must be exercised, for the chemically killed brush forms a hot and flashy fuel that burns explosively. Burning should be carried out only by competent personnel with adequate fire control equipment available and good wide firelines around the area to be burned. Furthermore, burning may stimulate germination of dormant brush seeds in the soil or create conditions favorable for the germination of others. Where susceptible species have been killed with herbicides, burning may thus result in a new stand of brush seedlings that will require treatment at additional cost in order to insure survival and growth of planted or seeded conifers.

Almost invariably, however, when mechanical methods or burning are used to clear brushfields, intelligent use of herbicides can supplement the primary method of brush control, improve the degree of control obtained, insure a longer lasting effect, and safeguard the investment.

As is evident from the discussion above, no one method can be prescribed for brushfield reclamation on all sites. Therefore, let us consider some examples of brushfield reclamation projects that have been carried out in several different brush types in southwestern Oregon.

Howell Manzanita

A green-leaved manzanita, tentatively identified as Howell manzanita (Arctostaphylos hispidula),[2/] is one of the most abundant manzanitas on the western slope of the Cascade Range and in the

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[2/] McMinn, Howard E. An illustrated manual of California shrubs. 662 pp. Berkeley. 1951. In the key for Arctostaphylos spp., this manzanita appears to best fit the description for Howell manzanita, Arctostaphylos hispidula Howell. Exact identity is in question.

Siskiyou Mountains in southwestern Oregon. Extensive relatively pure stands of the species are found in eastern Jackson County. The shrubs do not crown-sprout when the tops are chopped off a few inches above the ground or when the aerial parts are killed with herbicides.

This manzanita can be readily killed with 2-pound aehg formulations of low-volatile esters of either 2, 4-D or 2, 4, 5-T, but 2, 4-D is most effective and economical. The herbicide can be applied as a foliage spray in either water or oil-in-water emulsion carriers during the growing season.

Aerial application of low-volatile esters of 2, 4-D at a rate of 2 pounds ae (acid equivalent) per acre during early June killed a high percentage of large, vigorous shrubs on the Rogue River National Forest (table 2). The herbicides were applied in an oil-in-water emulsion containing 1 gallon of black diesel oil per acre plus sufficient water to make a spray volume of 7 gallons per acre. Results indicate that 3 pounds ae of 2, 4-D per acre would have provided almost complete control.

Table 2.--Effect of aerial applications of low-volatile esters of 2,4-D and 2,4,5-T in oil-in-water emulsions on Howell manzanita, as shown by data recorded two growing seasons after spraying

Herbicide	Pounds acid equivalent per acre	Average kill	
		Tops killed	Shrubs dead
		Percent	
2,4-D	2	96.9	74
2,4-D	4	98.9	96
2,4-D plus 2,4,5-T	2 1	99.8	96

But brush control is only the first step toward success in a brushfield reclamation project. After brush competition has been eliminated or reduced to an acceptable degree, conifers must be established on the site by planting or seeding. In this project, 2-0 ponderosa pines were planted under crowns of the dying manzanita shrubs during the first fall season after spraying. Almost 100 percent of these trees were destroyed during the first winter by rabbits that moved about freely under the standing, chemically killed shrubs. In contrast, on a 20-acre mechanically cleared area nearby, rabbit damage was noticeably less and seemed to be restricted to a strip around the edge of the cleared area. The rodents may have been reluctant to move out into the center of the clearing away from the protective cover of brush at the edges, but no definite conclusion can be reached on the basis of limited observation.

Much work needs to be done on the reforestation phase of brushfield reclamation. Information is urgently needed on methods of reforestation, choice of species, rodent levels in different brush types, and effective methods of rodent control. Reforestation of brushfields even after achieving an adequate degree of brush control will be much more difficult than regeneration of formerly timbered sites immediately after cutting and slash disposal. Even on the latter areas, failures are all too common.

Tanoak-Madrone

Thousands of acres in the Siskiyou Mountains and southern end of the Coast Ranges are occupied by relatively pure stands of tanoak (Lithocarpus densiflorus), or by tanoak and Pacific madrone (Arbutus menziesii) in mixture with other species. Where a seed source is present, excellent stands of conifers are often found under tanoak and madrone, but there are also many thousands of nonstocked acres of this brush type. Although data are not available on acreage occupied by the various brush species, tanoak and tanoak in mixture with other species is undoubtedly one of the most widespread brush types in the area.

In an experiment in southwestern Oregon, low-volatile esters of 2, 4-D proved just as effective as 2, 4, 5-T when applied as foliage sprays on scrub tanoak (Lithocarpus densiflorus var. montanus) during the growing season (9). Diesel oil emulsions were much more effective than water carriers for both herbicides. And although 2, 4, 5-T was more effective than 2, 4-D on tanoak sprout clumps in northern California (18), there was no difference in kill achieved

with these herbicides after three successive applications as foliage sprays on scrub tanoak in southwestern Oregon.

Aerial sprays have proved very effective on tanoak in the Siskiyou National Forest, but two successive applications may be necessary in order to achieve an acceptable degree of control before reforestation. At present the most effective treatment appears to be: (1) an initial aerial application of 3 pounds ae of low-volatile esters of 2, 4-D per acre applied during early April in 7. 25 gallons of water or in an oil-in-water emulsion containing 1. 5 gallons of black diesel oil plus 5. 75 gallons of water, and (2) a respray 2 years later applying 1. 5 to 2 pounds ae of 2, 4-D per acre in similar carriers and at the same total spray volume per acre.

Season of application seems especially important in spraying tanoak. Foresters on the Siskiyou National Forest have tried early July, mid-August, and early April spray applications. Observation indicates that early spring is by far the most effective time for aerial spraying to control tanoak.

Aerial seeding with endrin-treated Douglas-fir seed following aerial brush control shows promise in one reclamation project in a tanoak-madrone brushfield where litter is very light and mineral soil exposed in many places. The area was seeded with one-half pound of endrin-treated Douglas-fir seed per acre during December following two aerial applications of herbicides. An excellent catch resulted, and the standing dead stems of the 20-foot-tall defoliated tanoak provide an ideal partial shade for the seedlings. Additional trials of this method of reclamation are planned by foresters on the Siskiyou National Forest. An approximate cost for two aerial applications of herbicides and an aerial application of one-half pound of endrin-treated Douglas-fir seed per acre would be about $25 per acre.

One word of caution: In our zeal to do good, let us not destroy trees which--though of little or no value today--may be marketable in the near future. Stands of large, well-formed tanoak trees are found on many sites in southwestern Oregon. Although no market exists for these trees today, they will undoubtedly be marketable in the future.

Greenleaf Manzanita-Mountain Whitethorn
Ceanothus-Canyon Live Oak

Brushfields of this species composition (*Arctostaphylos patula-Ceanothus cordulatus-Quercus chrysolepis*) occupy large areas

on drier sites in the interior of the Siskiyou Uplands. Other species that typically occur in mixture are golden evergreenchinkapin (Castanopsis chrysophylla var. minor), hoary manzanita (Arctostaphylos canescens), California buckthorn (Rhamnus californica), and scrub tanoak. Generally, these are poorer sites than those from the coast to the crest of the Coast Ranges and will not justify as high an expenditure for reclamation.

In 1955, the Siskiyou National Forest and the Pacific Northwest Forest and Range Experiment Station initiated a reclamation study in this brush type west of Grants Pass to learn what could be done with herbicides and to determine approximate costs of site preparation and reforestation. Three areas were sprayed with different formulations of herbicides from a fixed-wing aircraft during July 1955 (table 3). Fifteen months after treatment, there was little difference in the degree of control on all three areas. Tops of all species died back to some extent and a few manzanitas were killed in the lighter treatments, but almost every species resprouted. The

Table 3.--Results of a midsummer aerial application of herbicides on mature shrubs of evergreen brush species in the Siskiyou Mountains

Treatment[1]		Percent kill[2]			
Herbicide	Pounds per acre	Greenleaf manzanita	Canyon live oak	Golden evergreenchinkapin	Mountain whitethorn ceanothus
2,4-D	3	100/30	25/0	43/0	84/0
2,4-D plus 2,4,5-T	2 2	82/15	17/0	34/0	72/0
2,4-D plus 2,4,5-T	4 4	91/0	18/0	37/0	98/0

[1] Low-volatile esters applied in oil-in-water emulsion containing 1.5 gallons of black diesel oil plus water to make 7.5 gallons per acre.

[2] Top kill in percent/percent of shrubs dead.

dense mass of chemically killed brush formed an impenetrable barrier on all three areas; and although the brush was set back, it was obvious that additional treatment was needed if the areas were to be reclaimed.

More than 80 acres of the chemically killed brush was burned late in September 1956 by personnel of the Siskiyou National Forest. One area was left unburned. The dead brush proved a hot and flashy fuel that burned rapidly and cooled quickly, leaving a light layer of ash on the ground. The prescribed burn removed the impenetrable mass of dead brush from the ground, burned off the new sprouts, and prepared the area for reforestation. But extensive resprouting occurred once again, and two resprays were applied on the areas in 1958 and 1959. Each respray consisted of 3 pounds ae of 2,4-D per acre in 1.5 gallons of diesel oil and 5.75 gallons of water. Most of the manzanitas on the areas have now been killed; all other species have either been killed or are resprouting very slowly; and the areas are now considered ready for reforestation. Cost of such site preparation, including three aerial applications of 3 pounds ae of 2,4-D per acre plus controlled burning, is approximately $35 to $40 per acre.

Although prescribed burning may be necessary on some sites to remove the impenetrable dead brush and prepare the areas for reforestation, burning may stimulate germination of dormant brush seeds in the soil and result in dense stands of brush seedlings that might endanger survival of conifer plantations in the burned areas. Sampling at the end of the first summer after burning showed that the burned areas contained an average of more than 10,000 new brush seedlings per acre. In contrast, only a few seedlings were found in the sprayed brushfield that was not burned and under untreated green brush in the vicinity. In resprouting brush types such as this, however, germination of brush seedlings after burning is no serious drawback. The first respray after burning killed more than 90 percent of the new seedlings, and almost all of the surviving seedlings were killed by the second respray.

Mountain Whitethorn Ceanothus

A somewhat different brushfield reclamation problem exists at high elevations in the Cascade Range, where dense stands of mountain whitethorn ceanothus are present on many old burns and cuttings.

Mountain whitethorn ceanothus occurs in high-elevation brushfields in the Coast Ranges, Cascade Range, and Siskiyou

Mountains of southwestern Oregon. Small groups of a spreading, procumbent form are common in the evergreen brushfields of the Siskiyou Uplands. The seeds germinate copiously after fire; and a taller, more erect form of this spiny shrub is abundant in broadcast-burned cuttings on pumice soils near Diamond Lake in the Cascade Range. The species produces a dense mass of roots near the surface that provides intense competition for young conifers. The shrubs sprout prolifically when the tops are cut off or killed with chemicals.

Herbicides are relatively ineffective for site preparation in these dense stands of mountain whitethorn ceanothus. On many cuttings, the shrubs attain heights of 8 to 10 feet within a few years after logging and slash disposal; and although a high percentage of kill might be possible with two or three aerial applications of low-volatile esters of 2, 4, 5-T in water or oil-in-water emulsions, the interlocked, spiny stems of the dead ceanothus would make it impossible to plant the sprayed areas. Aerial seeding with repellant-treated seed following aerial brush control may have some chance of success, but has not yet been tried in southwestern Oregon.

Mechanical clearing by tractors equipped with brush blades has been used to reclaim several cuttings occupied by mountain whitethorn ceanothus on pumice soils in the Umpqua National Forest. Logging slash and ceanothus have been windrowed, and the areas planted with Douglas-fir and ponderosa pine. Survival of both species has been good during the first two summers after planting. A small amount of resprouting has taken place from ceanothus roots that remained in the ground. Touchup spraying of these young sprouts using a backpack sprayer is planned. This will eliminate any possibility of further resprouting and insure the success of the mechanical clearing operation. Bid prices have ranged from $50 to $75 per acre on contracts for this type of clearing. These costs are considerably higher than those cited for mechanical clearing in the Southeast (14).

RELEASE OF CONIFERS

Use of herbicides to release conifers from competition of undesirable woody plants has become an accepted silvicultural practice throughout the United States (1, 3, 4, 5, 6, 7, 13, 16). Until recently, however, foresters in southwestern Oregon have been deterred from using herbicides for this purpose by a lack of necessary information on susceptibility of native conifers to herbicides, proper rates of application, carriers, spray volumes, and timing. Some of the required information has now been developed and herbicides have been used to release conifers in several areas.

Aerial spraying to release conifers from brush competition will undoubtedly be one of the most profitable uses for herbicides on forest lands in southwestern Oregon. Excellent young stands of conifers are present under many different brush associations in all parts of the area, but trees on many sites require long periods of time to emerge from the brush. One or two aerial applications of herbicides at relatively low cost can release young conifers, minimize mortality, and thereby improve final stocking and timber volume on these sites.

Our objective in aerial release spraying is not necessarily to kill the brush, but to increase the amount of light reaching young conifers in the understory and to decrease brush competition for soil moisture and nutrients. To accomplish this we need only obtain a high percentage of defoliation, a fair amount of top kill, and a minimum of resprouting. Actually, a complete top kill may stimulate development of basal sprouts on some species and result in more rapid recovery and greater competition than if some of the original crown remains alive. Granted 3 to 5 years of improved light and moisture, young conifers on many sites will outstrip the herbicide-damaged brush and be permanently released. On other sites, where recovery of brush may threaten to once again overtop the trees, a second aerial application of herbicides may be necessary. Even then, the greatest return per dollar invested in a herbicide program will probably be realized on aerial release rather than brushfield reclamation projects in southwestern Oregon.

A great handicap in releasing conifers from brush competition is that we have no herbicide that is truly selective--one that will kill all undesirable brush species and leave conifers unharmed. Low-volatile esters of 2, 4-D and 2, 4, 5-T are currently being used for release work in southwestern Oregon as in other parts of the United States; but the effect of these herbicides on Douglas-fir, ponderosa pine, and sugar pine varies considerably depending upon carrier, season, and rate of application.

Douglas-fir is far more resistant to 2, 4-D and 2, 4, 5-T than are ponderosa pine and sugar pine. When saplings of all three species were sprayed during the growing season, both pines suffered severe damage and a high percentage of mortality even when the chemicals were applied in water carriers; but Douglas-fir sustained little damage except when oil was used in the carrier in these high-volume applications. The pines suffered less damage from 2, 4, 5-T than from 2, 4-D in both summer and fall sprays, but Douglas-fir was

equally resistant to both herbicides. Dormant season applications of herbicides proved far less damaging than growing season applications on all three conifers. During both seasons, damage to the conifers was greater when the herbicides were applied in oil-in-water emulsions than when applied in water carriers (11).

The study described above indicates that low-volatile esters of either 2, 4-D or 2, 4, 5-T can be used to release Douglas-fir in southwestern Oregon, the choice of either chemical--or the proportions when used in mixture--being dependent upon species composition of brush. At present, attempts to release far more susceptible ponderosa or sugar pines are not advocated in this area. If pine release should prove possible, 2, 4, 5-T will probably be preferred for the job.

There is no conclusive evidence that any one low-volatile ester of 2, 4-D or 2, 4, 5-T is superior to others for aerial spraying to release conifers in the Pacific Northwest. A recent publication (15) indicates a difference in mortality of Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla) sprayed with commercial formulations of three different esters of 2, 4, 5-T, but this variation could have been due to differences in the systems in which the esters were formulated as well as differences among the esters themselves.

Release of Douglas-fir from Tanoak and Pacific Madrone

Where a seed source is present, excellent young stands of Douglas-fir are often found under tanoak and madrone in the Coast Ranges and in wetter portions of the Siskiyou Mountains. Although many of the conifers grow and--in time--emerge from the brush, others remain suppressed for long periods and eventually die. These stands offer excellent opportunities for aerial application of herbicides to release the conifers.

Foresters on the Siskiyou National Forest have used two successive applications of 2, 4-D and 2, 4, 5-T in mixture to release Douglas-fir from tanoak and madrone up to 30 feet tall near Brookings, Oreg. The initial spray was applied in mid-August, followed by an early April respray 20 months later. The mid-August treatment caused a defoliation of new growth on branches of exposed Douglas-firs, but the buds remained undamaged and the trees suffered no permanent harm. The April treatment effectively completed release of the conifers without visible damage to any of the exposed trees.

But the consensus at present is that the treatment described above is not the most effective and economical for releasing Douglas-fir from tanoak and madrone. Since Douglas-fir is as resistant to 2, 4-D as to 2, 4, 5-T, aerial spraying to release Douglas-fir from tanoak and madrone is now regarded as a one- or two-phase operation using 2, 4-D. This will reduce the cost per acre. An initial aerial application rate of 3 pounds ae of a low-volatile ester of 2, 4-D per acre in 0.75 gallon of white diesel oil and 6.5 gallons of water may be all that is necessary on some sites. If necessary, a second milder application of 1.5 to 2 pounds of 2, 4-D per acre in 7.5 gallons of water can be applied as a respray one or two years later. Since early spring applications appear to be most effective on tanoak and least damaging to Douglas-fir, both applications should be made before the conifers burst their buds and begin height growth in the spring. In respray treatments, carriers and amounts of herbicide should be varied according to condition of the treated brush and degree of exposure of the conifers.

Although oil is preferred as a carrier in early spring aerial applications on red alder and vine maple in the northern portion of the Douglas-fir region, there seems to be little difference in results with water, oil-in-water emulsion, or oil carriers on tanoak and madrone in southwestern Oregon. The Bureau of Land Management compared oil with an oil-in-water emulsion as a carrier for 2 pounds ae of 2, 4, 5-T plus 1 pound ae of 2, 4-D per acre on adjacent 20-acre plots of tanoak and madrone in the Coast Ranges. No noticeable difference in effect could be detected by observation 15 months after treatment. Tanoak and madrone suffered extensive defoliation and partial top kill, while Douglas-firs were not damaged.

Species characteristics may be at least partially responsible for the greater effectiveness of water and oil-in-water emulsion as carriers in southwestern Oregon. Red alder and vine maple are deciduous species, while tanoak and madrone are evergreen. Pre-budburst sprays on deciduous species act primarily on the stems, and oil is more effective than water in carrying the herbicide through the bark to living stem tissue. In contrast, early spring applications on evergreen brush species act largely as foliage sprays; and oil is not as necessary for penetration into leaf tissues.

Release of Ponderosa Pine from Snowbrush Ceanothus

Snowbrush ceanothus is a major component of many brush-fields at high elevations in the Cascade Range and is often especially

abundant on clearcuts where logging slash has been burned (17). Dense stands of snowbrush often engulf young stands of ponderosa pine and other conifers in such cuttings. On many sites the conifers grow rapidly and readily emerge from the brush; but on others, growth of the trees is retarded and some are suppressed and die.

Basal spraying was used to release small ponderosa pines from snowbrush in a cutting near Diamond Lake on the Umpqua National Forest. A 16-pound aehg solution of low-volatile esters of 2, 4, 5-T in diesel oil applied on the root crowns and lower stems produced an almost complete kill of treated plants. This method requires careful supervision to insure that the herbicides thoroughly wet the lower stems and root crown of the ceanothus but are not allowed to come in contact with the pines. Basal spraying should be effective through most of the year. But since small splashes of spray solution and herbicide vapors from the snowbrush may injure pines, it would probably be wise to defer treatment until September or October, after the pines have ceased height growth, set their buds, and become more resistant to herbicides. Basal spraying is a suitable method for releasing ponderosa pine in small areas. On large areas, aerial application of herbicides would be much more economical; but treatments must yet be developed to accomplish this without damaging the pines.

CONCLUSION

In southwestern Oregon, more information is needed on (1) absorption and translocation of herbicides in resistant brush species, (2) the best seasons and treatments for releasing ponderosa and sugar pines, (3) effects of various oils and other additives in carriers, and (4) economic limits for expenditures on herbicide programs.

Herbicides have already proved an effective silvicultural tool for preparing sites for reforestation and releasing conifers from brush competition in southwestern Oregon. Although much work remains to be done before we have adequate techniques for most of our important brush associations, usable prescriptions have already been developed for some brush types--especially for the tanoak-madrone brushfields of the Coast Ranges and Siskiyou Mountains. These treatments should be put into use and refined as additional information becomes available. Development of suitable treatments for additional brush types can be speeded up by cooperative efforts between management and research.

Herbicide programs should be used to prevent brush from taking over new cuttings, and this should prove more profitable than reclamation of long-established brushfields. Brush seedlings and sprouts generally can be controlled at lower cost than mature brush of the same species. In addition, we would definitely be working with lands capable of producing timber crops. In brushfield reclamation, many of the sites are of questionable quality; and even after economical methods for reclamation are developed, a reliable guide for judging site quality must also be developed to insure a wise selection of areas to be reclaimed. Therefore, it should cost less to hold one acre that threatens to revert to brush than to reclaim one acre in a well-established brushfield, and an acceptable return per dollar invested will be much more certain.

Practicing foresters have played an important part in developing the use of herbicides as a silvicultural tool in southwestern Oregon, and their free and willing exchange of information has made available much of the information presented in this paper. Perhaps their experience in the examples cited will point the way for additional work on other problems.

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