PLANTATION SURVIVAL AND GROWTH IN TWO BRUSH-THREAT AREAS IN COASTAL OREGON

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SUMMARY

Conifer plantations were established in the spring of 1949 in the brushy portions of two clear-cut tracts in the Oregon Coast Range, one in the Douglas-fir type on Henderson Creek southeast of Florence, and one in the Sitka spruce-western hemlock type on Sloan Creek north of Otis. Examinations were then made over a 5-year period to determine factors influencing survival and growth in the brush-threat areas. Salmonberry and associated shrubs were the major competitors, with red alder becoming increasingly important after the second growing season.

By the spring of 1954, only 37 percent of the Douglas-fir trees planted at Henderson Creek were considered definitely established. Others were still alive but overtopped by brush and alder and not expected to survive. Some natural seedlings of Douglas-fir, western hemlock, and western red cedar became established in small openings in the brush and brought the stocking up to 410 trees per acre. Distribution was poor, however, with brush, alder, and willow dominating 50 percent of the site.

At Sloan Creek where 1000 trees per acre were planted, only 252 per acre were definitely established 5 years later. It was estimated that half of these were "naturals" that had become established mostly on rotten wood, where the brush did not grow. Approximately 64 percent of the site was dominated by brush, alder, and herbs.

Competition between planted trees and herbs, brush, and alder was intense. Although conifers continued to live under as much as three-fourths shading by competing vegetation, height growth was greatly retarded. Once trees are overtopped by brush, their chances for ultimate survival are negligible, unless released.

Planting brush-threat areas was found to definitely improve stocking by giving the trees a head start on the brush. However, the planting stock must be carefully selected and areas must be planted immediately following completion of logging and slash disposal. Any treatment to retard brush development without serious damage to the site will help. In this study, broadcast burning killed many brush stems and retarded growth until new sprouts grew from the roots. However, chemical brush control, although not included in the study, shows more promise for killing brush or retarding its development.

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by

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Pacific Northwest Forest and Range Experiment Station
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INTRODUCTION

Competition from brush and herbaceous plants following clearcutting is a major obstacle to establishment of natural reproduction or survival of planted trees in most areas of coastal Oregon.

Present timber stands are often understocked, particularly in moist locations near creeks. Much of this understocking may be partially the result of vegetative competition when the stands were established many years ago. These understocked stands characteristically have a dense brush understory. Removal of the overstory exposes the brush plants to full sunlight and they often dominate the site to the exclusion of conifer reproduction.

Many Douglas-fir (Pseudotsuga menziesii) forests can produce more than 1,200 board-feet per acre annually. Many mixed stands of Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla) can produce more than 1,500 board-feet per acre yearly over a rotation. It is important that this highly productive land be fully utilized for growing timber, with a minimum area lost to brush.

Following clearcutting, the objective is to get a new stand established as quickly and economically as possible. Decisions must be made on where to burn slash, where to depend on natural regeneration, where and what species to plant, and what follow-up measures are needed to be sure of adequate reforestation. This paper discusses the results of two studies established to determine the factors influencing plantation survival and growth in the brushy parts of clearcut areas--one in the Douglas-fir type and one in the spruce-hemlock type.

1/ Willamette Research Center, Corvallis, Oreg. Maintained in cooperation with the School of Forestry, Oregon State College. This study was suggested by personnel of the Siuslaw National Forest, who cooperated by planting the trees in the study area.

THE HENDERSON CREEK DOUGLAS-FIR PLANTATION

A 44-acre tract in the Henderson Creek drainage 7 miles southeast of Florence, Oreg., was clearcut in 1947 and the slash broadcast burned that fall. The burn was excellent and the area seemed in good shape for establishment of natural regeneration. It was surrounded by a well-stocked stand of 150-year-old Douglas-fir on site II with an understory of 90-year-old hemlock, which was expected to provide an adequate seed supply. However, there was a very poor Douglas-fir seed crop in both 1947 and 1948, and it soon became apparent that the clearcut tract might not regenerate naturally.

The problem was most acute in an area of deep, moist soil along a small creek running out of the tract toward the east. Originally this portion of the clearcut had supported only 38 trees per acre and a dense brush understory. During logging, most of the brush was knocked down by falling trees and defoliated by yarding logs through it. The slash fire had burned a large amount of brush but had not covered all of this moist location (fig. 1). Examination the first spring after logging and burning (1948), showed numerous brush sprouts averaging 6 to 12 inches tall. Logging and burning had destroyed most brush stems but had left many roots undamaged.

The tract was planted in March 1949 with 3-0 Douglas-fir seedlings. In the brush-threat area, 445 trees in 4 planted plots were staked and numbered. Four check plots had been left unplanted. The staked trees were examined periodically to measure factors that influenced growth and survival. Examinations were made in June 1949, three months after planting; in October 1950, after the second growing season; in August 1952, near the end of the fourth growing season, and in April 1954, after the fifth growing season. At each examination, tree heights were measured, shading was classified, and browsing damage was noted. Brush and herbaceous shade were classified separately after the first examination.

Brush Growth

Principal brush and tree species that were competing with the planted trees after the fifth growing season are listed below in order of importance:

Common name	Scientific name
Salmonberry	Rubus spectabilis
Western thimbleberry	Rubus parviflorus
Red alder	Alnus rubra
Pacific red elder	Sambucus callicarpa
Willow	Salix spp.
Vine maple	Acer circinatum

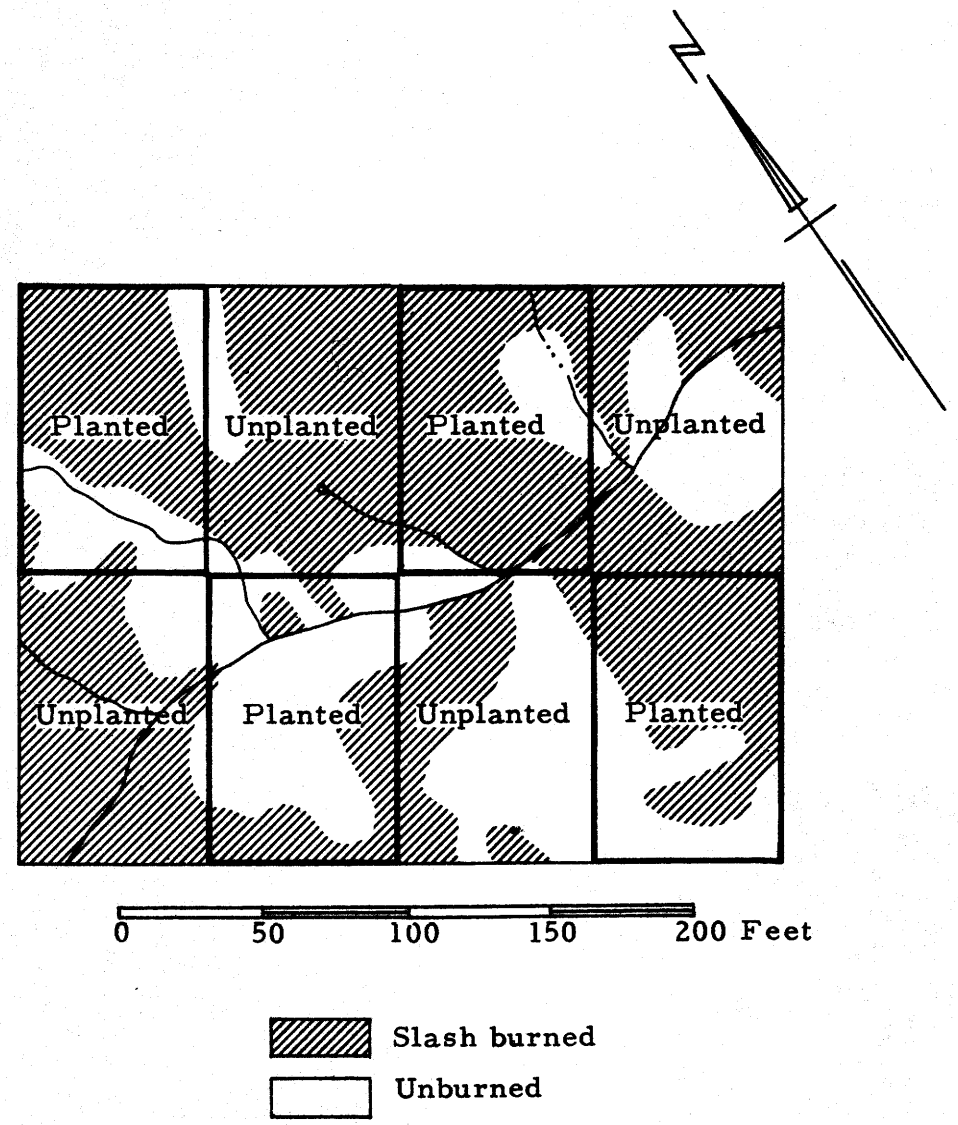

Figure 1.--Henderson Creek Douglas-fir plantation, showing plantings on burned and unburned areas.

Three months after the Douglas-fir seedlings were planted, competing vegetation averaged 2 feet tall. Five years later it averaged 5 to 6 feet tall (fig. 2), compared with an average height of slightly over 3 feet for the Douglas-firs.

Red alder seedlings were first noted during the third and fourth growing seasons. By the end of the fifth season, alder was present in several small groups and as scattered individual trees, averaging 18 feet tall. Some willow trees also had become established in narrow strips along the creek. Competition from both of these fast-growing species presented another obstacle to survival and growth of the plantation. Some Douglas-fir trees that had kept ahead of the initial brush species were later overtopped and suppressed by alder and willow.

Shade

Degree of shading had an important influence on height growth and survival (table 1 and fig. 3). Height growth was gradually reduced as shading increased up to three-fourths (fig. 4). The only exception was during the third and fourth growing seasons, when trees growing in the open did not do as well as those one-fourth shaded. This, however, may be a result of the small sample. For trees that were overtopped, both height growth and survival were greatly reduced. Apparently Douglas-firs, in the age classes studied, can tolerate up to three-fourths shade and still survive, but their height growth is retarded. Heavier shading will greatly reduce growth and may kill the trees.

Table 1.--Effect of shade on height growth and survival of trees not browsed, Henderson Creek plantation

Shade Class	Third and fourth growing seasons since planting			Fifth growing season since planting		
	Trees	Average Annual Height Growth	Survival	Trees	Average Annual Height Growth	Survival
	Number	Inches	Percent	Number	Inches	Percent
Not shaded	5	10.9	100	19	25.0	100
1/4 shaded	37	14.7	100	28	24.6	100
1/2 shaded	57	11.0	98	34	18.2	100
3/4 shaded	48	7.9	100	26	17.0	100
Overtopped	14	4.4	68	25	8.0	89

Browsing

Browsing by Columbia black-tailed deer (Odocoileus columbianus columbianus), mountain beaver (Aplodontia rufa pacifica), and perhaps brush rabbits (Sylvilagus bachmani ubericolor) also affected height growth. Many trees had been browsed by the end of the second growing season; others, by the fourth or fifth season. Some trees were damaged two or three times (fig. 5). The effect of browsing on the total height of 330 trees still alive by the end of the fifth season was:

	Average height (Inches)
Not browsed	55.9
Browsed once	40.1
Browsed twice	16.5
Browsed three times	8.3
Average, all trees	37.2

Few trees were killed by browsing alone, but reduced height growth and loss of vigor from browsing contributed to overtopping by brush and herbs and many trees subsequently died. Because competing vegetation grew faster than the trees, the plantation was more heavily shaded in 1952 than in 1950, and the increase in shading was greater for browsed than for unbrowsed trees.

The animals seemed to prefer shaded trees. Percent of trees browsed by shade classes was:

	Percent browsed	
	1950	1952
Not shaded	44	4
1/4 shaded	45	8
1/2 shaded	46	17
3/4 shaded	48	30
Overtopped	61	48

This preference for shaded trees made the effect of browsing particularly significant. Browsing of trees already struggling against heavy competition greatly reduced their chances for survival.

Burning

Broadcast burning had little effect on survival and growth of the plantation. Although both survival and growth were slightly better for trees planted on the burned surface, the differences were too small to be considered significant (table 2).

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Figure 2.--Brush in the Henderson Creek plantation area after logging and slash burning. A, In June of the second growing season, brush averaged 2 feet tall. B, In June of the seventh growing season, brush averaged between 5 and 6 feet tall. Part of this brush patch has been cut away to show how a planted tree was overtopped and suppressed.

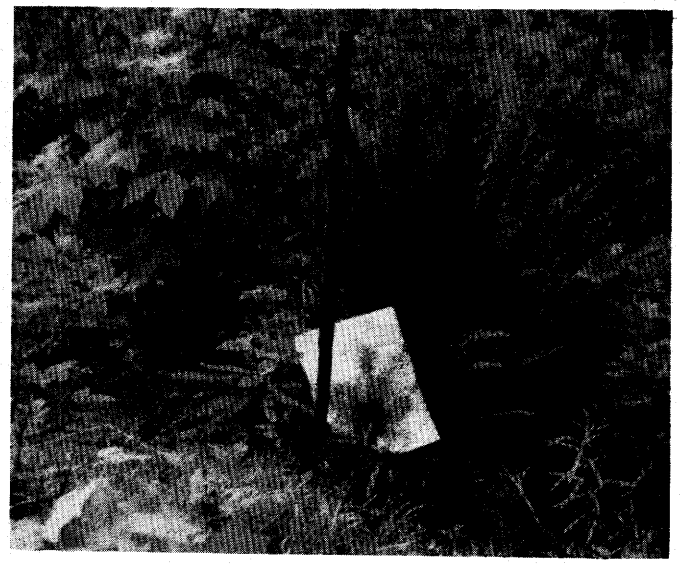

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Figure 3.--This tree in the Henderson Creek plantation was typical of those classed as one-fourth shaded. Trees in this class grew a total of 29.4 inches during the third and fourth growing seasons.

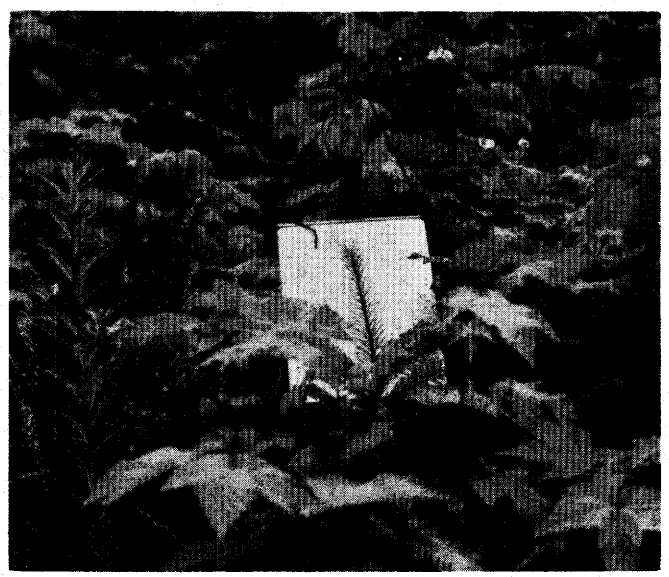

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Figure 4.--Also in the Henderson Creek plantation, this tree was classified as three-fourths shaded by competing vegetation, apparently the maximum amount of competition Douglas-fir trees could tolerate without affecting survival.

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Figure 5.--This tree in the Henderson Creek plantation was severely retarded by browsing. It was only 5 inches tall at the end of the fourth growing season, when trees not browsed averaged 35 inches tall.

Table 2.--Effect of slash burning on survival and growth, Henderson Creek plantation

Observation date	Growing seasons since planting	Burned		Unburned	
		Survival	Average height living trees	Survival	Average height living trees
		Percent	Inches	Percent	Inches
June 13, 1949	1	98		94	
Oct. 24, 1950	2	85	11	84	11
Aug. 6, 1952	4	80	27	78	26
April 6, 1954	5	77	38	74	37

Stocking

The original planting of Douglas-fir was 742 trees per acre. By the end of the fifth growing season, 558 trees still survived. But only 277 of these--less than half--could be considered definitely established. They averaged 59 inches tall. Most of the other surviving trees were overtopped and not expected to live more than a few years.

Stocking of the planted plots was supplemented by scattered natural reproduction that had become established in small openings or had managed to keep ahead of the competing vegetation. Total stocking of well-spaced trees 7 years after logging (5 years after planting) was as follows:

Species and type	Established trees per acre	
	Planted plots	Unplanted plots
Planted Douglas-fir	277	0
Natural regeneration		
Douglas-fir	37	32
Western hemlock	83	78
Western redcedar	13	5
Total	410	115

Natural reproduction resulted in a new stand averaging only 124 trees to the acre (115 on the unplanted plots, 133 on the planted). And due to poor distribution, natural trees dominated on 20 percent of the unplanted area, leaving about 80 percent dominated by brush, alder,

and willow. Furthermore, more than 60 percent of the naturals were hemlock, which are considered to be of secondary desirability in the area.

Planting 2 years after logging and burning, on the other hand, resulted in establishment of 410 planted and natural trees per acre. These trees dominated an estimated 50 percent of the area, the remainder being taken over by competing vegetation. If most of the trees classed as "established" survive and become crop trees, the new timber stand on both the planted and unplanted areas will contain more trees per acre than the stand that was logged. But the planted area will have a much better stand than the unplanted and it will be predominantly Douglas-fir. On the unplanted area, the new stand will be predominantly hemlock. On neither area, however, will the site be completely utilized for conifer production.

Stocking was better on portions of the clear-cut tract outside of the brush-threat area, according to a survey based on stocked mil-acre plots. An average of 600 trees to the acre, ranging from 30 to 48 inches high, was found outside the brush-threat area. An additional 110 trees to the acre were alive but overtopped by brush and alder. The average 600 established trees consisted of 370 planted and natural Douglas-firs, 210 western hemlocks, and 20 western red-cedars.

THE SLOAN CREEK PLANTATIONS

In 1949, eight plantations were established on the Cascade Head Experimental Forest on part of an 81-acre clear-cut tract that had been logged in the spring of 1948. The timber had been 100-year-old Sitka spruce and western hemlock, with some Douglas-fir and red alder. The stand had been generally well stocked except in an area of deep, moist soil along a creek near the south boundary of the tract where it averaged only 43 trees per acre, with a volume estimated at 65,000 board-feet per acre. The experimental plantations were established in this area.

An understory of tall brush was knocked down and defoliated during the falling, bucking, and high-lead yarding operation (fig. 6). The brush on part of the study area was further destroyed by fire when the slash on half the area was broadcast burned in September 1948. Although general conditions were favorable for burning in this moist location, only the brush in and near the slash accumulations would burn. The fire actually covered only about two-thirds of the surface designated for burning.

In the spring of 1949, four plots each on burned and unburned parts of the tract were planted. Sitka spruce, western hemlock,

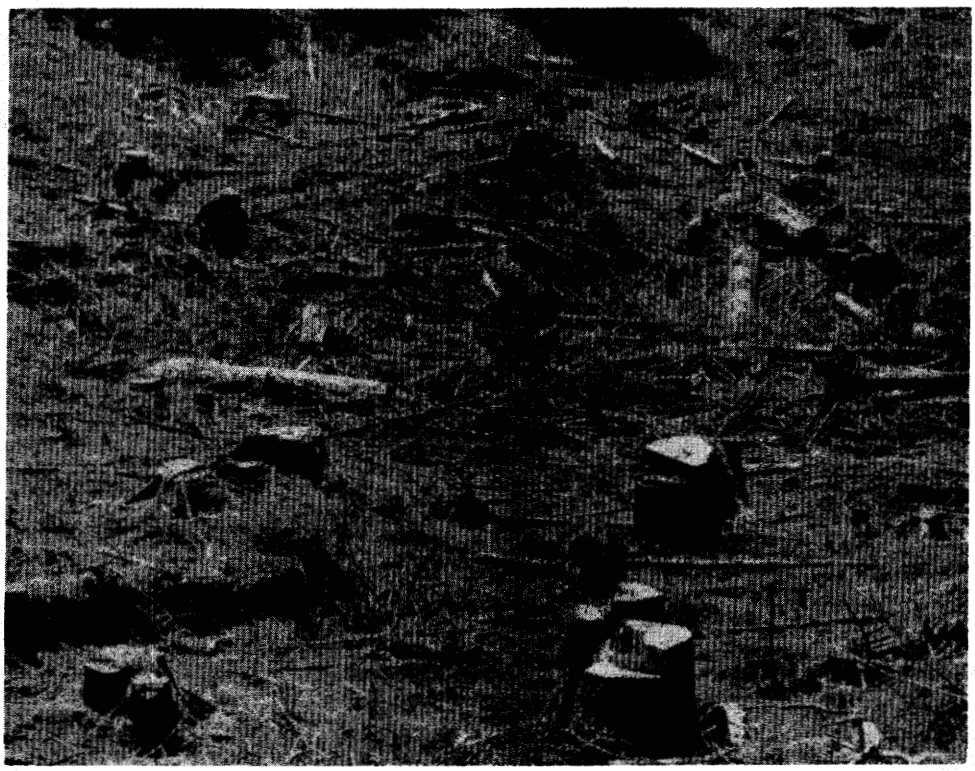

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Figure 6.--The poorly stocked timber stand on this area in the Sloan Creek drainage had a dense brush understory that was knocked down and defoliated during the logging operation.

Douglas-fir, and Port-Orford-cedar (Chamaecyparis lawsoniana) were used. Age and average height of planting stock were:

Species	Age (Years)	Average height (Inches)
Sitka spruce	3-0	4.0
Western hemlock	2-0	2.5
Douglas-fir	3-0	6.0
Port-Orford-cedar	3-0	7.0

The plantings were made for the dual purpose of determining what factors influence survival and growth of planted seedlings and which species is best able to compete with the brush and herbaceous plants. Fifty trees in each plantation were staked and numbered. Only trees actually planted on burned surface were staked in the burned plots.

The first examination of the plantations was in September 1950, at the end of the second growing season. Subsequent examinations were in February 1952, after the third season; in October 1952, after the fourth; and in March 1954, after the fifth growing season. Heights were measured and trees classified for shading and browsing, as was done in the Henderson Creek study.

Brush Growth

Principal brush and tree species that were competing with planted trees in the Sloan Creek plantations at the end of the fifth growing season are listed in order of importance:

Common name	Scientific name
Salmonberry	Rubus spectabilis
Red alder	Alnus rubra
Western thimbleberry	Rubus parviflorus
Vine maple	Acer circinatum
Pacific red elder	Sambucus callicarpa
Red whortleberry 2/	Vaccinium parvifolium
Willow	Salix spp.

Most of the brush sprouted the first year after logging; some from root crowns and some from lower stems. By early June, the brush was 1 to 2 feet tall. Five years later, it had grown together into dense patches averaging 6 feet high and completely dominated 29 percent of the plantation area (fig. 7).

2/ Locally called red huckleberry.

Red alder that became established during the first and second growing seasons put on rapid height growth during the third and fourth seasons and began to compete with the planted trees. At the end of the fifth season, the alder averaged between 20 and 25 feet tall and dominated 32 percent of the area. Many planted trees that managed to keep ahead of the brush were later overtopped and suppressed by alder (fig. 8).

Shade

All four species responded similarly to shading. As in the Henderson Creek plantation, height growth gradually decreased as shading increased to three-fourths. Heavier shading caused an abrupt decrease in growth and substantially reduced survival (table 3). Trees three-fourths shaded grew an average of 12.3 inches per year compared to overtopped trees that averaged only 4.0 inches per year.

Table 3.--Effect of shade on annual height growth and survival of trees not browsed, all species, Sloan Creek plantations

Shade class	Growing season since planting					
	Third		Fourth		Fifth	
	Average height growth	Survival	Average height growth	Survival	Average height growth	Survival
	Inches	Percent	Inches	Percent	Inches	Percent
Not shaded	12	100	23	100	27	100
1/4 shaded	14	100	21	100	23	100
1/2 shaded	13	98	15	100	18	97
3/4 shaded	10	96	11	100	16	100
Overtopped	2	40	4	95	6	86

Browsing

Browsing by deer, mountain beaver, and rabbits retarded height growth and increased mortality. Few trees were killed by browsing alone, but the reduced height growth and loss of vigor in many instances permitted other vegetation to gain dominance. Some trees were browsed one or more times and were still alive at the end of the fifth growing season. The average height of browsed and unbrowsed trees for all species combined, at the end of the fifth growing season, was as follows:

A

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Figure 7.--Brush competition with planted trees in the Sloan Creek plantation area. A, During the first growing season, individual brush plants averaged 1 to 2 feet tall. B, The same area 5 years later was dominated by a dense brush canopy 6 feet high.

B

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A

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Figure 8.--Many planted trees in the Sloan Creek plantations kept ahead of brush but were overtaken by red alder. A, During the first growing season, this Douglas-fir seedling at the base of the stake was classed as one-fourth shaded by the adjacent salmonberry plant. B, By the fourth season, the seedling was 70 inches tall. It had kept ahead of the salmonberry brush but had been overtopped and suppressed by alder.

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	Average height (Inches)
Not browsed	62
Browsed one season	24
Browsed two seasons	21
Browsed three seasons	7
Browsed four seasons	12

Browsing was more severe on Douglas-fir than on other species, with about 30 percent of the trees browsed at least once. Hemlock was second with about 24 percent browsed. Cedar and spruce followed with approximately 10 percent each.

Burning

Considering all species, broadcast burning had little effect on height growth. At the end of the fifth growing season, trees on the burned area averaged 61 inches tall compared to 63 inches on the unburned. A look at individual species, however, shows considerable variation (table 4). Douglas-fir and Port-Orford-cedar grew faster on the unburned area; hemlock, faster on the burned; and spruce, about the same on both areas.

For all species combined, survival averaged 12 percent better on the burned area than on the unburned; but in this case there was even wider variation between species. Douglas-fir survival was 69 percent better on the burned plot and western hemlock, 11 percent better. Survival of Port-Orford-cedar, however, was 18 percent better on the unburned area. Again spruce was about the same on both areas. The generally poor showing of western hemlock was mostly attributed to very small planting stock. Port-Orford-cedar survived better and grew faster in the moist brush-threat area than any of the other species.

Some of these differences in survival and growth on the burned and unburned areas can be traced to differences in competition from brush and herbaceous plants. During the course of the study, living trees averaged about one-half shaded on both burned and unburned areas. On the burned area, shade was approximately half from brush and half from herbaceous plants. On the unburned area, 70 percent of the shade was from brush. Douglas-fir trees on the unburned plot were more heavily shaded than those on the burned plot, which may account for the difference in survival of this species.

Table 4.--Survival and total height of unbrowsed trees on burned and unburned areas, Sloan Creek Plantation

Species	Growing seasons since planting	Survival		Average height, living trees	
		Burned	Unburned	Burned	Unburned
		Percent	Percent	Inches	Inches
Douglas-fir:	2	98	50	17	14
	3	96	33	31	29
	4	96	25	50	59
	5	94	25	70	76
Sitka spruce:	2	80	91	8	9
	3	77	80	16	17
	4	77	80	27	29
	5	75	74	41	43
Western hemlock:	2	56	38	10	6
	3	41	24	19	10
	4	41	24	28	18
	5	33	22	38	30
Port-Orford-cedar:	2	90	100	18	21
	3	85	95	33	40
	4	85	95	52	62
	5	77	95	76	85

Stocking

An estimated 1,000 trees were planted per acre in the brush-threat area in the spring of 1949. Five years later, a 100-percent count of all well-spaced trees not overtopped by brush or alder showed that only 252 trees per acre appeared to be definitely established. About half of these were natural reproduction that had become established in small openings in the brush and alder.

During the period of study, the fall of spruce and hemlock seed was ample for natural regeneration. An average of 243,300 viable seed of these species fell annually near the center of the clear-cut tract.3/

3/ Ruth, Robert H. and Berntsen, Carl M. A 4-year record of Sitka spruce and western hemlock seed fall. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Research Paper 12, 13 pp., illus., March 1955. (Processed.)

The brush-threat area was nearer to the seed source and probably received more seed.

At the end of the study (1954), the best overall stocking was found where Sitka spruce had been planted in unburned slash (table 5). Brush here was not as dense as on the other plantations and a good crop of natural spruce and hemlock seedlings supplemented planted trees. Western hemlock plantations--on both burned and unburned plots--had the poorest stocking. This is attributed mainly to the very small planting stock that was used. Stocking on all other plantations was close to average for the study area.

Table 5.--Combined stocking of planted and natural trees established in brush-threat area, Sloan Creek plantations, June 1954

Treatment and plantation	Stocking				
	Spruce	Hemlock	Fir	Cedar	Total
	Number of trees per acre				
Slash burned					
Sitka spruce	205	48	2	0	255
Western hemlock	30	51	0	0	81
Douglas-fir	55	57	167	0	279
Port-Orford-cedar	50	6	1	180	237
Slash unburned					
Sitka spruce	364	314	3	0	681
Western hemlock	20	26	0	0	46
Douglas-fir	75	41	147	0	263
Port-Orford-cedar	59	26	0	161	246

Spruce and hemlock seedlings that became established naturally in dense brush areas were almost invariably found to be growing on rotten wood (fig. 9). Wherever an old stump or rotten log occurred, a small opening was usually maintained in the brush, and this is where natural spruce and hemlock trees were able to survive. The ability of these species to survive and grow on rotten wood, where brush establishment is inhibited, permitted some conifer stocking in areas that would otherwise be completely dominated by brush. There were indications that much of the original stand had become established in this way. It was noted, for example, that the root crowns of many of the original trees were two or more feet above ground level, indicating that the seed had apparently germinated and grown on old stumps or logs that had since rotted away.

As previously stated, the mature stand that was cut from the plantation area averaged only 43 trees per acre. If the new stand of established natural and planted trees live to become crop trees, it will have 252 trees per acre, a considerable improvement. However, an estimated 64 percent of the area is still dominated by brush, alder, or herbs. Therefore, the site is not being fully used for conifer production.

DISCUSSION

Any treatment that will retard brush development in coastal areas without seriously damaging the site will benefit establishment of a new timber stand. In the areas studied it was evident that burning the aerial parts of the brush plants retarded their development and set them back at least one season. However, the long-range effects of burning on site and brush development need further study. Burning obviously facilitated the planting job and reduced planting costs by decreasing slash and brush.

In the Oregon Coast Range, there is little danger of getting too severe a burn in brushy areas, as they are usually in moist locations. Often the problem is to get such places to burn at all. However, when these moist areas are dry enough to burn, adjoining ridges and south slopes are often too dry for safe burning. This situation can be helped by identifying problem areas in advance of logging and then felling timber into the brush to knock it down and provide slash accumulations to facilitate burning.

Chemical control, although not included in this study, is a second method that shows promise for killing brush or retarding its development until the new stand is established. It has been demonstrated that red alder can be killed with chemicals 4/ 5/ and methods of salmonberry control are under intensive study at the present time.

Just as any treatment to retard brush development will benefit stand establishment, treatments to increase stocking and speed tree growth will also help. The planted part of the Henderson Creek brush-threat area supported more than three times as many established trees 7 years after logging as the unplanted area. Also, the dominant species was Douglas-fir, in contrast to the western hemlock that

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4/ Dahms, Walter G. and James, George A. Brush control on forest lands. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Research Paper 13, 81 pp. May 1955. (Processed.)

5/ Ruth, Robert H. and Berntsen, Carl M. Chemical basal treatments to control red alder. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Research Note 128, 6 pp., illus. March 1956. (Processed.)

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Figure 9.--Spruce and hemlock reproduction that became naturally established in dense brush areas of the Sloan Creek plantations was almost invariably growing on rotten wood where the brush could not survive.

dominated the natural reproduction on the unplanted area. However, many planted trees were still overtopped by brush, alder, or willow. Planting immediately after burning would have increased survival by giving the seedlings a head start. It also may have helped if larger and more sturdy trees had been planted--perhaps trees that had been 1 year in the transplant bed at the nursery. The natural reproduction that became established in the Henderson Creek brush-threat area was in small openings in the brush. Few trees grew from seed and kept ahead of the brush.

In the Sloan Creek plantations, about half the trees established 5 years after logging had been planted. Planting, therefore, approximately doubled the stocking that would have resulted from natural reproduction alone. Here, too, results might have been much better if larger and sturdier seedlings had been planted. Sturdier seedlings could be expected to put on more rapid height growth and prevent some overtopping by alder and brush. Perhaps planting in fall rather than spring would also have helped by giving the trees more time to get firmly established before the first growing season. As at Henderson Creek, very few natural seedlings were able to keep ahead of the brush and alder; those that did mostly grew in small openings, almost always on rotten wood. The planting of brush areas appears to be a desirable practice, whether there is a good seed crop that year or not.

At Sloan Creek, Port-Orford-cedar survived better and grew faster in the moist brush-threat area than Sitka spruce or western hemlock. Douglas-fir survived better on the burned surface, but grew faster on the unburned.

Results at both Henderson Creek and Sloan Creek indicate that if a tree is three-fourths shaded and the shading increases, there is a strong possibility that the tree will be lost. Plantations should be inspected periodically and trees about to be overtopped by brush should be released by slashing the competing vegetation or treating it with chemicals. No planted conifer can equal the rapid early height growth of alder and willow. When these two species become established on an area managed for production of conifers, they should immediately be chemically treated or slashed.

Browsing will kill some planted trees and reduce growth and vigor of others, permitting competing vegetation to crowd them out. In the Henderson Creek area, browsing was definitely more severe on trees in heavy shade.

Recommendations

Recommendations for improved stocking in brush-threat areas in the Oregon Coast Range are:

1. Identify areas before clearcutting and plan special treatments to insure prompt regeneration.

2. Apply needed treatments as soon as possible after logging.

3. If burning is planned, fell timber into brush patches to knock down the brush and provide slash to facilitate the burning.

4. Arrange yarding so that logs will be dragged through the brush patches.

5. Unless there is established reproduction on the ground, broadcast burn brushy areas to retard brush development and clean up the area for planting. Long-range effects of burning, however, need further study.

6. Plant brush-threat areas as soon as possible to give trees a head start on the brush.

7. Select the best stock available to plant in brush-threat areas.

8. Inspect the plantation periodically and release trees being overtopped by brush through slashing or chemical control.