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A Comparison of Techniques to Control Sprouting Hardwoods on Harsh Sites in Western Mendocino County

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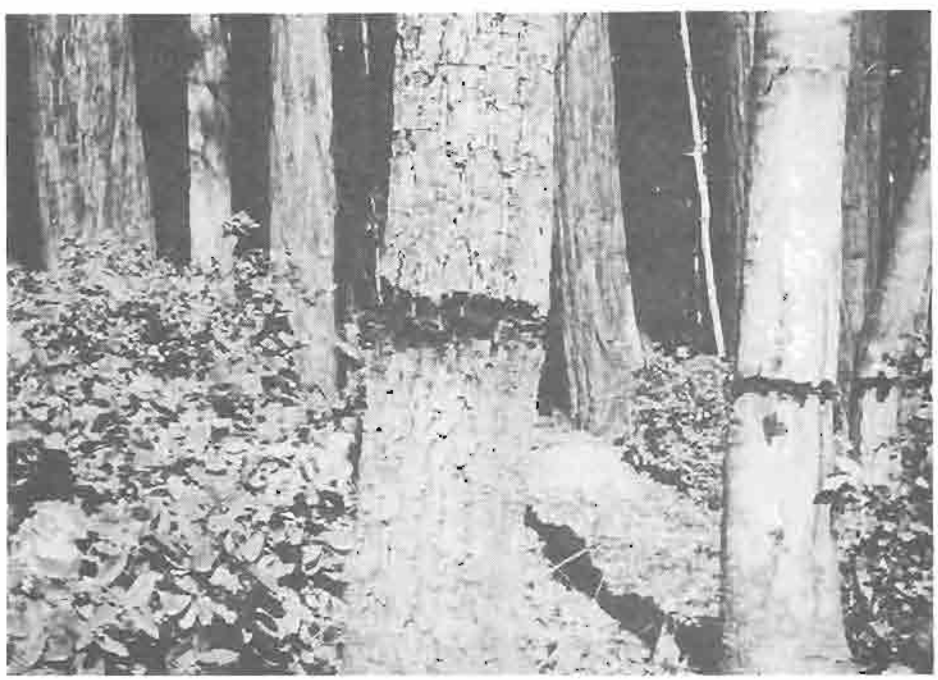

Example of frilled tanoak stems.

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Abstract

Three methods were tested to control sprouting hardwoods on a relatively poor growing site in the James Creek basin of Jackson Demonstration State Forest. The site has a mixture of hardwoods, dominated by tanoak of all size classes, and conifer stocking consisting of young coast redwood and Douglas-fir. Severing tanoak stems and treating the cut surface with the herbicide triclopyr provided the best control, with only 20% resprouting after 1 1/2 years. Frilling the tanoak stems with overlapping cuts and injecting the same herbicide killed about 60% of the trees less than 6 inches in diameter, when the treatment was performed as specified. It was considerably more difficult to kill larger tanoaks with this method. A "thinline" basal spray with undiluted triclopyr caused 55% mortality on tanoak stems less than one inch, but was ineffective for larger stems. Due to the heterogeneous nature of the stand conditions on this site, it appears likely that significant conifer growth increases will be difficult to detect here. Results from this study should be applicable to growing sites throughout the redwood region.

Keywords: tanoak, hardwood control, herbicides, conifer release

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INTRODUCTION

The hardwood component of many coast redwood stands on drier inland sites in northern California has increased as a result of harvesting practices during the past four decades. Old-growth conifers were generally removed in two stages, and as a result hardwoods were released on the harsher sites. The young-growth stands that resulted from these entries are a mosaic of conifers and hardwoods, keyed to aspect, soil depth, and topographic position. Hardwoods tend to dominate on south facing slopes, on shallow soils, and on ridges and upper slope positions.

Tanoak (Lithocarpus densiflorus) is the dominant hardwood competing with conifers on the North Coast of California. It is an evergreen broadleaf tree that sprouts vigorously after being cut. Sprouts may reach 12 feet in three growing seasons (Kay et al. 1961). Tanoak trees may be single stemmed or multi-stemmed. They sprout from burls (adventitious buds) at the base of the stems below ground. Burl formation begins at five to ten years of age. Clump size is more strongly related to the size of the parent tree than to time since cutting (Tappeiner et al. 1984). Tanoak is more shade tolerant than other hardwoods, such as madrone, in these types of stands.

Competition from tanoak sprout clumps can inhibit regeneration of conifers and limit their growth and yield. Few papers have been published in the redwood region on competing vegetation on very steep, rugged, harsh sites. Usually, these types of stands have been ignored and left to grow naturally. Little is known about stand growth in these areas and how it could be improved through a vegetation management program. Additionally, few published reports exist on the economic feasibility of such an operation.

While this species is currently undesirable in stands intensively managed for sawtimber, it is valuable to other resources. Tanoak is a prolific seeder and its acorns are a major food source for wildlife species. Recent observations indicate it may provide spotted owl habitat in the absence of other canopy. Its presence on steep slopes enhances slope stability and reduces soil erosion. The wood itself is useful for pulp, wood chips, firewood, and for some applications, lumber (Passof 1983).

Mechanical clearing of tanoak with crawler tractors can be successful on gentle terrain if the stumps are dug out (Lunak 1981), but this technique is inappropriate for most of the steep North Coast. Broadcast burning results in vigorous sprouting and is of no use in controlling these species. Aerial application of herbicides has proven to be very successful in treating red alder in extreme north coastal California, Oregon, and Washington, but it is not effective on stands covered with tanoak (Radosevich et al. 1976). Additionally, it is not socially acceptable in most of California. Therefore, only individual tree treatment is left as a feasible alternative to control hardwoods here. Since this type of treatment is expensive, there must be reasonable assurance that it will be successful. The goal of this study was to test several hardwood control techniques on a harsh site to see which were the most effective.

LITERATURE REVIEW

One of the earliest studies on controlling hardwoods in Mendocino County was conducted by Fritz and Rydelius (1966). Their study site was 12 miles east of Fort Bragg and had been clearcut 23 years earlier. Tanoak, madrone, and ceanothus dominated the site, with manzanita, rhododendron, redwood and Douglas-fir in the understory. Basal spray with Weedone Brush Killer (2,4-D and 2,4,5-T diluted in diesel) in April 1962 was effective only on ceanothus, while basal spray and frilling killed ceanothus, manzanita, and madrone. Most of the tanoak and rhododendron were dead or judged to be dying by the end of the year after re-friling and injection with Ammate (ammonium sulfamate).

Radosevich et al. (1976) studied tanoak and madrone control on a site eight miles west of Ukiah. On plots 50 feet square, three to four inch tanoak and madrone were frilled and treated with undiluted 2,4-D, 2,4,5-T or picloram in April 1964. After ten years, stems on the plots were reexamined. Mortality for the various treatments were 87, 79, and 94 percent for 2,4-D, 2,4,5-T and picloram, respectively. Some tanoak survival due to stem recovery was observed with each herbicide.

Warren (1980) tested the herbicide Garlon 4 (triclopyr ester) as a basal spray on small tanoak stems near Fort Bragg in March, June, and September 1975. Growth stages during these months were late dormant, rapid growth, and post-growth, respectively. Control of tanoak after two years was good with three gallons of Garlon 4 diluted in 100 gallons of diesel spray solution (gph) when applied in March and the stems were less than three inches in diameter. Only one to two gph provided good control in June and September. Madrone less than three inches in diameter were readily killed by Garlon 4 at two gph.

A refinement of the basal spray method was successfully tested by Warren (1982) near Ukiah. Tanoak up to three inches in diameter were treated with an undiluted thin stream of Garlon 4 to all sides of the stems six inches above the base. Doses of 8, 16, and 24 ml per stem were applied in September 1980. After one year, trees treated with 8, 16, and 24 ml per tree had 60, 100, and 83% top-kill, respectively.

More recently, Tappeiner et al. (1987) did a comparison of three application methods with two forms of Garlon. On sites near Brookings, Oregon, nearly pure tanoak stands which originated from sprouting 40 to 55 years earlier were treated with cut surface, stem frill, and basal spray applications. Stem diameters ranged from 2 to 16 inches. Two years after treatment with Garlon 3A (triclopyr amine), 80 to 100% of the trees with cut surface treatments in November and February had failed to sprout, as compared to 5% to 45% of the trees treated in May and August. However, four years after treatment, there was considerable sprouting; only 35% of the November and 60% of the February treated trees had failed to sprout.

Tanoak dieback with Garlon 3A stem frill treatments done in November and February was significantly greater than for May and August. More than 95% of the trees treated in November and February experienced dieback after four years. About 78% of the November trees died, while 62% of the February trees were killed. The basal spray method proved to be the least effective. Four years after treatment with Garlon 4 diluted to 3% by volume with diesel, mortality averaged slightly above 30% for May application. It was less for the other months tested. Crown dieback averaged almost 90% on those trees treated with this method in August, but was lower for the other months tested.

Conrad and Emmingham (1984) summarized the effects of many different types of herbicides on 17 different species of trees and shrubs. They stated that there should be very severe injury to tanoak, madrone, manzanita, chinquapin, canyon live oak, and bigleaf maple with a basal spray treatment of diluted Garlon 4. All stem surfaces from the ground up to 18 inches must be covered to the point of runoff. Cut surface treatments (frill and cut stump) with Garlon 3A were judged to cause very severe injury to tanoak, madrone, manzanita, and bigleaf maple.

STUDY SITE

The study area is part of the James Creek watershed, located about 20 miles east of Fort Bragg, California, and the Pacific Ocean (see Figure 1). It is a 5000-acre tributary basin of Big River, which enters the sea at Mendocino. James Creek is near the eastern edge of the coast redwood (Sequoia sempervirens) range; this species requires an abundance of cool, foggy summer days. In addition to redwood, Douglas-fir (Pseudotsuga menziesii), tanoak, Pacific madrone (Arbutus menziesii), and chinquapin (Castanopsis chrysophylla) exist in the overstory. Understory vegetation consists of rhododendron (Rhododendron macrophyllum), huckleberry (Vaccinium ovatum), salal (Gaultheria shallon), blueblossom (Ceanothus thyrsiflorus), wax myrtle (Myrica californica), canyon live oak (Quercus chrysolepis), bigleaf maple (Acer macrophyllum), and hairy manzanita (Arctostaphylos columbiana). Elevations at the study sites range from 1200 to 1600 feet. Precipitation occurs primarily as rainfall, and averages over 60 inches annually. Summer maximum temperatures are near 100° F, and winter minimums are slightly below freezing.

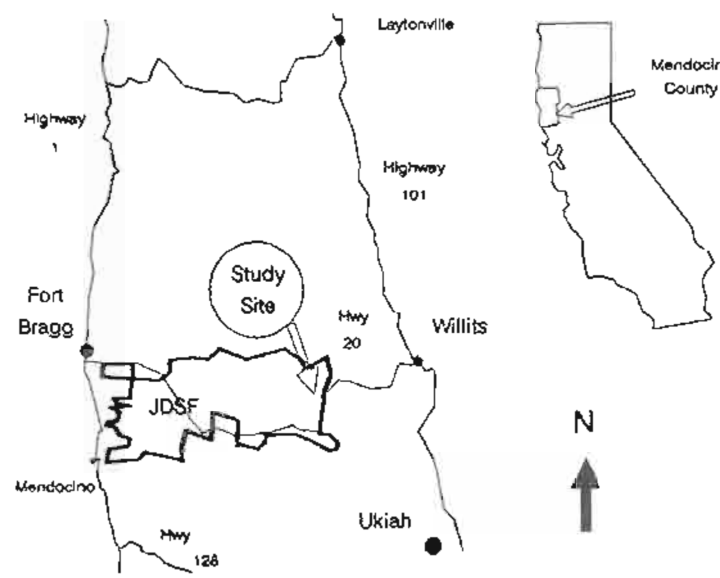

Figure 1. Large scale view of the study site location.

The soil types found here are included in the Yellowhound-Kibesillah complex (loamy-skeletal, mixed, isomesic Ultic Haplustalfs). They have surface horizon textures classified as very gravelly loams, and very gravelly clay loam B horizons. Soil depth is generally 40 inches or less. The soils are derived from the Franciscan formation, which is made up of highly fractured sandstone and shale. The potential for mass failure events with these soil types is high. The droughty surface layer greatly reduces seedling survival on south/southwest facing slopes. The terrain is youthful, and continues to be actively uplifted by tectonic forces. Slopes range from 15 to 70 percent, with an average of 50 percent.

Our study utilized 24 acres of the 474 acre James Creek 1979 Timber Sale. The area was logged with crawler tractors in 1959, when roughly 70% of the old-growth volume was removed. In 1979, the remaining old-growth was harvested. The prescription was to remove all conifers larger than 22 inches in diameter at breast height (dbh). Approximately 20,000 board feet per acre was cut. Crawler tractors were used above Road 1020, and a skyline cable system below. Site class ranges from III to IV here (McArdle 1949), largely dependent on aspect and topographic position.

This particular site was chosen for the study because it has conifers that are directly competing with hardwood species (i.e., conifers and hardwoods with similar heights are present). After the more recent logging, a prescribed burn was done in the area of Block 3 (see Figure 2), and Douglas-fir seedlings were planted in 1981. Site preparation and planting were not done for the remainder of the area, and the conifer regeneration present has sprouted or seeded in naturally. The stand conditions in the area are a mixture of the following components: 1) 20 to 30 year-old redwood and Douglas-fir, 2) large overstory tanoak, madrone, chinquapin, and a few redwoods, 3) 5 to 10 year-old redwood sprouts and Douglas-fir seedlings, 4) young tanoak and madrone sprouts, 5) mixed brush species (ceanothus, manzanita, rhododendron, and huckleberry), and 6) disturbed areas (i.e., compacted skid trails, landings, and landslide areas).

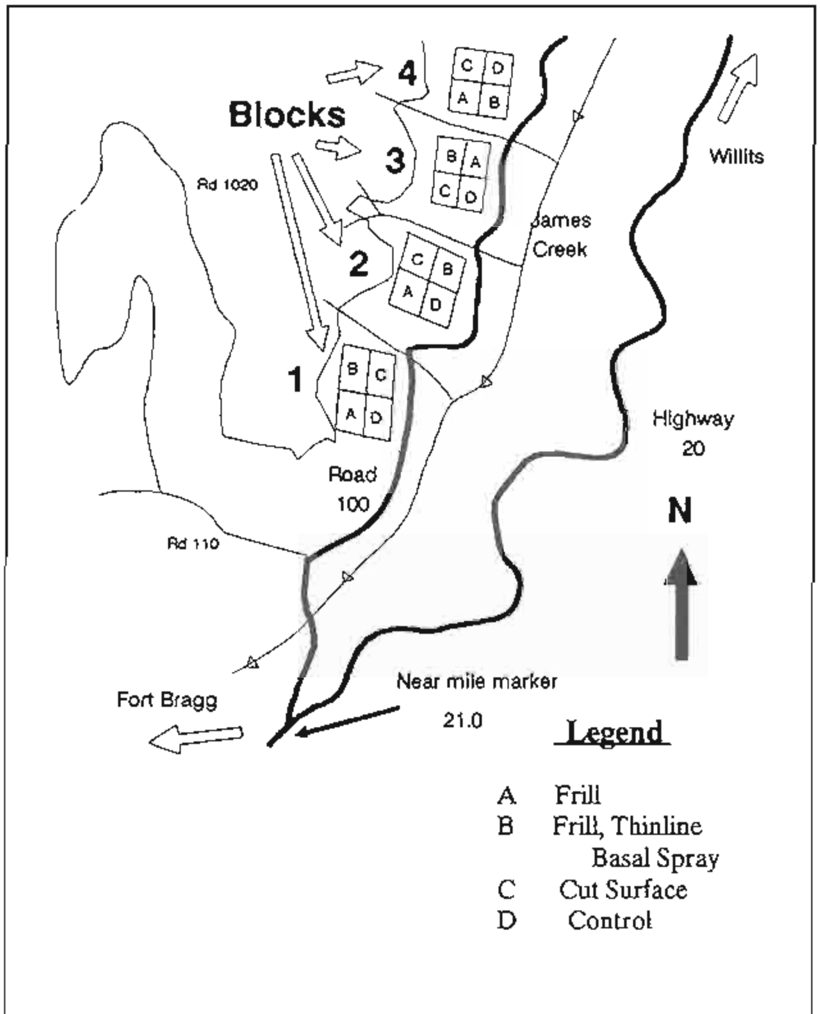

Figure 2. Location of the blocks in James Creek.

METHODS

Three herbicide application methods were tested at the James Creek site. Chemicals and treatment times were chosen which were thought to be the most effective for the area. The study utilized a randomized block design, with 4 treatments and 4 blocks. All blocks were installed in locations where there were adequate numbers of conifers to release from brush and tree competition. Within each block, the 4 treatments were assigned randomly (see Figure 2). Each block was 6 acres in size, and each of the 4 plots in a block was 1.5 acres. The specified treatments covered the entire plot, but the effectiveness of the hardwood control was analyzed only in smaller 1/5 acre square subplots, centered within the larger plot. The specifications for the herbicide application methods tested were:

1) Frill- All hardwood stems greater than 3 inches in diameter at 12 inches above the ground level, and within a 5 foot radius of a conifer crop tree were treated. Horizontal, overlapping cuts, 2 to 3 inches long, were made through the bark into the wood of a tree at a height of about 4 feet. One ml of undiluted triclopyr amine (Garlon 3A) was injected immediately into each cut. Treatment was done on October 24-27, 1988.

2) Thinline Basal Spray- All hardwood stems less than 3 inches diameter at 12 inches above ground within a 5 foot radius of a conifer crop tree were treated with a thinline basal spray. At least 3 sides of a clump and no less that one-half the circumference of a single stem were required to be sprayed. Undiluted triclopyr ester (Garlon 4) was applied in a thin stream at a rate of 50 ml per clump to all sides of the sprouts as close to ground level as possible, but no higher than 12 inches above the ground. Small spray bottles were used for this work. Treatment was done during the period of active growth (April 12-13 and May 19, 1988).

3) Cut Surface- All hardwood stems less than 10 inches DBH within a 5 foot radius of a designated crop tree were felled no more than 8 inches above ground level. Triclopyr amine (Garlon 3A) with dye was applied at full strength to the cut surface immediately after cutting, in a 1 to 2 inch band covering the bark, cambium, and outer part of the xylem (see Figure 3). Treatment was done on October 25- 28, and December 5-7, 1988.

Figure 3. Application of Garlon 3A herbicide to a freshly cut tanoak stem.

The four treatments on each 6-acre block were: 1) **frill**, 2) **frill** and **thinline basal spray**, 3) **cut surface**, and 4) **control** (see Figure 2).

The contractor supplied information on the amount of chemical used per plot and the number of person-hours used per plot.

The subplots were examined during March 1990 and all trees which had been treated were rated for herbicide effectiveness. For each tree or stem of a clump, the following parameters were recorded: species, size category, treatment, degree of kill, and completeness of treatment. A limited number of chi-square tests were run to test for statistically significant dif-

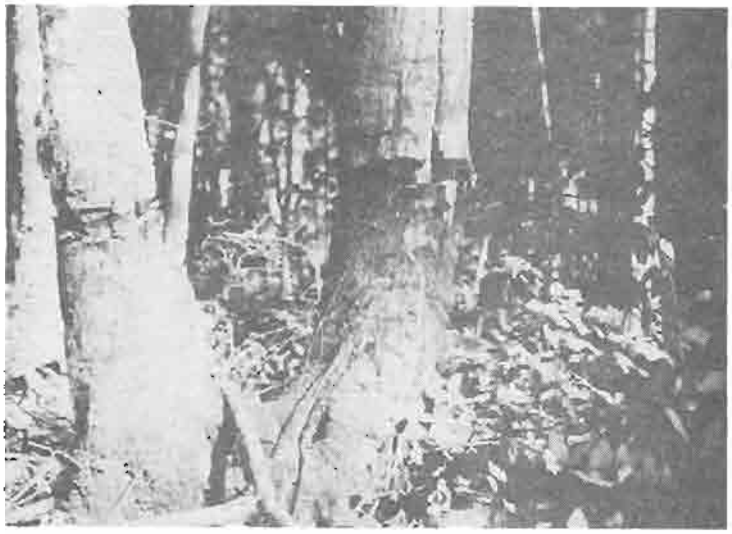

Figure 4. Example of tanoak trees with complete frills.

Trees which were still alive were assigned to several different categories. These groups included: top dead above frill (with green branches or sprouts below), 90% top kill, less than 90% top kill, and zero kill. Figure 5 illustrates how the various size classes were affected by the treatment. Overall, the smaller the stem size, the greater the effect of the treatment.

ferences between the treatments.

To allow future comparisons to be made on the effectiveness of the treatments for conifer release, the subplots with the cut stump treatment and the subplots with both frill and thinline basal spray treatment were surveyed for potential crop trees. Crop trees were defined as redwood or Douglas-fir on a 10 foot by 10 foot spacing. The number of trees, their height, diameter, and species were recorded. In addition, they were tagged for future growth comparisons.

RESULTS AND DISCUSSION

Frill Method

Examination of the eight 1/5 acre plots where the frill method was prescribed showed that 208 hardwoods were treated. Approximately 62 percent were judged to have complete overlapping cuts through the bark, as was specified by the contract (see Figure 4). The remaining trees had cuts that did not go totally around the tree or were too shallow. Ninety-nine percent of the frilled trees were tanoak. For the trees that had complete frills and were less than 6 inches in diameter, 61% were killed by the treatment. Trees with incomplete frills in this size category experienced 27% mortality. Overall, 49% of these trees died. Complete frills on trees from 6 to 10 inches in diameter killed only 41 percent, while incomplete frills produced 15% mortality. No trees larger than 10 inches were killed, regardless of frill quality. For all the trees examined, regardless of size or the quality of treatment, 41% died.

Thinline Basal Spray Method

Four 1/5 acre plots were treated with the thinline basal spray method. A total of 729 observations were made on individual stems, some of which were part of large clumps with the same root system (see Figure 6). Species breakdown was as follows: tanoak - 87%, manzanita - 11%, madrone - 1%, and ceanothus - 1%. For many of the stems, the dye was faded and the quality of the application was difficult to evaluate. Therefore, no distinction was made between complete coverage and coverage that did not meet contract specifications.

Tanoak stems less than 1 inch in diameter were killed 55% of the time with the thinline method. About 12% of the tanoak stems from 1 to 3 inches in diameter experienced mortality. This difference between diameter classes was

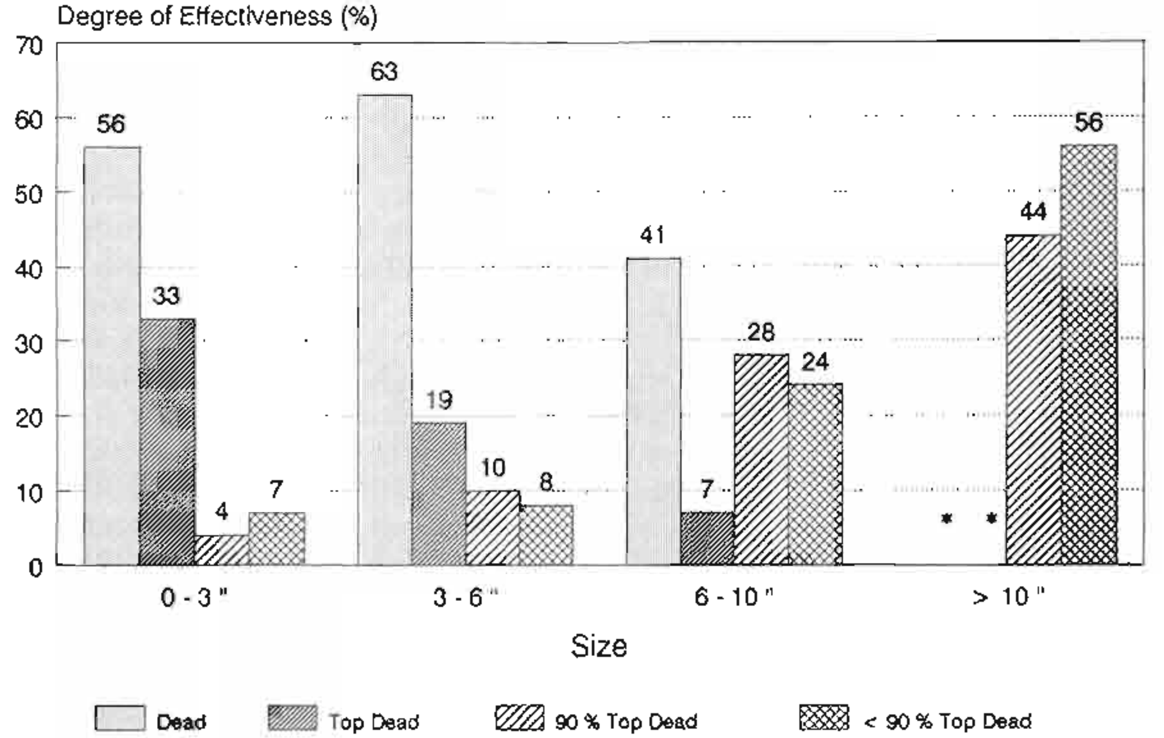

Figure 5. Frill treatment on tanoak when performed to specifications. ("" denotes zero observations)*

Figure 6. Example of a multi-stemmed tanoak clump treated with the thinline basal spray method.

significantly different at the alpha equals 0.05 level. A few stems larger than 3 inches were sprayed, even though they were not to be treated with this method. No mortality was incurred in these larger size classes. In almost all cases with large multi-stemmed tanoak clumps, several of the larger stems remained alive, while many of the smaller stems were killed. The manzanita stems treated were less than 3 inches in diameter, and 86% were killed.

The other categories for evaluating the effectiveness of the spray were: top dead above spray line, top mostly dead above spray line, minor dieback above spray line, and zero kill. Figure 7 shows that tanoak stems less than one inch are clearly the most heavily impacted. Apparently, the thinner bark on young tanoaks allows better penetration of the herbicide.

Cut Surface Method

Four 1/5 acre plots were used to evaluate the cut surface method. A total of 481 observations were made on individual severed stems, some of which were part of large clumps. The species breakdown was as follows: tanoak - 92%, rhododendron - 5%, manzanita - 2%, and madrone - 1%. As was the case with the thinline basal, it was difficult to evaluate the coverage of the stump with herbicide, since the dye was often faded. Again, no quality of treatment distinction was made for this method.

Cut tanoak stems less than 3 inches in diameter showed no evidence of sprouting 84% of the time. Tanoak stems 3 to 6 inches and 6 to 10 inches showed no evidence of sprouting 83% and 80% of the time, respectively (see Figures 8 and 9). Rhododendron stems, which are generally small, showed no evidence of sprouting 15% of the time. Garlon appears to have little effect on this species. Observations on madrone were too limited to evaluate it's response to this treatment.

The cut surface method produced apparent mortality that was significantly greater than that resulting from either the frill or thinline basal spray methods for stems less than three inches in diameter (alpha = 0.05). Future evaluation of the cut surface plots should be done to see if additional resprouting occurs.

A comparison of the various treatments, along with selected past research results, is presented in Table 1.

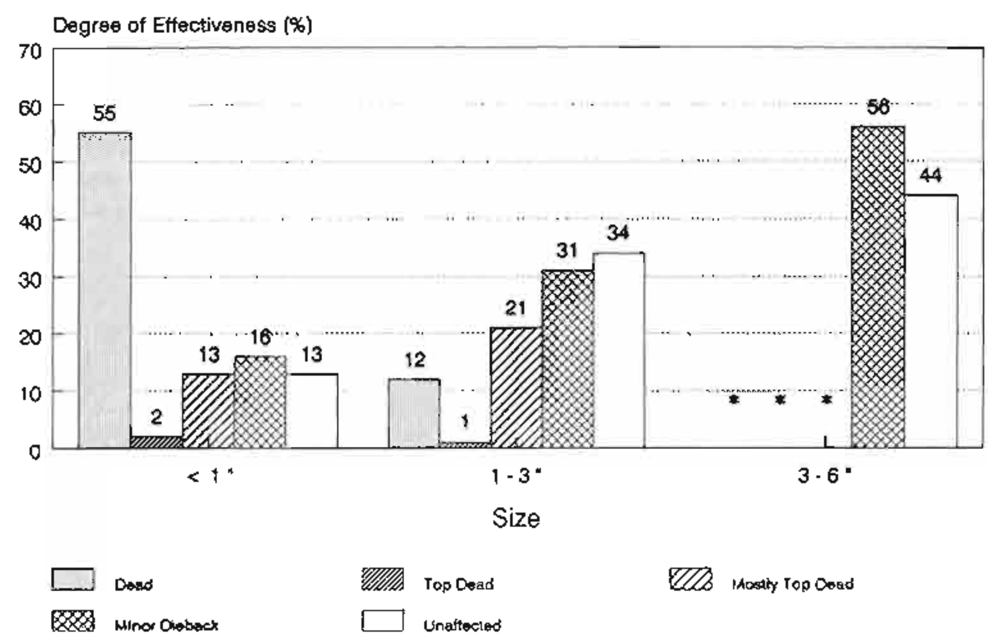

Figure 7. Thinline basal spray on tanoak. ("" denotes zero observations)*

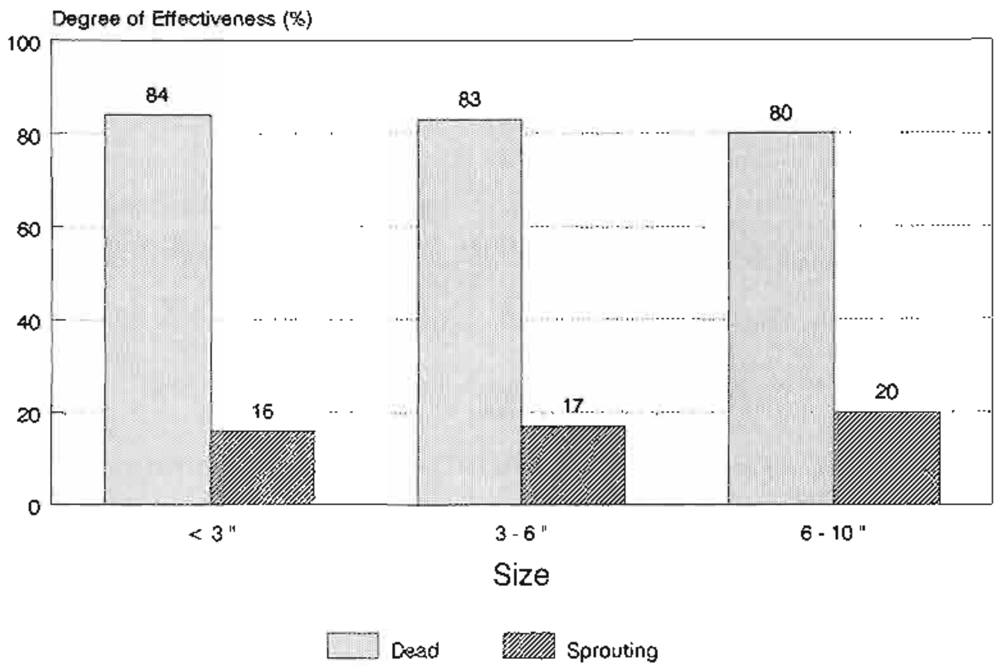

Figure 8. Cut surface treatment on tanoak.

Figure 9. Example of a severed tanoak stem that did not resprout after treatment.

Chemical Usage and Production Rates

Twelve acres were treated with the frill method on the James Creek plots. A total of 31.5 quarts of Garlon 3A was used, with an average of about 2.6 quarts per acre. Assuming the number of stems treated on the 1/5 acre subplots can be extrapolated to the larger 1.5 acre blocks, 130 stems per acre were treated. This means that almost 50 stems were treated with a quart of Garlon, and approximately 0.6 oz (20 ml) was applied per stem. A total of 77.5 person-hours were used to do this treatment. Therefore, it took about 6.5 person-hours per acre (see Table 2). While this production rate may appear to be

Table 1. Summary of herbicide studies. (Results for JDSF work obtained from contract application of herbicide)

Treatment	Source	Species	Size	Month Performed	Chem/ Stem	Herbicide	Time Since Treatment	Mortality/ Non-sprout	Top Kill
Frill	JDSF	Tanoak	0 - 6"	Oct.	20 ml	Garlon 3A	$1^1/2$ yr	61 % *	---
	Radosevich et. al. 1976	Tanoak / Madrone	3 - 4"	April	2 ml / cut	2,4 - D	10 yr	87 %	---
	Tappeiner & Pabst 1987	Tanoak	2 - 16"	Nov.	1 ml / cut	Garlon 3A	4 yr	77 %	---
Cut Surface	JDSF	Tanoak	0 - 10"	Oct. / Dec.	6 ml	Garlon 3A	$1^1/2$ yr	80 - 84 %	---
	Tappeiner & Pabst 1987	Tanoak	2 - 16"	Nov.	?	Garlon 3A	2 yr	80 - 100 %	---
Thinline Basal	JDSF	Tanoak	0 - 3"	April / May	5 ml	Garlon 4	2 yr	-----	47 %
	Warren 1982	Tanoak	0 - 3"	Sept.	8 ml	Garlon 4	1 yr	-----	60 %

" * " only includes trees with complete frills.

Table 2. Comparison of production rates for the various methods.

Treatment	Herbicide / Acre (qts.)	Stems / Acre	Chemical / Stem (fl. oz.)	Hours / Acre	Cost / Acre ($)
Frill	2.6	130	0.6	6.5	140
Cut Surface	3.7	600	0.2	13.3	320
Thinline Basal	4.3	910	0.15	6.8	190

low, it can be partially explained by the very steep, rugged conditions found on this site. On some plots, a large percentage of the tanoaks were not treated, since there were no conifers near them (i.e., contract specifications only required treatment when conifers were within 5 feet of a hardwood stem).

Six acres were treated with the thinline basal spray method. Approximately 26 quarts of Garlon 4 were used, so the average was about 4.3 quarts per acre. Extrapolating the 1/5 acre plot stem counts, there were 910 stems treated per acre. Roughly 200 stems were sprayed with a quart of herbicide, with about 0.15 oz (5 ml) per stem. A total of 41 person-hours were used to do this work, so the average was 6.8 hours per acre. Probably one-third to one-half the tanoak clumps were not treated, due to the lack of conifer regeneration in close proximity.

Six acres were treated with the cut surface method. Twenty-two quarts of Garlon 3A were used, yielding an average of 3.7 quarts per acre. Through 1/5 acre plot extrapolation, an average of 600 stems per acre is assumed. About 160 stems were treated with a quart of herbicide, with about 0.2 oz (6 ml) per stem. A total of 80 person-hours were used for this treatment, so the average was 13.3 hours per acre. As with the other methods, a large percentage of the tanoaks remained uncut where conifers were not present.

Using 1988 dollars, the costs of the various treatments were as follows: frill - \$140/ac, thinline basal spray - \$190/ac, and cut surface - \$320/ac. The values do not include the contractors expenses for transportation, lodging, or food. They do reflect costs for the herbicide (\$84/gal), labor with overhead, and miscellaneous expenses.

Conifer Stocking

Surveys of conifers greater than 4.5 feet in height on eight 1/5 acre subplots showed that there were an average of 38 "crop" trees per subplot. This corresponds to 190 trees per acre. Fifty-seven percent were Douglas-fir and 43% were coast redwood. Most of the Douglas-fir ranged from 6 to 22 feet in height, while most of the redwood were 10 to 30 feet in height. Douglas-fir diameters at breast height were generally less than 3 inches, while the redwood were mostly less than 5 inches.

The distribution of these species varied considerably. A large percentage of the Douglas-fir trees were found on old skid trails and landings, where bare mineral soil had been exposed and provided an adequate seedbed. The exception to this was in Block 3, where the planted Douglas-fir provided more uniform stocking, but were generally smaller. Most of the redwoods were in sprout clumps associated with cut stumps, and hence were scattered throughout the blocks. These blocks were stocked with conifers, but the spatial distribution of the trees was not optimal. If we had chosen sites on more southerly aspects, the stocking would have been considerably poorer.

Due to a variety of factors, we believe it will be difficult to observe a statistically significant conifer growth increase from the treatments implemented on this site. Many of the conifers were overtopped by hardwoods that had stems more than five feet away and were not treated because of the contract specifications. Deer browsing on the smaller Douglas-fir is very heavy and further complicates the analysis.

Selected conifers will have growth increases on these sites from hardwood control, but it is doubtful that the costs compounded for the remainder of the rotation will be justified here. Future research should address whether treating all the hardwoods in selected units on at least moderate sites can produce accelerated conifer growth. On better sites with coastal influence, both woody and herbaceous vegetation must be controlled to get coniferous growth response (Wagner 1988).

MANAGEMENT RECOMMENDATIONS

Based on the results from this study and other observations made on Jackson Demonstration State Forest, we conclude the following:

1) The best control of tanoak is achieved by the cut surface method. This work must be done in the fall months, when the greatest downward translocation in the phloem occurs. The cut surface method is the most expensive and results in high fuel loading on the ground. This can injure small conifer saplings and greatly increase the fire hazard in a unit with established stocking. It can only be done safely after an area has been logged, since standing conifers make it very difficult to cut tanoak and have the stems reach the ground. If the unit is cable logged, most of the tanoak trees are commonly knocked over by the rigging and few may remain to be treated following harvest. Broadcast burning may be required to create plantable sites in freshly logged areas.

2) The frill method can be relatively successful on trees less than six inches in diameter, if care is given to place the cuts deep enough and they are over-lapping. On steep, rugged ground, this is nearly impossible to accomplish in some instances, and very difficult in many others. In cases where cable logging will likely knock down most of the stems, frilling of small to moderate sized tanoak should be prescribed one year in advance of logging. Since it is extremely difficult to kill very large tanoak with this method, a combination of cut surface and frill may be a desirable prescription in some instances. This would mean frilling before harvest on stems less than 6 inches and cutting the larger trees still standing following harvest and treating the stumps.

3) The thinline basal spray treatment proved to be very difficult to implement on the steep, rugged slopes found in James Creek. Mobility was impaired by large amounts of woody debris on the ground. Evaluations of the subplots showed that this treatment was relatively ineffective. More acceptable results may occur if the treatment is performed within two growing seasons after logging, so that all the tanoak stems in a clump are less than one inch in diameter.

4) It may be difficult to observe significant growth increases on poor sites with a mixture of conifer sizes, scattered stocking, and only partial hardwood control. Conifer release work on these types of stands should be done such that all hardwoods influencing crop trees are treated. Designating a small radius around a crop tree for treatment, such as the five foot specification used in this study, is inappropriate.

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