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SURVIVAL AND GROWTH OF THIRTEEN TREE SPECIES IN COASTAL OREGON

by James T. Krygier

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
R. W. COWLIN, DIRECTOR
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

PORTLAND, OREGON



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SURVIVAL AND GROWTH OF THIRTEEN TREE SPECIES
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James T. Krygier

Willamette Research Center
(Maintained in cooperation with the
School of Forestry, Oregon State College)

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INTRODUCTION

Extraordinary growth of introduced tree species--such as Monterey and other pines in Australia, New Zealand, and South Africa, and Sitka spruce, Douglas-fir, and grand fir in Great Britain--has lent impetus to tests of exotic species. Planting of most exotics in the United States has generally met with poor success.^{1/} Yet there is always speculation that an introduced species may grow faster than a local one, or perhaps supply a type of wood not readily available. Occasionally, introduced species have been planted on a large scale without scientific evidence of adequate survival, satisfactory growth, and desirable form; and gross failures have resulted. Review of survival and growth of experimental plantations, as was done in this study, should assist in appraising the usefulness of both local and introduced species for tree planting programs.

Thirteen species were planted at Cascade Head Experimental Forest on the Oregon Coast between 1937 and 1947 in an attempt to determine which ones were adapted to the local soil and climate and to the dense bracken (Pteridium aquilinum pubescens) of an old burn.^{2/} These tree species were:

<u>Scientific name</u>	<u>Common name</u>
<u>Abies concolor</u>	white fir
<u>Chamaecyparis lawsoniana</u>	Port-Orford-cedar
<u>Juglans nigra</u>	black walnut
<u>Picea abies</u>	Norway spruce
<u>Pinus radiata</u>	Monterey pine
<u>Pinus resinosa</u>	red pine
<u>Populus spp.</u>	hybrid poplars
<u>Populus trichocarpa</u>	black cottonwood
<u>Pseudotsuga menziesii</u>	Douglas-fir

^{1/} Boyce, J. S. Introduction of exotic trees--dangers from diseases and insect pests. Unasylva 8(1):8-14. 1954.

^{2/} Thornton T. Munger and many additional researchers contributed to this study by establishing, measuring, and reporting on the progress of the plantations.

Rhamnus purshiana
Sequoia gigantea
Sequoia sempervirens
Taxodium distichum

cascara buckthorn
giant sequoia
redwood
baldcypress

Plantations varied in size from 44 to over 700 trees each. In the case of cascara, Douglas-fir, and Port-Orford-cedar, more than one plantation was established (table 1).

THE PLANTING SITE

The planting area is located 4 miles northeast of Otis, Oreg., and 4 miles from the Pacific Ocean. It covers 160 acres on a south-facing slope where annual burning was once common. These periodic fires were doubtless responsible for the establishment of a dense cover of bracken fern (fig. 1), which provided a favorable habitat for mountain beaver (Aplodontia rufa pacifica), rabbits (Sylvilagus



Figure 1. --Bracken fern dominates the site of failed black cottonwood and Monterey pine plantations. Bracken is 5-6 feet high. This was typical cover of plantation sites.

Table 1. -- Establishment and survival data for plantations in a bracken fern area of coastal Oregon

Species	Seed source	Date established	Age of planting : stock	Years	Number	Feet	Number	Percent	Average Survival : height (1955) : (1955)
Survived:									
Red pine	--	April 1940			94	8x8	16	93	22
Port-Orford-cedar	Coos Co., Oreg. (elev. 0-500 ft.)								
1. (1/)		March 1937	1-1		187	12x12	19	89	24
2.		March 1937	1-1		520	8x8	19	88	31
3.		Nov. 1939	2-0		400	8x8	16	82	19
4.		April 1940	2-0		400	8x8	16	54	19
Redwood	--	Feb. 1937			648	8x8	19	65	2/26
Failed:									
Baldcypress	Mississippi	April 1940	1-3		44	7x7	16	0	0
Black cottonwood	Cuttings, 6 miles from planting site	Feb. 1938	1-0		725	6x6	18	0	0
Black walnut	Albany, Oreg. (Shade tree)	March 1937	1-0		676	8x8	19	0	0
Cascara buckthorn	Wild seedlings								
1.	Blaine, Oreg.								
2. (4/)		Feb. 1937	2 to 6-0		729	8x8	19	(3/)	25
Douglas-fir	Willamette Valley, Oreg.	March 1937			324	12x12	19	1	1
1.		May 1937	2-0		136	12x12	19	13	24
2. (1/)		May 1937	2-0		102	12x12	19	14	24
Giant sequoia	--	Feb. 1939			48	8x8	17	19	10
Hybrid poplars	--	April 1939	2-0		488	6x6	17	2	40
Monterey pine	Near San Francisco Bay	Feb. 1947	1-0		288	6x6	9	(3/)	3
Norway spruce	--	April 1940	2-2		51	7x7	16	18	9
White fir	--	April 1937	2-0		42	8x8	19	0	0

1/ Mixed planting with cascara.

2/ Top-killed by frost, fall 1955, after last measurement; reducing approximate average height to 16-18 feet.

3/ Survival less than 0.5 percent.

4/ Mixed planting with Douglas-fir and Port-Orford-cedar.

bachmani ubericolor), and deer (Odocoileus hemionus columbianus).^{3/} The last known fire was in 1925, almost 12 years before the first plantations were established.^{4/} Seed trees were scattered throughout the burn and Douglas-fir, Sitka spruce (Picea sitchensis), western hemlock (Tsuga heterophylla), and red alder (Alnus rubra) seeded in around the plantations and afforded a basis for later comparison. A dense stand of native trees surrounded the plantations by 1955.

Topography is gentle and dissected by the headwaters of numerous small streams. The steepest slope of any plantation is 40 percent, but most plantations are on slopes less than 20 percent. Although general aspect is southerly, two Port-Orford-cedar plantations have partial northern exposure. Elevations range from 500 to 950 feet above sea level.

Soil is well-drained, 2 to 6 feet deep, with silt loam near the surface and clay loam below. Classification is the Astoria series of the Brown Latosol great soil group. Parent material is sedimentary, deeply weathered acid shale. Surface mineral soil is acid, and acidity increases with depth.

Climate is marine, typical of the "fog belt" along the Oregon Coast. It is characterized by equable temperatures, much cloudiness, and frequent rains except in summer--and fogs even then. There is a long frost-free season. The nearest weather station is located at the experimental forest headquarters, 1 mile from the planting site. Averages and extremes from 17 years' record, 1936 to 1952, are:^{5/}

Average annual temperature	50.7° (F.)
Highest temperature	97.0° (F.)
Lowest temperature	4.0° (F.)

^{3/} Moore, A. W. Wild animal damage to seed and seedlings on cutover Douglas fir lands of Oregon and Washington. U. S. Dept. Agr. Tech. Bul. 706, 28 pp., illus. 1940.

^{4/} Christmas, R. Don. Reforestation of bracken fern areas in western Oregon. Thesis, College of Forestry, State University of New York, Syracuse. 113 pp., illus. 1952.

^{5/} Ruth, Robert H. Cascade Head climatological data: 1936-1952. 29 pp. Pacific Northwest Forest and Range Expt. Sta. 1954.

Average frost-free period	190 days
Average annual precipitation	89.05 inches
Average annual number of days with precipitation	180 days
Greatest number of consecutive days without recorded precipitation	35 days
Greatest annual snowfall	20.5 inches
Average annual number of cloudy days	160 days

PLANTATION ESTABLISHMENT, CARE, AND MEASUREMENT

The plantations were established between 1937 and 1947, and most species were planted prior to 1940 (table 1). Season of planting was spring, except for one Port-Orford-cedar plantation established in the fall to test fall versus spring planting. Grub hoes were used in planting most species. Complete seed source records are not available for all plantings.

Site preparation involved slashing of major competitive species, except bracken. Alder was the most common species removed, but conifers and brush were also cut back when they were present. The hybrid poplar area was burned before planting. In later years, periodic release from alders and conifers was given those plantations where survival was good but where growth appeared to be hindered by vegetative competition.

The plantations were checked periodically for survival and height growth, beginning the first year after planting and then at 2-, 3-, or 5-year intervals. Trees in each plantation were staked and mapped so that growth of individuals could be recorded. Poor form, animal damage, and other factors affecting survival and growth were noted.

SURVIVAL AND GROWTH

Most of the plantings were failures. Red pine and Port-Orford-cedar, with 93 and 78^{6/} percent survival respectively, are the only species with a survival and growth rate sufficient to be considered successful (table 2). The redwood plantation, with 65 percent

^{6/} Average of four plantations.

Table 2.--Survival of planted trees in a bracken fern area of coastal Oregon

(In percent)

Species	Growing seasons since planting																
	1	2	3	4	5	6	7	8	9	10	11	12	14	16	17	19	1955
Red pine	--	--	98	--	98	--	--	--	--	--	94	--	--	93	--	--	93
Port-Orford-cedar																	
1. (<u>1/</u>)	98	--	97	--	97	--	<u>2/</u> 99	95	--	95	--	--	91	--	--	89	89
2.	97	95	--	94	--	91	--	93	--	92	--	--	91	--	--	88	88
3.	98	--	--	86	84	--	<u>2/</u> 85	--	--	--	83	--	--	82	--	--	82
4.	84	--	--	61	57	--	<u>2/</u> 58	--	--	--	57	--	--	54	--	--	54
Redwood	--	--	86	86	--	75	--	76	--	76	--	--	73	--	--	65	65
Baldcypress	--	--	25	--	--	25	23	--	--	--	0	--	--	--	--	--	0
Black cottonwood	--	74	--	--	8	--	0	--	--	--	--	--	--	--	--	--	0
Black walnut	99	--	88	88	--	57	--	30	--	<u>2/</u> 35	--	--	--	--	--	0	0
Cascara buckthorn																	
1.	--	92	<u>3/</u> 91	89	--	79	--	56	--	34	--	--	--	--	--	0	0
2. (<u>4/</u>)	94	--	<u>3/</u> 71	79	--	83	--	54	--	42	--	--	--	--	--	1	1
Douglas-fir																	
1.	81	--	<u>3/</u> 54	73	--	23	--	25	--	--	--	--	--	--	--	13	13
2. (<u>1/</u>)	79	--	<u>3/</u> 45	60	--	34	--	21	--	20	--	--	--	--	--	14	14
Giant sequoia	56	50	--	35	--	42	--	46	--	--	--	33	--	--	19	--	19
Hybrid poplars	--	--	--	--	55	13	--	--	--	--	--	--	--	--	2	--	2
Monterey pine	59	--	--	2	--	--	--	--	0	--	--	--	--	--	--	--	0
Norway spruce	--	--	55	--	55	--	--	--	--	--	45	--	--	18	--	--	18
White fir	98	--	--	--	--	--	74	60	--	48	--	--	--	--	--	0	0

1/ Mixed planting with cascara.2/ Fluctuation in percent survival was attributed to difficulties in locating some trees.3/ Mortality of cascara and Douglas-fir replaced, February 1940.4/ Mixed planting with Douglas-fir and Port-Orford-cedar.

survival and fair growth, has poor form from repeated frost damage; it suffered a severe setback from a fall freeze in 1955.

Animal damage was the most significant cause of mortality in all plantations. Damage to 100 percent of the planted trees in a single plantation has been recorded at a single measurement. Mountain beaver and Columbian black-tailed deer were the principal offenders. However, some damage attributed to mountain beaver may have been the work of the brush rabbit since the damage is very similar. Repeated clipping and browsing resulted in hedge-like trees, many of which eventually died. Forking at the base of trees occurred in areas where animal damage was most severe.

Red Pine

After 16 growing seasons, survival of red pine was 93 percent--highest of all species planted. Mortality was primarily caused by overtopping of deer-rubbed trees. Deer rubbing was not serious, however, and other animal damage was negligible. Tree form is excellent, with only one tree forked and no crooked trees. Neighboring, native, dominant Douglas-firs had leaders killed by frost in the fall of 1955, but red pine was unaffected.

Red pine, although planted in very dense and tall bracken, suffered no obvious suppression, crushing, or smothering from the fern. Suppression and poor growth may have occurred, however, had the stand not been released from native alder and conifer competition (fig. 2).

Steady and rapid growth of red pine was only exceeded in one of the Port-Orford-cedar plantations (fig. 3). Red pine was taller than all other species until the 11th year, when it was overtaken by the cedar. On good sites, within its natural range, average height of red pine is 24 feet at 20 years.^{7/} Projected height of this plantation is 29 feet at 20 years. Average annual height growth since planting was 1.3 feet; during the last 5 years, annual growth was 1.9 feet. Average diameter in 1955 was 5 inches.

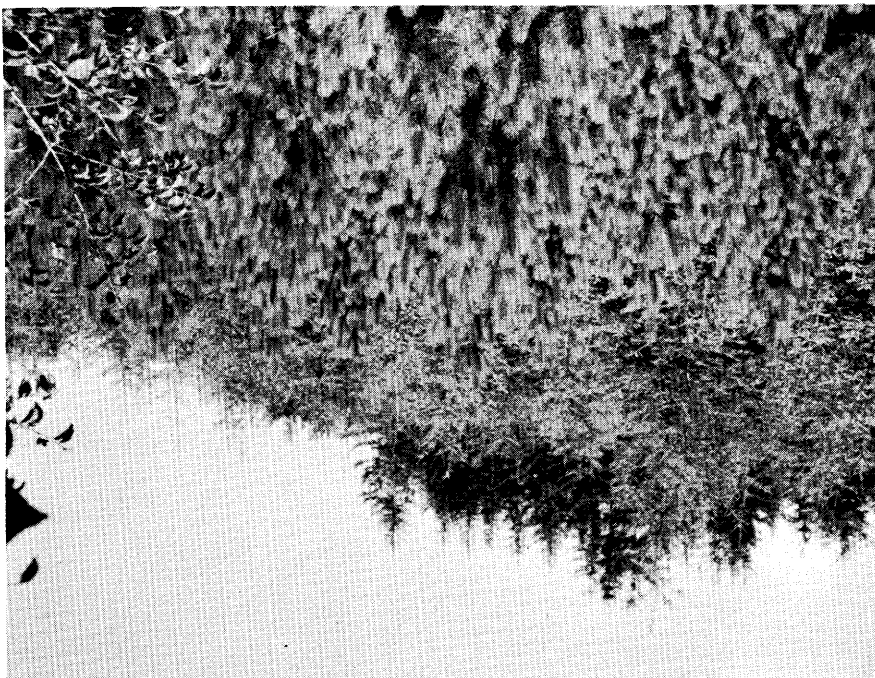
^{7/} Eyre, F. H., and Zehngraff, Paul. Red pine management in Minnesota. U. S. Dept. Agr. Cir. 778, 70 pp., illus. 1948.

Survival of Port-Orford-cedar was far superior to that of most other species tested. For three plantations, survival averaged 86 percent at the last measurement; on the fourth plantation (spring planted, 1940) survival was 54 percent. Poor results of the latter cannot be ascribed to spring planting for certain, however, since the two 1937 plantations were spring planted and had best survival. After 16 years, mortality in the 1940 spring planting was significantly higher on the southwest exposure. In the 1939 fall planting, however,

Two plantations were established in 1937. One was a pure plantation (No. 2) and one was a mixed planting with cascara (No. 1). Two additional areas (Nos. 3 and 4) were planted 3 years later with cedar to measure effects of fall versus spring planting (fig. 4). The 1939-1940 plantations adjoin each other and straddle a ridge so that each has a northeast and a southwest exposure.

Port-Orford-Cedar

Figure 2. --Red pine plantation in what was formerly a dense bracken area. Dominant trees of surrounding natural reproduction are 5-10 feet taller than the pine, which averages 22 feet.



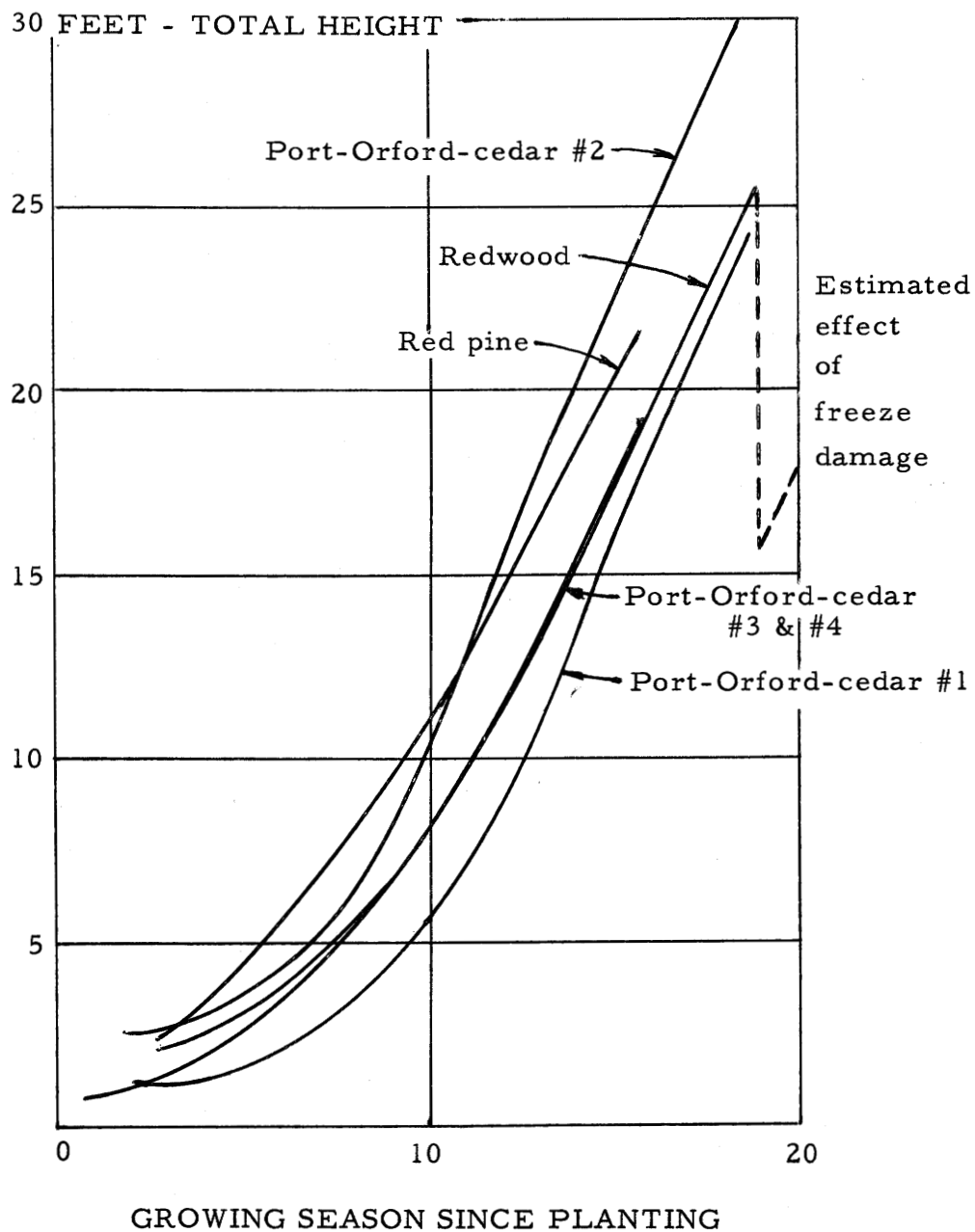


Figure 3. --Height of several plantations in a bracken fern area of coastal Oregon.

Wherever large colonies of mountain beaver were present, higher mortality was noted. Clipping of leaders and side branches by mountain beaver was common, particularly during the first few growing seasons. A type of damage not reported before was girdling of pole-size trees (fig. 6). Evidence indicates that this is the work of the mountain beaver, but similarity of tooth marks between

Most cedar mortality can be assigned to mountain beaver, rabbits, and deer. As high as 55 percent of the trees were damaged by rodents in the cedar-cascara plantation during the third growing season. Deer rubbing and browsing were common during the early years in all four plantations (fig. 5).

In the mixed plantation, practically all cascara trees died; therefore the influence of cascara on stand development could not be evaluated.

there was no significant difference in mortality between the northeast and the southwest exposures.

Figure 4. --Port-Orford-cedar plantation (fall planted), with average height of 19 feet. Area surrounding plantation is densely covered with native trees.





Figure 5. --Deer rubbing of Port-Orford-cedar.

A, This 2-inch tree was still growing and has a good chance to recover. B, Top-killed. A new leader will have to compete with 6- to 8-foot bracken during the growing season. Native Sitka spruces in the background were not damaged by deer.

rabbits and mountain beaver prevented accurate identification. About 5 percent of the 1939-40 plantations was damaged.

No climatic damage had occurred in the Port-Orford-cedar plantings at the time of the 1955 remeasurement. However, a spot check of the plantations in 1956 revealed some frost damage from the 1955 cold wave.^{8/} The 1937 mixed plantation, which was located at the highest elevation (950 feet), had about 5 percent of the trees killed outright and most of the remaining trees had leaders or tops killed. Some cedars, apparently more resistant, suffered no damage. Leaders and top growth of surrounding native conifers were

^{8/} Duffield, John W. Damage to western Washington forests from November 1955 cold wave. Pacific Northwest Forest & Range Expt. Sta. Res. Note 129, 8 pp., illus. 1956.



Figure 6. -- A
Port-Orford-
cedar girdled
by rodents;
probably
mountain
beaver.

also killed. Other Port-Orford-cedar plantations escaped damage except for an occasional killed leader.

Tree form was moderately good, but animal damage had affected the quality of some surviving stems. In the four plantations, crooked and forked stems varied from 7 to 17 percent of the total.

Height growth of Port-Orford-cedar was good but varied considerably between the 4 plantations (fig. 3). The pure plantation (No. 2) exceeded all plantations in total height since its eleventh year. This superior height growth is attributed to poorly drained soil in part of the plantation. Average height in this part was 40 feet as compared with 28 feet in the remainder of the plantation. The three other cedar plantations (Nos. 1, 3, and 4) were almost equal in height at 16 years.

A study by Hayes^{9/} compared heights of 37 Port-Orford-cedar plantations, including those at Cascade Head and some in Europe. Height growth in the better part of plantation No. 2 equalled the best in the Hayes' study. The other cedar plantations at Cascade Head were within 2 feet of average for their age.

Average annual height growth for all Port-Orford-cedar plantations at Cascade Head ranged from 1.2 to 1.6 feet. During the last five years it ranged from 1.9 to 2.4 feet. Average diameters of the plantations ranged from 4 to 7 inches.

Redwood

At the time of the 1955 examination, 65 percent of the planted redwoods had survived and made good height growth despite recurrent light frost damage. Later examination, after the 1955 cold wave, showed that 100 percent of the plantation had been severely damaged. Tops of most of the larger trees were killed back 8 to 10 feet and many smaller trees were killed. Neighboring Douglas-fir and hemlock had only an occasional leader nipped by the frost. It is now apparent (fig. 3) that periodic frosts may seriously limit survival and growth of redwood at Cascade Head.

Early mortality was high. Until the fourth growing season approximately 50 percent of the mortality was attributed to mountain beaver. Deer rubbing was also common.

At the 1955 examination, a third of surviving trees were forked, crooked, or had dead tops. Frost, alder whipping, and animal damage, in that order, were responsible for these defects. Whipping was done by approximately 35 dominant alders that had become established in the plantation. Mean diameter of the stand was 7.2 inches; largest diameter, 14.3 inches.

Baldcypress

Mortality of baldcypress, caused mostly by mountain beaver, was 75 percent after only three growing seasons. The plantation failed completely by the 11th year.

^{9/} Correspondence with G. L. Hayes, Siskiyou-Cascade Res. Center, Pacific Northwest Forest and Range Expt. Sta., August 17, 1956.

Black Cottonwood

Complete failure of planted black cottonwoods occurred by the seventh growing season. After two growing seasons, 56 percent of the trees had been cropped by rodents and 33 percent had been browsed by deer. Maximum height of the trees was approximately 2 feet.

Black Walnut

After 10 years only 35 percent of the black walnut trees were living; all had died by the end of 19 years. Growth during the first 4 years was slow, even though survival was good (88 percent) and animal damage was not severe. After the fourth growing season, trees were heavily cropped but the animals responsible were not identified. During the sixth growing season, 50 percent of the trees had top-kill of unknown origin. Maximum average height reached by the plantation was 1.4 feet, and the tallest tree recorded was 6 feet at 8 years. On optimum sites within its range, walnut will grow 8 feet tall in 2 years.

Cascara Buckthorn

Two plantations of cascara were established in 1937. One was pure cascara (No. 1) and the other was planted between rows of Douglas-fir and Port-Orford-cedar (No. 2). The story of survival is similar for both plantations--a constant decline under the pressure of deer and rodent cropping. Fifty-five and 82 percent of the trees were cropped during the first 3 growing seasons. Dead trees were replaced in 1940 but survival continued to decline. Most of the trees grew less than a foot in height before dropping out of the plantations. Two trees in the pure plantation attained 25 feet in height, but these were heavily forked and severely scarred from deer rubbing.

Douglas-Fir

Two plantations were established in 1937 in adjoining areas, one pure (No. 1) and one in mixture with cascara (No. 2). Both failed by the third growing season. Over 60 percent of the trees had been cropped, primarily by mountain beaver. Minor grouse clipping was noted on 10 percent of the seedlings.

Dead trees were replaced in 1940 but survival continued to decline until only 14 percent of both plantations was alive in 1955.

Average height of surviving trees was 24 feet. Height growth of surviving planted trees was less than that of natural Douglas-fir.

Giant Sequoia

In 1939, at the end of the first growing season, 44 percent of the trees had been cropped by mountain beaver. Only 50 percent of the plantation survived the second growing season. Trees continued to die, generally from deer rubbing, until in 1955 only 19 percent of the sequoias were living. Naturally established spruce, hemlock, and alder will soon overtop most of the survivors.

Hybrid Poplars

Twenty-five strains of Oxford Paper Company hybrid poplars were set out in a bracken area after broadcast burning the fern. Even though the area had been baited for rodents, all trees were cropped by mountain beaver within two weeks after planting and survival was only 55 percent after five growing seasons. Trees that managed to grow above the bracken were severely deer rubbed. Height of surviving trees by lot number are shown below. Tallest trees are over 45 feet, with one 60 feet (fig. 7).

<u>Lot No.</u>	<u>Total height in feet</u>
39	60, 48, 45
54	40, 30, 26
53	36
11	46
50	28, 28

Monterey Pine

A combination of crushing and smothering from bracken plus animal cropping caused early failure of the Monterey pine plantings. Only 59 percent of the seedlings were alive after one growing season and 68 percent of these had dead leaders or had been cropped. One tree was alive in 1955 but had been deer rubbed, and died subsequently.

Norway Spruce

Slow growth plus repeated animal browsing and rubbing resulted in 82 percent mortality by 1955. In addition, weevils (Pissodes sp.) killed the leaders of many of the taller trees (fig. 8). The nine remaining trees will probably be killed by deer rubbing or remain shrub-like from continued weeviling.

White Fir

A 93-percent survival after the first growing season in 1937 was followed by a gradual decline until all white firs died sometime between the 10th and 19th seasons. The trees lacked vigor and never grew over 2.5 feet tall.

Mortality can be attributed to several causes. Seedlings were matted down by fern, eventually overtopped by dense alder, heavily cropped by mountain beaver, and rubbed and browsed by deer.

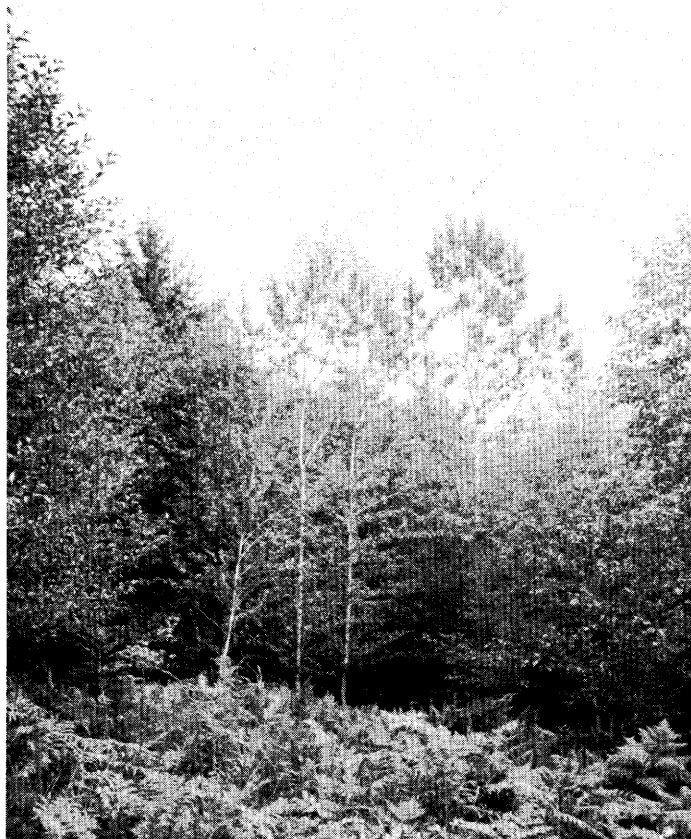


Figure 7.--Surviving hybrid poplars were 20 feet taller than surrounding alder. Non-stocked bracken area in foreground was formerly occupied by a Norway spruce plantation.

Figure 8. -- One of the few surviving Norway spruces, severely deer rubbed and heavily weeviled. This tree is 15 feet tall.



COMPARISON WITH LOCAL TREES

Local tree species became established around and between test plantations about the time of planting or slightly before. The area is now covered with a mixed stand of Douglas-fir, Sitka spruce, western hemlock, and red alder, and with scattered pure stands of alder. Local species, similar in crown class and spacing to the plantations, were measured and their heights compared with those of the plantation species.^{10/}

On this site, alder and Douglas-fir established an early lead in height growth and maintained superior height over other native

^{10/} Local species were sectioned or whorls counted to determine height at a given age. Basis: Douglas-fir, 9 trees, 36 measurements; Sitka spruce, 10 trees, 36 measurements; hemlock, 16 trees, 59 measurements; alder, 14 trees, 76 measurements.

species and over all planted species (figs. 3 and 9). At 16 years of age, alder was 6 to 8 feet taller than Douglas-fir (native); Douglas-fir was 6 to 8 feet taller than hemlock; and hemlock was 3 to 4 feet taller than Sitka spruce. Local Douglas-fir was 13 feet taller than planted Douglas-fir of Willamette Valley origin. The tallest planting of Port-Orford-cedar (No. 2) was about equal to western hemlock in height. Height of red pine was between that of western hemlock and Sitka spruce. Spruce was equivalent in height to redwood and Port-Orford-cedar plantations 1, 3, and 4. Redwood, however, suffered severely from freeze damage after the 19th year and is now shorter than any of the native species.

DISCUSSION

Results of experience with these plantations point up the important influence of animals on the survival of planted trees. Gross failures occurred for all species except red pine, Port-Orford-cedar, and redwood, as a result of depredations by mountain beaver, rabbits, and deer. Some species, i. e. hybrid poplars, might have grown well were it not for severe animal damage. Overcoming this environmental barrier, however, would be difficult.

Best height growth of introduced species--that of red pine and Port-Orford-cedar--was not comparable with growth of native Douglas-fir or red alder but about equalled growth of native western hemlock and Sitka spruce--the latter being inland and off its best site. Therefore, growth of red pine and Port-Orford-cedar can be considered acceptable, but it would be unwise to plant either species except on an experimental basis. Results obtained for red pine are based on a single, small plantation and Port-Orford-cedar is considered a poor risk for reforestation because of *Phytophthora* root rot (*P. lateralis*).^{11/} This disease is widespread in the Northwest and is capable of killing Port-Orford-cedar wherever an infection occurs. Redwood survived and grew satisfactorily but was damaged by repeated frost injury, resulting in poor form.

Present reforestation programs in coastal Oregon emphasize planting native trees on their best sites; results of this study provide no basis for change. Excellent survival and growth of local species

^{11/} Hunt, John, and Dimock, Edward II. Port-Orford-cedar--a poor reforestation risk. Pacific Northwest Forest & Range Expt. Sta. Res. Note 139, 3 pp. 1957.

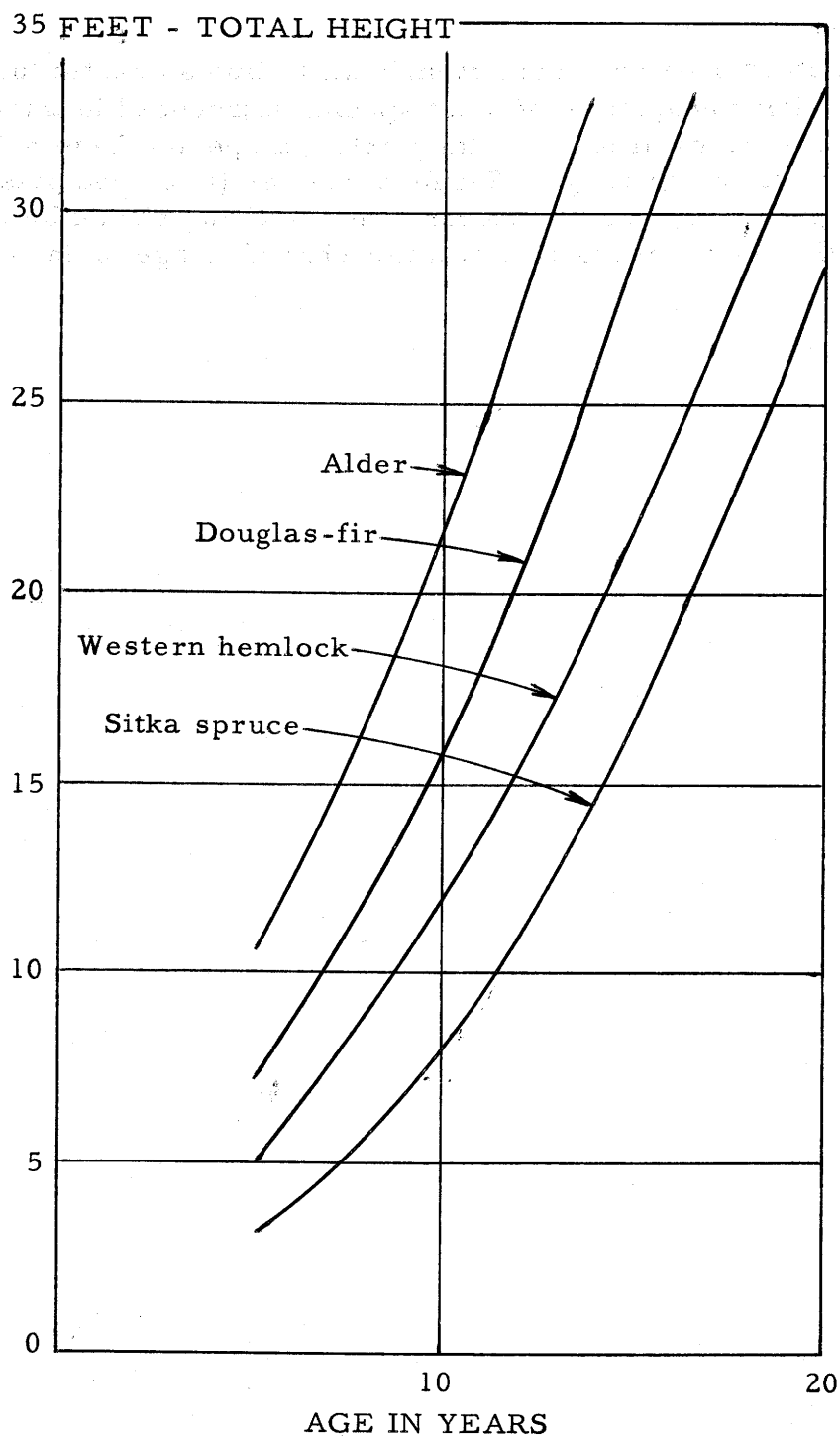


Figure 9. --Height growth for local tree species bordering plantations in a bracken fern area of coastal Oregon.

in the coastal forest will make it difficult to find an exotic that can compete. Poor adaptation of most species introduced in this study demonstrates risks attendant with planting a species from a different site, provenance, or range. Should a species (i. e. red pine) survive and grow well, use in general forest planting should be conservative until volume production at a merchantable age is demonstrated.