United States General Accounting Office 131999

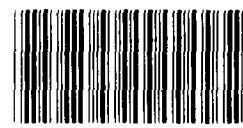
GAO

Fact Sheet for the Chairman, Subcommittee on General Oversight, Northwest Power, and Forest Management, Committee on Interior and Insular Affairs, House of Representatives

December 1986

NATIONAL FORESTS

Estimated Costs and Results of Alternative Silvicultural Treatments



GAO/RCED-87-61FS

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division
B-225882

December 30, 1986

The Honorable James Weaver
Chairman, Subcommittee on General Oversight,
Northwest Power, and Forest Management
Committee on Interior and Insular Affairs
House of Representatives

Dear Mr. Chairman:

In your April 28, 1986, letter, you requested per-acre cost information on the use of herbicides, manual, and mechanical methods for site preparation, release, and thinning work carried out on tree plantations in the Forest Service's Region 6 (the Pacific Northwest). These methods are referred to as silvicultural treatments and are used to achieve forest production goals. You asked us to obtain the cost information for a 4-year period—the year prior to the institution of a court-ordered herbicides ban in Region 6 (1983), the year in which the ban took effect (1984), and 1985 and 1986.

Section 2 of this fact sheet contains tables that show the cost per-acre information you requested for six forests in Region 6. However, cost comparisons between each forest or within forests may not be meaningful because costs can vary due to the different physical characteristics of each forest, such as steepness of terrain, types of vegetation, watersheds, and climate. Such differences may account for the varying cost per-acre amounts shown in the tables. Section 1 contains more details on these differences.

In developing the cost information, we relied primarily on Forest Service data and did not independently verify its accuracy or trace its support to Forest Service records. We discussed the information with cognizant forest officials and representatives of the Office of the Chief of the Forest Service. Their suggestions are incorporated where appropriate.

You also asked us to develop a bibliography of studies comparing the results of using herbicides and other silvicultural methods for site preparation, release, and thinning work. This bibliography is in section 3.

In making this request, you referred to an earlier GAO report, Better Data Needed to Determine the Extent to Which Herbicides Should Be Used on Forest Lands, (CED-81-46, April 17, 1981), which identified a number of

problems. The report stressed that the Forest Service lacked an adequate data base for comparing the use of herbicides with other treatment methods and recommended that the Secretary of Agriculture instruct the Chief of the Forest Service to gather more comprehensive and complete cost data on its site preparation and release projects. Forest Service officials told us that a directive was not issued requiring action on our recommendation because the Service is currently working to implement a cost accounting system that could help overcome the problems surfaced in our report.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this fact sheet until 10 days from the date of this letter. At that time, we will send copies to the Secretary of Agriculture, the Director of the Office of Management and Budget, and other interested parties. Copies will be available to others upon request. Should you need further information, please contact me at (202) 275-5138.

Major contributors to this fact sheet are listed in appendix I.

Sincerely yours,

Brian P. Crowley
Senior Associate Director

Contents

Abbreviations

GAO General Accounting Office

Background, Scope, and Limitations of Data

Silvicultural Practices

The Forest Service manages a commercial species of trees to ensure full stocking (desired number of trees per acre) by temporarily suppressing or controlling the growth of competing vegetation—other tree species, brush, or grass. In managing a forest to achieve desired production goals, certain activities, often referred to as silvicultural practices, are carried out. These activities include, but are not limited to, site preparation, release, and thinning.

Site preparation involves clearing the land of logging debris and vegetation. This may be done by burning; applying herbicides from the air or on the ground; using machines such as crawler tractors with discs, roller drums, or other equipment; and/or cutting with chain saws and axes.

Release refers to promoting the growth of selected trees by temporarily suppressing vegetation that is competing with the trees being managed for production. If needed, release work is usually carried out 3 to 5 years after the seedlings are planted. Once the selected trees have grown big enough to compete with other vegetation, they are generally considered released. Herbicides, both from the air and on the ground, as well as manual methods are used in release.

Thinning refers to cutting and/or removing some trees to stimulate the growth of others. This activity increases the total yield of useful material by concentrating the stand's potential wood production on a limited number of selected trees. Thinning may be carried out by hand, with machines, or with herbicides, usually by injecting the herbicide in the unwanted trees.

Scope and Methodology

To develop comparative data on different silvicultural treatments, we reviewed information for six Region 6 national forests—the Gifford Pinchot in Washington; Rogue River, Siskiyou, Siuslaw, Umpqua, and Willamette in Oregon. Collectively, these six forests accounted for over 80 percent of all the Forest Service's herbicide-treated acreage in the region in fiscal year 1983, the last year herbicides were used. None of the other 13 forests in the region accounted individually for more than 5 percent of the region's total herbicide-treated acreage that year.

Officials at the six forests developed both the contract and administrative cost data shown. At our request, they included as administrative costs only those amounts incurred by district and forest office personnel who were directly involved in the forests' vegetation management program. As agreed with your office, we did not have them include such

overhead items as general administrative expenses; planning costs involved in the area of vegetation management; or other regional or national program costs, such as those incurred in preparing environmental impact statements and litigation. These costs were excluded because the Forest Service accounting system does not portray them, and they are difficult to estimate. We do believe, however, that such costs are important and could be significant in comparing herbicides costs with manual or mechanical treatment methods.

To develop the bibliography requested, we wrote to 46 universities cited in the March 1986 Journal of Forestry as having the major schools of forestry; 25 forestry associations, industry, or public interest groups; 8 Forest Service forest and range experiment stations; and the Congressional Research Service. As requested, we asked them to provide us with any reports, studies, or theses started or completed after 1983 that dealt with the use of herbicides, manual, and mechanical methods to prepare, release, or thin a tree plantation.

Factors That Could Limit the Usefulness of Cost Per-Acre Information

Officials at the six forests and Region 6 headquarters pointed out that certain factors could limit the usefulness of the data in section 2 for making comparisons between forests or between the three treatment methods.

- The Siuslaw National Forest, one of the heaviest herbicide users in Region 6, significantly reduced its herbicide program in fiscal year 1983 while the court was deliberating whether herbicides should be banned, and it used manual or mechanical methods on acres for which the forest would have normally used herbicides.
- Administrative costs are not separately accounted for in the Forest Service accounting system and, therefore, they could not be directly linked to specific contracts or types of projects. Forest Service officials provided estimates of administrative costs, which are used in the tables in section 2.
- Physical characteristics, such as steepness of terrain, types of vegetation, watersheds, and climate, can vary considerably between forests and between areas within a forest. Among the six forests covered, warm, dry summers and steep terrain generally characterize the southern three forests—Siskiyou, Rogue River, and Umpqua—while cooler, wet summers and more level terrain characterize two of the northern three forests— Gifford Pinchot and Willamette. The other northern forest— the Siuslaw—is close to the Pacific Coast and is characterized by cool, wet summers with comparatively steep terrain. Such

different physical characteristics influence vegetation types, the kinds of alternative treatment methods available economically, and, in turn, per-acre costs of the projects affected.

Per-acre costs shown in section 2 tables are averages for both the herbicide and manual/mechanical categories, but the averages are often composed of projects with widely varying costs per acre. For example, in the herbicide category, aerial applications (helicopters) were generally used, but ground applications were also used, which generally cost more per acre than aerial applications.

In some areas it is necessary to apply a follow-up treatment of herbicides when the competing vegetation has not been initially destroyed. The costs of these treatments are not reflected in the tables in section 2, and we were unable to locate any related studies measuring the extent of follow-up treatments ordinarily required in Region 6 forests. However, officials from each forest visited indicated that manual/mechanical applications normally require more follow-up treatments and, ultimately, may realize less timber growth and harvest levels than herbicide applications.

Estimated Costs of Using Herbicides, Manual, and Mechanical Methods to Site Prepare, Release, and Thin Tree Plantations

The data in tables 2.1 through 2.6 show per-acre contract and administrative costs and the number of acres involved in fiscal years 1983 through 1986 in applying herbicides, manual and mechanical methods for site preparation, release, and thinning activities. No manual or mechanical site preparation work was carried out on the Gifford Pinchot National Forest for the 3 years after 1983. (See table 2.1.) Site preparation data for the Siskiyou National Forest could not be separately determined and is included in the data for release work. (See table 2.3.)

Table 2.1: Treatment of Reforested Lands, Gifford Pinchot National Forest, Fiscal Years 1983-86

	1983		1984	1985	1986 [a]
	Herbicides	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical
Site preparation					
Acreage treated	2,383 [b]	82	0	0	0
Cost per acre					
Contract	$ 72	$596	•	•	•
Administrative	$ 17	$137	•	•	•
Total	$ 89	$733	•	•	•
Release					
Acreage treated	748	589	0	164	118
Cost per acre					
Contract	$ 70	$ 52	•	$ 68	$ 67
Administrative	$ 16	$ 12	•	$ 16	$ 15
Total	$ 86	$ 64	•	$ 84	$ 82
Thinning					
Acreage treated	190	7,435	9,807	8,238 [c]	7,261
Cost per acre					
Contract	$ 51	$ 92	$ 86	$ 83	$ 95
Administrative	$ 11	$ 21	$ 20	$ 19	$ 22
Total	$ 62	$113	$106	$102	$117

[a]Fiscal year costs are estimates based on contracts as of January 31, 1986.

[b]Site preparation acreage includes 732 acres of aerial release and site preparation combined, representing units having a mixture of planted and unplanted areas at a contract price of $70 per acre.

[c]Includes 371 acres which had not been completed at the end of the fiscal year.

Table 2.2: Treatment of Reforested Lands, Rouge River National Forest, Fiscal Years, 1983-86

	1983		1984	1985	1986[a]
	Herbicides[b]	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical
Site preparation					
Acreage treated	560	739	720	68	840
Cost per acre					
Contract	$ 79	$151	$210	$365	$156
Administrative	$ 32	$ 36	$ 47	$53	$ 29
Total	$111	$187	$257	$418	$185
Release					
Acreage treated	1,540	1,450	1,033	1,110	207
Cost per acre					
Contract	$ 81	$149	$210	$350	$158
Administrative	$ 31	$ 35	$ 48	$ 51	$ 29
Total	$112	$184	$258	$401	$187
Thinning					
Acreage treated	0	382	413	40	494
Cost per acre					
Contract	•	$ 92	$ 96	$ 95	$118
Administrative	•	$ 38	$ 32	$ 43	$ 36
Total	•	$130	$128	$138	$154

In addition to the costs in the table, the forest incurred the following estimated non-contract costs by using its own labor force (force account):

	1983				1984		1985		1986	
	Herbicide		Manual		Manual		Manual		Manual	
	Acres	Cost/acre	Acres	Cost/acre	Acres	Cost/acre	Acres	Cost/acre	Acres	Cost/acre
Site preparation	329	$189	602	$141	800	$138	596	$146	452	$152
Release	469	$100	762	$103	503	$ 86	576	$ 88	390	$107
Thinning	0	•	236	$ 75	85	$ 87	138	$ 90	0	•

[a]Fiscal year 1986 costs are estimates based on bids received for contracts through July 8, 1986.

[b]The forest predominantly used ground applications for herbicides as part of a reforestation process called "shelter wood," in which new trees are interplanted under a stock of trees left after logging. Because the process is a protection technique that leaves fully grown trees for shade and other purposes, it precludes aerial applications of herbicides.

Table 2.3: Treatment of Reforested Lands, Siskiyou National Forest, Fiscal Years 1983-86

	1983		1984	1985	1986 [a]
	Herbicides	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical
Site preparation[b]					
Acreage treated	•	•	•	•	•
Cost per acre					
Contract	•	•	•	•	•
Administrative	•	•	•	•	•
Total	•	•	•	•	•
Release					
Acreage treated	11,998 [c,d]	519	648	1,037	1,298
Cost per acre					
Contract	$ 35	$160	$221	$205	$213
Administrative	$ 26	$ 49	$ 49	$ 49	$ 49
Total	$ 61	$209	$270	$254	$262
Thinning					
Acreage treated	0	3,238	2,058	2,164	2,244
Cost per acre					
Contract	•	$116	$121	$138	$143
Administrative	•	$ 32	$ 32	$ 32	$ 32
Total	•	$148	$153	$170	$175

[a]Fiscal year 1986 costs are estimates based on bids awarded as of July 22, 1986.

[b]Site preparation data, not separately determinable, is included in release and is about 2 percent of total work done.

[c]Includes 140 acres treated with herbicides by a ground application called "cut stump." Contract costs were $332 per acre; total costs were $438 per acre.

[d]Consists of aerial application of 11,168 acres averaging $56 per acre in total cost and ground application of 830 acres averaging $124 per acre in total cost.

Table 2.4: Treatment of Reforested Lands, Siuslaw National Forest, Fiscal Years 1983-86

	1983 [a]		1984	1985	1986 [b]
	Herbicides	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical
Site preparation					
Acreage treated	385	784	1,087	1,564	1,092
Cost per acre					
Contract	$ 41	$167	$181	$174	$151
Administrative	$ 31	$ 22	$ 20	$ 20	$ 20
Total	$ 72	$189	$201	$194	$171
Release [c]					
Acreage treated	1,379 [d]	1,765	3,571	4,105	4,665
Cost per acre					
Contract	$ 91	$ 79	$ 77	$ 77	$ 75
Administrative	$ 31	$ 27	$ 25	$ 25	$ 25
Total	$122	$106	$102	$102	$100
Thinning					
Acreage treated	0	4,832	3,011	4,188	4,648
Cost per acre					
Contract	•	$ 73	$ 81	$ 93	$ 96
Administrative	•	$ 20	$ 20	$ 20	$ 20
Total	•	$ 93	$101	$113	$116

[a] Because of the controversy over continued use of herbicides, the program was reduced in acreage to about 30 percent of what its size had been in prior years.

[b] Fiscal year 1986 costs are estimates based on bids received through August 7, 1986.

[c] For the last 3 years, from 367 to 758 acres were treated annually by grazing sheep at a contract cost of $5 to $9 per acre, which tended to lower average release costs by this forest.

[d] Includes aerial applications on 658 acres averaging $42 per acre in total costs and ground applications on 721 acres averaging $137 per acre in total costs.

Table 2.5: Treatment of Reforested Lands, Umpqua National Forest, Fiscal Years 1983-86

	1983		1984	1985	1986 [a]
	Herbicides	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical
Site preparation					
Acreage treated	0	459	78	0	0
Cost per acre					
Contract	•	$220	$463	•	•
Administrative	•	$ 31	$ 74	•	•
Total	•	$251	$537	•	•
Release					
Acreage treated	4,361	1,201	864	389	132
Cost per acre					
Contract	$ 52	$112	$175	$161	$169
Administrative	$ 43	$ 52	$ 70	$107	$107
Total	$ 95	$164	$245	$268	$276
Thinning					
Acreage treated	0	6,449	3,658	3,788	3,237
Cost per acre					
Contract	•	$ 83	$109	$ 89	$ 76
Administrative	•	$ 38	$ 42	$ 51	$ 53
Total	•	$121	$151	$140	$129

[a]Fiscal year costs are estimates based on contracts through July 31, 1986.

Table 2.6: Treatment of Reforested Lands, Willamette National Forest, Fiscal Years 1983-86

	1983		1984	1985	1986 [a]
	Herbicides	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical	Manual and Mechanical
Site preparation					
Acreage treated	636	130	132	242	0
Cost per acre					
Contract	$ 68	$202	$ 56	$ 63	•
Administrative	$ 37	$224	$ 39	$ 54	•
Total	$ 105	$426	$ 95	$117	•
Release					
Acreage treated	1,076	359	567	710	0
Cost per acre					
Contract	$ 55	$179	$121	$105	•
Administrative	$ 35	$ 67	$ 48	$ 28	•
Total	$ 90	$246	$169	$133	•
Thinning					
Acreage treated	0	9,440	7,896	7,888	5,050
Cost per acre					
Contract	•	$ 64	$ 95	$ 91	$ 91
Administrative	•	$ 21	$ 25	$ 25	$ 46
Total	•	$ 85	$120	$116	$137

[a]Fiscal year costs are estimates based on contracts as of June 30, 1986.

Bibliography of Reports, Studies, and Theses Dealing With Alternative Silvicultural Methods

Baumbauer, D. A., and Blake, G. M. Effects of Grass Control on Ponderosa Pine Seedlings in Colstrip, Montana, Plantations. University of Montana, Research Note No. 21, School of Forestry, Missoula, Mont.: 1984.

This study deals with the problem of reestablishing ponderosa pine on regraded mine soils. Grasses influence ponderosa pine seedlings by competing for moisture and nutrients and by affecting soil and air temperatures near ground level. Newly regraded mine soils were seeded with a native grass/forb mixture for surface stabilization. Wild grasses and forbs were already present in the seeded areas. Both contributed to a dense mat of grass and forbs that developed around newly planted seedlings. Herbicides to control the grass and forb competition were applied to one area while another was left untreated as a control. After two growing seasons, tree mortality rates on the treated area and the control plot were not significantly different. However, seedling growth rates between the chemically treated plot and the control plot were strikingly different. Sprayed seedlings showed significant increase in leader growth over unsprayed seedlings. Grasses and forb control was excellent. The untreated area was quickly invaded by the grasses and forbs. This competition appears to reduce growth and will probably result in increased mortality.

Boyer, W. D. First-year Survival of Planted Longleaf Pine Bare-root and Container Stock as Affected by Site Preparation and Release. Third Biennial Southern Silvicultural Research Conference, General Technical Report SO-54. New Orleans, La.: 1985.

Poor survival of planted longleaf pine has been a problem in Georgia. This study deals with the effect of field conditions, particularly the degree of pre- and post-planting competition control, on the survival of longleaf pine on a wide range of coastal plain sites in Georgia. The researchers selected five sites and four treatments—two mechanical site preparations, one release, and one control (no treatment). A herbicide was used in the release treatments. About 10,000 bare-root seedlings and about 1,900 container-grown seedlings were planted after the areas were mechanically site-prepared. The survival of containerized seedlings during the first year was far superior to that of bare-root nursery stock. Intensive advance preparation of the planting site can improve the first-year survival of longleaf pine seedlings, according to the results of this study. Release spraying with herbicides reduces longleaf seedling survival considerably. Except for one site, containerized seedlings suffered relatively light mortality from the herbicide compared to bare-root

stock. Deferring the herbicide treatment until the second year after planting, particularly for bare-root stock, may be more desirable. While the herbicide treatment reduced seedling survival, it had not significantly improved the growth of survivors by year's end. The treatment did significantly reduce herbaceous competition. Whether this competition will impede seedling growth during their second year remains to be seen.

Boyer, W. D. Growth of Young Longleaf Pine as Affected by Biennial Burns Plus Chemical or Mechanical Treatments for Competition Control. Southern Silvicultural Research Conference. New Orleans, La.: 1982.

Longleaf pine appears to be more sensitive to competition than other pines. Elimination of understory hardwoods should promote a positive growth response in longleaf at least as great as that observed in other pines. To eliminate the hardwood understory, twelve treatment combinations were selected—four burning treatments, including prescribed fire at 2-year intervals in winter, spring, summer, and an unburned control. Three supplemental treatments were combined with each burning treatment. These were herbicide treatment of all woody stems, handclearing of all woody vegetation 4.5 feet or more in height at the beginning of the study and at 2-year intervals thereafter, and an untreated. The supplemental treatment eliminated nearly all hardwood competition above the 0.5 inch diameter class on all plots. Yet these treatments, while eliminating mid- and understory hardwoods, did not significantly improve pine growth. Apparently, under the conditions studied, competition on untreated plots was not great enough to adversely affect growth of overstory pine. None of the treatment combinations can be justified on the basis of improved pine growth, although some may be desirable because of other benefits resulting from change in the structure and composition of understory vegetation.

Fling, L., and Childs, S. "Increasing Water Use Efficiency for Improved Seedling Growth." Forestry Intensified Research, Vol. 7, No. 1 (Spring 1985), pp. 7-8.

The study covered 2 years of field work to assess shading, mulching, and vegetation control effects on Douglas-fir seedling water use and growth. The amount of soil water used was measured in a cylinder of soil 1 foot in diameter and 2 feet deep beneath each seedling. Herbicide spraying and scalping the ground completely controlled competing vegetation. The herbicide treatment used significantly less water for most of the growing season than all other treatments, including the scalping

treatment. The difference in water use between the herbicide and scalp treatments was due to increased evaporation for the scalp treatment. Herbicide and, to a lesser degree, mulch used less water in relation to the amount of diameter growth attained by the seedlings, while scalping used relatively more water because of increased evaporation.

Harrington, T. B. Douglas-Fir Treatment Means by Site for the CRAFTS Coast Range Release Study. Oregon State University, Forest Research Laboratory. Corvallis, Ore.: 1985.

This report provides follow-up statistical data on the mean amount of second-year Douglas-fir survival, diameter and diameter growth, and height and height growth; and the development of competing brush and herbaceous cover that has occurred through the third year after treatment. Second-year survival rates did not show any strong trends in the data for the six sites studied. Diameter and diameter growth rates both revealed consistently higher values on each site where the shrubs were completely removed compared with the other five treatments. Height and height growth revealed no strong trends because of treatments across the six sites. Although reductions in brush cover have occurred in the second and third years on the areas treated with Roundup, combined cover from brush and herbs has not changed greatly. A strong change in total vegetation cover is evident on the complete removal treatment areas only, where Douglas-fir growth responses have occurred.

Harrington, T. B., Douglas-fir Treatment Means by Site for the CRAFTS Coast Range Competition Release Study: Three Years Following Treatment Application. Oregon State University, Forest Research Laboratory. Corvallis, Ore.: 1985.

This report provides follow-up statistical data on the mean amount of third-year Douglas-fir survival, diameter and diameter growth, and height and height growth; and the development of competing brush and herbaceous cover that has occurred through the third year after treatment. Third-year survival rate data did not show any strong trends for the six sites studied. Diameter and diameter growth rates both revealed consistently higher values on each site where the shrubs were completely removed compared to the other five treatments. Height and height growth revealed no strong trends because of treatment across the six sites. Although reductions in brush cover have occurred in the second and third years on the areas treated with Roundup, combined cover from brush and herbs has not changed greatly. A strong change in

total vegetation cover was evident on the complete removal treatment areas only, where Douglas-fir growth responses occurred.

Lanini, W. T., and Radosevich, S. R. "Response of Three Conifer Species to Site Preparation and Shrub Control." Forest Science, Vol. 32, No 1. (1986), pp. 61-77.

A 5-year field study was conducted to determine the effect of variations in water and light availability owing to various combinations of site preparation and shrub suppression on the survival, growth, and seasonal water potential of ponderosa pine, sugar pine, and white fir seedlings. The initial site preparation treatments included either rotary mastication, tractor-mounted brushraking, or controlled burning. After the trees were planted, herbicides were applied to control the shrubs emerging in some of the newly planted plots. Ponderosa pine survived better than sugar pine or white fir regardless of shrub presence or absence. Shrub canopy volume did not influence tree survival; however, the presence of shrub debris from some treatments increased planting difficulty and resulted in increased tree mortality. Predawn and mid-day water potential, height, stem diameter, and canopy volume of conifers were highest when shrub canopy volumes were low.

Miller, G. W. Releasing Young Hardwood Crop Trees—Use of a Chain Saw Costs Less Than Herbicides. Northeastern Forest Experiment Station Research Paper, NE-550. Broomall, Pa.: 1984.

This study compares the costs of mechanical and chemical treatments for releasing crop trees in a 12-year old Appalachian hardwood stand. The study considered three options for eliminating unwanted trees from the young hardwood stands. Competing trees could be chemically treated either by stem injection or basal spraying with an appropriate herbicide, or by cutting the competing trees with a chain saw. Cost data were collected for each method studied. First, the unwanted trees were marked. Second, the unwanted trees were injected and the costs—labor hours and chemicals used—were tabulated. Third, the basal area of the unwanted trees was sprayed and similar costs were tabulated. Finally, the trees were felled with a chain saw and the costs—labor and machine hours—were tabulated. The results—labor and materials—were (1) felling eliminated unwanted trees at the lowest cost—about $.42 a crop tree (the trees that were released from the unwanted tree competition and permitted to grow to maturity), (2) spraying the basal area of the tree cost about $.80 a crop tree, and (3) injecting chemicals cost about $.61 a crop tree. The total cost of labor was highest for stem injection.

While unwanted trees in the felling and basal spraying operations could be treated from one side, injection required the workers to walk around trees to properly space the injections. The added walking and difficulty of movement through the dense young stand combined to reduce productivity for injection.

Owston, P. W. Survival and Growth of Douglas-fir and Western Hemlock Seedlings Following Release From Salmonberry. Pacific Northwest Forest and Range Experiment Station, FS-PNW-1021-F19. Corvallis, Ore.: 1986.

The objective of this Forest Service study was to determine survival and height growth of Douglas-fir and western hemlock seedlings following various degrees of release techniques. Release treatments included areas where (1) no treatment was conducted, (2) herbicides were applied and the brush was allowed to resprout, (3) herbicides were applied, brush was allowed to resprout and herbicides were applied after several years, and (4) the brush was cut manually, and the remaining stumps were sprayed with herbicides. None of the release treatments resulted in significant increases in height or diameter of the Douglas-fir or western hemlock seedlings. Shrubs in the areas treated never overtopped the seedlings, which illustrated the benefits of good site preparation and high quality planting stock.

Shiver, B. D., Rheney, J. W. Fortson, J. C., and Pienar, L. V. Five Year Results of the PMRC Coastal Plain Site Preparation Study. PMRC Technical Report 1985-7. Athens, Ga.: 1985.

In 1979, the University of Georgia Plantation Management Research Cooperative embarked on a site preparation study with the objective of developing site-specific yield models for different site preparation treatments. Twenty installations, each consisting of twelve one-half acre treatment plots, were located in the Atlantic Coast flatwoods. Four soil conditions—ranging from poorly drained to poorly to moderately well drained were selected. Site preparation techniques included mechanical treatments, such as roller chopping, burning, and bedding, as well as combinations of these three treatments. In addition, both fertilizer and herbicide treatments were imposed on the mechanical treatments as well as a control area, where nothing was done to prepare the soil for planting. Separate analyses were conducted for average height and diameter growth of the pine seedlings planted. The analyses presented indicated that after 5 years the average height and diameter growth were similar regardless of the different site preparation techniques

used. The similarity in response indicates that there is no evidence that burning or roller chopping result in significantly better growth than doing nothing. Further, there is evidence that fertilizing, bedding, and controlling competing vegetation with herbicides results in significantly better growth regardless of the four soil conditions tested.

Stein, W. I. Comparison of Site Preparation Methods on Coast Range Sites. Pacific Northwest Forest and Range Experiment Station, FS-PNW-1202-8029. Corvallis, Ore.: 1984.

Several site preparation practices were used to combat brush competition on selected Pacific Coast Range sites. The practices included spraying herbicides, burning the vegetation, manually cutting (slashing) the vegetation, a combination of slashing and burning, and a combination of spraying and burning. A control area was not treated. In addition, a number of the seedlings were protected by plastic mesh tubing from browsing animals. The third year after the seedlings were planted, seedling survival, height and diameter growth, and vegetative cover and height were measured and reported. Nearly 80 percent of all seedlings survived the third year. Survival averaged highest for the spray-and-burn treated areas and lowest for the untreated control area. Survival was higher where slash—limbs, bark, stumps left on the ground after logging—was burned, but survival after the aerial herbicide spray treatment was not materially lower than after the broadcast burn or manual slash and burn treatments. Third-year height and diameters tended to be better in areas where burning was used exclusively or in a combination with manual cutting and herbicides. Seedlings protected by plastic mesh tubing continue to be taller and larger in stem diameter than unprotected seedlings.

Stein, W. I. Manual And Chemical Options for Releasing Douglas-fir From Competing Brush in Oregon's Coast Range. Pacific Northwest Forest and Range Experiment Station, FS-PNW-1201-8030. Corvallis, Ore.: 1985.

In the highly productive forests of the Oregon and Washington coast ranges, unchecked competition from salmonberry, thimbleberry, red alder, and associated woody species may reduce the survival and growth of Douglas-fir seedling plantations. Overtopping by such competing vegetation and concurrent setbacks from animal damage, rather than real shortages of soil moisture, appear to be the primary impediments to development of the young stands. This report presents the results of the third year of a study initiated in 1980 to determine the

relative effectiveness of seven practices for releasing Douglas-fir from the above competing vegetation. The practices used were manual cutting, spraying with the herbicide fosamine, spraying with the herbicide glyphosate, and manual cutting and spraying with fosamine. There was also a control area. Tree mortality was light and scattered. The least mortality occurred in the area that was manually cut and the most occurred in the areas that were either manually cut and sprayed with herbicides or in the control area. Significant differences in total tree height have developed since the release treatments were applied. Trees in the manually cut area were taller on the average than trees in the control area. Trees in the area sprayed with glyphosate were no taller than the trees in the control area. Trees in the fosamine-treated area were intermediate in height. Average stem diameter of trees in any of the treated areas was significantly greater than the average stem diameter in the control area.

Stein, W. I. Comparison of Site Preparation Methods on Cascade Range Sites. Pacific Northwest Forest and Range Experiment Station, FS-PNW-1201-8031. Corvallis, Ore.: 1985.

Site preparation practices in the Cascades do not produce uniformly satisfactory plantation establishment or minimize need for later release treatments. Currently, slash burning is the most commonly used site preparation practice. Some observers question the need for burning and suggest that alternative methods, including manual brush removal, might produce equivalent or superior results. Six site preparation practices were chosen to be studied on four clear-cut sites where snowbrush might develop vigorously after Douglas-fir seedlings were planted. There was also a control area. The practices used included spraying herbicides using aerial equipment, scalping the ground, spraying herbicides using equipment on the ground, burning, and burning and pulling any brush that survived. Vexbar tubing was used on 50 percent of the seedlings as a protection against animal browsing. The site preparation work was completed in the fall of 1982, and the seedlings were planted in the spring of 1983. The first-year observances were recorded in the summer and fall of 1983. First-year survival averaged 85 percent, except in the area where ground spraying of herbicides killed many seedlings. That area was replanted. The amount of brush growing in the burned area ranged from light to moderate.

Stein, W. I. Manual and Chemical Options for Releasing Douglas-fir and Noble Fir From Competing Brush in the Cascade Range. Pacific Northwest Forest and Range Experiment Station, FS-PNW-1201-8032. Corvallis, Ore.: 1985.

Dense stands of snowbrush develop to compete with Douglas-fir and noble fir plantations on western slopes of the Cascade Range. Such brush stands can threaten the survival and impede the growth of plantations by overtopping the trees and, particularly, by depleting soil moisture to critical levels in the summer. In the past, herbicides were used primarily to reduce brush competition, but manual methods appear promising. The original study, approved in 1980, was delayed several times and was modified because of a legal injunction on the use of herbicides. Any use of herbicides during the study—May 1984 through April 1985—was deleted from the study's methodology. Three manual practices—grubbing, cutting the brush once, and cutting the brush a second time—and a controlled area are being studied in six clear cuts in the Willamette National Forest. These practices, which began in the spring of 1985, are being studied in three clear-cut areas with Douglas-fir and three areas with noble fir. The results will be reported in subsequent follow-up reports.

Stewart, R. E., Gross, L. L., and Honkala, B. H. Effects of Competing Vegetation on Forest Trees: A Bibliography With Abstracts. Forest Service. Washington, D.C.: 1984.

This publication contains a compilation of both published and unpublished sources of data on the effects of competing vegetation on forest trees. Different sources reporting results from the same study are cross-referenced and only the most recent or completed cited document was abstracted. Each abstract describes the study location, vegetation and site conditions, treatments used, study design, results, and conclusions. Whenever possible, study results are summarized in tabular form. Cited documents are listed in order by a three-letter, six-digit identification number. The species index lists abstracts' identification number by five categories: forest crop tree species, vegetation management practice, competing vegetation type, vegetation control methods used, and type of data reported in the study results.

Tesch, S. "Seedling Root and Shoot Growth Severely Impacted By Sprout Competition." Forestry Intensified Research, Vol. 7, No. 4 (Winter 1986), pp. 2-4.

After three growing seasons, survival rates and height and diameter growth of Douglas-fir seedlings were measured on sites where the brush was sprayed with herbicides or slashed by hand before the seedlings were planted. Douglas-fir seedlings planted on a harsh, rocky site exhibited much greater growth when all competition was eliminated by herbicide application before planting. Seedlings planted in areas that were hand-slashed before planting but allowed to sprout were slightly smaller in shoot and root weight, height growth, and diameter growth than the seedlings planted in the herbicide-sprayed areas.

Trappeiner, J. C., II, and Radosevich, S. R. "Effect of Bearmat on Soil Moisture and Ponderosa Pine Growth." Weed Science, Vol. 30 No. 98 (1982), pp. 98-101.

An experiment was conducted to determine the influence of bearmat—a common shrub on south-to-west-facing slopes in the Sierra Nevada Mountains of California—on ponderosa pine survival and growth. Before planting ponderosa pine seedlings, the study team divided the area with bearmat into three sections and applied a different technique to each section: (1) left untreated, (2) sprayed with a mixture of 2,4-D and 2,4,5-T herbicides, and (3) applied a combination of herbicide, clipping shrub sprouts, and trenching to prevent root and rhizome invasion. Ponderosa pine survival after 19 years averaged 9, 66, and 90 percent, respectively, for the three treatments. Tree height after 19 years averaged 1.6, 1.9, and 5.7 meters, respectively, for the three treatments. Soil moisture use was initially less on the herbicide-treated than on the untreated plots, but bearmat quickly sprouted after herbicide applications and competed with the pine seedlings for moisture. After 19 years, the bearmat was more dense and appeared to be more vigorous on the sprayed plots than on those receiving no treatment. The authors estimated that a 75 percent reduction in net wood production could result after 50 years on the site from bearmat competition.

Wagner, R. G. Two-Year Response of Eight Coast Range Brush Species, Oregon State University, Forest Research Laboratory. Corvallis, Ore.: 1984.

A primary objective of this study was to determine the effects of six treatments on the major brush species associated with Douglas-fir in the Oregon and Washington coast range. This report describes the effects that three aerially applied herbicides, manual cutting, complete vegetation removal, and untreated control treatments have had on controlling the major brush species competing with Douglas-fir plantations in the

first and second growing seasons following the treatments. Herbicides—particularly Roundup—were generally the best operational release treatment for reducing levels of brush, providing good control through the second year after the treatment. Manual cutting was moderately effective in reducing brush crown volumes during the first growing season following treatment. However, sprouting from cut stumps allowed substantial second-year recovery. Estimates of brush overtopping around individual trees revealed that overtopping was reduced by 54 percent over the untreated control area in the first year but was not significantly different by the second year. Levels of brush encroachment exceeded pretreatment levels within 2 years after manual cutting.

Major Contributors to This Fact Sheet

Resources, Community, and Economic Development Division, Washington, D.C.

Brian P. Crowley, Senior Associate Director (202) 275-5138
John W. Harman, Associate Director
Jim Wells, Group Director
Robert J. Mancuso, Assignment Manager
Carol Herrnstadt Shulman, Writer-Editor

Seattle Regional Office Staff

Walter A. Choruby, Evaluator-in-Charge
Charles G. Kilian, Evaluator
Hugo W. Wolter, Jr., Evaluator
Stanley G. Stenersen, Evaluator

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.

United States
General Accounting Office
Washington, D.C. 20548

Official Business
Penalty for Private Use $300

Address Correction Requested

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100