United States
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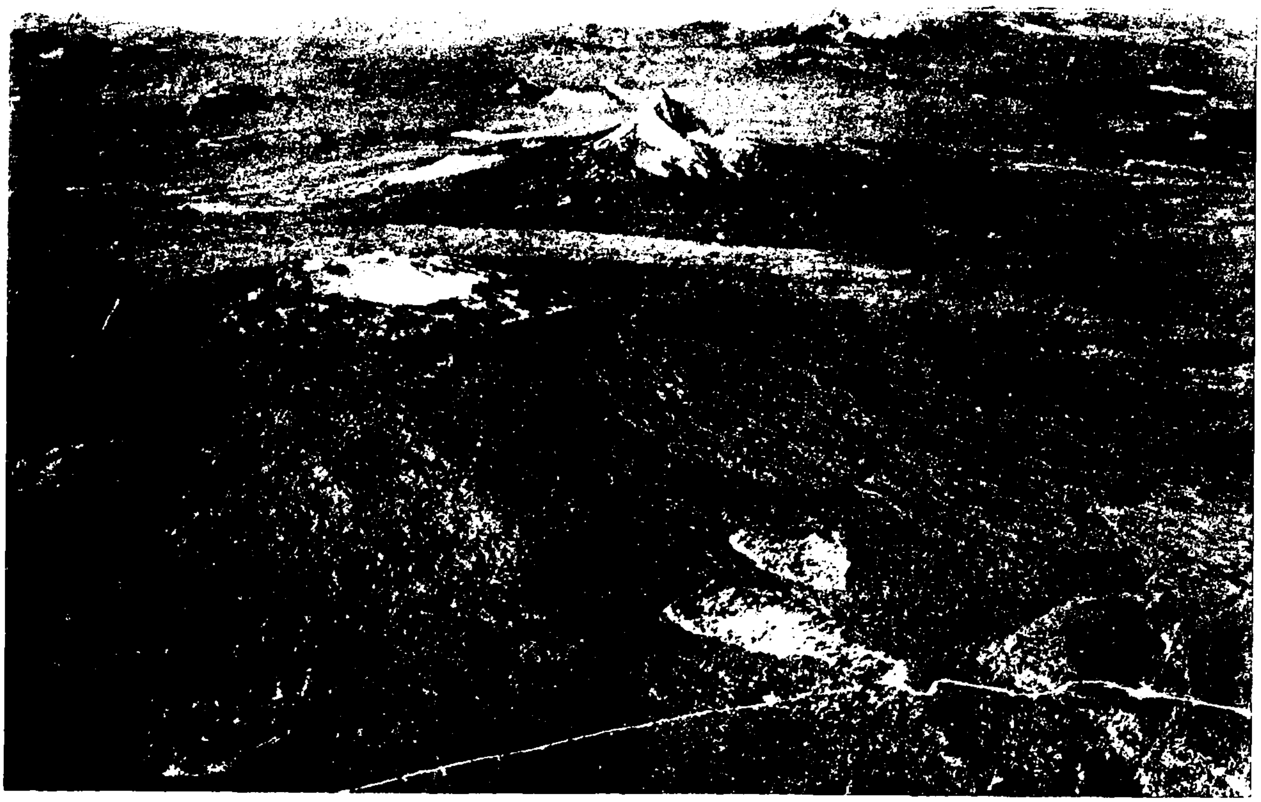
Plant Association and Management Guide for the Pacific Silver Fir Zone

Mt. Hood and Willamette National Forests



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PLANT ASSOCIATION AND MANAGEMENT GUIDE FOR THE PACIFIC SILVER FIR ZONE, MT. HOOD AND WILLAMETTE NATIONAL FORESTS

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INTRODUCTION

Increasingly intensive management of National Forest lands requires accurate evaluation of land condition, capability and response to management. Several questions frequently arise. How can different forest types be distinguished? How do they respond to manipulation? How productive are they? Complete knowledge, acre by acre, of species populations, growth rates, biomass, soils, and environment would provide the ideal data base. At present we cannot compile such a data base. A reasonable alternative is to let the vegetation and soils of a site indicate potential species composition, productivity and response to management. Plant populations which have existed on a site for a long period have come into balance with, and are useful indicators of, their environment. A classification of long-term, stable plant communities (or associations), especially where combined with soils information, can be the basis of resources evaluation, project planning, and land management planning.

Classification of plant associations allows us to:

1. Plan management strategies--evaluate resource condition, productivity, responses to manipulation.

2. Communicate--record successes or failures of management actions, provide a common description of forest conditions for various disciplines.

3. Apply research--provide a direct link between research results and practical land management.

OBJECTIVES

The objective of this project is to provide a vegetative basis for land stratification in the Pacific silver fir zone which could be used for project and land management planning. Three major tasks were involved:

1. Describe plant associations in the Pacific silver fir zone of the Mt. Hood and Willamette National Forests and provide a means for project managers to identify them in the field.

2. Compile environmental profiles and management implications for these associations from field measurements, research results, and the experience of working managers.

3. Sample tree growth and soils in different plant associations and provide estimates of site productivity.

Classification of the Pacific silver fir zone is part of a larger project to classify all lands on the Mt. Hood, Siuslaw, and Willamette National Forests. Sampling has begun in the western hemlock, Douglas-fir, and Sitka spruce forests of the Siuslaw National Forest. A guide to those forests is planned for 1985. Sampling will begin in the lower elevation west-side forests of the Mt. Hood and Willamette National Forests in 1982 with a guide planned for 1986. East-side forests of the Mt. Hood National Forest will be sampled beginning in 1987 with a guide planned for 1990.

CLASSIFICATION CONCEPTS

Plant communities are useful indicators of environment. After a disturbance, temperature, moisture, light and nutrient availability all act as filters which sort from the large pool of available plant species those which can most effectively occupy a site. After a relatively long disturbance-free period, only those plants which can grow and reproduce in competition with their neighbors remain. This long-term stable collection is the association or climax community. Different environments will develop different plant associations and plant associations are repeated across the landscape wherever the environment is suitable (Fig. 1). For the sake of practical application, plant associations are defined as more or less discrete, recurring collections of plant species which maintain stable populations over a long time period. This concept is similar to habitat type (Daubenmire 1968, Franklin 1966, Pfister et al. 1977). The definition of habitat type includes climax plant communities <u>and</u> the land area they occupy.

Climax forests rarely occur in the Pacific Northwest. Although major natural disturbances, especially fire, are infrequent (Hemstrom 1979, Henderson and Peter 1981, Burke 1979), pioneer conifer species can be very long lived. Douglas-fir and noble fir, the two most important pioneer conifer species in the Pacific silver fir zone, frequently live over 750 and 400 years, respectively (Franklin and Hemstrom 1981). Climax forest species composition and structure can develop only after these species have died out of the stand. Under some conditions, climax species are the only pioneers. Where this happens, climax forests of Pacific silver fir, mountain hemlock, grand fir-white fir[1/], and western hemlock develop in a relatively short time. In general the names of climax associations, such as Pacific silver fir/coolwort foamflower, do not imply that Pacific silver fir is currently the major canopy

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[1/] White fir, <u>Abies concolor</u>, and grand fir, <u>Abies grandis</u>, both shade-tolerant species, occur in the Pacific silver fir zone. Although grand fir is most abundant at low elevations while white fir is more common on upper slopes, they interbreed causing morphological and ecological intergradation (Daniels 1969). We will refer to all the trees we sampled in the <u>Abies grandis</u> - <u>Abies concolor</u> complex as white fir.

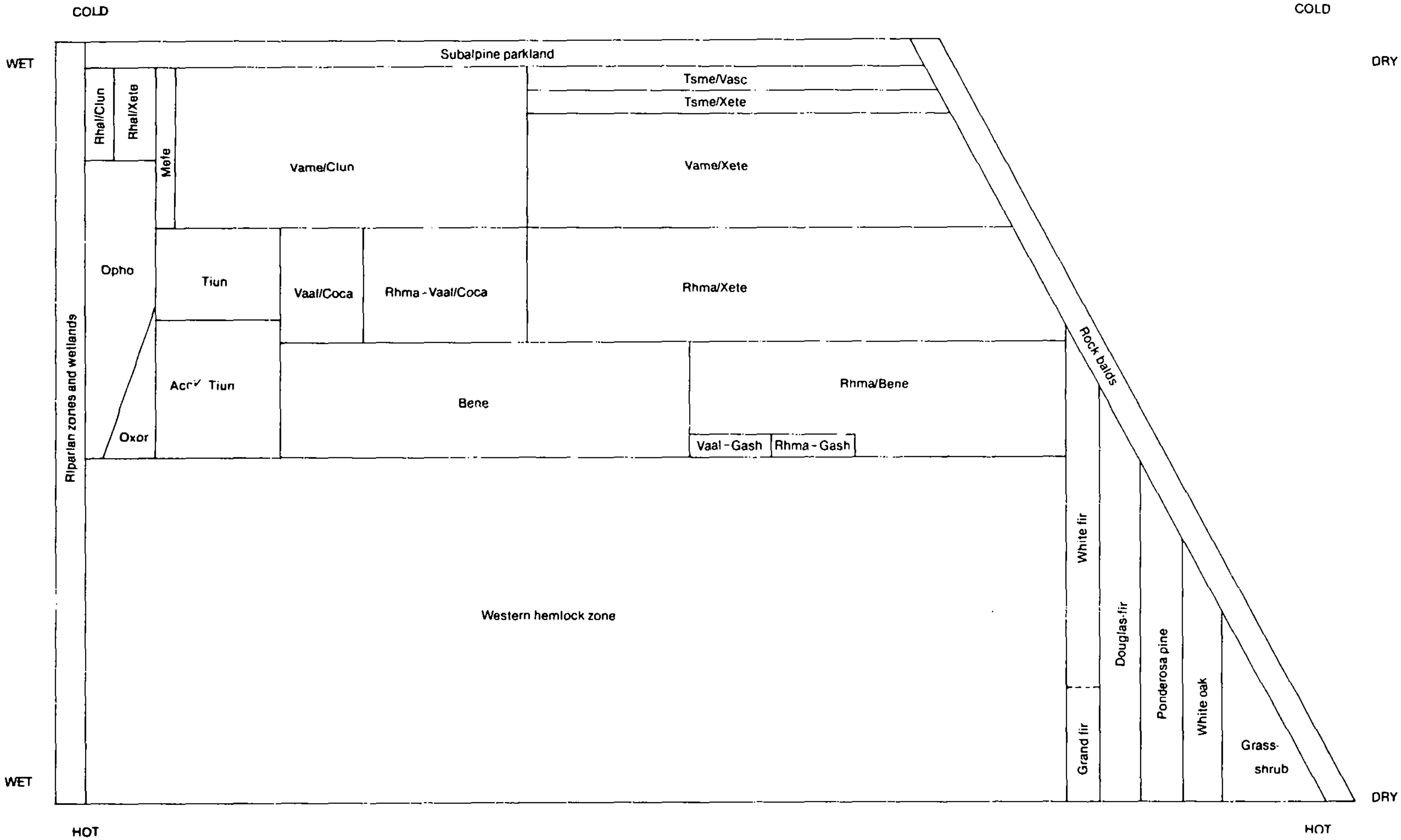

Figure 1. Relative relationships of Pacific silver fir and mountain hemock associations and other vegetative zones to temperature and moisture gradients on the Mt. Hood and Willamette National Forests.

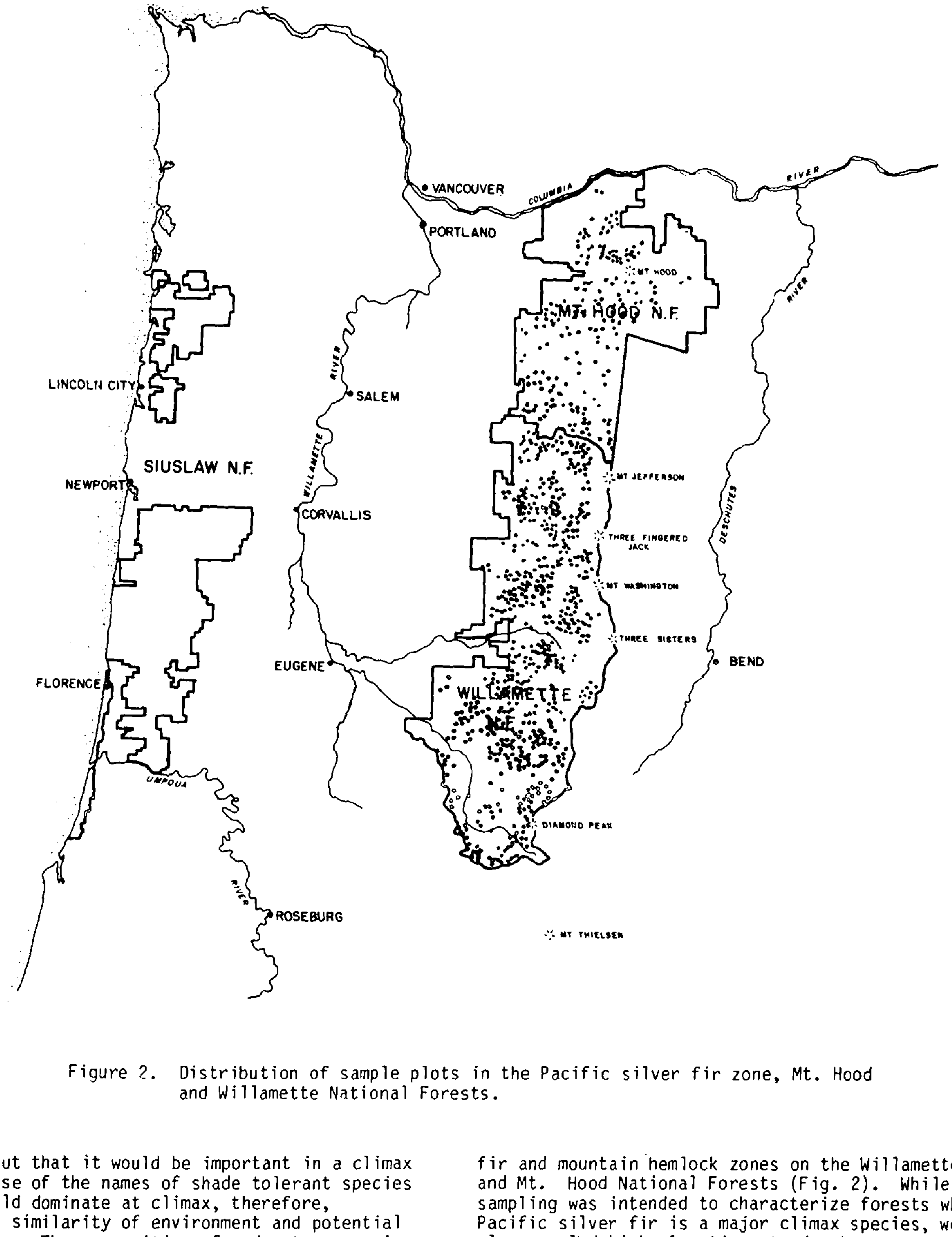

Figure 2. Distribution of sample plots in the Pacific silver fir zone, Mt. Hood and Willamette National Forests.

species but that it would be important in a climax stand. Use of the names of shade tolerant species which would dominate at climax, therefore, indicates similarity of environment and potential vegetation. The composition of understory species, which stabilizes within 50 to 100 years in most situations, and tree regeneration allow seral stands to be classified into plant associations.

The classification presented in this guide is based on over 800 sample plots in the Pacific silver fir and mountain hemlock zones on the Willamette and Mt. Hood National Forests (Fig. 2). While sampling was intended to characterize forests where Pacific silver fir is a major climax species, we also sampled high-elevation stands where mountain hemlock is a major climax species. Two mountain hemlock associations which were well sampled and have been previously described in the literature are included with the 16 Pacific silver fir associations described in this guide.

THE STUDY AREA

The Pacific silver fir zone occurs on the western slopes of the Cascade Range from British Columbia south to about 44°N latitude, near the southern end of the Willamette National Forest (Franklin and Dyrness 1973). Smaller areas of the Pacific silver fir zone are found in the Olympic Mountains, in cool, wet sites in the Cascades east of the Crest, in isolated areas of the northern Oregon Coast Range, and south to about 43°N latitude. Elevations usually range from about 3,000 feet (900 m) to 5,000 feet (1,500 m) on the Mt. Hood National Forest and 3,500 (1,060 m) to 5,500 feet (1,670 m) at the south end of the Willamette National Forest. Below the Pacific silver fir zone, western hemlock, Douglas-fir, grand fir, and ponderosa pine are climax species, depending on local site conditions. At elevations above 5,000 to 5,500 feet (1,500 to 1,670 m), mountain hemlock is a major climax species, especially on the high Cascades plateau. At the south end of the Willamette National Forest, white fir becomes an increasingly important climax species. Extensive mixed forests of Pacific silver fir and white fir are found on south-facing slopes in the McKenzie, Blue River, Oakridge, and Rigdon Ranger Districts. East of the Cascade Crest on the Mt. Hood National Forest, the Pacific silver fir zone is not widespread, usually occurs above 4,500 feet (1,360 m) and often contains a mixture of conifers more typical of inland subalpine forests.

CLIMATE

The Pacific silver fir zone is wet in winter with deep snow accumulations at upper elevations, and relatively dry in summer. Annual precipitation ranges from about 70 inches (1,800 mm) in local rain shadows to over 130 inches (3,350 mm) on some high ridges (Fig. 3) (U.S. Weather Bureau 1964). Much of this accumulates as a snowpack 3 to 10 feet (1 m to 3 m) deep that melts from May to July. Precipitation patterns are heavily influenced by topography (Fig. 3). Precipitation peaks occur west of Mt. Hood, near the headwaters of the Molalla River at Thunder Mountain and near Wildcat Mountain. Local rain shadows are present west of West Pinhead Butte, in the Breitenbush area, and south of the McKenzie River. The south half of the Willamette National Forest is considerably drier than the north half - an important factor in vegetation distribution.

Mean maximum air temperatures usually occur in August and range from about 75°F (24°C) in the Pacific silver fir/Oregon grape association to about 63°F (17°C) in the Mountain hemlock/Big huckleberry/Beargrass association (Table 1, Fig. 4, Emmingham and Lundberg 1977). At the soil surface in burns or clearcuts, temperatures often exceed 120°F (50°C) in mid-summer (Halverson and Emmingham 1982). Soils cool rapidly when fall rains begin and usually remain constant at about 32°F to 35°F (0°C to 2°C) under the snowpack (Fig. 4). Growing seasons are short at upper elevations. Temperature regimes are markedly different from clearcuts or openings to adjacent closed stands (Fig. 4). Summer frost frequently occurs in openings at upper elevations, particularly on gentle topography (Halverson and Emmingham 1982).

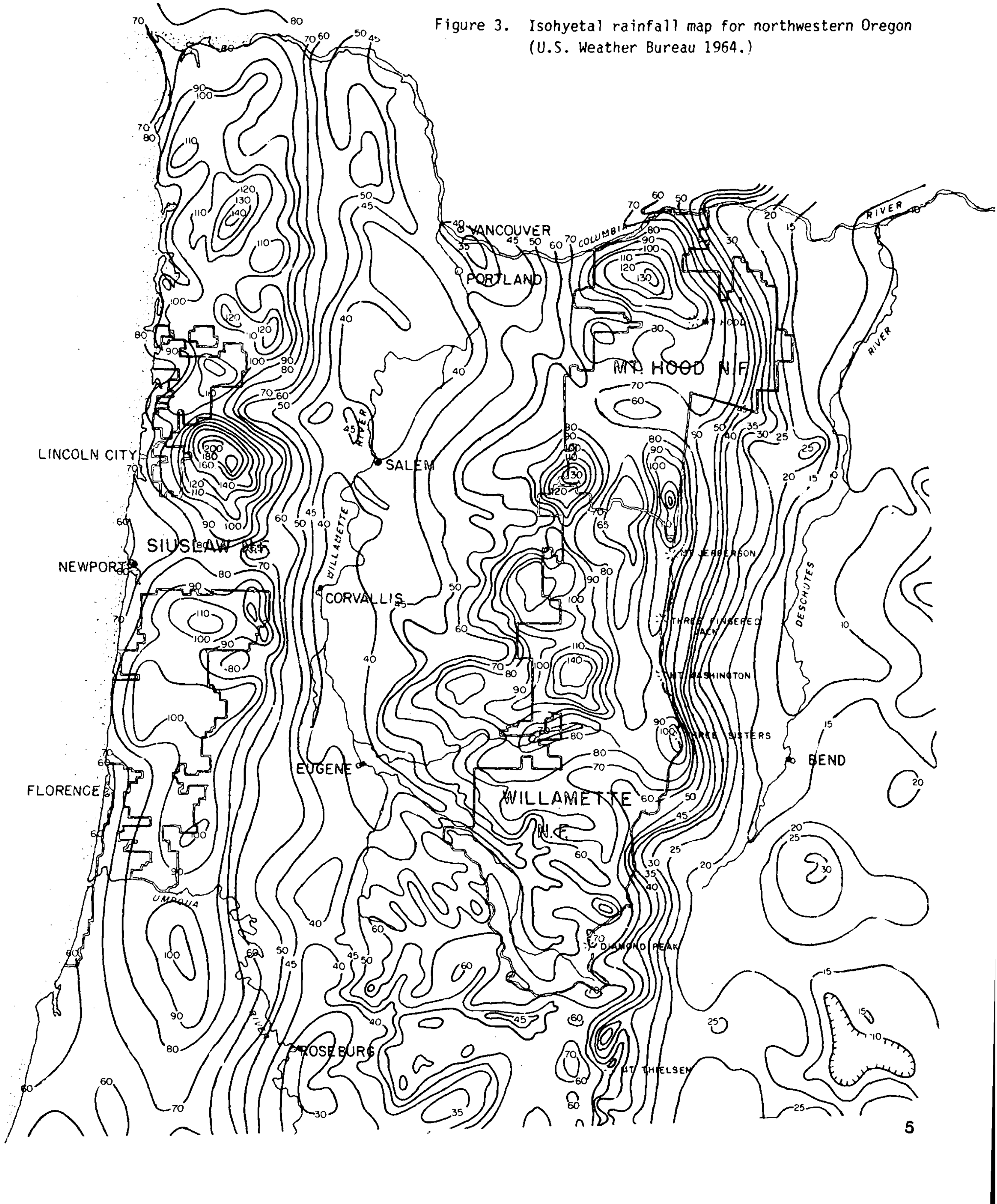

Figure 3. Isohyetal rainfall map for northwestern Oregon (U.S. Weather Bureau 1964.)

Table 1. Average air and soil temperatures for reference stands on the H. J. Andrews Experimental Forest[1] corresponding to several Pacific silver fir zone plant associations.

Plant Community	Elevation m	Elevation ft	Aspect	Slope %	Month	Mean Max. Air Temp. C°	Mean Max. Air Temp. F°	Mean Min. Air Temp. C°	Mean Min. Air Temp. F°	Mean Soil Temp. C°	Mean Soil Temp. F°	Max. Soil Temp. C°	Max. Soil Temp. F°	Min. Soil Temp. C°	Min. Soil Temp. F°	Similar PSFZ Association	General Environ.
Douglas-fir/Oceanspray	510	1680	SW	35	Jan	4.8	41	-.6	31	3.4	38	4.8	41	2.2	36	None	Hot, Dry
					Aug	24.9	77	11.4	53	15.6	60	16.9	63	14.0	57		
Western hemlock-Pacific silver fir/Twinflower	950	3140	SW	10	Jan[2]	1.1	34	-2.5	27	2.0	36	2.5	36	1.9	35	ABAM/BENE	Warm
					Aug[2]	23.8	75	12.7	55	13.9	57	15.3	59	1.22	54		
Western hemlock-Pacific silver fir/Rhododendron-Oregon grape	920	3040	N	18	Jan[3]	2.9	37	-.8	31	1.6	35	2.7	37	.7	33	ABAM/RHMA-BENE	Warm, Dry
					Aug[4]	19.8	68	10.9	52	13.5	56	15.3	59	11.9	53		
Pacific silver fir/ Alaska hucklebery/ dogwood bunchberry	1020	3370	W	10	Jan[2]	-1.0	30	-2.7	27	.8	33	1.4	34	.5	33	ABAM/VAAL/ COCA	Cool, Moist
					Aug[3]	21.0	70	10.4	51	12.2	54	14.0	57	10.3	51		
Pacific silver fir/ coolwort foamflower	1440	4750	SW	10	Jan[3]	.7	33	-1.5	29	.2	32	.2	32	.2	32	ABAM/TIUN	Cool, Moist
					Aug[4]	17.5	63	9.7	49	12.2	54	13.8	57	10.0	50		
Pacific silver fir-mountain hemlock/ beargrass	1570	5180	NW	15	Jan[4]	1.4	34	-3.9	26	.7	33	1.6	35	.4	33	TSME/VAME/ XETE	Cold, Dry
					Aug[4]	17.1	63	9.9	50	10.4	51	12.7	55	8.0	46		

[1] Emmingham and Lundberg (1977).

[2] Temperature data collected in 1973 and 1974.

[3] Temperature data collected in 1973, 1974, and 1976.

[4] Temperature data collected in 1973, 1974, 1975, and 1976.

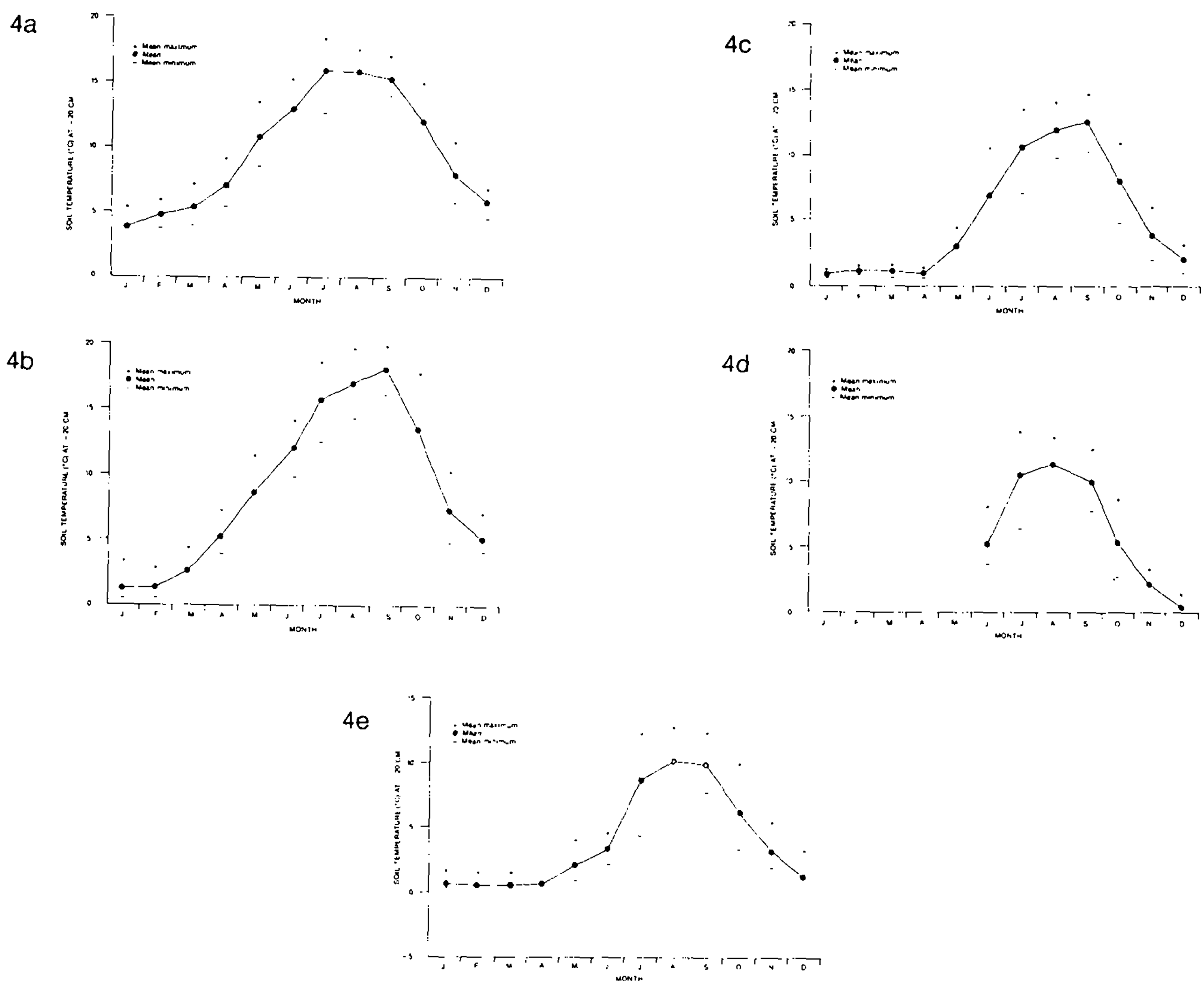

Figure 4. Soil temperature regimes in plant associations spanning the temperature gradient in the H.J. Andrews Experimental Forest (Emmingham and Lundberg 1977):
4a. Douglas-fir/oceanspray, uncut. Hot and dry.
4b. Douglas-fir/oceanspray, clearcut.
4c. Pacific silver fir/coolwort foamflower, uncut. Cool and moist.
4d. Pacific silver fir/coolwort foamflower, clearcut.
4e. Mountain hemlock/big huckleberry/beargrass, uncut. Cold.

Predawn plant moisture stress (Waring and Cleary 1967), a measure of the ability of plants to replenish their water supply from the soil at night, usually reaches only -6 to -8 bars in mid-summer (Emmingham and Lundberg 1977); a level which can slow growth but is not often fatal to conifer seedlings. Moisture stress can be higher in seedlings planted in cold soils because root growth and function are impeded (Halverson and Emmingham 1982).

GEOLOGY, TOPOGRAPHY, AND SOILS

The Oregon Cascade Range is divided into two major geologic provinces (Franklin and Dyrness 1973, Legard and Meyer 1973, Howes 1979). The geologically older Western Cascades are largely composed of Oligocene and Miocene volcanic and pyroclastic formations, particularly the Little Butte Volcanic Series and the Sardine Formation. Tuffs and breccias, which dominate the Little Butte Series, weather relatively rapidly and completely to deep, fine textured soils which can be very unstable. Flows of basalt and andesite, most abundant in the Sardine Formation, weather slowly, often producing well-drained, coarse, stony soils much less subject to mass movement (Legard and Meyer 1973). A long history of glacial and stream erosion has produced highly dissected topography, especially in the west-facing half of the Western Cascades. Ridge tops are typically about 5,000 feet (1,500 m) elevation with only a few peaks reaching 6,000 feet (1,800 m).

Soils in the Western Cascades can be divided into two major groups; those derived from pyroclastic parent materials (tuffs and breccias) and those derived from basic igneous rocks (basalt and andesite) (Franklin and Dyrness 1973). Soils forming from pyroclastic parent materials on gentle slopes are often deep, fine textured Haploxerults that are poorly drained and subject to mass soil movements (Franklin and Dyrness 1973). Those which develop on steeper slopes are usually less well-developed, stonier, gravelly clay loams, generally classified as Haplumbrepts or Xerumbrepts (Franklin and Dryness 1973).

Basalt and andesite bedrocks weather more slowly to produce generally more well-drained, stonier, coarser textured soils than pyroclastic parent materials. On steep slopes these soils are poorly developed and, especially at higher elevations, often contain significant amounts of volcanic ash and pumice (Franklin and Dyrness 1973). Well-developed soils are usually classified as Argixerolls or Haplohumults and poorly developed soils as Xerumbrepts (Franklin and Dyrness 1973).

High Cascades soils are usually immature and developed in volcanic ejecta or glacial till (Franklin and Dyrness 1973). Soils developed in glacial till, most abundant on the Mt. Hood National Forest, typically have stony or gravelly loam subsoils overlain by loam or gravelly loam surface layers which may show weak A2 horizon development and are generally classified as Cryorthods, Haplorthods, or Cryumbrepts (Franklin and Dyrness 1973). The high plateau, especially on the Willamette National Forest, has extensive soils derived from volcanic ejecta. These poorly developed soils are usually classified as Vitrandepts (Franklin and Dyrness 1973). Valuable soil data which should be used in conjunction with plant association information, has been compiled in Soil Resource Inventories on both the Mt. Hood and Willamette National Forests (Legard and Meyer 1973, Howes 1979).

The High Cascades province consists of rolling uplands and plateaus punctuated by high volcanoes. The broad, relatively flat plateau ranges from about 4,500 feet (1,360 m) to 5,500 feet (1,670 m) elevation with several deep, glaciated valleys. Volcanic peaks rise 150 feet (50 m) to over 5,300 feet (1,600 m) above the surrounding plateau. Most of the surface rocks are geologically recent volcanic deposits. These andesite and basalt lavas and pyroclastic rocks are overlain in many places by extensive ash, cinder and pumice deposits, particularly Mazama ash at the south end of the Willamette National Forest. Glacial deposits are locally abundant adjacent to the higher peaks.

VEGETATION OVERVIEW

The Pacific silver fir zone is a highly variable forest zone. At upper elevations it blends into the mountain hemlock zone. At lower elevations western hemlock replaces Pacific silver fir as the major climax species. South of the McKenzie River, the Pacific silver fir zone coalesces with the grand fir-white fir and Shasta red fir forest zones. East of the Cascade Crest it merges with mixed conifer forests more typical of inland mountains. For purposes of sampling and classification, we have defined the Pacific silver fir zone as forests where Pacific silver fir would be a dominant species at climax.

Pacific silver fir zone associations range from highly productive forests in moist, protected locations to species-poor, marginally productive stands in severe high elevation environments. At least 16 conifer species are locally common, including: Pacific silver fir (Abies amabilis), subalpine fir (Abies lasiocarpa), grand fir - white fir (Abies grandis - Abies concolor), noble fir (Abies procera), Shasta red fir (Abies magnifica var. shastensis), Alaska cedar (Chamaecyparis nootkatensis), western larch (Larix occidentalis), Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), western white pine (Pinus monticola), white bark pine (Pinus albicaulis), Douglas-fir (Pseudotsuga menziesii), western redcedar (Thuja plicata), western hemlock (Tsuga heterophylla), and mountain hemlock (Tsuga mertensiana).[2/] Autecological characteristics of these species vary tremendously (Table 2).

Different conifer species are typically found on particular topographic positions and elevations depending on latitude (Figures 5 - 8). The distribution of conifer species on the Mt. Hood National Forest and the north half of the Willamette National Forest is distinctly different from that on the Willamette National Forest south of the McKenzie River. At the south end of the Willamette National Forest, noble fir intergrades with Shasta red fir (Franklin et al. 1978), white fir becomes increasingly important and species more common on dry sites farther north are scattered through the Pacific silver fir zone. Western larch does not occur on the Willamette National Forest. Alaska cedar is restricted to high elevation cirques and cold air drainage areas at the south end of the Willamette National Forest but is more widespread on the Mt. Hood National Forest.

2/ Botanical names are from Hitchcock and Cronquist (1973).

Table 2. Comparative autecological characteristics of important Pacific silver fir zone conifer species[1]

Species	Shade Tolerance	Frost Tolerance	Drought Tolerance	Snow Damage Resistance	Fire Resistance	Root Rot Resistance	Seed Weight	Seed Crop Frequency
Pacific silver fir	H	M	L	M	L[2]	L	H	M
Subalpine fir	H	M	M	H[2]	L	M	M	M
White fir	M	M	L	M	M	L[2]	H	M[2]
Grand fir	H	M	M	M[2]	M	L	M	M
Noble fir	L	M[2]	L[2]	M	M	M[2]	H	M[2]
Shasta red fir	M	H	L	H	M[2]	M[2]	H	M[2]
Alaska cedar	M	M[2]	L[2]	H[2]	L[2]	H[2]	M	NA[3]
Western larch	L	H[2]	M	M[2]	H	M	L	M
Engelmann spruce	L	H	M	H[2]	L	M	L	M
Lodgepole pine	L	H	H	M[2]	L	M	M	H
Western white pine	M	H	M	M	M	M	M	H
Douglas-fir	L	L	M	L	H	L	M	M
Western redcedar	H	L	M	M[2]	L	H	L	M
Western hemlock	H	L	L	H	L	M	L	M
Mountain hemlock	H	H	L	H	M	L	M	M

[1]Compiled from Minore, 1979. H - high, M - moderate, L - low.

[2]Not listed in Minore (1979), estimated from field observations and species similarities.

[3]No estimates available.

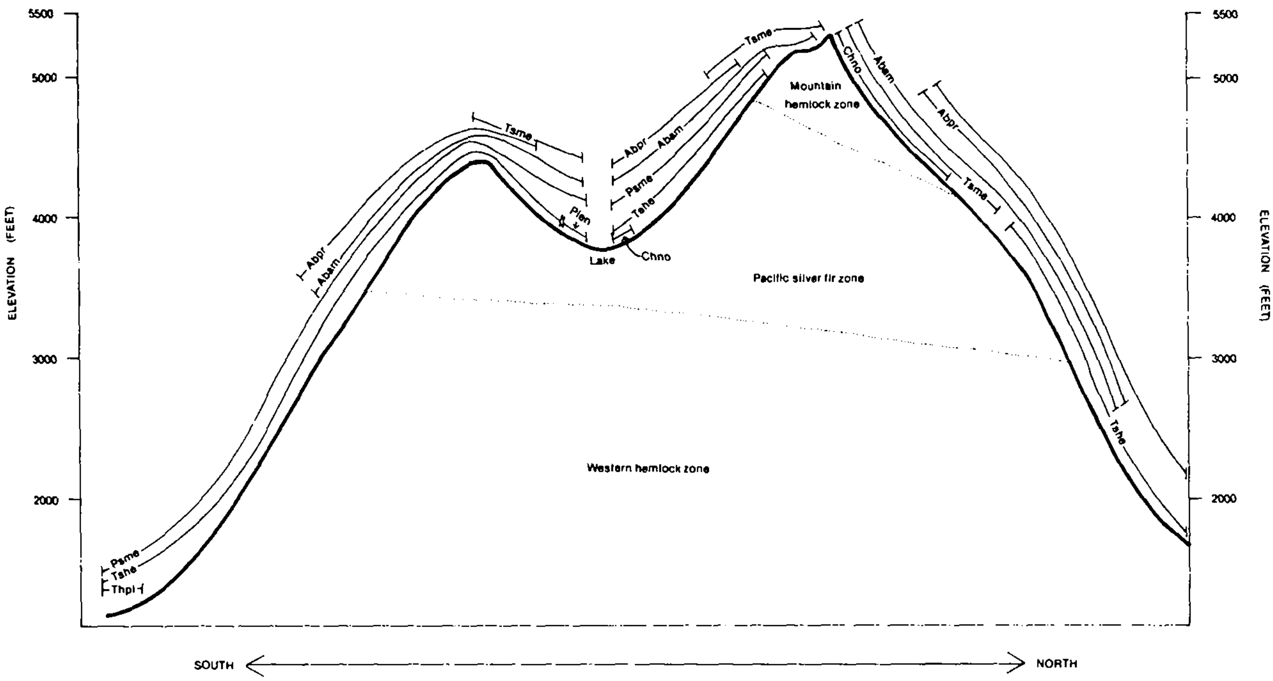

Figure 5. Distribution of important conifers on south-facing and north-facing slopes at different elevations, Mt. Hood National Forest and north half of the Willamette National Forest.

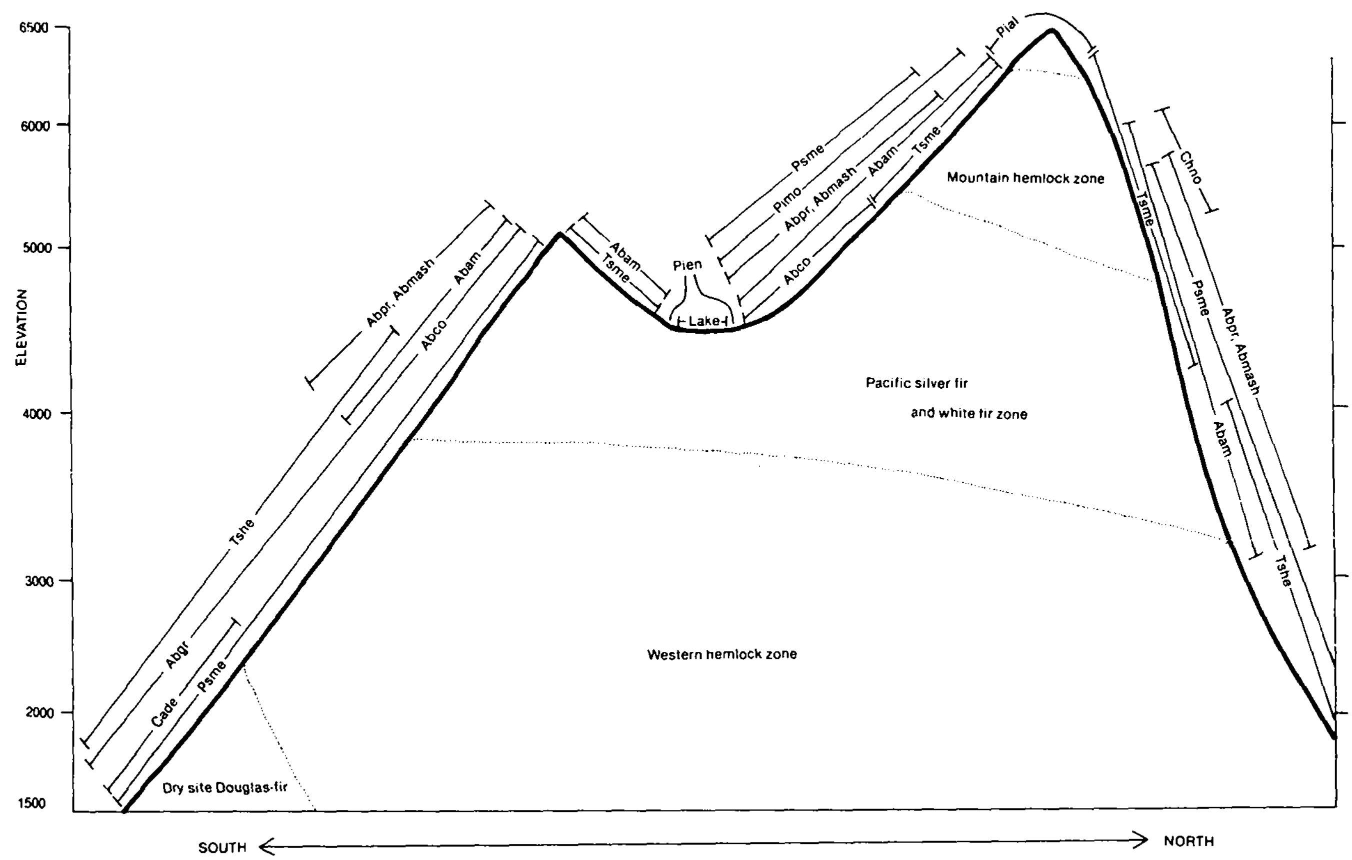

Figure 6. Distributions of important conifers on south-facing and north-facing slopes at different elevations, south half of the Willamette National Forest.

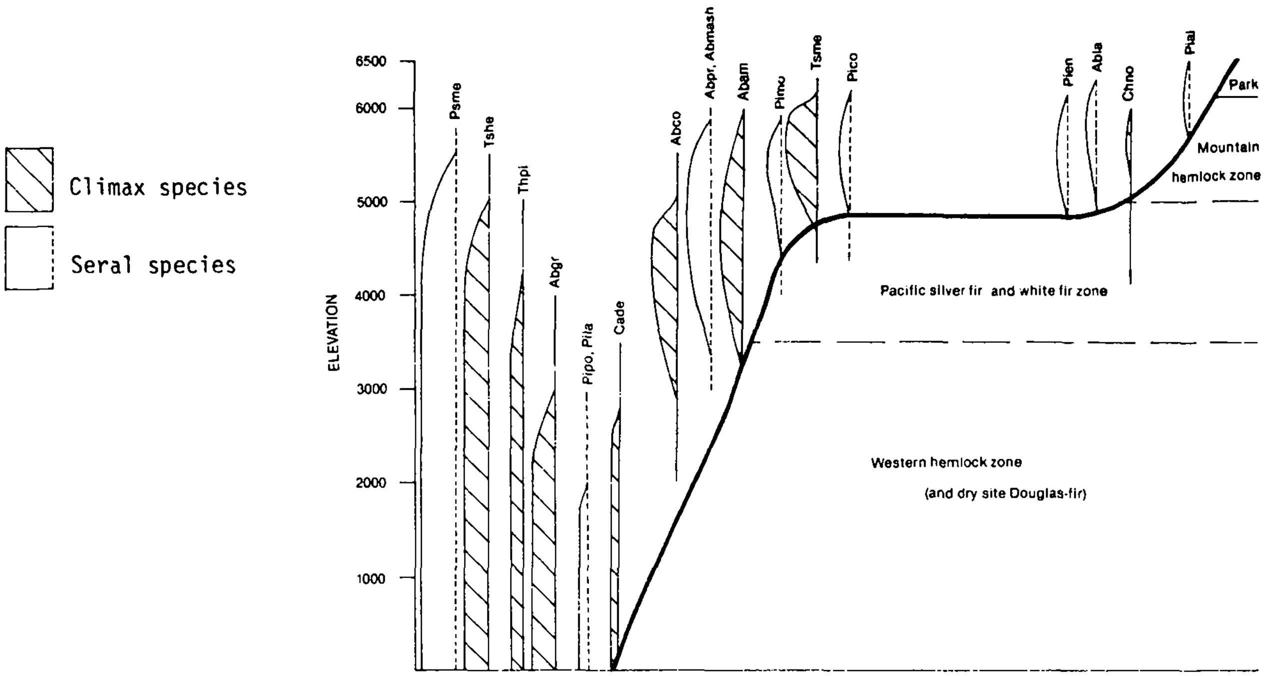

Figure 7. Relative abundance and successional status of important conifers over elevation, south half of the Willamette National Forest. Relative abundance indicated by the width of the bar for each species.

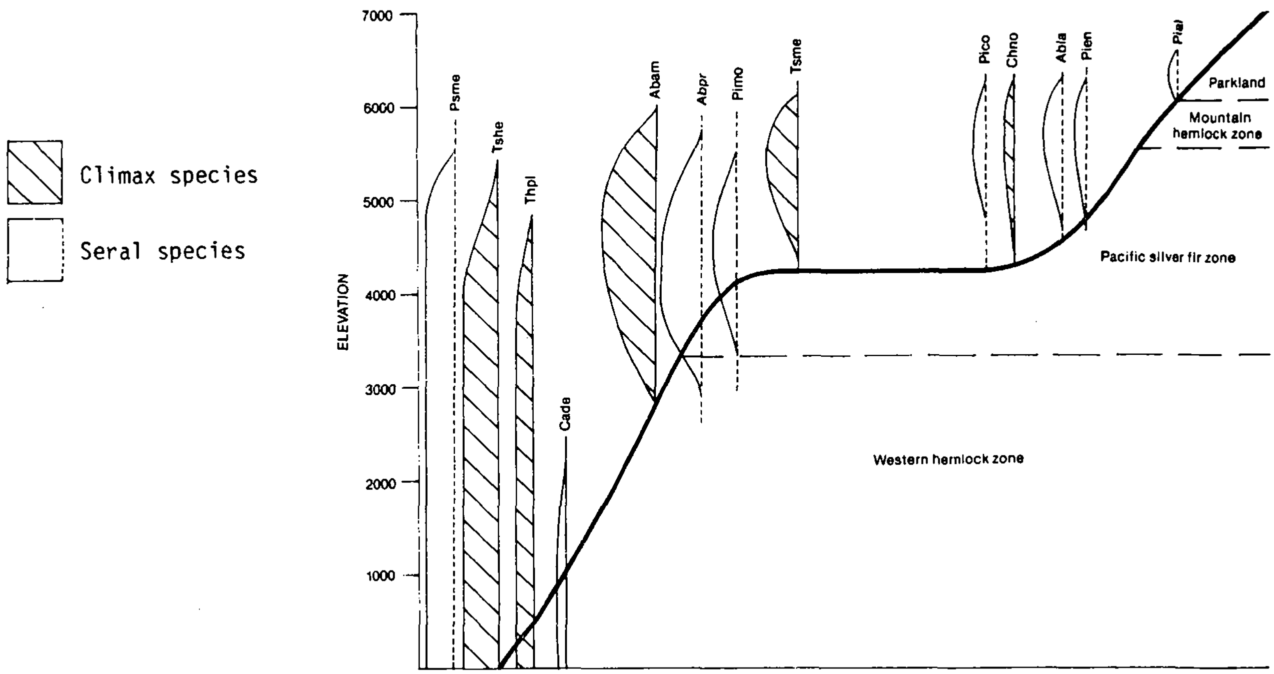

Figure 8. Relative abundance and successional status of important conifers over elevation, Mt. Hood National Forest and north half of the Willamette National Forest. Relative abundance indicated by the width of the bar for each species.

Shrub and herb distributions also change gradually from the Columbia River to the south end of the Willamette National Forest. Fool's huckleberry (Menziesia ferruginea) and Cascades azalea (Rhododendron albiflorum) are uncommon south of the North Santiam River and rare south of the McKenzie River. Devil's club (Oplopanax horridum) is not widespread south of the McKenzie River but is common farther north, especially in the Columbia Gorge and Zigzag Ranger Districts.

Most of these species shifts correlate well with precipitation patterns (Fig. 3). The vegetation of the Oakridge, Rigdon and parts of the Lowell, Blue River and McKenzie Ranger Districts on the Willamette National Forest is significantly different from that farther north. The Pacific silver fir zone is not as widespread on these Districts and, on south-facing slopes, is often replaced by climax grand fir, white fir and Douglas-fir forests.

REGENERATION

There are major differences in regeneration characteristics between plant associations of the Pacific silver fir zone.[3] In general, associations with a short growing season and high likelihood of frost during the summer (Table 3) are difficult to regenerate following clearcutting, and may be inadequately stocked for as long as 10 to 20 years after harvest. These include the mountain hemlock associations, the Pacific silver fir/big huckleberry/beargrass, Pacific silver fir/fools huckleberry and Pacific silver fir/Cascades azalea associations. Beargrass is an extremely frost tolerant species and severe frost problems should be anticipated where it dominates the herbaceous layer on ridgetops or benches.

Frost-prone associations are characterized by a sharp transition between winter and summer (due to late snowmelt) resulting in a very short planting season. Survival of emergent natural seedlings may be threatened by high surface temperatures where germination is delayed by late snowmelt. Frost may occur sporadically throughout the summer (especially in the mountain hemlock associations) and is especially likely on flat topography. Even the warmer associations in the Pacific silver fir zone may have frost problems if the pattern of clearcutting creates a frost pocket (Fig. 9). Flat topography retards air circulation at night and cold air often accumulates, even in slight depressions. Temperature inversions can occur in valleys resulting in prolonged frost. Reradiation of energy to the open sky on clear nights may combine with cold air accumulation to create frost pockets in unusual topographic situations, such as mid-slope benches or smooth hillsides with less than 15% slope. Fall frost may become a severe problem in the frost-prone associations because seedlings may not achieve full dormancy before freezing temperatures become common.

Generally, drought is not a major contributor to mortality among planted seedlings in the Pacific silver fir zone. However, droughty sites may be found on exposed slopes in the Pacific silver fir/rhododendron/ beargrass, Pacific silver fir-western hemlock/rhododendron-salal, Pacific silver fir/rhododendron-dwarf Oregon grape, Pacific silver fir/dwarf Oregon grape and Pacific silver fir/Alaska huckleberry-salal associations.

Various management practices can modify site environment. The shelterwood system can protect seedlings from both frost and drought. On less severe sites, seedlings may be protected by other means (i.e., shade cards or planting in the shade of logging debris). The latter method also provides nutrients as the organic matter decomposes. In the colder and drier parts of the Pacific silver fir zone the environmental tolerances of some tree species (notably Douglas-fir) are exceeded, and care must be taken in artificial reforestation to match the site with an appropriate species (Tables 3 and 4). Management of residual Pacific silver fir is an alternative to regenerating harvested areas by planting or natural seeding, particularly in the colder Pacific silver fir and mountain hemlock associations. Dense, although patchy, stands of Pacific silver fir usually exist in the understory in these areas and, if protected from damage during logging and slash disposal, can release and grow well.

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[3] A more complete discussion of reforestation in the Pacific silver fir zone is found in Halverson and Emmingham (1982).

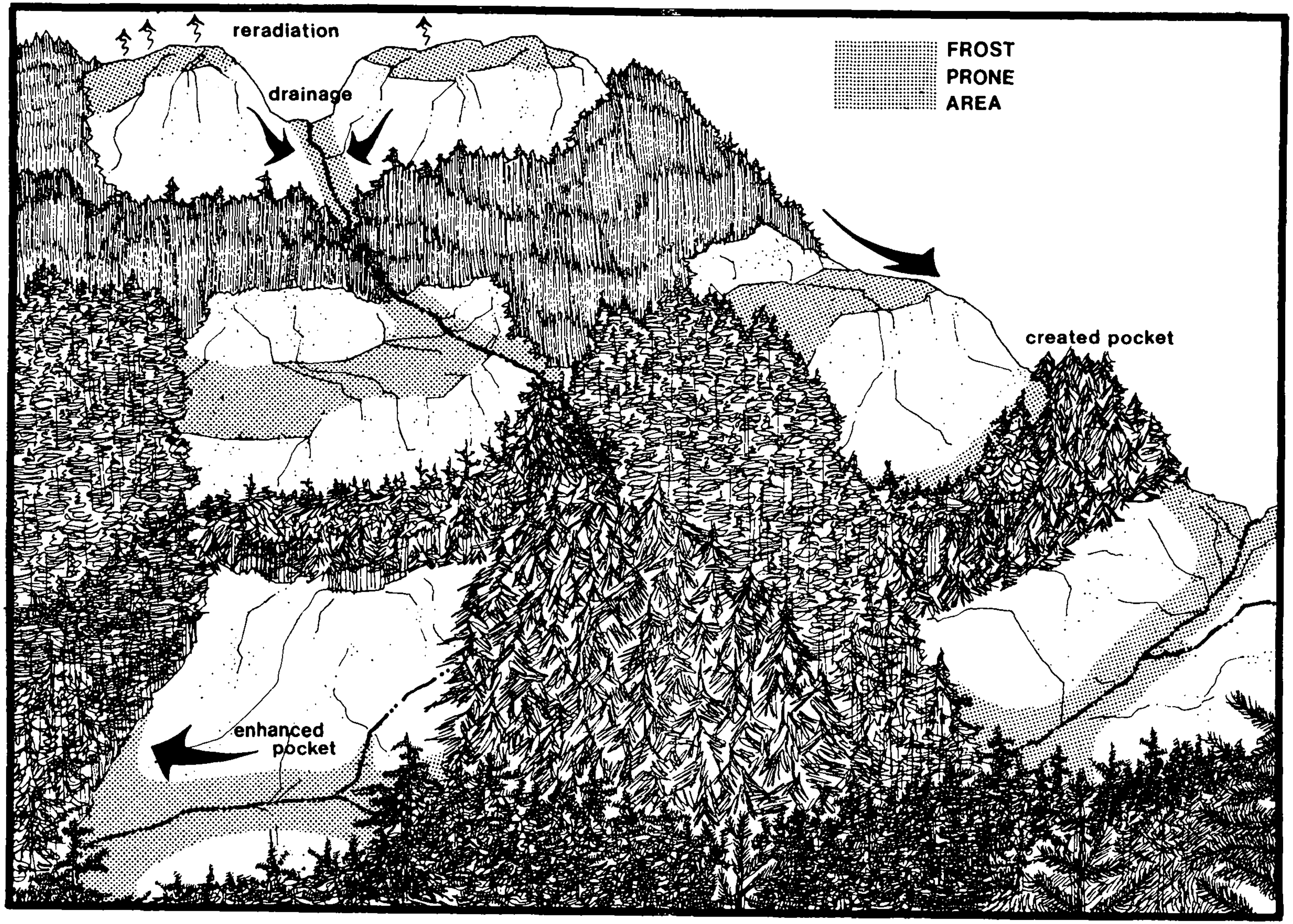

Figure 9. Development of frost prone areas in various topographic situations after clearcutting.

Table 3. Summary of regeneration characteristics for associations of the Pacific silver fir zone on the Mt. Hood and Willamette National Forests.

Association	Preferred Species for Reforestation[1/] Greater Than 15% Slope	Preferred Species for Reforestation[1/] Less Than 15% Slope	Frost Index[2/]	Snow Pack Index[2/]	Drought Index[2/]	Competition Index[2/]	Probable Competing Species
Pacific silver fir/ devil's club	ABPR[3/], PSME,	PIEN, ABPR, THPL, PSME	1	1	1	4	Salmonberry, huckleberries, vine maple
Pacific silver fir/ oxalis	PSME, ABPR, THPL	ABPR, PSME, THPL	1	1	1	3	Huckleberries, vine maple, rhododendron
Pacific silver fir/Cascades azalea/beargrass	ABPR, PIMO, PIEN, TSME	PIEN, TSME, PIMO	5	5	2	3	Huckleberries, vine maple, rhododendron
Pacific silver fir/Cascades azalea/queencup beadlily	ABPR, PIMO, TSME, PIEN	PIEN, TSME	5	5	1	3	Huckleberries, vine maple, rhododendron
Pacific silver fir/ coolwort foamflower	ABPR, PSME, PIMO	ABPR, PIMO	3	3	2	2	Huckleberries, vine maple, rhododendron
Pacific silver fir/vine maple/coolwort foamflower	ABPR, PSME, PIMO	ABPR, PIMO	3	3	2	3	Snowbrush ceanothus, huckleberries, vine maple, rhododendron
Pacific silver fir/ fool's huckleberry	ABPR, PIMO, ABAM, LAOC (Mt. Hood)	PIMO, ABPR, LAOC (Mt. Hood), ABAM, TSME	4	4	3	3	Huckleberries, vine maple, rhododendron
Pacific silver fir/ dwarf Oregon grape	PSME, ABPR	ABPR, PSME	2	2	3	2	Snowbrush ceanothus, vine maple
Pacific silver fir/ rhododendron/dwarf Oregon grape	PSME, ABPR	ABPR, PSME	2	2	4	2	Snowbrush ceanothus, huckleberries, vine maple, rhododendron
Pacific silver fir/rhododendron/Alaska huckleberry/ dogwood bunchberry	ABPR, PSME	ABPR, PSME, PIMO	3	3	2	3	Huckleberries, vine maple, rhododendron

[1/] Species likely to survive and grow the best when planted. ABAM advance regeneration is not included but could be preserved in most associations.

[2/] Subjective rating of frost, snowpack, drought and competition intensity; 1 = least severe, 5 = most severe.

[3/] Acronyms defined in Table 6.

Table 3. Continued.

Association	Preferred Species for Reforestation[1/] Greater Than 15% Slope	Less Than 15% Slope	Frost Index[2/]	Snow Pack Index[2/]	Drought Index[2/]	Competition Index[2/]	Probable Competing Species
Pacific silver fir/Alaska huckleberry/dogwood bunchberry	ABPR, PSME	ABPR, PIMO	3	3	2	2	Huckleberries, vine maple, rhododendron
Pacific silver fir-western hemlock/rhododendron-salal	PSME	PSME, ABPR	1	1	4	4	Snowbrush ceanothus, huckleberries, vine maple, rhododendron
Pacific silver fir/Alaska huckleberry-salal	PSME,ABPR[3/]	ABPR, PSME	2	2	4	2	Snowbrush, ceanothus,huckleberry, vine maple, rhododendron
Pacific silver fir/rhododendron/beargrass	ABPR, PSME	ABPR, PIMO	4	3	5	3	Snowbrush ceanothus, huckleberries, vine maple, rhododendron, beargrass, sedges, pocket gophers
Pacific silver fir/big huckleberry/queencup beadlily	ABPR, PIMO, PSME	PIMO, PIEN, ABPR, ABAM	4	4	2	2	Huckleberries, vine maple, rhododendron
Pacific silver fir/big huckleberry/beargrass	ABPR, PIMO, TSME	PIMO, PIEN, ABPR, ABAM, PICO, LAOC (Mt. Hood)	5	5	4	4	Beargrass, sedges, pocket gophers
Mtn. hemlock/big huckleberry/beargrass	PIMO, ABPR, TSME, ABAM, LAOC (Mt. Hood)	PIMO, TSME, PICO, LAOC (Mt. Hood)	5	5	4	4	Beargrass, sedges, pocket gophers
Mtn. hemlock/grouse huckleberry	PIMO, ABPR, TSME ABAM, LAOC (Mt. Hood)	PIMO, TSME, PICO, LAOC (Mt. Hood)	5	5	5	1	Huckleberries, beargrass, sedges, pocket gophers

1/ Species likely to survive and grow the best when planted. ABAM advance regeneration is not included but could be preserved in most associations.

2/ Subjective rating of frost, snowpack, drought and competition intensity; 1 = least severe, 5 = most severe.

3/ Acronyms defined in Table 6.

Table 4. Regeneration characteristics of Pacific silver fir zone conifer species, Mt. Hood and Willamette National Forests

Species	Acceptable Association/Slope	Remarks
Alaska cedar	ABAM/RHAL/CLUN[1] ABAM/RHAL/XETE	Frost tolerant. Requires high soil moisture. Slow growth. May be important as advanced regeneration.
Douglas-fir	All associations except: ABAM/RHAL/CLUN ABAM/RHAL/XETE ABAM/MEFE TSME/VAME/XETE TSME/VASC ABAM/TIUN (<15% slope) ABAM/ACCI/TIUN (<15% slope) ABAM/RHMA/XETE (<15% slope) ABAM/VAME/CLUN (<15% slope) ABAM/VAME/XETE	Good early growth, slower diameter growth in dense stands than noble fir. At upper elevations seedlings must be from high elevation seed collections.
Engelmann spruce	ABAM/RHAL/CLUN ABAM/RHAL/XETE ABAM/OPHO ABAM/VAME/CLUN ABAM/VAME/XETE (<15% slope)	Very frost tolerant. Grows best with abundant soil moisture.
white fir	Substitute for Pacific silver fir on warm slopes at the south end of the Willamette National Forest.	Climax species on many sites south of the McKenzie River.
larch	ABAM/VAME/XETE (<15% slope) ABAM/MEFE TSME/VAME/XETE TSME/VASC	Data lacking. Probably adapted to the Pacific silver fir zone north of the Willamette National Forest. Very frost tolerant.
lodgepole pine	ABAM/VAME/XETE (<15% slope) TSME/VAME/XETE (<15% slope) TSME/VASC (<15% slope)	Good for rehabilitation. Exceptionally frost and drought tolerant.

mountain hemlock	ABAM/MEFE ABAM/VAME/XETE (<15% slope) ABAM/RHAL/XETE ABAM/RHAL/CLUN TSME/VAME/XETE TSME/VASC	Slow early growth. Very frost tolerant. Noble fir will usually do better on slopes over 15%.
noble fir	All associations except: ABAM-TSHE/RHMA-GASH (>15% slope) TSME/VAME/XETE (<15% slope) TSME/VASC (<15% slope) ABAM/RHAL/XETE (<15% slope) ABAM/RHAL/CLUN (<15% slope)	Slow early growth. Rapid sustained late growth in dense stands. Tolerant of cold soils.
Pacific silver fir	All associations.	Slower growth than noble fir or Douglas-fir. Important natural advanced regeneration on cold sites. Shade tolerant, drought intolerant.
western hemlock	ABAM/ACCI/TIUN ABAM/BENE ABAM/RHMA-BENE ABAM/VAAL-GASH ABAM-TSHE/RHMA-GASH	Not usually a good choice. Douglas-fir will grow better on sites where western hemlock could be used. shade tolerant.
western redcedar	ABAM/OXOR ABAM/OPHO	Relatively slow growth. Best on moist sites. Shade tolerant.
western white pine	All associations except: ABAM/OPHO ABAM/OXOR	Very frost tolerant. Rapid height growth. Try to get rust-resistant stock.

[1]/Acronyms from Table 6.

The likelihood that competing vegetation will influence reforestation success varies by plant association (Table 3) and management activity. Snowbrush ceanothus is a rapid increaser on burned clearcuts in some associations, particularly in the Pacific silver fir/vine maple/coolwort foamflower, Pacific silver fir/rhododendron-dwarf Oregon grape and Pacific silver fir-western hemlock/rhododendron-salal associations. Beargrass and sedges are stimulated by ground disturbance and are commonly found in clearcuts in all associations where beargrass is a significant component of the herbaceous layer. Pocket gophers, which are often found in openings in beargrass-dominated associations, may feed heavily on young tree seedlings. Pine species and Engelmann spruce seem to be damaged less often by pocket gophers than other conifers.

Dense vine maple, rhododendron and huckleberry thickets develop in openings in some associations. The Pacific silver fir/devil's club, oxalis, Cascades azalea/beargrass, Cascades azalea/queencup beadlily, vine maple/coolwort foamflower, fool's huckleberry, rhododendron-Alaska huckleberry/dogwood bunchberry, Alaska huckleberry-salal and big huckleberry/queencup beadlily associations are common sites for this type of brush development. Vine maple and huckleberry are easier to control and are usually less extreme competitors with tree seedlings in Pacific silver fir zone clearcuts than snowbrush ceanothus, beargrass or sedge species. Quick establishment of rapidly growing seedlings will limit the effects of most competing vegetation.

SOIL FERTILITY

NUTRIENT CYCLING

Nutrient cycling is particularly important in Pacific silver fir zone forests. A number of factors combine to make Pacific silver fir zone soils relatively nutrient-poor with slow nutrient cycling rates, including:

1. Low temperatures. Biological mineralization of organic detritus is critical to the maintenance of the soil nutrient stocks required for tree growth. Cool or cold soil temperatures, which predominate in the Pacific silver fir zone, decrease decomposition rates.

2. Little available rooting space. The higher elevations of the Pacific silver fir zone include many areas with shallow, stony soils. Decreased volume for microbial nutrient cycling and rooting make the soil more prone to leaching of important nutrients.

3. Soils derived from volcanic ejecta. Cascade soils are frequently of recent volcanic origin. These include the cindery andepts derived from various eruptions, particularly the Mt. Mazama pumice (which is more abundant at upper elevations at the south end of the Willamette National Forest). These soils have low colloid content and low cation exchange potential. Their relative youth has prevented the accumulation of substantial soil organic matter. They are also so coarse that they are particularly prone to loss of nutrients through leaching.

4. Leaching due to high precipitation. High precipitation in the Pacific silver fir zone enhances leaching losses of mobile nutrients. Rapid snowmelt in late spring effectively flushes the soil of nutrients which are not bound to exchange sites.

The degree to which sites within the Pacific silver fir zone are influenced by these low nutrient conditions is reflected in the vegetation. The mountain hemlock associations are likely to have the slowest nutrient cycling processes and lowest soil fertility. Plant associations characterized by beargrass or evergreen shrubs (rhododendron) with few other herbs are also likely to be nutrient-poor. The herb-rich associations are thought to be less critically nutrient-limited.

The nutrient cycling processes and species adaptations to soil infertility can be summarized as follows: low soil nutrients are caused by the interplay of soil youth, porosity, leaching, and slow decomposition rates. Plants are favored which are very efficient at utilizing available nutrients (Waring and Franklin 1979), leading to the dominance of evergreens with long leaf retention. Foliage from these species is very acidic and upon decomposition enhances nutrient leaching and decreases solubility of critical nutrients such as nitrogen, phosphorus, magnesium, and calcium. Organic matter which accumulates on the soil surface due to slow decomposition includes substantial portions of the soil nutrient stocks. These litter layers are particularly susceptible to destruction by wildfire, prescribed burning, or erosion (Youngberg 1979). All of these potential losses can lead to long-term declines in forest productivity, unless careful management is pursued. Management of high elevation forests must be particularly aimed at conserving the soil organic matter resources, including the forest floor layers.

ORGANIC MATTER

Organic matter is the crucial component of nutrient cycling processes and soil fertility in the Pacific silver fir zone. Organic matter directly supplies much of the nutrition

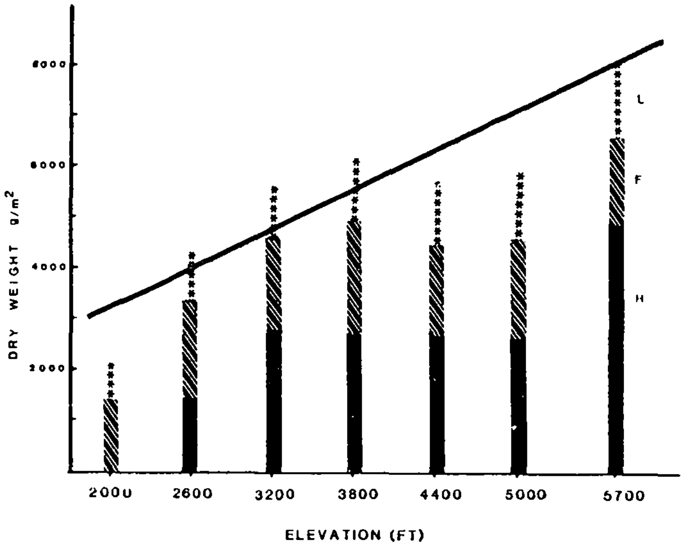

Fig. 10. Increasing forest floor weight along an elevation transect in the Salmon Creek Drainage, Willamette National Forest. L, F and H are the litter, fragmentation and humus layers.

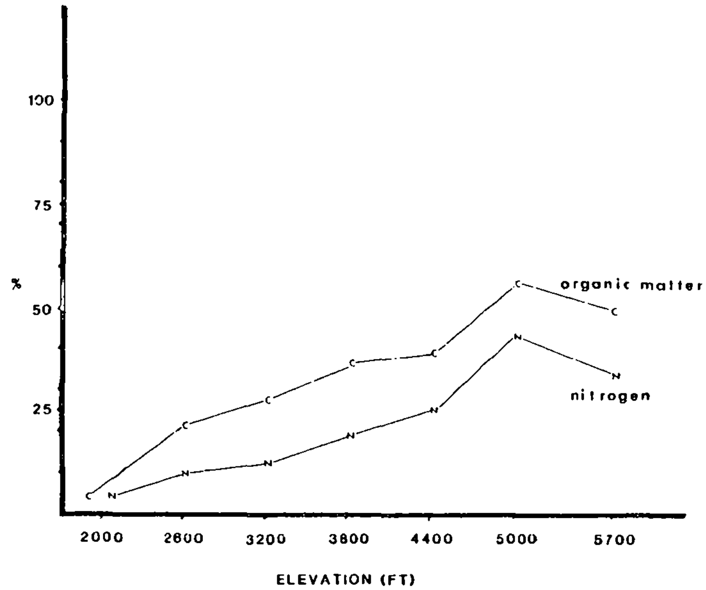

Fig. 11. Percent of total soil organic matter and nitrogen contained in the forest floor along an elevation transect in the Salmon Creek Drainage, Willamette National Forest.

required for plant growth. In addition, organic matter provides sites for cation exchange (essential for soil nutrient retention), especially critical in coarse soils with low clay content. It also enhances development of soil structure which creates a positive environment for root growth and soil microbial activities.

In the Pacific silver fir zone an especially high proportion of the soil organic matter lies on the soil surface. These forest floor layers may contain abundant feeding roots which absorb large portions of the nutrients required for the growth of the forest. While large woody detritus decomposes very slowly, it is important as rooting space for the mycorrhizal roots essential for trees.

The forest floor composition is often related to the productivity of a site (Lowe and Klinka 1981). A recent study of an elevational transect in a typical watershed of the Willamette National Forest (Salmon Creek) shows that the forest floor mass increases linearly with elevation (Topik 1982) (Fig. 10). Forest floor mass is greatest in the mountain hemlock zone where the forest floor contains a large portion of the critical soil nutrients (Fig. 11). Clearly, the forest floor contains such a large stock of the nutrients in upper elevation soils that it should be carefully managed.

RECOMMENDATIONS

The following recommendations should be considered throughout the Pacific silver fir zone, but especially in the mountain hemlock and herb-poor plant associations where nutrients may be most limiting and are held in surface organic layers:

1. The forest floor should be conserved during timber harvest. Intense burning causes large losses of nitrogen (Grier 1975) and accelerated losses of calcium (Adams and Boyle 1980). Sites with shallow rocky soils and thick forest floors are particularly sensitive. Removal of leaf litter from coniferous plantations has been shown to decrease tree production (Ballard 1977).

2. Woody detritus and slash contain important nutrient reserves and serve important nutrient cycling functions. This material decomposes very slowly (Harvey et al. 1981), is important in decreasing down-slope erosion after clearcutting (Cromack et al. 1979), and serves other ecosystem functions (Triska and Cromack 1979). It also is the site of considerable tree mycorrhizal rooting, particularly in Pacific silver fir forests (Vogt et al. 1981). Burning and PUM yarding should be minimized to protect this resource.

3. Extensive soil disturbance should be minimized to prevent surface erosion of light organic material, especially on compactible soils. The wettest plant associations are most prone to soil compaction, including the Pacific silver fir/fool's huckleberry, Pacific silver fir/Cascades azalea/queencup beadlily and Pacific silver fir/devil's club plant associations. Soil compaction also will alter soil structure to the detriment of microbial nutrient cycling processes (Greacen and Sands 1980). The forests of much of the Pacific silver fir zone have thick forest floor layers (Williams and Dyrness 1967) which include abundant mycorrhizal roots crucial for tree growth at these sites (Trappe and Fogel 1977). Reduced disturbance of the forest floor will aid in maintaining the viability of advanced regeneration by protecting their mycorrhizal roots.

4. Although nitrogen-fixing species are not abundant in the Pacific silver fir zone, they can produce large amounts of this often limiting element (Heilman 1979). Of course, adverse competition with crop trees can result in dense *Ceanothus velutinus* stands. Yet, in some instances ceanothus has been shown to aid Douglas-fir stocking (Scott 1970). With careful monitoring, the beneficial nitrogen accretion from species like ceanothus should prove worthwhile for enhancing long-term forest productivity. Ceanothus is most abundant in disturbed openings in warmer plant associations of the Pacific silver fir zone.

PRODUCTIVITY AND HEIGHT GROWTH

Height growth patterns of most high-elevation conifers west of the Cascade Crest are poorly understood. Height growth of many species must be estimated from growth of the same species in other geographic regions. Conifer height growth east of the Crest often starts slower but is more prolonged compared to the same species west of the Crest (Appendix II). We compared height-age patterns of conifers on ecology and Forest Inventory plots with published height-age relationships to select published curves which most closely match height growth patterns in the Pacific silver fir zone.

Height growth of Douglas-fir and noble fir at high elevations has been well documented. Height-age and site index curves for high-elevation Douglas-fir and noble fir (Curtis et al. 1974, Herman et al. 1978) seem to closely fit height-age data from the Pacific silver fir zone (Appendix II). Published curves may overestimate height by several feet above age 200. But, since we could not perform stem analyses, our heights for old trees may include some trees which suffered top damage that is no longer apparent.

Johnson's (1981) recent height-age and site index curves for mountain hemlock on three habitat types east of the Cascade Crest do not appear to fit mountain hemlock height growth patterns on the Mt. Hood and Willamette National Forests (Appendix II). Height growth is slower initially and more prolonged east of the Crest. The same is true for mountain hemlock in Idaho and Montana (Wykoff et al. 1981). Although Barnes' (1962) western hemlock curves presented for western and mountain hemlock combined in FSH 2409.26d.61.3 do not accurately reflect height growth on many sites (Herman and Franklin 1976), they are better than other published curves we reviewed (Appendix II). A good interim solution, until better west-side analyses are available would be adjustment of mountain hemlock curves from Idaho and Montana contained in the Stand Prognosis model (Wykoff et al. 1981) to fit Pacific silver fir zone height growth curve forms.

Western white pine height growth has been well studied east of the Cascade Crest (Haig 1932, Dietschman and Green 1965). Comparison of the most recent Idaho and Montana height growth models (Wykoff et al. 1981) and western white pine height growth in the Pacific silver fir zone indicate similar patterns (Appendix II). Although our sample of western white pine was small, curves from the Stand Prognosis model (Wykoff et al. 1981) for the subalpine fir/queencup beadlily and subalpine fir/beargrass habitat types from Montana and Idaho seem to match the best and poorest western white pine height growth on plant associations in the Pacific silver fir zone.

Engelmann spruce height growth appears to vary widely from one geographic area to another. Alexander's (1967) height growth curves from Colorado match spruce height growth in the Pacific silver fir zone fairly well. The Engelmann spruce height growth model embedded in the Stand Prognosis model (Wykoff et al. 1981) predicts much slower growth during the first 100 years and faster growth in the second and third centuries. Engelmann spruce can grow very well (occasionally reaching 140 feet in 100 years) in moist sites in the Pacific silver fir zone, particularly in the Pacific silver fir/big huckleberry/queencup beadlily association.

Our data for lodgepole pine suggest that it grows more slowly in the Pacific silver fir zone than in many inland areas. Even the poorest lodgepole pine sites in Idaho and Montana (Wykoff et al. 1981) grow lodgepole pine better than the mountain hemlock associations in which it occurs on the Mt. Hood and Willamette National Forests. Dahm's (1964) low site curves appear to fit lodgepole pine in the Pacific silver fir zone fairly well (Appendix II).

We have few samples of subalpine fir and grand fir-white fir in the Pacific silver fir zone. Based on patterns observed in other species, Prognosis model (Wykoff et al. 1981) curves for subalpine fir (Appendix II) probably underestimate early height growth and overestimate late height growth. Cochran's (1979) curves for grand fir-white fir predict rapid early growth and probably apply well to grand fir-white fir in the Pacific silver fir zone. Unfortunately his curves do not extend beyond age 100, making site index estimation in older stands difficult.

Although Pacific silver fir dominates many high elevation stands in the Cascades, very little has been published about its height growth and productivity. Pacific silver fir is combined with noble fir and California red fir in the Silvicultural Practices Handbook (FSH 2409.26d.61.5) but its height growth is not comparable to noble fir at high elevations. The best currently available site index curves for Pacific silver fir were developed in British Columbia and fit our height-age data well (Hegyi et al. 1981, Appendix II).

Several methods are available for estimating stand volume growth at near culmination age, including: growth basal area (GBA) multiplied by site index and a correction factor (Hall 1973), stand density index (SDI, Reineke 1933) using normal stand densities and yields for the Pacific Northwest[4/] (Knapp 1981), and yields for site index classes (eg. McArdle et al. 1961).

All of these methods rely to some degree on "normal" stand height and volume growth. Normal stand tables assume particular stocking levels and are developed as averages over large areas. Normal stand developement and volume growth may not apply in severe environments or to particular localities (MacLean and Bolsinger 1973).

In order to check the applicability of timber productivity estimates derived by these methods, we developed a technique to use field measurements of trees from Forest Inventory and ecology plots to estimate stand volume and volume increment without using normal yield tables or site index classes. Our method involves projecting volume and volume increment from a sample of measured trees in a stand to the whole stand using stand basal area, each species' contribution to stand basal area and stand diameter distribution.[5/] The resulting stand volume and volume increment are empirical estimates of net productivity, without accounting for mortality, of unmanaged, mixed species stands. We combined plant associations into high, medium and low productivity classes and graphed periodic annual increment versus stand age (Appendix II). From these graphs the three productivity classes seem to produce about 135 to 205 ft^3/A./yr, 80 to 180 ft^3/A./yr, and 55 to 85 ft^3/A./yr at culmination of periodic annual increment.

Productivity estimates using GBA, SDI and empirical methods are presented in Table 5. Empirical and SDI estimates are usually similar but SDI seems to overestimate productivity of the most productive stands. GBA estimates, although variable, are often close to SDI and empirical estimates and might be improved if better site index tables were

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4/ Stand density index is most well suited to separating commercial from non-commercial stands at the 20ft^3/A./yr level. It is not as accurate for yield prediction in more productive stands.

5/ A more complete method is available from the Area Ecologist, Willamette National Forest, Eugene, OR.

Table 5. Productivity summary for Pacific silver fir and mountain hemlock zone plant associations, Mt. Hood and Willamette National Forests.

Plant Association	No. of Plots	Site Index-Douglas-fir[1]		Site Index-Noble fir[2]		GBA[3] Douglas-fir		GBA Noble fir		GBA Cu. ft.[4] Douglas-fir	
		Mean/n[8]	SD	Mean/n	SD	Mean	SD	Mean	SD	Mean	SD
ABAM/OXOR ABAM/OPHO	10	123/8	22	135/5	24	375	71	500	109	231	57
ABAM/RHAL/CLUN ABAM/RHAL/XETE ABAM/MEFE	12	73/3	8	-	-	282	95	-	-	106	49
ABAM/TIUN	18	119/12	24	128/14	14	398	114	398	153	242	89
ABAM/ACCI/TIUN	6	133/6	12	140/4	12	452	83	505	102	302	62
ABAM/RHMA-VAAL/ COCA	17[9]	97/7	18	95/2	7	347	140	361	200	114	52
ABAM/VAAL/COCA	9	102/6	6	110/1	-	394	74	407	-	201	40
ABAM/BENE ABAM/RHMA-BENE	6	104/6	25	76/2	23	296	60	303	81	158	54
ABAM-TSHE/ RHMA-GASH	5[9]	101/5	32	-	-	276	93	-	-	138	46
ABAM/VAAL-GASH	2[9]	72/2	18	-	-	420	78	-	-	147	27
ABAM/RHMA/XETE	12	96/11	21	96/6	31	341	87	501	159	167	60
ABAM/VAME/CLUN	9	112/6	26	126/2	20	254	53	453	86	144	58
ABAM/VAME/XETE	12	96/6	12	94/6	12	301	39	337	71	146	34
TSME/VAME/XETE	15	95/3	8	71/4	1	312	67	351	144	145	26
TSME/VASC	8	70/1	-	70/1	-	184	-	465	-	64	-

1/ Curtis et al 1974.
2/ Herman et al 1978.
3/ Growth Basal Area (Hall 1971)
4/ Index of relative productivity - not an actual estimate of $ft^3/A/yr$.
5/ Reineke 1933, Knapp 1981.
6/ Knapp 1981.
7/ Empirical estimate of $ft^3/A./yr$. for 3 productivity classes, High - 135 to 205 $ft^3/A./yr$., Med. - 80 to 180 $ft^3/A./yr$., Low - 55 to 85 $ft^3/A./yr$., see Appendix II.
8/ Number of plots sampled which contained the given species. Dashes indicate no trees or only one tree of that species occurred in our plots.
9/ No productivity plots. Reconnaissance plot data used.
10/ Percent herb cover multiplied by a constant, (P. Alaback, H.J. Andrews Experimental Forest, personal communication, 1982).

Table 5. Continued.

GBA Cu. ft.4/ Noble fir		Stand Density Index5/		SDI Cu. ft.6/		Quadratic Mean Diam. Inches		Stand Basal Area Sq. ft.		Productivity Class7/	Herbage Lbs/A.10/	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD
344	122	581	232	188	84	19	9	387	117	High	580 499	268 246
-	-	481	104	69	19	15	4	303	51	Low	273 262 242	186 182 146
255	101	532	154	196	62	19	6	364	82	High	478	206
366	105	484	89	197	36	21	8	347	78	High	478	239
121	67	-	-	-	-	-	-	318	125	Med	236	200
224	-	500	96	118	29	19	3	355	74	Med	305	189
126	61	469	103	138	63	14	5	287	68	Med Med	230 109	137 99
-	-	-	-	-	-	-	-	296	108	Med	175	107
-	-	-	-	-	-	-	-	440	113	Med	225	56
257	146	507	125	121	57	15	6	332	109	Med	222	151
284	9	460	117	137	37	16	7	298	86	Med	225	148
156	28	556	161	125	63	12	5	318	91	Med	246	183
123	55	548	134	108	39	10	4	295	80	Low	309	191
163	-	469	205	54	20	8	2	234	102	Low	235	194

available and if different multiplication constants were developed. Herbage estimates were made using a regression equation developed for the H. J. Andrews Experimental Forest which predicts herb biomass from percent herb cover (Paul Alaback, H. J. Andrews data base manager, personal communication, 1982).

KEY TO PLANT ASSOCIATIONS

The steps in using the key are:

1. Select a vegetatively uniform area about 12.5 meters (42 feet) in diameter or 500 square meters in size. The plot should be representative of a larger area.

2. Identify and list tree, shrub, and herb species and estimate the cover of each. Cover is estimated to the nearest percent up to 10 percent cover and to the nearest 5 percent thereafter.

3. Work through the association key (step by step) to a preliminary identification.

4. Review the association description to verify the identification.

5. Only after verification, note the management implications for the association.

It is important to follow these steps rigorously since a misidentification may lead to the wrong management implications.

The associations are abstractions based upon plot data taken throughout the Forests. In each case, plots were grouped according to plant community similarity and used as the basis for an abstraction process. Few stands will exactly conform to descriptions of average stands in the association descriptions.

Variation in vegetation across the landscape is continuous. Although we sampled in a systematic manner, there are many ecotonal areas which will not fit neatly into any particular association. Such areas should be managed according to the characteristics of the associations between which they fall (Fig. 1). In most cases, adjacent associations have similar management properties.

This key and guide should be used in the field to aid proper identification of associations. Questions concerning identification should be addressed in the field where species composition and cover are easily and correctly measured.

There are only about 50 common herb and shrub species used in the key and association descriptions. Table 6 contains the abbreviations, scientific and common names used in this guide.

Key to plant associations and ecoclass codes for the Pacific silver fir zone, Mt. Hood and Willamette National Forests.

1. ABAM[6/], ABPR, TSME or ABLA2 not present in regeneration layer under closed stands . . . not included in Pacific silver fir zone key.

1. ABAM, ABPR, TSME, or ABLA2 regeneration present. 2

2. OPHO cover over 5 % . . . . ABAM/OPHO
CFS3-51, p.31

2. OPHO minor or absent 3

3. RHAL cover over 5% 4

3. RHAL minor or absent 5

4. Herb poor, ERMO or XETE may be the only significant herbs
. . . . ABAM/RHAL/XETE
CFS5-51, p.37

4. Several herbs in addition to XETE present, especially COCA, ACTR, STRO, TIUN, and CLUN. XETE usually abundant . . . . ABAM/RHAL/CLUN
CFS5-52, p.35

5. MEFE cover over 5% or greater than VAAL, VAOV, or VAME . . ABAM/MEFE
CFS2-54, p.39

5. MEFE minor or absent 6

6. OXOR cover over 5% . . . . ABAM/OXOR
CFF1-53, p.33

6. OXOR minor or absent 7

7. GASH cover over 5% 8

7. GASH minor or absent 9

8. VAAL or VAOV cover over 10% . . . . ABAM/VAAL-GASH
CFS2-55, p.51

8. VAAL and VAOV minor, RHMA usually abundant . . ABAM-TSHE/RHMA-GASH
CFC2-51, p.49

9. VASC cover over 5% or, in shrub poor areas, greater than VAME cover . . . . .TSME/VASC
CMS1-14, p.65

9. VASC minor or absent 10

10. TIUN or SMST cover over 5% or three or more of the following moisture indicating herbs with over 2% cover each: TIUN, SMST, STRO, ASCA, VAHE, ACTR 11

10. Moist site indicating herbs minor or absent 12

11. ACCI cover over 15% . . . . ABAM/ACCI/TIUN
CFS6-51, p.43

6/ Acronyms defined in Table 6.

11. ACCI minor or absent . . . . ABAM/TIUN
CFF1-52, p.41

12. VAAL or VAOV cover over 10% 13

12. VAAL and VAOV minor or absent 14

13. RHMA cover over 30% . . . . .ABAM/RHMA-VAAL/COCA
CFS6-54, p.47

13. RHMA cover less than 30% . . . . ABAM/VAAL/COCA
CFS2-53, p.45

14. RHMA cover greater than 30% or, in shrub poor areas, RHMA the only significant tall shrub 15

14. RHMA cover less than 30% 16

15. XETE cover over 10% or XETE the only herb present . . ABAM/RHMA/XETE
CFS6-53, p.57

15. XETE minor or absent. BENE usually important . . . . ABAM/RHMA-BENE
CFS6-52, p.55

16. BENE cover over 5%. VAME cover usually less the 10% . . ABAM/BENE
CFS1-51, p.53

16. BENE minor or absent. VAME usually the major shrub 17

17. Several herbs other than XETE present, usually including CLUN, SMST and ACTR . . . . ABAM/VAME/CLUN
CFS2-56, p.59

17. XETE the major herb, moisture-indicating herbs minor <u>or</u> herbs absent 18

18. TSME regeneration over 2% cover . . . . TSME/VAME/XETE
CMS2-16, p.61

18. TSME regeneration minor or absent . . . . ABAM/VAME/XETE
CFS2-51, p.63

TABLE 6. LIST OF TRI ABBREVIATIONS [1/]
SCIENTIFIC AND COMMON NAMES OF TREES, SHRUBS, AND HERBS
USED IN THE KEY AND ASSOCIATION DESCRIPTIONS

TREES

TRI CODES	SCIENTIFIC NAME	COMMON NAME	INDICATION[2/]
ABAM *	Abies amabilis	Pacific silver fir	cool
ABCO	Abies concolor	White fir	
ABGR	Abies grandis	Grand fir	
ABLA2*	Abies lasiocarpa	Subalpine fir	cool
ABPR *	Abies procera	Noble fir	
CADE	Calocedrus decurrens	Incense cedar	hot
CHNO	Chamaecyparis nootkatensis	Alaska cedar	cold, wet
LAOC	Larix occidentalis	Western larch	
PIAL	Pinus albicaulis	Whitebark pine	cold, deep snow
PIEN	Picea engelmannii	Engelmann spruce	cold
PICO	Pinus contorta	Lodgepole pine	
PIMO	Pinus monticola	Western white pine	
PIPO	Pinus ponderosa	Ponderosa pine	hot, dry
PSME	Pseudotsuga menziesii	Douglas-fir	
TABR	Taxus brevifolia	Pacific yew	
THPL	Thuja plicata	Western redcedar	
TSHE *	Tsuga heterophylla	Western hemlock	warm
TSME *	Tsuga mertensiana	Mountain hemlock	cold, deep snow

SHRUBS

TRI CODES	SCIENTIFIC NAME	COMMON NAME	INDICATION[2/]
ACCI *	Acer circinatum	Vine maple	
ACGLD	Acer glabrum douglasii	Rocky Mt. maple	
ARNE	Arctostaphylos nevadensis	Pinemat manzanita	dry
BENE *	Berberis nervosa	Dwarf Oregon grape	warm
CACH	Castanopsis chrysophylla	Chinquapin	warm
CEVE	Ceanothus velutinus	Snowbrush	disturbance
CHME	Chimaphila menziesii	Little prince's pine	
CHUM	Chimaphila umbellata	Prince's pine	
COCO	Corylus cornuta	California hazel	warm
CONU	Cornus nuttallii	Pacific dogwood	warm
GAOV	Gaultheria ovatifolia	Wintergreen	
GASH *	Gaultheria shallon	Salal	warm, dry
HODI	Holodiscus discolor	Ocean-spray	dry
MEFE *	Menziesia ferruginea	Fool's huckleberry	cool
OPHO *	Oplopanax horridum	Devil's club	wet
PAMY	Pachistima myrsinites	Oregon boxwood	warm
RHAL *	Rhododendron albiflorum	Cascades azalea	cold, wet
RHMA *	Rhododendron macrophyllum	Rhododendron	
RHDI	Rhus diversiloba	Poison oak	hot, dry
RILA	Ribes lacustre	Prickly currant	
ROGY	Rosa gymnocarpa	Baldhip rose	warm, dry
RULA	Rubus lasiococcus	Dwarf bramble	cool
RULE	Rubus leucodermis	Black raspberry	
RUNI	Rubus nivalis	Snow dewberry	
RUPA	Rubus parviflorus	Thimbleberry	
RUPE	Rubus pedatus	Five-leaved blackberry	cool
RUSP	Rubus spectabilis	Salmonberry	warm, wet
RUUR	Rubus ursinus	Trailing blackberry	warm
SOSI	Sorbus sitchensis	Sitka mountain ash	
SYMO	Symphoricarpos mollis	Snowberry (trailing)	warm, dry
VACCI *	Vaccinium spp.	Huckleberry species	

SHRUBS (Continued)

TRI CODES		SCIENTIFIC NAME	COMMON NAME	INDICATION[2/]
VAAL	*	Vaccinium alaskaense	Alaska huckleberry	cool
VAME	*	Vaccinium membranaceum	Big huckleberry	cool-cold
VAOV	*	Vaccinium ovalifolium	Oval-leaf huckleberry	cool
VAPA	*	Vaccinium parvifolium	Red huckleberry	warm
VASC	*	Vaccinium scoparium	Grouse huckleberry	cold, dry

HERBS AND GRASSES

TRI CODE		SCIENTIFIC NAME	COMMON NAME	INDICATION[2/]
ACTR	*	Achlys triphylla	Vanilla leaf (deerfoot)	moist
ACRU		Actaea rubra	Baneberry	
ADBI		Adenocaulon bicolor	Pathfinder	
ADPE		*Adiantum pedatum*	*Maidenhair fern*	wet
ANDE		Anemone deltoidea	Three-leaved anemone	moist
ANLY2		Anemone lyallii	Nine-leaved anemone	moist
AQFO		Aquilegia formosa	Sitka columbine	
ARCA3		Aralia californica	California aralia	
ARMA3		Arenaria macrophylla	Bluntleaf sandwort	
ARLA		Arnica latifolia	Broadleaf arnica	
ASCA3		Asarum caudatum	Wild ginger	moist
ATFI		Athyrium filix-femina	Ladyfern	moist, wet
BLSP		Blechnum spicant	Deerfern	moist
CABU2		Calypso bulbosa	Calypso orchid	
CASC2		Campanula scouleri	Scouler's bluebell	
CAPE5		Carex pensylvanica	Long-stolon sedge	
CIAL		Circaea alpina	Alpine circaea	
CIRSI		Cirsium spp.	Thistle	
CLUN	*	Clintonia uniflora	Queencup beadlily	cool, moist
COLA		Coptis laciniata	Goldthread	moist
COMA3		Corallorhiza maculata	Coral-root	
COCA	*	Cornus canadensis	Dogwood bunchberry	cool, moist
DIFO		Dicentra formosa	Pacific bleeding heart	moist
DIHO		Disporum hookeri	Fairybells	
ERMO	*	Erythronium montanum	Avalanche lily	cold, deep snow
EQUIS		Equisetum spp.	Horsetail	moist
FRAGA		Fragaria spp.	Strawberry	
GAOR		Galium oreganum	Oregon bedstraw	
GATR		Galium triflorum	Sweetscented bedstraw	
GOOB		Goodyera oblongifolia	Rattlesnake plantain	
GYDR		Gymnocarpium dryopteris	Oak fern	moist
HIAL		Hieracium albiflorum	White hawkweed	
HYCA		Hydrophyllum capitatum	Ballhead waterleaf	
HYMO		Hypopitys monotropa	Pinesap	
IRTE		Iris tenax	Oregon iris (purple)	
LIBO2		Linnaea borealis	Twinflower	warm
LIBO		Listera borealis	Twayblade	
LUZUL		*Luzula spp.*	*Luzula*	
MADI2		Maianthemum dilatatum	False lily-of-the-valley	moist
MIBR		Mitella breweri	Brewer miterwort	moist
MOSI		Montia sibirica	Miner's lettuce	moist
OSCH		Osmorhiza chilensis	Sweet cicely	
OXOR	*	Oxalis oregana	Oregon oxalis	moist
PERA		Pedicularis racemosa	Stickletop pedicularis	cool, moist
POMU		Polystichum munitum	Western swordfern	warm, mesic
PTAQ		Pteridium aquilinum	Bracken fern	disturbance
PYPI		Pyrola picta	White vein pyrola	
PYSE		Pyrola secunda	Sidebells pyrola	cool, dry
PYAS		Pyrola asarifolia	Alpine pyrola	
SAME3		Saxifraga mertensiana	Mertens saxifrage	
SMRA		Smilacina racemosa	Feather solomplume, False solomonseal	moist

HERBS AND GRASSES (Continued)

TRI CODES		SCIENTIFIC NAME	COMMON NAME	INDICATION[2/]
SMST	*	Smilacina stellata	Starry solomonplume, False solomonseal	moist
STRO	*	Streptopus roseus	Rosy twistedstalk	moist
TIUN	*	Tiarella unifoliata	Coolwort foamflower	moist
TRLA2		Trientalis latifolia	Western starflower	
TROV		Trillium ovatum	Pacific trillium	
VASI		Valeriana sitchensis	Sitka valerian	moist, cool
VAHE	*	Vancouveria hexandra	Inside-out-flower	moist, warm
VECA		Veratrum californicum	False hellebore	moist, cold
VIGL		Viola glabella	Pioneer violet	moist
VIOR2		Viola orbiculata	Vetch violet	moist
VISE		Viola sempervirens	Redwoods violet	
XETE	*	Xerophyllum tenax	Beargrass (common)	cold, dry

1/ Keyed to "Northwest Plant Names and Symbols for Ecosystem Inventory and Analysis," USDA Forest Service Gen. Tech. Rev. PNW-46, Fourth Edition, 1976, and "Flora of the Pacific Northwest," Hitchcock and Cronquist, 1973.

2/ Environmental indication is strong when several similar species are present and their cover is high. Opposite indications should be weighed by number of indicators present and their percent cover.

* Diagnostic, used in key as an important indicator plant.

Pacific silver fir/devil's club
ABAM/OPHO CFS3-51

Douglas-fir, western hemlock, Pacific silver fir, noble fir and western redcedar dominate the overstory in most stands (Appendix I). Alaska cedar occurs in particularly cool environments. Pacific silver fir is usually more abundant than western hemlock in the regeneration layer. Western redcedar regenerates well in some stands.

Dense, spiny shrub thickets are usually painfully obvious (Appendix I). Devil's club cover is characteristically above 5 percent and usually ranges from 10 to 90 percent. Alaska huckleberry, big huckleberry, oval-leaf huckleberry, salmonberry, and vine maple are often abundant. Many other shrub species may be present. Total tall shrub cover averages 59 percent.

At least 17 herbaceous species are common (Appendix I). Ten or more additional species may be present. The most common herbs include: dogwood bunchberry, fairybells, vanilla leaf, Pacific trillium, swordfern, inside-out flower, anemone, wild ginger, pathfinder, rattlesnake plantain, sidebells pyrola, rosy twisted stalk, starry solomonplume, coolwort foamflower, miner's lettuce, ladyfern, and queencup beadlily. Total herb cover is high, averaging 70 percent. Where the devil's club association grades into the Pacific silver fir/oxalis association, oxalis cover may be greater than 20 percent.

Environmental Conditions

The Pacific silver fir/devil's club association indicates wet sites, usually with impeded drainage or near streams, which are warmer and accumulate shallower snowpacks than the Pacific silver fir/Cascades azalea associations (Fig.1). It is more moist than the Alaska huckleberry and coolwort foamflower associations with which it intergrades.

This association occurs at elevations between 3,000 feet and 4,000 feet (910 and 1210 m) on the Mt. Hood National Forest and between 3,300 and 4,500 feet (1000 and 1360 m) on the Willamette National Forest (Appendix I). Most sites are situated on northerly-facing lower or mid-slopes with impeded drainage or near streams. The deep and moderately stony soils are usually sandy, silty or clay loams developed in colluvium or, less often, residuum or volcanic tephra.

Productivity and Management Implications

The Pacific silver fir/devil's club association presents some management challenges. While conifer growth rates and volume production are often high, wet soils and proximity to streams may limit timber harvesting methods. Both Douglas-fir and noble fir grow well. Douglas-fir site index (Curtis et al. 1974) averages 123 and often exceeds 140 (Table 5). Noble fir site index averages 135 (Herman et al. 1978). Since noble fir typically has better diameter growth in dense stands, it would probably produce more volume over a rotation. Our volume productivity estimates, which were conbined with the Pacific silver fir/oxalis association, suggest that culmination of net mean annual increment in unmanaged stands is about 175 ft^3/ A./yr (Table 5). Stand density index volume increment estimates average 188 ft^3/A./yr.

Regeneration should not be difficult if seedlings are planted soon after timber harvest to allow them to gain a height advantage over competing shrubs. Shrub competition may be intense within 3 to 4 years following cutting, typically from vine maple, salmonberry, huckleberries and thimbleberry. Frost is not generally a problem. High watertables may prevent establishment of Douglas-fir except on raised planting sites. Western redcedar, which is more tolerant of saturated soils, may do well under these conditions.

Wildlife and watershed values are often high. Palatable shrubs and herbs abound in cutover devil's club stands. Most natural stands are adjacent to streams. Many are composed of widely spaced old-growth Douglas-fir which may be important habitat for some animal species.

Soils are usually saturated through the summer. Harvesting methods should emphasize reduction of soil disturbance and compaction.

Comparisons

The Pacific silver fir/devil's club association has been widely described in the Washington and Oregon Cascades. It changes from a common indicator of wet, relatively warm sites in the Washington Cascades and Olympic Mountains to an association of higher elevation, wet, cooler sites in the central Oregon Cascades. Henderson and Peter (1981a) did not describe a devil's club association in either the Pacific silver fir or western hemlock zone on the White River Ranger District, Mt. Baker-Snoqualmie National Forest. They did describe a western hemlock/devil's club association that occurs below 1500 feet (450 m) near streams on the Shelton Ranger District, Olympic National Forest (Henderson and Peter 1981b). At Mt. Rainier (Franklin et al. 1979), the devil's club association ranges from the low elevation western hemlock zone into the mid-elevations of the Pacific silver fir zone. The Pacific silver fir/devil's club association on the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981) occurs along wet alluvial benches and on wet slopes at moderate elevations. In the H. J. Andrews Experimental Forest (Dyrness et al. 1974), the Alaska cedar/devil's club association occurs on steep, north-facing high elevation sites with persistent snowpacks. The Pacific silver fir/devil's club association is widespread in the Columbia Gorge, Zigzag, Estacada and Clackamas Ranger Districts on the Mt. Hood National Forest. It is common in the Detroit and Sweet Home Districts of the Willamette National Forest but becomes increasingly rare and restricted to higher elevations farther south. In the Oakridge and Rigdon Ranger Districts it most often occurs above 4,000 feet (1210 m) in wet, cold drainages.

Douglas-fir, western hemlock, Pacific silver fir, and noble fir are the major canopy species (Appendix I). Western redcedar is locally common. Pacific silver fir and western hemlock usually dominate the regeneration layer. Very large Douglas-fir and noble fir are common in older stands.

While the tall shrub layer is not usually well developed, rhododendron, vine maple, several huckleberry species (red, Alaska, big leaf and oval-leaf) and, to a lesser extent, devil's club may be present (Appendix I). High coverages, over 5 and 20 percent respectively, of devil's club and huckleberry species indicate gradation to other associations. Dwarf Oregon grape, prince's pine, dwarf bramble, and five-leaved blackberry are common low shrubs. In some stands, rhododendron cover exceeds 30 percent, indicating lower site index and productivity.

Environmental Conditions

This uncommon association indicates wet, relatively warm conditions which are more typical of the western hemlock zone. The relative unimportance of devil's club cover implies better soil drainage than in the devil's club association. Although both associations indicate well-watered, productive sites, the oxalis association is less common and usually occurs on benches away from streams where soils are moist, but not saturated during the summer. The wide occurrence of old growth noble fir and Douglas-fir stands in the oxalis association reflects the low natural fire occurrence in the moist environment.

Summer frosts in openings are infrequent. Elevations range between 3,000 and 3,900 feet (910 and 1180 m) on the Mt. Hood National Forest and between 3,400 and 4,600 feet (1030 and 1390 m) on the Willamette National Forest (Appendix I). Slopes are often moderately steep, 30 to 65 percent, and face various aspects. Soils are usually deep, 10 to 60 inches (50 to 150 cm) stony silt loams, clay loams or loams developed in colluvium or, occasionally, glacial till.

Productivity and Management Implications

The Pacific silver fir/oxalis and devil's club associations were combined for productivity analysis. Both associations occur on well watered, productive sites. Tree growth rates are high. Both Douglas-fir and noble fir site indices often exceed 140 and average 123 and 135, respectively. Diameter growth rates are usually better in noble fir at the same stand density. Volume growth is high: 188 ft^3/A./yr from stand density index and 175 ft^3/A./yr from empirical estimates (Table 5).

Competing vegetation should be the only major obstacle to successful regeneration. Since this association is often not shrub-rich, shrub competition should not be as intense as in the devil's club association. Frost should be a minor problem except in frost pockets. In some areas, cutting may raise the water table enough to restrict planted Douglas-fir and noble fir to high spots and make western redcedar a more suitable species to plant.

Moist, compactable, erodable soils may require careful falling and yarding to more stable soils. Since most natural stands are composed of large old growth, wildlife habitat values may be high. Cut areas will produce abundant shrub and herb forage.

Comparisons

Deer fern is a diagnostic species of the Pacific silver fir/oxalis association in the Mt. Rainier province (Franklin 1966), but is not as important south of the Columbia River. Franklin et al. (1979), Emmingham and Hemstrom (1981) and Dyrness et al. (1974) did not describe a similar Pacific silver fir zone association. Oxalis has more often been described as a component of the low elevation, moist western hemlock/swordfern/ oxalis association (Dyrness et al. 1974). Henderson and Peter (1981b) list a similar Pacific silver fir/oxalis association on the Shelton Ranger District, Olympic National Forest, that is most common on the west side of the Olympic Mountains.

The oxalis association is most common on upper slopes with high precipitation on the west side of Mt. Hood, particularly in the Bull Run watershed. Farther south, it is increasingly rare and found at slightly higher elevations. We have only three sample plots on the Oakridge and Rigdon Ranger Districts, all of which are on cool slopes near 4,500 feet (1360 m).

Pacific silver fir/Cascades azalea/queencup beadlily
ABAM/RHAL/CLUN CFS5-52

Pacific silver fir is the most common canopy species (Appendix I). Mountain hemlock and western hemlock are frequently present. Engelmann spruce, Douglas-fir, Alaska cedar, western white pine and noble fir may be locally abundant. Pacific silver fir dominates the regeneration layer as well. Mountain hemlock, western hemlock, Alaska cedar, and western white pine seedlings may be present in small amounts.

Cascades azalea, rhododendron, big huckleberry, oval-leaf huckleberry, Alaska huckleberry, and fool's huckleberry comprise the dense high shrub layer (Appendix I). Dwarf bramble and five-leaved blackberry are common. Total tall shrub cover averages 71 percent.

The herbaceous layer can be relatively rich and diverse, averaging 43 percent cover (Appendix I).

Fifteen or more species may occur, of which beargrass, queencup beadlily, coolwort foamflower, anemone, vanilla leaf and dogwood bunchberry are the most important. Avalanche lily may be locally common.

Environmental Conditions

This relatively uncommon association indicates conditions similar to the Pacific silver fir/Cascades azalea/beargrass association: long, cold winters with deep snowpacks and short, frosty summers. However, it is either more well-watered or has impeded drainage (Fig. 1). Elevations range from 3,500 to 4,800 feet (1060 to 1450 m) (Appendix I). Slopes are usually gentle, flat to 30 percent, but occasionally range up to 75 percent. Slope aspect is usually northerly. Soil depth is variable, ranging from 20 inches to 60 inches (50 to 150 cm). Soil textures vary from deep sandy loams developed in volcanic ash to shallow, stony loams developed in colluvium, glacial till or residuum.

Productivity and Management Implications

Both of the Pacific silver fir/Cascades azalea associations produce low timber yields and are difficult to regenerate. The Cascades azalea/queencup beadlily association is more moist than the Cascades azalea/beargrass association. The Cascades azalea associations and the Pacific silver fir/fool's huckleberry association were combined for productivity estimates. Noble fir site index averaged 80 while Douglas-fir site index averaged 73. Pacific silver fir grows slowly, reaching about 70 feet in 100 years (Appendix II). Mountain hemlock grows at about the same rate, approximately 70 feet in 100 years, but has more prolonged height growth, usually reaching a maximum of about 120 feet (Appendix II). Western white pine probably has the best height growth potential, but our sample was too small to develop height growth estimates. Volume growth estimates are equally low: 69 ft^3/A./yr from stand density index and 75 ft^3/A./yr from empirical data (Appendix II).

Regeneration will be difficult because of summer frost, deep winter snowpacks and, to a smaller degree, competing vegetation. Winter snowpacks often exceed 10 feet (3 m) and melt in June or July. Only frost resistant species should be planted. Noble fir from high elevation seed is the best choice on slopes. Otherwise, western white pine, Englemann spruce, mountain hemlock and advanced regeneration Pacific silver fir are most likely to survive and grow (Table 3), particularly in flat areas.

Moist, compactable, erodable soils will require careful falling and yarding. Shelterwood cuts would provide protection for seedlings and encourage natural regeneration but may experience blowdown since soils are moist and often shallow. Because it is relatively herb-rich, the Pacific silver fir/Cascades azalea/queencup beadlily association has more herb biomass than the Pacific silver fir/Cascaes azalea/beargrass association (Table 5). Both are used by deer and elk for summer range.

Comparisons

This association is similar to Franklin's (1966) Alaska cedar/Cascades azalea/gley podzol, the Pacific silver fir/Cascades azalea association at Mt. Rainier (Franklin et al. 1979) and the Pacific silver fir/Cascades azalea/queencup beadlily association on the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981), except that Alaska cedar plays a less important role south of the Columbia River. The mountain hemlock/Cascades azalea association on the Olympic and Mt. Baker-Snoqualmie National Forests (Henderson and Peter 1981a, 1981b) is less herb-rich and more strongly dominated by mountain hemlock at climax. No similar type was described in the central Oregon Cascades (Dyrness et al. 1974).

While the Cascades azalea/queencup beadlily association is fairly common on north-facing upper slopes on the Mt. Hood National Forest, it is rare on the Willamette National Forest. Our few samples on the Willamette National Forest are from steep, north-facing slopes generally above 3,900 feet (1180 m) on the Detroit and Sweet Home Ranger Districts. The Cascades azalea associations are apparently not found more than a short distance south of Santiam Pass.

Pacific silver fir/Cascades azalea/beargrass
ABAM/RHAL/XETE CFF5-51

Pacific silver fir and mountain hemlock usually dominate the canopy. Alaska cedar, noble fir, western hemlock, Douglas-fir and western white pine may be present (Appendix I). Pacific silver fir, typically in combination with mountain hemlock and western hemlock, is the major regenerating species. Cascades azalea associations are the only ones in which Alaska cedar frequently regenerates.

Cascades azalea, Alaska huckleberry, big huckleberry, fool's huckleberry, and, in some stands, rhododendron dominate the shrub layer (Appendix I). Dwarf bramble and Sitka mountain ash are often present. Total tall shrub cover averages 63 percent. The herb layer is usually sparse, often containing only beargrass and avalanche fawnlily (Appendix I).

Environmental Conditions
The Pacific silver fir/Cascades azalea/beargrass association indicates deep, late-melting winter snowpacks and cool summers. Frost can occur in openings any time during the growing season, particularly on gentle slopes or where cold air collects. Sites are colder than in the devil's club association and wetter, with more persistent snowpacks than in the big huckleberry/queencup beadlily association (Fig. 1). Elevations range from 4,100 feet to 5,200 feet (1240 to 1580 m) (Table 6). Slopes are usually moderate to steep, 10 to 70 percent, and face northwest to east. Soils are relatively shallow, 22 to (rarely) 60 inches (56 to 150 cm) deep and very stony. Soil textures range from loamy sands to sandy loams, silt loams and clay loams developed in colluvium, glacial till or, less often, residuum or volcanic tephra.

Productivity and Management Implications
The Pacific silver fir/Cascades azalea/beargrass association indicates drier environments than the Cascades azalea/queencup beadlily association. It is slightly easier to manage for timber because soils are not usually saturated. Frost and deep, late-melting snowpacks pose the same difficulties for regeneration as in the Cascades azalea/queencup beadlily association. Growth rates are low. Refer to the Cascades azalea/queencup beadlily association for productivity estimates and

management implications.

Comparisons

In Franklin's (1966) Alaska cedar/Cascades azalea/gley podzol association of the Mt. Adams province, Alaska cedar is a climax codominant, Engelmann spruce is a locally common seral species, and beargrass is a minor species. His association is more closely related to our Pacific silver fir/Cascades azalea/queencup beadlily association. The same is true of the Pacific silver fir/Cascades azalea habitat type at Mt. Rainier (Franklin et al. 1979). Emmingham and Hemstrom's (1981) Pacific silver fir/Cascades azalea-typic phase on the Gifford Pinchot National Forest has a slightly less important beargrass component but is otherwise similar. The mountain hemlock/Cascades azalea association on the Olympic National Forest (Henderson and Peter 1981a) is more herb-poor than the Pacific silver fir/Cascades azalea/queencup beadlily association and lacks beargrass. Mountain hemlock and avalanche fawnlily are more abundant farther north.

Cascades azalea associations become increasingly rare toward the south. Our only samples from the Willamette National Forest are from the Detroit and Sweet Home Ranger Districts. No similar type has been described for the H. J. Andrews Experimental Forest (Dyrness et al. 1974).

Pacific silver fir dominates the canopy in mixtures with western hemlock, Douglas-fir, mountain hemlock and, to a smaller degree, western redcedar, noble fir and Engelmann spruce (Appendix I). The regeneration layer is mostly Pacific silver fir with small quantities of western hemlock, mountain hemlock, and, occasionally, western redcedar. A profuse, species-rich shrub layer is characteristic (Appendix I). Several huckleberry species and rhododendron may be the dominant shrubs, but fool's huckleberry is always present at more than 5 percent cover. Cascades azalea, devil's club, salmonberry, wintergreen, dwarf bramble, five-leafed blackberry, and Sitka mountain ash may also occur. If Cascades azalea is present, fool's huckleberry cover is significantly greater than Cascades azalea cover. Devil's club cover is less than 5 percent. Total tall shrub cover averages 81 percent.

The herb layer may be diverse and substantial, averaging 32 percent total cover (Appendix I). Beargrass, dogwood bunchberry, queencup beadlily, starry solomonplume, coolwort foamflower, Pacific trillium, vanilla leaf, and rattlesnake plantain are the most common herbs. Ten or more additional species occur, but not usually all in one stand.

Environmental Conditions

This association indicates an environment slightly more moist than the Pacific silver fir/big huckleberry/queencup beadlily association, but not as cold and wet as the Pacific silver fir/Cascades azalea/queencup beadlily association (Fig. 1). The Pacific silver fir/fool's huckleberry association occurs at higher elevations and often on steeper, cooler, more northerly-facing slopes than the Pacific silver fir/Alaska huckleberry/dogwood bunchberry association with which it intergrades in many places. Snowpacks are deep and long lasting. Elevations range from 3,300 feet to 4,300 feet (1000 to 1300 m). Slopes may be gentle but commonly exceed 50 percent. Soils are shallow to moderately deep (17 to 60 inches, 40 to 150 cm), rocky, sandy loams, silt loams, and clay loams developed in a variety of glacial till, volcanic ash and colluvial substrates.

Productivity and Management Implications

Productivity information was combined for the Pacific silver fir/Cascades azalea/queencup beadlily, Pacific silver fir/Cascades azalea/beargrass and Pacific silver fir/fool's huckleberry associations. Refer to the Cascades azalea/queencup beadlily association for productivity estimates.

Summer frost is the major obstacle to planted seedling survival. Frost tolerant species should be planted. Since western larch naturally occurs on some Pacific silver fir/fool's huckleberry sites on the Mt. Hood National Forest and is very frost tolerant, it should be considered for planting. Shelterwood cutting would provide additional protection from frost. Soils in this association dry sooner in the summer and are not as susceptible to compaction as those in the Cascades azalea associations. Herb biomass is lower than in most other moist Pacific silver fir zone associations (Table 5) but light summer range use by deer and elk may occur.

Comparisons

In the Pacific silver fir/oval-leaf huckleberry association of the Mt. Adams province (Franklin 1966), oval-leaf huckleberry is more common, fool's huckleberry is less conspicuous, and the herb layer is less rich. The Pacific silver fir/fool's huckleberry habitat type at Mt. Rainier (Franklin et al. 1979) has an important Alaska cedar canopy component and a less well developed herb layer. The Pacific silver fir/fool's huckleberry - typic phase on the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981) is very similar but occurs more often on deep soils, usually with a pronounced rocky or popcorn pumice layer. A similar, uncommon, Pacific silver fir/fool's huckleberry association occurs on the Mt. Baker Snoqualmie National Forest (Henderson and Peter 1981a). Dyrness et al. (1974) did not describe a similar community in the central Oregon Cascades.

The fool's huckleberry association is relatively rare on the Mt. Hood and Willamette National Forests. All our samples are from the Mt. Hood National Forest. Although the association occurs in a few places on the Sweet Home and Detroit Ranger Districts, it is not found farther south.

Douglas-fir, Pacific silver fir, western hemlock and noble fir are the major canopy species (Appendix I). Several other species may be common, including western white pine, Engelmann spruce, mountain hemlock, white fir, and western redcedar. Pacific silver fir dominates the regeneration layer, usually accompanied by western hemlock. At the south end of the Willamette National Forest, white fir becomes an increasingly important canopy and regenerating species.

The tall shrub layer is characteristically less well-developed than the herb layer (Appendix I). Rhododendron, red huckleberry, big huckleberry, baldhip rose and snowberry are the most abundant tall shrubs. Small amounts of devil's club and Sitka mountain ash may be present. The most common low shrubs are dwarf Oregon grape, prince's pine, trailing blackberry, dwarf bramble and wintergreen. Shrub cover averages 31 percent.

The herb layer is diverse and profuse (Appendix I). Twenty or more species may be present. Vanilla leaf, dogwood bunchberry, coolwort foamflower, starry solomonplume, and queencup beadlily are usually abundant. Fairybells, Pacific trillium, inside-out flower, three-leaved and nine-leaved anemone, wild ginger, rosy twistedstalk, violet, and several species of pyrola also occur in most stands. Herb cover averages 68 percent.

Environmental Conditions

The combination of moist, cool-site indicating plants and high tree growth rates in this association implies a moist, cool environment and relatively fertile soils. Snowpacks are shallower than in Cascades azalea associations. The growing season is longer and warmer than in big huckleberry and Cascades azalea associations, but not as warm as in the Pacific silver fir/dwarf Oregon grape association (Fig. 1). The coolwort foamflower association is usually found between 4,000 and 5,000 feet (1210 and 1520 m) on the Willamette National Forest and between 3,300 and 4,600 feet (1000 and 1390 m) on the Mt. Hood National Forest. Above 5,000 feet (1520 m), environmental conditions are more severe and summer frost more frequent. Coolwort foamflower sites are occasionally flat or gentle but usually occur on steeper lower or mid-slopes. Slopes face various aspects. Soils are shallow to moderately deep and often stony. Soil texture varies from loamy sand or sandy loam to clay loam developed in colluvium, glacial till, volcanic tephra, or residual material.

Productivity and Management Implications

The Pacific silver fir/coolwort foamflower association is one of the most productive and easily regenerated associations in the Pacific silver fir zone. Noble fir grows faster than Douglas-fir. Noble fir site index averages 128 versus 119 for Douglas-fir (Table 5). Other species, particularly western white pine, also grow well. Volume productivity is about the same as in the devil's club and oxalis associations; 196 ft^3/A./yr from stand density index, 175 ft^3/A./yr from empirical data (Table 5). Above 5000 feet (1520 m), productivity and height growth decline.

Regeneration should not be difficult in most cases. On slopes over 15 percent, noble fir and Douglas-fir should survive and grow well. Seedlings may require shade for survival on steep, south-facing slopes with rocky soils. Vegetative competition, usually huckleberries, vine maple and rhododendron, should not be severe, especially if seedlings are established the first year after harvesting. Frost-hardy species should be planted (Table 3) and seedlings protected on slopes less than 15 percent or above 5000 feet (1520 m) where frost can occur during the growing season. Soils may be moist and compactable well into the summer. Because of large herb biomass and moist conditions, elk and deer may use this association extensively for summer range.

Comparisons

This plant assemblage has often been described west of the Cascade Crest in Washington and Oregon. Franklin's (1966) very similar Pacific silver fir/starry solomonplume association has a slightly more dense shrub layer. Pacific silver fir/coolwort foamflower associations from Mt. Rainier (Franklin et al. 1979), the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981), and the central Oregon Cascades (Dyrness et al. 1974) have essentially identical floristic characteristics. Henderson and Peter's (1981a) Pacific silver fir/rosy twistedstalk association on the Mt. Baker-Snoqualmie National Forest has a similar herb layer, but lacks an important shrub component and occurs on cooler sites. Stands in the Mt. Hood and Willamette National Forests tend to be more shrubby than those described elsewhere. Sites which support this association change from mid-elevation, warm, well-watered sites in Washington to higher elevation, cool, well-watered sites in Oregon. Excellent stands of noble fir are common in forests less than 350 years old, regardless of latitude.

At the south end of the Willamette National Forest, Pacific silver fir is gradually replaced by white fir and noble fir by Shasta red fir. Coolwort foamflower is less important and starry solomonplume more important. Several other herbs become more common, particularly Scouler's bluebell, bedstraw, and fairybells.

Pacific silver fir/vine maple/coolwort foamflower
ABAM/ACCI/TIUN CFS6-51

Douglas-fir, Pacific silver fir, noble fir and western hemlock usually dominate the canopy (Appendix I). Mountain hemlock and white fir may be locally common. The regeneration layer is almost entirely composed of Pacific silver fir and western hemlock. White fir or western redcedar regenerate in some stands.

Shrubs are more prominent in this association than in the coolwort foamflower association. Vine maple is present in all stands and averages 38 percent cover (Appendix I). Big huckleberry, baldhip rose, rhododendron, and Alaska huckleberry are common tall shrubs. Common low shrubs include prince's pine, dwarf Oregon grape, trailing blackberry and dwarf bramble. Total shrub cover averages 59 percent.

The rich herbaceous layer resembles that of the Pacific silver fir/coolwort foamflower association. Vanilla leaf, wild ginger, three-leaved anemone, starry solomonplume, coolwort foamflower and queencup beadlily occur in most stands (Appendix I). Several other herbs may be present, including: bedstraw, pathfinder, inside-out flower, dogwood bunchberry, fairybells, redwoods violet, Pacific trillium, rattlesnake plantain and miner's lettuce. Total herb cover averages 58 percent.

Environmental Conditions

This association occurs on slightly warmer sites than the Pacific silver fir/ coolwort foamflower association. Elevations range from 3,300 feet to 4,900 feet (1000 to 1480 m) (Appendix I). Stands are usually on gentle to steep mid-slopes facing east, south, or west. Soils are usually over 40 inches (100 cm) deep, often rocky, sandy, silty or clay loams developed in colluvium or residuum. The combination of environmental and vegetative characteristics indicates a well-watered, well-drained, relatively warm, productive site. Summer frost may occur in depressions or flat areas.

Productivity and Management Implications

The Pacific silver fir/vine maple/coolwort foamflower association is the most productive Pacific silver fir zone association (Table 5). Both noble fir and Douglas-fir grow well. Noble fir and Douglas-fir site indices average 140 and 133 respectively. Other species also grow very well, especially western white pine. Volume growth is high. Stand density index productivity estimates averaged 197 ft^3/A./yr. Empirical data suggest that net productivity at culmination should be about 175 ft^3/A./yr. Growth basal area productivity indices for both Douglas-fir and noble fir are higher than for any other association.

Productivity decreases above 5000 feet (1520 m) elevation.

Generally, regeneration should not be difficult (Table 3). Shrub competition (snowbrush ceanothus on warm slopes, vine maple, huckleberries and rhododendron) may develop within 3 to 4 years following stand opening. On steep, south-facing, rocky slopes high summer isolation, rodent damage and shrub competition may hinder seedling establishment. Seedling shading on such sites may increase survival. Sullivan (1978) recommends shelterwood cutting, except where blowdown could occur, in the Pacific silver fir/vanilla leaf association (a generally similar association found on the H. J. Andrews Experimental Forest). Soils may be moist and compactable through much of the summer.

Abundant herbage and moist conditions make the Pacific silver fir/vine maple/coolwort foamflower association good summer range for deer and elk.

Comparisons

The Pacific silver fir/vine maple/coolwort foamflower association has not been previously described. The closest descriptions are of Pacific silver fir/ coolwort foamflower and Pacific silver fir-western hemlock/vine maple/vanilla leaf associations from Mt. Rainier (Franklin et al. 1979) and southern Washington (Emmingham and Hemstrom 1981). Vine maple/vanilla leaf associations lack the important moist site indicating herb complement found in the vine maple/coolwort foamflower association. The Pacific silver fir/vanilla leaf association described on the H.J. Andrews Experimental Forest (Dyrness et al. 1974) has a similar herb layer but is not as shrubby.

South of the McKenzie River, the vine maple/coolwort foamflower association often has white fir in the canopy and regeneration layer and starry solomonplume, Scouler's bluebell and bedstraw are more important herbs.

Most of our samples in this association are from old-growth stands in drainage bottoms or on benches near streams. Douglas-fir, western hemlock and Pacific silver fir dominate the canopy (Appendix I). Noble fir and western redcedar are prominent on some sites. Pacific silver fir, western hemlock and, occasionally, western redcedar dominate the regeneration layer.

The shrub layer is usually dense. Alaska huckleberry, oval-leaf huckleberry, big huckleberry, vine maple, and rhododendron contribute to the diverse shrub layer which averages 59 percent cover. Red huckleberry, dwarf Oregon grape and trailing blackberry may also be present. Rhododendron cover is less than 30 percent.

Dogwood bunchberry, twinflower, vanilla leaf, beargrass and queencup beadlily are the most common and abundant herbs. The herb layer is well developed, averaging 37 percent cover, and may contain several additional species, especially Pacific trillium, threeleaf anemone, starry solomonplume, coolwort foamflower, and sidebells pyrola. In general, this association is more herb rich and productive than the rhododendron-Alaska huckleberry/dogwood bunchberry association.

Environmental Conditions

The Alaska huckleberry/dogwood bunchberry association indicates mesic, relatively productive conditions (Fig. 1). It occurs on a wide range of lower and mid-slope landforms, often near streams, from 2,700 to 4,500 feet (820 to 1360 m) elevation (Table 6). Slopes are typically gentle, flat to 25 percent, and usually face northwest to east. Soils are usually deep, from 18 to over 60 inches (45 to over 150 cm), and occasionally stony. Soil texture is usually silt loam, clay loam, or loam, becoming more clayey near the bottom of the profile. Soils are frequently developed in colluvium, residuum or tephra. The presence of moist-site indicating herbs combined with topographic location imply a cool, moist, well-drained environment.

Productivity and Management Implications

The Pacific silver fir/Alaska huckleberry/dogwood bunchberry association is moderately productive and easy to manage for timber. Douglas-fir and noble fir site indices average 102 and 110 respectively (Table 5). As in most of the Pacific silver fir zone, noble fir will probably produce more volume than Douglas-fir in managed stands. Volume growth appears to culminate at about 125 ft^3/A./yr (Table 5). Stand density index productivity estimates average 118 ft^3/A./yr. Growth basal area productivity estimates rank volume productivity in the Alaska huckleberry/dogwood bunchberry association between that of the cooler, higher elevation associations and the more moist, warm associations.

Regeneration may be complicated by frost in cold air accumulation areas but should not generally be difficult (Table 3). In frost-prone areas, western white pine or Englemann spruce should be planted. On dry, warm slopes Douglas-fir should do well, otherwise noble fir will produce high volumes without suffering frost damage.

This association typically occurs near streams or in protected draws. Natural fires are infrequent and stands are usually old. Watershed and wildlife values may be high. Soils are usually well drained and not saturated except shortly after snowmelt.

Comparisons

This association is almost identical to the Pacific silver fir/Alaska huckleberry/dogwood bunchberry association in the H. J. Andrews Experimental Forest (Dyrness et al. 1974). Similar associations have been described north of the Columbia River; Pacific silver fir/ Alaska huckleberry - typic (Franklin et al. 1979, Emmingham and Hemstrom 1981) and Pacific silver fir/ Alaska huckleberry (Henderson and Peter 1981a). This is the most widespread Pacific silver fir zone association in the central and northern Washington Cascades but becomes increasingly rare farther south. It is fairly common on the Mt. Hood National Forest but uncommon at the south end of the Willamette National Forest.

Douglas-fir dominates the canopy in most stands, usually accompanied by western hemlock and Pacific silver fir. Other species, including mountain hemlock, western redcedar, noble fir and western white pine may be present (Appendix I). Pacific silver fir is the major regenerating species, usually mixed with western hemlock.

Rhododendron dominates the shrub layer, averaging 65 percent cover (Appendix I). Alaska huckleberry cover exceeds 5 percent in most stands. Other common shrubs include prince's pine, big huckleberry, dwarf Oregon grape, trailing blackberry, dwarf bramble, and vine maple.

The herb layer is characteristically poor. Twinflower, dogwood bunchberry, beargrass and queencup beadlily occur in most stands. Vanilla leaf, Pacific trillium, starry solomonplume, and other herbs may be present. Total herb cover averages 37 percent.

Environmental Conditions

The rhododendron-Alaska huckleberry/dogwood bunchberry association is slightly drier and warmer than the Alaska huckleberry/dogwood bunchberry association (Fig. 1). There may be low levels of available nitrogen in the most herb-poor sites (McKee et al. 1980). Elevations range from near 3,300 to 4,500 feet (1000 to 1360 m). Slopes are gentle to moderate and usually north-facing. Most stands are on middle to lower slopes. Soil depth is variable, from 16 to over 60 inches (40 to 150 cm). Soils may be rocky and are usually sandy loams, loams or clay loams developed in colluvium, residuum, or volcanic tephra.

Productivity and Management Implications

Productivity in the Pacific silver fir/rhododendron-Alaska huckleberry/ dogwood bunchberry association is lower than average for the Pacific silver fir zone and is slightly lower than that of the Alaska huckleberry/dogwood bunchberry association. Douglas-fir and noble fir site indices are roughly equal, averaging 97 and 95, respectively, in our samples. We have no productivity plots in this association so volume increment can only be estimated from GBA and site index, providing an index of relative productivity that averaged 114 and 121 ft^3/A./yr for Douglas-fir and noble fir, lower than for most other associations. Stand basal area averaged 318 ft^2/A. and was highly variable.

Since the rhododendron-Alaska huckleberry/dogwood bunchberry association occupies cool sites, noble fir is preferred over Douglas-fir for artificial reforestation. Douglas-fir is appropriate on warmer slopes. While frost is not a widespread threat to reforestation in this association, western white pine will survive best where frost hazard exists, especially on flat areas. Soils are generally well-drained and soil compaction should not be severe. Moderate competition from shrub species, such as rhododendron, huckleberries and vine maple can occur in clearcuts. Seedlings should be established as soon as possible following timber harvest. Herbaceous biomass is moderate to low. This association receives moderate use from deer and elk.

Comparisons

Dyrness et al. (1974) described a similar association in the H. J. Andrews Experimental Forest. Pacific silver fir/Alaska huckleberry (Henderson and Peter 1981a and 1981b), Pacific silver fir/Alaska huckleberry - typic (Franklin 1966, Emmingham and Hemstrom 1981) and Pacific silver fir/Alaska huckleberry/five-leaved blackberry (Franklin et al. 1979) associations which have been described north of the Columbia River are typically found on cooler sites and lack rhododendron. These associations are more herb rich than the rhododendron-Alaska huckleberry/dogwood bunchberry association south of the Columbia River.

The Pacific silver fir/rhododendron-Alaska huckleberry/dogwood bunchberry association is not common in our area. Although our samples are entirely from the Willamette National Forest, mostly from the Detroit and Sweet Home Districts, this association also occurs on the Mt. Hood National Forest.

This uncommon association is a high elevation extension of the widespread western hemlock/salal association. Western hemlock and Douglas-fir are consistent canopy dominants (Appendix I). Pacific silver fir, western redcedar and noble fir occur in many stands. While Pacific silver fir regeneration is present in all stands, western hemlock is more abundant.

A dense shrub layer, dominated by rhododendron, characterizes this association. Red huckleberry, vine maple, chinquapin, dwarf Oregon grape, prince's pine and Oregon boxwood are usually present. Salal cover is at least 5 percent. Total tall shrub cover averages nearly 100 percent. The herb layer is depauperate or absent. Beargrass, twinflower, and dogwood bunchberry are the most common species. Total herb cover averages 10 percent.

Environmental Conditions

This association occupies the warmest and driest sites in the Pacific silver fir zone (Fig. 1). It is found on steep, south-facing lower and midslopes below 4,100 feet (1240 m) (Appendix I). Soils range from less than 20 to over 60 inches (50 to over 150 cm) deep and are usually very rocky. Soil texture varies from sandy to sandy loam and loam, often becoming more clay-rich at depth. Parent material is most often colluvium or residuum. Summers are warm and dry without growing season frosts. Winter snowpacks are neither deep nor long-lasting. Nitrogen may be limiting, especially in stands lacking an herb layer.

Productivity and Management Implications

The Pacific silver fir-western hemlock/rhododendron-salal association is rare. Our few samples may not adequately characterize productivity. Douglas-fir site index averaged 101 but was highly variable. As in other associations dominated by rhododendron, tree growth is often slow, possibly limited by low nitrogen. Growth of western white pine may exceed that of both Douglas-fir and noble fir on nutrient-poor sites.

Douglas-fir is generally more suitable than noble fir for artificial regeneration. On sites with high insolation, high surface temperatures may kill emergent natural seedlings. Although summer frost is infrequent, frost pockets may develop in depressions or where timber harvest creates a cold air dam on a slope. Noble fir or western white pine are better choices than Douglas-fir for frost-prone sites. The rhododendron-salal association is one of the few in the Pacific silver fir zone where drought is likely to contribute to regeneration difficulty. Especially on south slopes or droughty soils, some type of shade protection for seedlings may be necessary. Dense shrub fields may develop 4-5 years following clearcutting, especially where ground disturbance is severe. Snowbrush ceanothus, huckleberry species, vine maple, rhododendron and salal may be present and slow tree growth through competition. Big game use is largely for thermal cover since forage is not abundant.

Comparisons

This association is comparable to the western hemlock/rhododendron-salal association on the H. J. Andrews Experimental Forest (Dyrness et al. 1974) except that Pacific silver fir is a major climax species. Pacific silver fir/rhododendron-salal stands sampled for this guide represent an extension of the western hemlock association into upper elevations where Pacific silver fir and western hemlock are co-climax species. Pacific silver fir/Alaska huckleberry-salal and Pacific silver fir/salal associations described farther north (Franklin 1966, Franklin et al. 1979, Emmingham and Hemstrom 1981, Henderson and Peter 1981a and 1981b) lack significant rhododendron and occur in cooler environments.

This association is not common. In our few samples, Douglas-fir, western hemlock, silver fir, and western redcedar are the primary canopy species (Appendix I). Although western hemlock and silver fir both occur in the regeneration layer, Pacific silver fir usually dominates. Western redcedar also commonly regenerates and would probably be well represented in climax stands.

A mixture of salal and Alaska huckleberry characterizes the shrub layer. Rhododendron, red huckleberry, dwarf Oregon grape, vine maple, chinquapin, prince's pine, wintergreen and dwarf bramble are common. Total shrub cover averages 62 percent.

The herbaceous layer is usually sparse, averaging 26 percent cover. Dogwood bunchberry is the most important species and may be accompanied by twinflower, rattlesnake plantain, Pacific trillium, false solomonplume, and beargrass.

Environmental Conditions

The Alaska huckleberry-salal association occurs on warmer, drier sites than the Pacific silver fir/Alaska huckleberry/dogwood bunchberry association (Fig. 1). It is found in the lower portion of the Pacific silver fir zone, between 2,900 feet and 3,300 feet (880 and 1000 m), and is most common on volcanic mudflow material. Based on our small sample, slopes are gentle and face southwest or northwest. Soils are moderately deep, stony, loamy sand or clay loams in the upper horizons and clays farther down. In general, this association indicates warm, dry sites with long growing seasons and poor soil nutrient status.

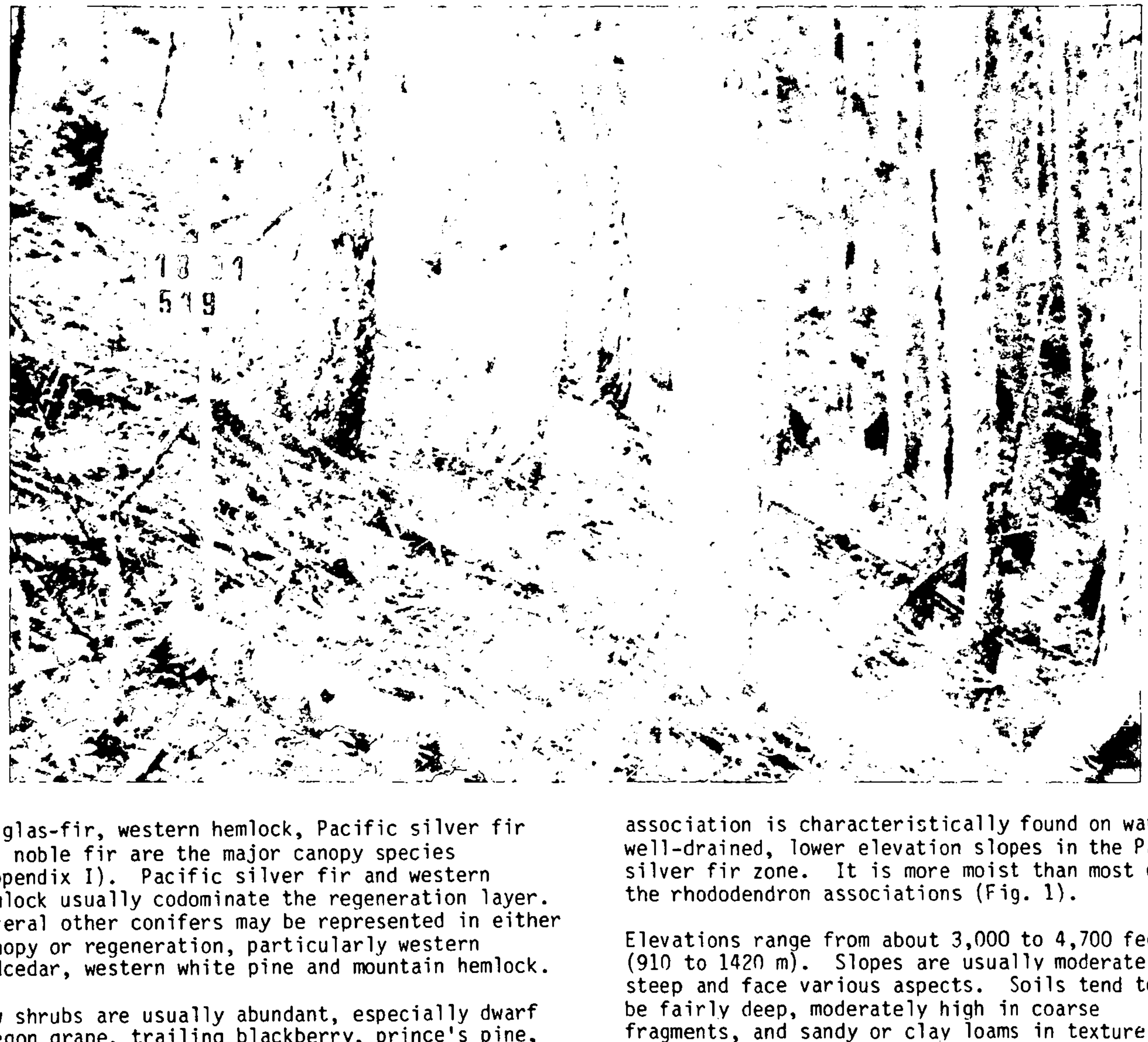
Productivity and Management Implications

Our few samples in this association may not adequately describe its productivity. Douglas-fir site index averaged 72, lower than all but one other association in the Pacific silver fir zone. The two stands in our sample are well stocked, and had average volume for the Pacific silver fir zone.

Heat damage to emergent natural seedlings and moisture stress in planted seedlings on droughty sites are the most common reforestation problems. As in the rhododendron-salal association, shade protection of seedlings is desirable on south-facing slopes. Douglas-fir and noble fir are suitable for reforestation in the Alaska huckleberry-salal association. Douglas-fir grows well on warmer sites, while noble fir should be planted in flat areas or other sites likely to become frost pockets. The risk of frost is slightly higher than in the rhododendron-salal association, but is low compared to the Pacific silver fir zone as a whole. Shrub competition in clearcuts is less severe in the Alaska huckleberry-salal association than the rhododendron-salal association and should not significantly hamper reforestation unless tree seedlings do not become established within 5 years. Snowbrush ceanothus may be a major competitor on scarified or severely burned clearcuts.

Comparisons

Similar associations are fairly common in the Washington Cascades and Olympics. The Pacific silver fir/salal associations on the Mt. Baker-Snoqualmie and Olympic National forests strongly intergrade into the western hemlock zone (Henderson and Peter 1981a and 1981b). Franklin et al. (1979) described Pacific silver fir/salal and western hemlock/salal habitat types at Mt. Rainier. Alaska huckleberry is less important and salal more important in these plant communities than in our Alaska huckleberry-salal association. Emmingham and Hemstrom (1981) identified a similar salal phase of the Pacific silver fir/Alaska huckleberry association on the Gifford Pinchot National Forest. The western hemlock/rhododendron-salal type defined in the H. J. Andrews Experimental Forest (Dyrness et al. 1974) is much shrubbier and has a conspicuous rhododendron component.



Douglas-fir, western hemlock, Pacific silver fir and noble fir are the major canopy species (Appendix I). Pacific silver fir and western hemlock usually codominate the regeneration layer. Several other conifers may be represented in either canopy or regeneration, particularly western redcedar, western white pine and mountain hemlock.

Low shrubs are usually abundant, especially dwarf Oregon grape, trailing blackberry, prince's pine, baldhip rose, and dwarf bramble. Rhododendron, vine maple, big huckleberry, and occasionally chinquapin, usually contribute an additional 20 percent or more to the shrub cover. Rhododendron cover is less than 30 percent. Total shrub cover averages 45 percent (Appendix I).

While the herb layer can be species rich, it is usually not as well developed as the shrub layer. Several moist-site indicating herbs may be present in small amounts, especially coolwort foamflower, anemone and queencup beadlily. Species typically found on moderate, warm sites, such as twinflower, dogwood bunchberry, Pacific trillium, and sidebells pyrola are also common. Herb cover averages 38 percent (Appendix I).

Environmental Conditions

The Pacific silver fir/dwarf Oregon grape association is characteristically found on warmer, well-drained, lower elevation slopes in the Pacific silver fir zone. It is more moist than most of the rhododendron associations (Fig. 1).

Elevations range from about 3,000 to 4,700 feet (910 to 1420 m). Slopes are usually moderately steep and face various aspects. Soils tend to be fairly deep, moderately high in coarse fragments, and sandy or clay loams in texture. This combination of characteristics produces a warm, well-drained to droughty site which experiences a relatively long frost-free growing season.

Productivity and Management Implications

The productivity of the Pacific silver fir/dwarf Oregon grape association falls in the middle to low portion of the range for the Pacific silver fir zone. Douglas fir site index averages 104 and is quite variable. Average noble fir site index is lower (76 feet) and equally variable. Basal area of sample stands averaged 267 ft^2/A. Volume increment appears to culminate at roughly 135 ft^3/A./yr (Appendix II).

The warm climate and long growing season of the Pacific silver fir/dwarf Oregon grape association produce conditions generally favorable for regeneration, except on exposed south-facing slopes with well-drained soils where drought is a potential problem. On those sites, shading could protect seedlings from excessive moisture loss. Heat damage to emergent natural seedlings may also occur on sites with high insolation. Frost is not generally a problem. Douglas-fir and noble fir are both suitable species for regeneration. Since soils are generally adequately drained in this association, no extraordinary measures are needed to protect them from logging impacts. Canopy removal and soil disturbance may encourage shrub development, especially snowbrush ceanothus and vine maple. If regeneration is delayed 2 or 3 years, brush may considerably inhibit seedling establishment.

Comparisons

The Pacific silver fir/dwarf Oregon grape association is similar to the Pacific silver fir/vine maple/dwarf Oregon grape association of the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981). It is also similar to the Pacific silver fir/dwarf Oregon grape habitat type at Mt. Rainier National Park (Franklin et al. 1979) and on the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1981a), both of which lack rhododendron and have less well developed tall shrub layers. Dyrness et al. (1974) described a Douglas-fir/vine maple/dwarf Oregon grape community in the H.J. Andrews Experimental Forest which is a seral stage of the Pacific silver fir/dwarf Oregon grape association.

Douglas-fir and western hemlock are the major canopy dominants (Appendix I). Silver fir and noble fir are common canopy species. Mountain hemlock, western redcedar, and western white pine occasionally occur. The regeneration layer can be composed of several species, including Pacific yew, mountain hemlock and western redcedar, but is usually dominated by Pacific silver fir and, to a smaller degree, western hemlock.

Rhododendron forms a dense high shrub layer on most sites, averaging 59 percent cover (Appendix I). Sites in this association which have low rhododendron cover are usually depauperate in other shrub and herb species as well. Other shrubs, mostly evergreen, may be abundant: dwarf Oregon grape, prince's pine, Oregon boxwood, red huckleberry, vine maple, wintergreen, dwarf bramble, and big huckleberry. Total shrub cover averages 76 percent.

Although several herb species may be present, especially twinflower, dogwood bunchberry, Pacific trillium, vanilla leaf, rattlesnake plantain, and beargrass, total herbaceous cover is usually low, averaging 20 percent (Appendix I). Some stands have a dense evergreen shrub layer and no noticeable herb layer. These usually have slow tree growth and may be nutrient limited.

Environmental Conditions

This association usually occurs on moderate to steep slopes, at middle elevations, 3,200 to 5,300 feet (970 to 1600 m) (Appendix I). At lower elevations, it grades into the western hemlock zone. Slope aspect is variable. Soils range from 27 to over 60 inches (70 to 150 cm) deep but tend to be shallow, well-drained, stony, loamy sands, loams or clays. The environment is relatively dry and warm in the summer with a long growing season and early snow melt (Fig. 1).

Productivity and Management Implications

Our small sample suggests productivity of this association is slightly lower than that of the Pacific silver fir/dwarf Oregon grape association. Samples from both associations were combined for productivity analysis. Average productivity was greater below 4000 feet (1210 m).

Regeneration characteristics for the two associations are also quite similar. The growing season is relatively long, and somewhat warmer and drier in the rhododendron-dwarf Oregon grape association. Shade blocking and early planting may improve seedling survival. Douglas-fir and noble fir are preferred species for planting. Douglas-fir is more appropriate for droughty slopes. Although frost is not a common problem in the rhododendron-dwarf Oregon grape association, noble fir should be planted in flat areas where cold air may accumulate. Development of large brush fields (snowbrush ceanothus, vine maple and rhododendron) often occurs, particularly where ground disturbance is severe. Seedlings should be established as rapidly as possible.

Big game use is concentrated in openings where palatable species, such as Oregon boxwood, are abundant.

Comparisons

Since rhododendron is rare north of the Columbia River, no comparable associations were described at Mt. Rainier (Franklin et al. 1979) or on the Gifford Pinchot, Olympic, or Mt. Baker-Snoqualmie National Forests (Emmingham and Hemstrom 1981, Henderson and Peter 1981a and 1981b). A very similar association, western hemlock-Pacific silver fir/rhododendron-dwarf Oregon grape was described by Dyrness et al. (1974) for the H. J. Andrews Experimental Forest.

The overstory in this widespread association is typically dominated by Douglas-fir, Pacific silver fir and western hemlock (Appendix I). Noble fir, mountain hemlock and western white pine are present in many stands. Pacific silver fir is the major regenerating species, usually in combination with western hemlock or, less frequently, mountain hemlock.

Rhododendron is the major shrub, averaging 55 percent cover. Dwarf Oregon grape, prince's pine, Alaska huckleberry, big huckleberry, wintergreen, and several other shrub species are usually present. Total shrub cover averages 68 percent. If rhododendron cover is below 30 percent, other shrub and herb species are similarly sparse.

The herb layer, except beargrass, is usually sparse, averaging 37 percent cover. Twinflower, dogwood bunchberry, rattlesnake plantain, and a few other herbs may be present, generally at less than 2 percent cover each. Beargrass occurred in nearly all our plots in this association and averaged 27 percent cover.

Environmental Conditions

The Pacific silver fir/rhododendron/beargrass association indicates a dry, cool environment and, possibly, low soil nitrogen (Fig. 1). Elevations range fron 3,100 to 5,300 feet (940 to 1610 m). Slope aspect is variable. Slopes are moderate to steep. Soils are well drained and shallow to moderately deep and rocky. These conditions combine to produce sites which are dry to droughty in the summer and, due to fairly late snowmelt and occasional summer frosts, have relatively short growing seasons. The Pacific silver fir/big huckleberry/beargrass association occurs at higher elevations and has cooler summers. The rhododendron-dwarf Oregon grape association is more moist and warm.

Productivity and Management Implications

As in other associations dominated by rhododendron, the productivity of the Pacific silver fir/rhododendron/beargrass association is relatively low. Both Douglas-fir and noble fir site index averaged 96 in our sample (Table 5). Stand basal area and volume are low to moderate compared to the rest of the Pacific silver fir zone. Productivity is highest below 4,000 feet (1210 m). Drought and frost are the major threats to seedling survival. Frost pockets are likely to occur wherever cold air accumulates. Noble fir and western white pine should be planted in frost-prone areas. Drought becomes a problem where late snowmelt delays planting until late spring or early summer when evaporative demand is high. Early planting is essential. Noble fir and Pacific silver fir are suitable species on many sites because their roots can function and grow at the cold temperatures of early spring. Douglas-fir should be planted only in the warmest sites. Shading may be necessary to reduce mortality. If seedlings are not established quickly (within 3-4 years), competition from other vegetation may become severe. A number of species (including huckleberries, rhododendron, and vine maple) may invade clearcut areas, but the worst problems are associated with extensive scarification or burning, which may encourage the spread of snowbrush ceanothus, beargrass and sedge species. Pocket gophers are an additional threat where beargrass and sedge mats develop.

Alternatives to clearcutting and artificial reforestation should be considered in the rhododendron/beargrass association. The shelterwood system may prevent problems associated with both frost and drought. In most cases, artificial regeneration is unnecessary following shelterwood harvest. In either clearcutting or shelterwood harvesting, management of residual Pacific silver fir seedlings can help ensure adequate stocking following harvest. If protected from damage during logging and slash disposal, Pacific silver fir can grow well and is quite resistant to defect-causing infections. Big game use is limited to thermal cover.

Comparisons

The Pacific silver fir/beargrass (Franklin et al. 1979, Henderson and Peter 1981a and 1981b) and Pacific silver fir/big huckleberry/beargrass (Emmingham and Hemstrom 1981) associations described north of the Columbia River are similar in some respects to the Pacific silver fir/rhododendron/beargrass associations on the Mt. Hood and Willamette National Forests. The absence of rhododendron and a slighly cooler microclimate are the major differences north of the Columbia River; other vegetative characteristics and environmental interpretations are similar. The Pacific silver fir/big huckleberry/beargrass association in the H. J. Andrews Experimental Forest (Dyrness et al. 1974) lacks rhododendron and occurs on cooler sites.

The canopy in this association can be diverse. Pacific silver fir, Douglas-fir, noble fir, mountain hemlock and western hemlock are common (Appendix I). White fir becomes important at the south end of the Willamette National Forest. Engelmann spruce may form nearly pure, very productive stands in particularly moist areas. Pacific silver fir dominates the regenerating layer, often with western hemlock on warmer sites and mountain hemlock on cooler sites. Cover of mountain hemlock regeneration is less than 2 percent, separating this association from the mountain hemlock zone.

Big huckleberry is the most important shrub. Other huckleberries and rhododendron may be present. Dwarf bramble and prince's pine are present in most stands. Total shrub cover averages 35 percent.

An appreciable herb cover in addition to beargrass distinguishes this association from the Pacific silver fir/big huckleberry/beargrass association. Fifteen or more herb species can occur, of which queencup beadlily, sidebells pyrola, vanilla leaf, dogwood bunchberry, coolwort foamflower, starry solomonplume, and beargrass are the most abundant. Total herb cover averages 48 percent.

Environmental Conditions

The big huckleberry/queencup beadlily association indicates relatively cool conditions during the growing season and long winters with deep snowpacks (Fig. 1). The herb-rich understory indicates more moist conditions than in the Pacific silver fir/big huckleberry/beargrass association. Elevations range from 3,500 to 5,600 feet (1060 to 1700 m). This association usually occurs on lower to middle slopes facing a variety of aspects. Slope steepness ranges from nearly flat to more than 50 percent. Soil textures range from loamy sand to clay. Soils are usually fine textured at the surface and stony at depth. Most soils are 24 to 60 inches (60 to 150 m) deep and developed in colluvium or residuum.

Productivity and Management Implications

The Pacific silver fir/big huckleberry/queencup beadlily association is more productive than the Pacific silver fir/big huckleberry/beargrass association (Table 5). Noble fir site index is considerably higher than Douglas-fir site index, averaging 125 versus 112. Many big huckleberry/queencup beadlily stands on moist, cool sites are dominated by rapidly growing Englemann spruce. While our sample of spruce-dominated stands is small, they appear to be very productive. Dominant spruce may reach 120 to 140 feet in 100 years with stand volume increment at culmination ranging from 125 ft^3/A./yr to 175 ft^3/A./yr. Typical big huckleberry/queencup beadlily stands are less productive, averaging 137 ft^3/A./yr from stand density index estimates or 125 ft^3/A./yr from empirical estimates (Table 5).

While big huckleberry/queencup beadlily sites are often cold, especially on flat terrain, frost is not as severe as in the mountain hemlock zone and Pacific silver fir/big huckleberry/beargrass association (Table 3). Frost resistant species should be planted on gentle slopes and flats. Shrub competition should be moderate, mostly from huckleberry species. Beargrass-sedge mats and pocket gophers should be less common in clearcuts than in beargrass-dominated associations. As in other cold, high-elevation associations, a significant portion of the soil nitrogen is in the duff and litter layers and would be lost during a hot burn. Soils may be moist and compactable through a good part of the summer. Herbaceous biomass is high. This association provides important deer and elk summer range, especially where the canopy is open and huckleberries are abundant.

Comparisons

The Pacific silver fir/big huckleberry/queencup beadlily association on the Mt. Hood and Willamette National Forests is very similar to the Pacific silver fir/big huckleberry/queencup beadlily association on the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981). North of the Columbia River, it occurs on lower slope positions and more often on east and south-facing aspects. While Franklin's (1966) Pacific silver fir/big huckleberry association from the Mt. Adams province is similar, typically with a depauperate understory dominated by beargrass, it is more closely related to our Pacific silver fir/big huckleberry/beargrass association. The Pacific silver fir/dwarf bramble/avalanche fawnlily association at Mt. Rainier (Franklin et al. 1979) is similar in many respects, but is not as herb-rich and more often has a mountain hemlock climax component. Henderson and Peter's (1981a) Pacific silver fir/big huckleberry association on the Mt. Baker-Snoqualmie National Forest is not as herb rich and has fewer moist site herbs. The seral noble fir/queencup beadlily community in the H. J. Andrews Experimental Forest (Dyrness et al. 1974) is not as shrubby and has a more profuse herb layer.

This is the most common plant association in the upper part of the Pacific silver fir zone. Pacific silver fir, Douglas-fir, noble fir and mountain hemlock are common canopy species (Appendix I). Western hemlock, western white pine, and white fir may also be present. Pacific silver fir is by far the most abundant regenerating species, usually mixed with minor amounts of either western or mountain hemlock.

While several shrub species may be present, especially dwarf Oregon grape, vine maple, rhododendron, chinquapin, prince's pine, and dwarf bramble, huckleberry species dominate. Big huckleberry is the most abundant. Total shrub cover averages 30 percent.

Except for beargrass, which averages 35 percent cover, the herb layer is generally depauperate, averaging less than 10 percent cover. Several herbs are common in small amounts: twinflower, dogwood bunchberry, vanilla leaf, Pacific trillium, rattlesnake plantain, sidebells pyrola, and queencup beadlily.

Environmental Conditions

The Pacific silver fir/big huckleberry/beargrass association occurs in harsh high-elevation environments. It indicates dry, cold summers and long winters with deep snowpacks (Fig. 1). Sites are more droughty than those of the Pacific silver fir/big huckleberry/queencup beadlily association and somewhat warmer than those of the mountain hemlock/big huckleberry/beargrass association. Frost can occur any time during the growing season (Halverson and Emmingham 1982), especially on gentle slopes or created frost pockets (Fig. 9). This association is usually found above 4,500 feet (1360 m) but may drop to 3,600 feet (1090 m) or less in frost-prone areas. It is common on both flat terrain subject to frequent summer frost and steep upper slopes. Soils are commonly thin and often very stony, developing in glacial till, colluvium, volcanic ash or residuum. Sand, sandy loams and loamy sands, occasionally grading into clay at depth, are the most common soil textures.

Productivity and Management Implications

Tree growth and volume production are better than in mountain hemlock associations and the Cascades azalea and fool's huckleberry associations, but less than in most of the Pacific silver fir zone. Douglas-fir and noble fir site indices average 96 and 94, respectively (Table 5). Although blister rust can severely reduce height growth, western white pine is very frost resistant and is often taller than either noble fir or Douglas-fir in natural stands. Western larch is also very frost tolerant and grows well on the Barlow, Bear Springs and Clackamas Districts. Pacific silver fir, which can provide good stocking through advanced regeneration, usually reaches 75 to 100 feet at age 100 (Appendix II). Lodgepole pine, which may be suitable for a nurse crop on the coldest sites, reaches 75 to 90 feet in 100 years. Mountain hemlock usually exceeds 80 feet by 100 years and has sustained height growth into the second and third centuries. Volume production culminates at about 125 ft^3/A./yr from both stand density index and empirical estimates (Appendix II).

Frost, particularly on flat areas, deep, persistent snowpacks, beargrass-sedge mats and pocket gophers often delay reforestation. Cold subsurface soil temperatures (which inhibit root function) coupled with high evaporative demand on sunny days may cause moisture stress and slow growth. For this reason, Douglas-fir is not usually suitable for planting. Noble fir and Pacific silver fir roots are more well adapted to cold soils. Both species are somewhat susceptible to frost damage and should not be planted in severe frost pockets (Table 3). Beargrass-sedge mats may compete with seedlings and, where pocket gophers are present adjacent to cut units, provide ideal pocket gopher feeding habitat that can result in high seedling loss. The pines and Englemann spruce seem less likely to suffer pocket gopher damage. Sullivan (1978) suggests small clearcuts or shelterwoods, where windthrow is not a problem, to reduce environmental extremes.

Where the canopy is open and huckleberries are abundant, this association provides important summer range for deer and elk.

Comparisons

The Pacific silver fir/big huckleberry/beargrass association has often been described in the southern Washington and northern Oregon Cascades. The Pacific silver fir-mountain hemlock/big huckleberry/beargrass association of the Mt. Adams province (Franklin 1966) has mountain hemlock as a sub-climax species, but otherwise is environmentally and vegetatively similar. At Mt. Rainier (Franklin et al. 1979), the Pacific silver fir/beargrass type is described in two phases: the more species-rich western hemlock phase and the higher elevation, depauperate mountain hemlock phase. The Pacific silver fir/beargrass association occurs on dry sites at the upper elevation end of the Pacific silver fir zone on the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1981a). Emmingham and Hemstrom (1981) described a very similar Pacific silver fir/big huckleberry/beargrass phase on the Gifford Pinchot National Forest. Herbaceous diversity increases from north to south.

Mature stands are dominated by mountain hemlock, western white pine, noble fir and Douglas-fir (Appendix I). Western hemlock, a seral species at high elevations (Thornburg 1967), often occurs in the canopy. Lodgepole pine is prominent in stands which were burned less than 100 years ago or where laminated root rot has opened the canopy. Subalpine fir is common, particularly on exposed ridges. Although Pacific silver fir regenerates in most stands, mountain hemlock regeneration cover is at least 2 percent where regeneration is abundant or equals Pacific silver fir where regeneration is scarce.

The shrub and herb layers are floristically similar to the Pacific silver fir/big huckleberry/beargrass association but are usually more species-poor. Big huckleberry is the most common tall shrub. Dwarf Oregon grape, prince's pine, grouse huckleberry, and dwarf bramble occur in small amounts. Total shrub cover averages 30 percent. Beargrass is present in most stands and averages 59 percent cover. A few other herb species, such as sidebells pyrola, queencup beadlily, and sickletop pedicularis, may be present. Total herb cover, without beargrass, is usually less than 5 percent.

Environmental Conditions

The mountain hemlock/big huckleberry/beargrass association occurs in one of the harshest forested environments west of the Cascade Crest (Fig. 1). It indicates short, cool, dry summers subject to frequent frost and long winters with deep snowpacks. Elevations range from about 4,100 to 6,100 feet (1240 to 1850 m). Slopes are usually moderate. Most stands of this association occur on high elevation flats or the middle to upper one-third of high ridges. Soils are normally 24 to 60 inches (60 to 150 cm) deep, developed in volcanic tephra and stony. Most soils are loamy sands or sandy loams.

Productivity and Management Implications

Tree growth is slow and reforestation difficult. Mean Douglas-fir site index (95) is higher than noble fir, but noble fir has better diameter increment in closed stands and may exceed Douglas-fir height by age 150 (Appendix II). Other conifers grow nearly as well and seedlings can better survive the severe environment. Western white pine is usually taller than other species in stands over 100 years old, typically reaching 70 to 80 feet by age 100 and 110 to 120 feet by age 200 (Appendix II). Blister rust can severely reduce height growth. Mountain hemlock, lodgepole pine and Pacific silver fir survive well in this association and usually reach 60 to 80 feet, 70 to 80 feet, and 70 to 90 feet, respectively, by age 100 (Appendix II). Western larch grows well on cool, dry sites and can be managed on the Mt. Hood National Forest. Volume growth at culmination is slightly better than in the mountain hemlock/grouse huckleberry association: 108 ft^3/A./yr from stand density index and 75 ft^3/A./yr from empirical estimates.

Regeneration is difficult. Because of slow decomposition, much of the available nitrogen is in the litter and duff layers. Hot burns can deplete nitrogen levels as well as eliminate advanced Pacific silver fir regeneration. Cold subsurface soil temperatures and high soil surface temperatures immediately following snowmelt, rapid soil drying, beargrass-sedge mats, pocket gophers, and a short growing season with frequent summer frost reduce seedling survival. Careful species selection is essential (Table 3). Advanced regeneration should be saved wherever possible. Sullivan (1978) recommends shelterwood cutting in the similar Pacific silver fir-mountain hemlock/beargrass association on the H. J. Andrews Experimental Forest. There are blowdown problems in some areas, particularly near Mt. Hood. Big game summer use is significant where huckleberries are abundant and the canopy is open.

Comparisons

The Pacific silver fir-mountain hemlock/big huckleberry/beargrass association described by Franklin (1966) and our mountain hemlock/ big huckleberry/beargrass association are similar in most respects. Species composition and environment are also quite similar to the Pacific silver fir/beargrass/mountain hemlock habitat type at Mt. Rainier (Franklin et al. 1974) and on the Gifford Pinchot National Forest (Emmingham and Hemstrom 1981). The mountain hemlock/big huckleberry association on the Olympic and Mt. Baker-Snoqualmie National Forests (Henderson and Peter 1981a and 1981b) is found on more moist sites than the mountain hemlock/big huckleberry/beargrass association in the Oregon Cascades. On the H. J. Andrews Experimental Forest, the Pacific silver fir-mountain hemlock/ beargrass association (Dyrness et al. 1974) is slightly more herb-rich and more often occurs on west and northwest-facing slopes, indicating more moist conditions.

Mountain hemlock and Pacific silver fir dominate the canopy (Appendix I). Several other species, including lodgepole and western white pine, western hemlock, Engelmann spruce, noble fir, Douglas-fir and subalpine fir, may be locally common. Pacific silver fir regenerates more successfully under the canopy in this association than in the mountain hemlock/big huckleberry/beargrass association but is still associated with significant mountain hemlock regeneration. Other high elevation conifers occasionally reproduce under the often broken canopy. The shrub and herb layers typically consist of only grouse huckleberry, big huckleberry, prince's pine, and beargrass.

Environmental Conditions

This association occupies the coldest, most severe environment described in this guide. Snowpacks are deep and persistent. Summers are short with frequent frost. Elevations range from 4,700 to 5,500 feet (1420 to 1670 m) (Appendix I). Aspects are variable. Slopes are usually less than 40 percent, causing cold air accumulation and accentuating summer frost. This association is characteristically found on the high Cascade plateau where moderately deep soils have developed from volcanic tephra. Soils are usually sand, sandy loams or loamy sand and may be rocky.

Productivity and Management Implications

The mountain hemlock/grouse huckleberry association is difficult to manage for timber. Productivity and conifer height growth are low. Our sampling included only one plot with Douglas-fir and noble fir. Site index averaged 70 for both species. Other conifers grow as well and survive better in this environmentally severe association. Western white pine usually is taller than other species. Although our samples of western white pine were limited and variable, dominant trees seem to reach 70 to 80 feet by age 100 and continue to grow to 110 to 120 feet by 200 years (Appendix II). Blister rust can severly reduce height growth. Mountain hemlock, lodgepole pine and Pacific silver fir survive well in this association, usually reaching 50, 50 to 70, and 50 to 70 feet by age 100, respectively, (Appendix II). Mountain hemlock height growth is prolonged into the second and third centuries and dominants are usually taller than other species except western white pine in old stands. Western larch can survive and grow well on cold sites and should be considered for managed stands on the Mt. Hood National Forest. Volume growth is low, less than 75 ft^3/A./yr from empirical data and 54 ft^3/A./yr from stand density index measurements.

Frequent, severe summer frost, development of beargrass-sedge mats, pocket gophers and long-lasting, deep winter snowpacks make regeneration difficult. Much of the soil nitrogen is in the litter and duff layers where it can be lost in intense burns. Hot burns can also eliminate advanced Pacific silver fir regeneration. Sullivan (1978) recommends shelterwood cutting in the less severe Pacific silver fir-mountain hemlock/ beargrass association on the H. J. Andrews Experimental Forest. Halverson and Emmingham (1982) found cold soil temperatures and high soil surface temperatures immediately following snowmelt followed by a very short growing season restrict successful planting to a short period and require frost resistant species (Table 3). They also recommend shelterwood cutting and saving advanced Pacific silver fir regeneration wherever possible.

Since this association usually occurs on High Cascades flats and benches, recreational values may be high. Big game summer use is low because forage is not abundant.

Comparisons

This high elevation association has been described by Franklin (1966) near timberline in the eastern (drier) part of the Mt. Adams province of southwestern Washington. It is most common on deep ash deposits on the high Cascade plateau at the southern end of the Willamette National Forest. Most of our samples are from the Oakridge District, Willamette National Forest. Our two samples from the Mt. Hood National Forest are from the Barlow District, east of the Cascade Crest; but this association, with a lodgepole pine overstory, also occurs north of Olallie Lake.

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APPENDIX I

VEGETATIVE, ENVIRONMENTAL, AND SOIL CHARACTERISTICS FOR EACH ASSOCIATION

Mean relative percent cover[1/] and percent constancy for important[2/] plant species in associations of the Pacific silver fir and Mountain hemlock Zones on the Willamette and Mt. Hood National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ DEVIL'S CLUB		PACIFIC SILVER FIR/ OXALIS		PACIFIC SILVER FIR/ CASCADES AZALEA/ BEARGRASS	
# OF PLOTS	46		30		13	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Mature Trees						
ABAMM	18	93	21	83	30	100
ABCOM	20	2	5	3		
ABGRM	3	4				
ABLAM						
ABPRM	18	39	26	37	4	31
CACHM			4	3		
CHNOM	26	7	15	3	9	23
PICOM						
PIENM	15	2				
PIMOM	3	2	5	3	3	15
PSMEM	23	74	32	90	5	15
TABRM	7	4	10	3		
THPLM	12	30	12	27		
TSHEM	17	93	16	93	8	31
TSMEM	3	7	7	10	27	85
Total Canopy Mature	62	100	73	100	58	100
Tree Regeneration						
ABAMR	12	98	12	93	26	100
ABCOR	5	2	8	3		
ABLAR						
CHNOR	1	4			10	23
PIMOR					5	8
PSMER			1	3		
TABRR	14	9	5	3		
THPLR	3	22	5	17		
TSHER	8	85	6	97	3	31
TSMER	2	2	3	7	4	31
Shrubs						
CONU			1	3		
CACH						
GASH						
VAPA	2	20	3	47		
ROGY	2	20	2	13	2	15
ACCI	16	48	16	47		
RHMA	6	24	18	43	15	31
GAOV	2	11	3	3	1	23
BENE	4	28	3	40		
RUUR	2	28	3	43		
CHUM	3	28	8	23		
CHME	1	22	1	37		
PAMY	1	4	1	13		
VAOV	8	39	13	20	4	31
VAAL	15	37	21	60	3	8
VAME	7	52	4	43	13	100
VASC					8	8
RULA	4	43	2	23	4	85
RUPE	3	20	5	17	5	8
MEFE	3	11	1	7	11	54
RUPA	5	26	1	7		
OPHO	32	98	3	23	10	8
RUSP	6	26	2	13		
RHAL	5	2			28	100
Total Shrub Cover	59	100	36	100	63	100

ASSOCIATION	PACIFIC SILVER FIR/ DEVIL'S CLUB		PACIFIC SILVER FIR/ OXALIS		PACIFIC SILVER FIR/ CASCADES AZALEA/ BEARGRASS	
# OF PLOTS	46		30		13	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Herbs						
CASC2	3	9	3	10	3	8
GAOR	4	24	2	7		
GATR	2	26	2	7		
DIHO	4	43	1	23		
TRLA	2	11	3	3		
ADBI	4	35	1	27		
OSCH	2	17	2	7		
VAHE	9	50	8	43		
ANDE	2	52	2	40	1	8
ANLY2	3	15	2	7		
ASCA	4	61	3	23		
SMST	17	87	5	80		
VIOR2	3	17	2	17	2	15
TIUN	10	91	6	90	1	8
STRO	4	48	2	20		
CLUN	7	89	4	60	4	23
OXOR	34	15	36	97		
MOSI	7	35	3	17		
ATFI	11	72	2	10		
GYDR	10	13	8	7		
BLSP	5	7	7	10		
LIBO2	6	22	5	40		
COCA	13	76	7	63	20	8
VISE	3	22	4	33	1	15
ACTR	10	91	10	73	1	8
TROV	2	67	1	83	2	8
PYPI	2	9	1	17		
GOOB	2	37	2	57		
POMU	3	48	1	63		
COLA	4	28	7	40		
XETE	2	2	2	20	29	100
PYSE	2	33	1	20	1	15
PERA	3	4	2	17	1	8
ERMO	2	2			19	54
PTAQ	3	13	5	13		
Total Herb Cover	70	100	62	100	42	100
Moss Cover	20	91	16	97	10	85

1/Percent cover for those plots in which the species occurred.

2/Percent of plots on which the species occurred.

Mean relative percent cover[1] and percent constancy for important[2] plant species in associations of the Pacific silver fir and Mountain hemlock Zones on the Willamette and Mt. Hood National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ CASCADES AZALEA/ QUEENCUP BEADLILY		PACIFIC SILVER FIR/ COOLWORT FOAMFLOWER		PACIFIC SILVER FIR/ VINE MAPLE/ COOLWORT FOAMFLOWER	
# OF PLOTS	17		91		33	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Mature Trees						
ABAMM	30	94	16	92	13	94
ABCOM			11	3	2	3
ABGRM			8	3	3	3
ABLAM	1	6	7	2		
ABPRM	27	29	20	67	15	73
CACHM					1	3
CHNOM	11	35	5	2		
PICOM	1	6				
PIENM	7	29	10	11		
PIMOM	3	29	3	20	1	12
PSMEM	10	35	30	86	37	100
TABRM			1	2	5	6
THPLM			9	9		
TSHEM	12	59	13	75	14	76
TSMEM	12	65	5	24	8	24
Total Canopy Mature			65	100	68	100
Tree Regeneration						
ABAMR	15	94	18	99	12	97
ABCOR			3	4	5	3
ABLAR	1	6	6	3		
CHNOR	3	41				
PIMOR	2	12	1	1		
PSMER					1	6
TABRR			11	4	6	6
THPLR			5	4		
TSHER	4	41	7	69	5	70
TSMER	7	29	3	12	4	15
Shrubs						
CONU					4	6
CACH			2	5	2	6
GASH						
VAPA	4	6	2	15	2	18
ROGY	2	6	3	44	5	55
ACCI			6	32	38	100
RHMA	21	35	11	21	11	21
GAOV	6	24	4	8		
BENE	2	29	8	43	10	48
RUUR			3	32	3	48
CHUM	1	24	7	62	7	76
CHME	2	6	2	42	1	42
PAMY	1	6	2	18	3	27
VAOV	14	59	4	20	1	6
VAAL	27	29	12	15	7	30
VAME	17	94	8	76	4	73
VASC	3	12	1	2		
RULA	5	88	5	60	2	36
RUPE	9	24	4	7	2	9
MEFE	4	24	3	2		
RUPA			6	9	5	24
OPHO	1	6	4	5		
RUSP			1	3	2	3
RHAL	27	100				
Total Shrub Cover	71	100	31	100	59	100

ASSOCIATION	PACIFIC SILVER FIR/ CASCADES AZALEA/ QUEENCUP BEADLILY		PACIFIC SILVER FIR/ COOLWORT FOAMFLOWER		PACIFIC SILVER FIR/ VINE MAPLE/ COOLWORT FOAMFLOWER	
# OF PLOTS	17		91		33	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Herbs						
CASC2	4	6	2	27	2	30
GAOR			5	40	2	39
GATR			2	19	2	45
DIHO			4	30	2	58
TRLA	3	6	3	16	3	33
ADBI			4	41	4	70
OSCH			2	24	3	15
VAHE	1	6	7	36	8	33
ANDE	3	53	2	53	3	82
ANLY2	3	12	2	23	3	18
ASCA			4	36	5	73
SMST	2	29	7	88	13	85
VIOR2	2	18	3	40	2	27
TIUN	4	47	8	90	8	94
STRO	5	29	4	15		
CLUN	6	88	7	86	6	91
OXOR			3	2		
MOSI			6	15	11	9
ATFI			2	12	2	3
GYDR					3	3
BLSP			2	3	2	3
LIBO2	7	29	14	34	11	33
COCA	12	65	13	57	11	48
VISE	1	12	3	43	3	36
ACTR	8	53	13	97	13	97
TROV	2	35	2	67	2	70
PYPI			2	26	1	36
GOOB	1	47	2	62	2	67
POMU			2	19	2	42
COLA			6	8	13	18
XETE	17	65	9	40	4	18
PYSE	2	35	3	70	2	55
PERA	2	12	7	21	2	15
ERMO	12	24				
PTAQ			3	34	2	42
Total Herb Cover	43	100	68	100	58	100
Moss Cover	13	94	9	80	6	79

1/ Percent cover for those plots in which the species occurred.

2/ Percent of plots on which the species occurred.

Mean relative percent cover[1/] and percent constancy for important[2/] plant species in associations of the Pacific silver fir and Mountain hemlock Zones on the Willamette and Mt. Hood National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ FOOL'S HUCKLEBERRY		PACIFIC SILVER FIR/ DWARF OREGON GRAPE		PACIFIC SILVER FIR/ RHODODENDRON-DWARF OREGON GRAPE	
# OF PLOTS	16		78		20	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Mature Trees						
ABAMM	31	94	13	83	10	70
ABCOM			9	9		
ABGRM			7	5	8	10
ABLAM						
ABPRM	7	25	14	32	15	50
CACHM			5	4	5	5
CHNOM						
PICOM	5	6				
PIENM	1	19	4	3		
PIMOM	1	6	4	28	2	25
PSMEM	12	56	31	100	29	100
TABRM			7	24	2	5
THPLM	13	38	11	18	13	25
TSHEM	13	81	20	96	25	90
TSMEM	13	75	4	12	4	25
Total Canopy Mature	59	100	68	100	68	100
Tree Regeneration						
ABAMR	15	94	14	92	9	100
ABCOR			2	5		
ABLAR						
CHNOR						
PIMOR	3	6	1	6		
PSMER	1	6	2	8		
TABRR			11	35	3	10
THPLR	3	25	4	14	7	20
TSHER	3	81	11	88	5	70
TSMER	5	25	2	8	4	10
Shrubs						
CONU			1	3	6	5
CACH	5	6	3	35	3	10
GASH					35	5
VAPA			3	29	5	35
ROGY	1	13	3	49	1	30
ACCI	5	13	17	59	18	35
RHMA	18	50	14	44	59	100
GAOV	6	44	3	18	3	40
BENE	3	6	16	100	10	95
RUUR	5	6	3	60	2	30
CHUM	1	6	8	90	3	80
CHME			2	33	2	30
PAMY	2	6	4	56	5	45
VAOV	23	63	7	6		
VAAL	14	50	8	23	3	20
VAME	19	94	6	62	3	50
VASC	10	6	4	3		
RULA	3	81	2	37	2	35
RUPE	4	38	2	6		
MEFE	23	94				
RUPA			1	5		
OPHO	3	19				
RUSP	7	6	1	3		
RHAL	5	25	4	1		
Total Shrub Cover	81	100	45	100	76	100

ASSOCIATION	PACIFIC SILVER FIR/ FOOL'S HUCKLEBERRY		PACIFIC SILVER FIR/ DWARF OREGON GRAPE		PACIFIC SILVER FIR/ RHODODENDRON-DWARF OREGON GRAPE	
# OF PLOTS	16		78		20	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Herbs						
CASC2			3	5	1	5
GAOR			1	3		
GATR	1	6	1	12		
DIHO			1	8	3	5
TRLA	2	6	3	23	2	10
ADBI			1	13	3	5
OSCH	2	6	1	4		
VAHE	1	6	3	14	4	5
ANDE	3	6	2	40	1	15
ANLY2			2	10		
ASCA	1	13	2	9		
SMST	1	31	2	29	1	15
VIOR2	2	19	2	36	1	15
TIUN	3	38	2	31	1	5
STRO	3	31	2	6		
CLUN	10	56	4	46	4	30
OXOR						
MOSI			4	1		
ATFI	3	19	1	1		
GYDR			2	1		
BLSP	9	13	4	1		
LIBO2	2	31	11	63	8	60
COCA	8	75	9	63	4	45
VISE			4	29	3	10
ACTR	7	44	8	78	5	35
TROV	1	44	2	63	1	30
PYPI	1	6	2	46	2	25
GOOB	2	44	2	63	2	70
POMU			2	21	1	5
COLA			3	8		
XETE	16	88	8	31	4	45
PYSE	1	25	2	59	2	30
PERA	2	25	6	6	1	5
ERMO	1	13	3	1		
PTAQ	1	6	4	13	4	15
Total Herb Cover	32	100	38	100	20	100
Moss Cover	21	100	17	99	14	80

[1]/Percent cover for those plots in which the species occurred.

[2]/Percent of plots on which the species occurred.

Mean relative percent cover[1/] and percent constancy for important[2/] plant species in associations of the Pacific silver fir and Mountain hemlock Zones on the Willamette and Mt. Hood National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ RHODODENDRON-ALASKA HUCKLEBERRY/DOGWOOD BUNCHBERRY		PACIFIC SILVER FIR/ ALASKA HUCKLEBERRY/ DOGWOOD BUNCHBERRY		PACIFIC SILVER FIR-WESTERN HEMLOCK/ RHODODENDRON-SALAL	
# OF PLOTS	18		29		5	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Mature Trees						
ABAMM	15	89	17	100	16	80
ABCOM						
ABGRM						
ABLAM						
ABPRM	10	33	24	34		
CACHM					3	40
CHNOM			10	3		
PICOM						
PIENM			5	3		
PIMOM	3	11	2	10	1	60
PSMEM	24	100	17	93	29	100
TABRM	2	6	6	7		
THPLM	9	17	13	38	6	80
TSHEM	19	83	20	79	16	100
TSMEM	45	6	18	21		
Total Canopy Mature	56	100	33	100	34	100
Tree Regeneration						
ABAMR	20	100	18	97	4	100
ABCOR						
ABLAR						
CHNOR	3	6				
PIMOR			3	3		
PSMER			2	3		
TABRR	3	11	5	3	2	20
THPLR	5	6	2	14	1	40
TSHER	5	61	7	72	7	80
TSMER			8	7		
Shrubs						
CONU					5	20
CACH	1	6	4	3	5	40
GASH					30	100
VAPA	1	28	2	24	3	60
ROGY	10	6	1	28		
ACCI	11	22	12	55	30	20
RHMA	65	100	7	69	62	100
GAOV	10	22	2	28	1	20
BENE	5	78	3	28	23	60
RUUR	3	39	2	34		
CHUM	4	67	5	55	3	60
CHME	1	44	1	38	1	40
PAMY	3	11	3	21	2	60
VAOV	15	28	18	45		
VAAL	15	72	25	97	1	20
VAME	6	50	6	69	2	20
VASC						
RULA	4	56	3	66		
RUPE	2	6	3	24		
MEFE			3	34		
RUPA			1	7		
OPHO			1	10		
RUSP			2	10		
RHAL			2	3		
Total Shrub Cover	81	100	59	100	100	100

ASSOCIATION	PACIFIC SILVER FIR/ RHODODENDRON-ALASKA HUCKLEBERRY/DOGWOOD BUNCHBERRY		PACIFIC SILVER FIR/ ALASKA HUCKLEBERRY/ DOGWOOD BUNCHBERRY		PACIFIC SILVER FIR-WESTERN HEMLOCK/ RHODODENDRON-SALAL	
# OF PLOTS	18		29		5	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Herbs						
CASC2						
GAOR			4	3		
GATR			1	3		
DIHO			1	14	1	20
TRLA						
ADBI	1	6	2	10		
OSCH			10	7		
VAHE	2	11	3	17		
ANDE			2	28		
ANLY2			1	3		
ASCA			1	10		
SMST	3	17	2	38		
VIOR2	2	6	1	14		
TIUN	2	22	2	55		
STRO			2	24		
CLUN	7	67	6	90		
OXOR						
MOSI						
ATFI			1	14		
GYDR			1	7		
BLSP	1	6	3	10		
LIBO2	7	72	7	62	15	20
COCA	13	89	11	93		
VISE	2	44	3	28		
ACTR	3	61	7	59	1	20
TROV	1	44	1	62	1	20
PYPI	2	17	1	14	1	20
GOOB	1	56	2	52	4	60
POMU	1	6	1	10	1	20
COLA	10	17	3	17		
XETE	5	67	9	48	7	60
PYSE	1	28	1	38		
PERA	13	33	4	31		
ERMO			4	14		
PTAQ	2	6	3	24		
Total Herb Cover	37	100	37	100	10	100
Moss Cover	16	100	22	100	23	80

1/ Percent cover for those plots in which the species occurred.

2/ Percent of plots on which the species occurred.

Mean relative percent cover[1/] and percent constancy for important[2/] plant species in associations of the Pacific silver fir and Mountain hemlock Zones on the Willamette and Mt. Hood National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ ALASKA HUCKLEBERRY-SALAL		PACIFIC SILVER FIR/ RHODODENDRON/ BEARGRASS		PACIFIC SILVER FIR/ BIG HUCKLEBERRY/ QUEENCUP BEADLILY	
# OF PLOTS	3		98		37	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Mature Trees						
ABAMM	16	100	15	84	27	95
ABCOM			6	4	9	11
ABGRM					25	3
ABLAM					4	5
ABPRM	1	67	12	43	18	57
CACHM			3	4		
CHNOM					5	3
PICOM			5	1		
PIENM					10	16
PIMOM			4	30	7	24
PSMEM	26	100	23	93	22	76
TABRM			1	3		
THPLM	15	100	4	15	5	5
TSHEM	20	100	22	77	16	51
TSMEM			15	47	11	57
Total Canopy Mature	50	100	32	100	64	100
Tree Regeneration						
ABAMR	17	67	15	94	18	100
ABCOR			2	1	2	5
ABLAR			3	1	10	5
CHNOR						
PIMOR			1	8	1	5
PSMER			3	2	2	3
TABRR			4	2	1	3
THPLR	3	67	1	10	3	5
TSHER	2	67	5	64	6	46
TSMER			6	33	5	30
Shrubs						
CONU					1	3
CACH	2	67	5	11		
GASH	9	100	3	4	1	3
VAPA	6	100	3	27	3	19
ROGY	2	33	2	10	8	24
ACCI	20	33	9	24	3	16
RHMA	12	100	55	100	3	16
GAOV	3	67	5	47	1	19
BENE	5	33	6	47	2	24
RUUR			2	22	7	65
CHUM	3	67	3	52	2	38
CHME	1	67	1	26	2	19
PAMY			3	27	5	27
VAOV	10	33	4	12	4	14
VAAL	22	100	11	41	19	100
VAME			7	69	1	3
VASC			4	3	5	78
RULA	5	33	4	36	8	14
RUPE	1	33	2	6	3	11
MEFE			8	3		
RUPA						
OPHO			1	1	2	3
RUSP					3	5
RHAL						
Total Shrub Cover	62	100	68	100	35	100

ASSOCIATION # OF PLOTS	PACIFIC SILVER FIR/ ALASKA HUCKLEBERRY-SALAL 3		PACIFIC SILVER FIR/ RHODODENDRON/ BEARGRASS 98		PACIFIC SILVER FIR/ BIG HUCKLEBERRY/ QUEENCUP BEADLILY 37	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Herbs						
CASC2			2	3	3	5
GAOR			2	2	3	8
GATR						
DIHO			1	1		
TRLA			5	3	3	11
ADBI					1	14
OSCH			1	1	1	5
VAHE			1	3	3	11
ANDE			1	10	3	35
ANLY2			2	2	2	27
ASCA			1	1		
SMST	30	33	4	5	2	38
VIOR2			2	12	3	38
TIUN	1	33	2	9	3	41
STRO					2	16
CLUN			3	23	7	89
OXOR			1	1		
MOSI						
ATFI						
GYDR			2	1		
BLSP						
LIBO2	15	33	5	45	8	19
COCA	8	100	5	31	13	49
VISE			2	14	3	49
ACTR			3	21	7	76
TROV	2	67	1	28	2	65
PYPI	2	33	1	12	2	22
GOOB	3	67	2	45	2	46
POMU			1	2	1	5
COLA			2	5	1	3
XETE			27	99	4	49
PYSE	3	33	2	23	4	78
PERA	2	33	7	13	13	24
ERMO			1	2	5	3
PTAQ			2	7	1	19
Total Herb Cover	26	100	37	100	35	100
Moss Cover	38	100	12	94	8	86

1/Percent cover for those plots in which the species occurred.

2/Percent of plots on which the species occurred.

Mean relative percent cover[1/] and percent constancy for important[2/] plant species in associations of the Pacific silver fir and Mountain hemlock Zones on the Willamette and Mt. Hood National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ BIG HUCKLEBERRY/ BEARGRASS		MOUNTAIN HEMLOCK/ BIG HUCKLEBERRY/ BEARGRASS		MOUNTAIN HEMLOCK/ GROUSE HUCKLEBERRY	
# OF PLOTS	84		25		19	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Mature Trees						
ABAMM	21	89	6	52	16	79
ABCOM	18	2	10	8		
ABGRM						
ABLAM	30	1	22	28	5	21
ABPRM	17	65	16	48	8	21
CACHM						
CHNOM	15	2				
PICOM	7	4	5	40	9	32
PIENM	4	1	3	8	5	16
PIMOM	4	31	4	36	6	58
PSMEM	17	74	12	48	26	16
TABRM	6	2				
THPLM	4	11				
TSHEM	22	48	10	8		
TSMEM	19	64	25	100	25	100
Total Canopy Mature	65	100	51	100	51	100
Tree Regeneration						
ABAMR	21	98	13	80	17	84
ABCOR			8	8	1	5
ABLAR	2	1	6	48	6	26
CHNOR	5	2	1	4		
PIMOR	1	4	3	28	3	37
PSMER	2	2	1	4		
TABRR	19	6				
THPLR	2	5				
TSHER	4	29	2	16		
TSMER	3	37	12	96	9	68
Shrubs						
CONU						
CACH	2	11	4	4	2	5
GASH	1	1				
VAPA	2	10	4	4		
ROGY	2	17	4	12	5	5
ACCI	3	6	5	4		
RHMA	8	24	8	24	40	5
GAOV	2	19	2	28	4	11
BENE	5	25	3	12		
RUUR	1	7	3	12		
CHUM	3	33	3	56	4	32
CHME	2	17	1	8	1	5
PAMY	2	13	6	8	3	11
VAOV	3	12	3	8		
VAAL	6	5				
VAME	16	98	15	100	21	74
VASC	2	6	1	20	29	100
RULA	3	60	3	60	3	37
RUPE	14	2	3	4		
MEFE	3	2	5	4		
RUPA					1	5
OPHO						
RUSP						
RHAL						
Total Shrub Cover	30	100	37	100	31	100

ASSOCIATION	PACIFIC SILVER FIR/ BIG HUCKLEBERRY/ BEARGRASS		MOUNTAIN HEMLOCK BIG HUCKLEBERRY/ BEARGRASS		MOUNTAIN HEMLOCK/ GROUSE HUCKLEBERRY	
# OF PLOTS	84		25		19	
	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %	Mean Relative Cover %	Constancy %
Herbs						
CASC2	3	5	3	4		
GAOR						
GATR	1	1				
DIHO						
TRLA	2	1				
ADBI	1	1				
OSCH						
VAHE	1	6				
ANDE	2	15	1	28	2	16
ANLY2	3	6	1	12	2	5
ASCA	1	1				
SMST	1	4	1	4		
VIOR2	2	25	1	20	4	11
TIUN	1	8				
STRO	1	2				
CLUN	3	56	2	20		
OXOR						
MOSI						
ATFI						
GYDR						
BLSP					1	5
LIBO2	4	14				
COCA	5	26				
VISE	2	18	2	28	3	11
ACTR	3	31	4	8	3	5
TROV	1	20	1	12		
PYPI	2	7	1	12		
GOOB	2	33	1	12	3	5
POMU	1	4				
COLA	1	1				
XETE	35	90	58	96	32	37
PYSE	3	57	1	52	1	42
PERA	3	20	1	8	3	26
ERMO	3	1				
PTAQ	1	4	4	8	2	5
Total Herb Cover	39	100	59	100	27	95
Moss Cover	13	88	9	80	4	74

1/ Percent cover for those plots in which the species occurred.

2/ Percent of plots on which the species occurred.

Slope aspect distribution, mean elevation, slope steepness and soils data for associations in the Pacific silver fir and mountain hemlock zones on the Mt. Hood and Willamette National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ DEVIL'S CLUB		PACIFIC SILVER FIR/ OXALIS		PACIFIC SILVER/ CASCADES AZALEA/ BEARGRASS		PACIFIC SILVER FIR/ CASCADES AZALEA/ QUEENCUP BEADLILY		PACIFIC SILVER FIR/ COOLWORT FOAMFLOWER	
# OF PLOTS	46		30		13		17		91	
Aspect										
% NE (0-90)	55		27		39		41		22	
% SE (91-180)	4		20		8		--		21	
% SW (181-270)	9		23		--		12		31	
% NW (271-360)	33		30		54		47		26	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
ELEVATION (ft)	2700-5200	3848	3000-4600	3830	4100-5200	4562	3500-5000	4359	3000-5600	4296
SLOPE (percent)	2-75	37	5-68	35	10-72	34	3-78	27	1-70	30
SOILS										
Litter % Cover	23-100	94	87-100	98	88-100	97	95-100	99	90-100	98
Litter Depth (in)	.2-7.0	2.3	.5-3.5	2.1	.8-3.5	1.8	.7-6	2.5	.1-5.0	1.8
Total Soil Depth (in)	24-99	50	18-90	51	22-44	30	18-60	39	19-99	49
"A" Layer Depth[1/] (in)	1-38	12	1-36	9	1-9	3	1-36	7	1-60	10
% Coarse Frag.	1-90	24	2-80	26	1-50	14	1-75	19	1-90	17
Sz Coarse Frag.(in)	1-4	1	1-6	2	----	1	1-6	2	1-7	2
"B" Layer Depth (in)	3-70	21	5-50	16	4-20	11	2-24	11	1-50	14
% Coarse Frag.	1-70	32	1-85	32	1-85	45	1-85	48	2-90	31
Sz Coarse Frag.(in)	1-8	3	1-30	4	1-20	5	1-12	4	1-15	3
"C" Layer Depth (in)	3-49	22	8-46	23	2-20	12	4-40	19	5-48	24
% Coarse Frag.	5-80	45	5-80	41	5-90	56	1-90	48	4-95	38
Sz Coarse Frag.(in)	1-10	4	1-30	5	1-18	5	1-9	3	1-20	4
"D" Layer Depth (in)	1-28	15	9-50	22	6-18	11	6-30	16	6-36	16
% Coarse Frag.	1-80	40	15-50	37	60-90	78	1-75	27	5-98	49
Sz Coarse Frag.(in)	1-8	3	1-8	4	2-8	4	----	1	1-8	3

[1/] Soil layer designations do not refer to developmental horizons.

Slope aspect distribution, mean elevation, slope steepness and soils data for associations in the Pacific silver fir and mountain hemlock zones on the Mt. Hood and Willamette National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ VINE MAPLE/ COOLWORT FOAMFLOWER		PACIFIC SILVER FIR/ FOOL'S HUCKLEBERRY		PACIFIC SILVER FIR/ DWARF OREGON GRAPE		PACIFIC SILVER FIR/ RHODODENDRON-DWARF OREGON GRAPE	
# OF PLOTS	33		16		78		20	
Aspect								
% NE (0-90)	9		31		26		37	
% SE (91-180)	36		13		23		21	
% SW (181-270)	46		13		33		26	
% NW (271-360)	9		44		18		16	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
ELEVATION (ft)	3300-5200	4218	3300-4700	4006	3000-4700	3762	3200-5300	3965
SLOPE (percent)	5-72	35	5-85	28	14-72	31	5-65	31
SOILS								
Litter % Cover	75-100	98	80-100	95	15-100	94	35-99	95
Litter Depth (in)	1-40	18	7-50	25	.5-6	1.7	.2-3	1.8
Total Soil Depth (in)	12-99	49	15-60	35	7-99	48	27-60	44
"A" Layer Depth[1/] (in)	1-60	11	1-14	6	1-60	14	1-30	8
% Coarse Frag.	1-60	15	5-80	24	1-90	27	1-70	32
Sz Coarse Frag.(in)	1-7	2	1-15	4	1-10	2	1-4	2
"B" Layer Depth (in)	5-60	21	1-40	12	2-60	22	6-40	18
% Coarse Frag.	1-75	29	5-90	43	3-85	38	10-70	39
Sz Coarse Frag.(in)	1-10	4	1-25	7	1-10	4	1-10	3
"C" Layer Depth (in)	9-40	21	4-31	15	2-75	24	11-44	22
% Coarse Frag.	1-80	34	1-95	35	1-90	46	2-70	46
Sz Coarse Frag.(in)	1-10	4	1-30	7	1-15	5	1-8	4
"D" Layer Depth (in)	8-40	23	6-20	12	3-30	13	8-30	18
% Coarse Frag.	5-50	26	6-80	73	20-75	46	20-75	58
Sz Coarse Frag.(in)	1-4	2	4-10	7	1-10	4	1-7	4

[1/] Soil layer designations do not refer to developmental horizons.

Slope aspect distribution, mean elevation, slope steepness and soils data for associations in the Pacific silver fir and mountain hemlock zones on the Mt. Hood and Willamette National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ RHODODENDRON-ALASKA HUCKLEBERRY/DOGWOOD BUNCHBERRY		PACIFIC SILVER FIR/ ALASKA HUCKLEBERRY/ DOGWOOD BUNCHBERRY		PACIFIC SILVER FIR-WESTERN HEMLOCK/ RHODODENDRON-SALAL		PACIFIC SILVER FIR/ ALASKA HUCKLEBERRY-SALAL	
# OF PLOTS	18		29		5		3	
Aspect								
% NE (0-90)	50		31		--		--	
% SE (91-180)	11		31		40		--	
% SW (181-270)	11		3		40		67	
% NW (271-360)	28		34		20		33	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
ELEVATION (ft)	3300-4500	3894	2700-4500	3741	3300-4100	3500	2900-3200	3033
SLOPE (percent)	5-55	29	2-55	20	18-60	44	2-23	10
SOILS								
Litter % Cover	90-00	97	85-99	98	-----	99	90-98	95
Litter Depth (in)	.2-3.9	1.8	.1-6.2	2.5	1-3	2.4	3-4	3.3
Total Soil Depth (in)	16-60	40	18-75	47	18-60	43	40-99	70
"A" Layer Depth[1/] (in)	2-30	14	1-75	16	8-20	13	4-13	7
% Coarse Frag.	3-70	24	2-80	19	1-85	42	15-60	32
Sz Coarse Frag.(in)	1-6	2	1-30	3	1-10	4	1-2	1
"B" Layer Depth (in)	4-50	26	4-50	13	10-20	14	5-20	13
% Coarse Frag.	10-95	43	1-90	30	30-95	54	20-70	43
Sz Coarse Frag.(in)	1-4	2	1-30	4	1-8	4	1-5	3
"C" Layer Depth (in)	8-24	15	5-40	18	14-30	23	6-88	47
% Coarse Frag.	5-90	38	5-90	43	30-70	47	5-45	25
Sz Coarse Frag.(in)	1-10	4	1-30	5	2-20	9	1-6	4
"D" Layer Depth (in)			10-25	17	-----	16	----	10
% Coarse Frag.			20-95	52	-----	10	----	5
Sz Coarse Frag.(in)			1-10	4	-----	1	----	5

[1/]Soil layer designations do not refer to developmental horizons.

Slope aspect distribution, mean elevation, slope steepness and soils data for associations in the Pacific silver fir and mountain hemlock zones on the Mt. Hood and Willamette National Forests.

ASSOCIATION	PACIFIC SILVER FIR/ RHODODENDRON/ BEARGRASS		PACIFIC SILVER FIR/ BIG HUCKLEBERRY/ QUEENCUP BEADLILY		PACIFIC SILVER FIR/ BIG HUCKLEBERRY/ BEARGRASS		MOUNTAIN HEMLOCK/ BIG HUCKLEBERRY/ BEARGRASS	
# OF PLOTS	98		37		84		25	
Aspect								
% NE (0-90)	27		27		28		12	
% SE (90-180)	19		16		24		20	
% SW (181-270)	25		30		24		40	
% NW (271-360)	29		27		23		28	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
ELEVATION (ft)	3100-5300	4052	3500-5580	4486	3300-5800	4528	4100-6100	4740
SLOPE (percent)	2-90	30	4-60	26	2-65	24	2-55	15
SOILS								
Litter % Cover	30-100	96	80-99	97	80-99	98	75-99	96
Litter Depth (in)	.1-9.9	1.8	.2-9.5	1.9	.1-3.5	1.7	.1-5	1.5
Total Soil Depth (in)	8-82	43	14-72	44	10-76	41	24-72	49
"A" Layer Depth[1/] (in)	1-78	12	1-36	9	1-40	7	1-60	15
% Coarse Frag.	1-85	29	1-40	14	1-80	19	1-80	24
Sz Coarse Frag. (in)	1-7	2	1-5	1	1-8	2	1-8	2
"B" Layer Depth (in)	1-50	17	1-60	16	1-42	15	4-60	18
% Coarse Frag.	3-90	38	4-60	25	1-95	35	1-90	35
Sz Coarse Frag. (in)	1-12	3	1-10	2	1-10	3	1-12	4
"C" Layer Depth (in)	6-60	24	6-38	21	4-50	22	6-45	18
% Coarse Frag.	5-90	47	5-80	48	5-95	48	2-90	39
Sz Coarse Frag. (in)	1-12	5	1-15	5	1-12	4	1-8	4
"D" Layer Depth (in)	5-44	18	3-40	19	2-35	14	12-43	22
% Coarse Frag.	0-90	53	5-60	26	20-95	52	5-90	42
Sz Coarse Frag. (in)	1-12	4	1-7	3	1-5	3	1-3	2

1/ Soil layer designations do not refer to developmental horizons.

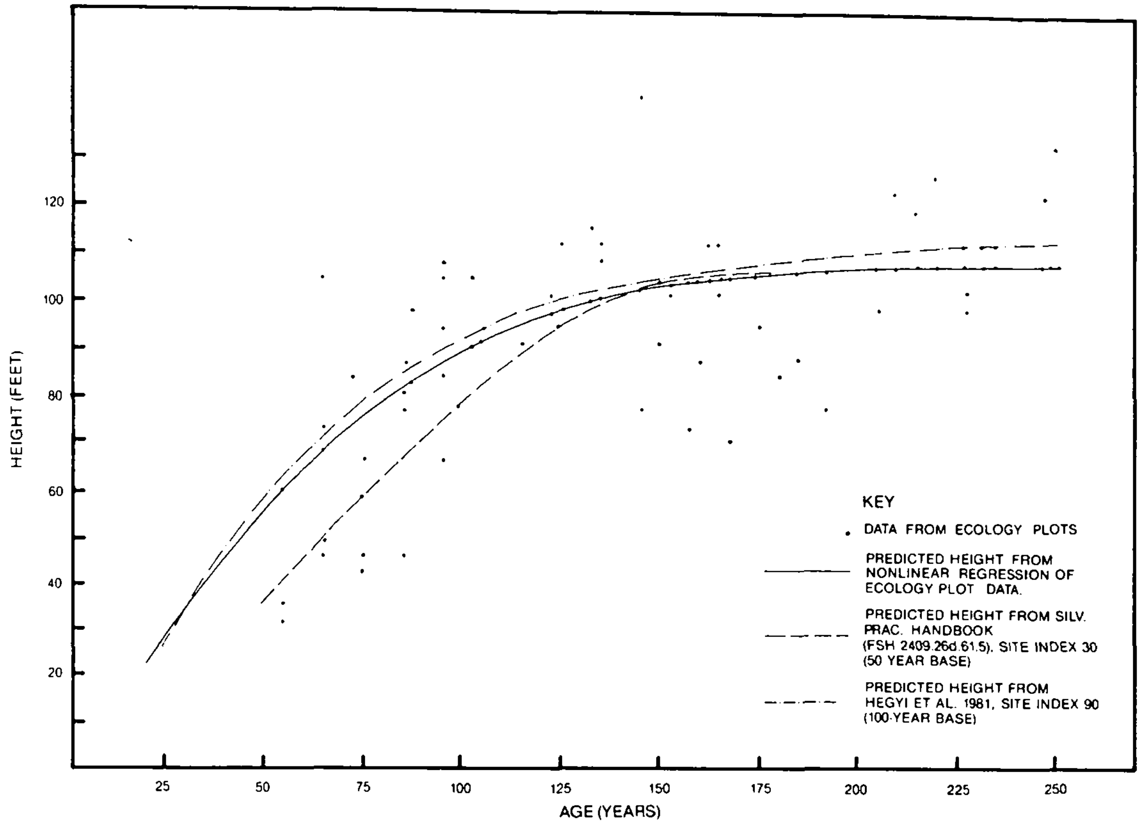
Slope aspect distribution, mean elevation, slope steepness and soils data for associations in the Pacific silver fir and mountain hemlock zones on the Mt. Hood and Willamette National Forests.

ASSOCIATION	MOUNTAIN HEMLOCK/ GROUSE HUCKLEBERRY	
# OF PLOTS	19	
Aspect		
% NE (0-90)	10	
% SE (90-18	21	
% SW (181-2	26	
% NW (271-3	42	
	Range	Mean
ELEVATION (ft)	3800-6100	5205
SLOPE (percent)	10-60	32
SOILS		
Litter % Cover	85-99	94
Litter Depth (in)	.5-2	1.2
Total Soil Depth (in)	24-60	41
"A" Layer Depth[1/] (in)	1-30	10
% Coarse Frag.	2-20	8
Sz Coarse Frag.(in	1-3	1
"B" Layer Depth (in)	2-40	16
% Coarse Frag.	6-85	35
Sz Coarse Frag.(in)	1-8	3
"C" Layer Depth (in)	8-30	15
% Coarse Frag.	5-60	31
Sz Coarse Frag.(in)	1-15	4
"D" Layer Depth (in)	10-30	22
% Coarse Frag.	20-60	45
Sz Coarse Frag.(in)	1-6	3

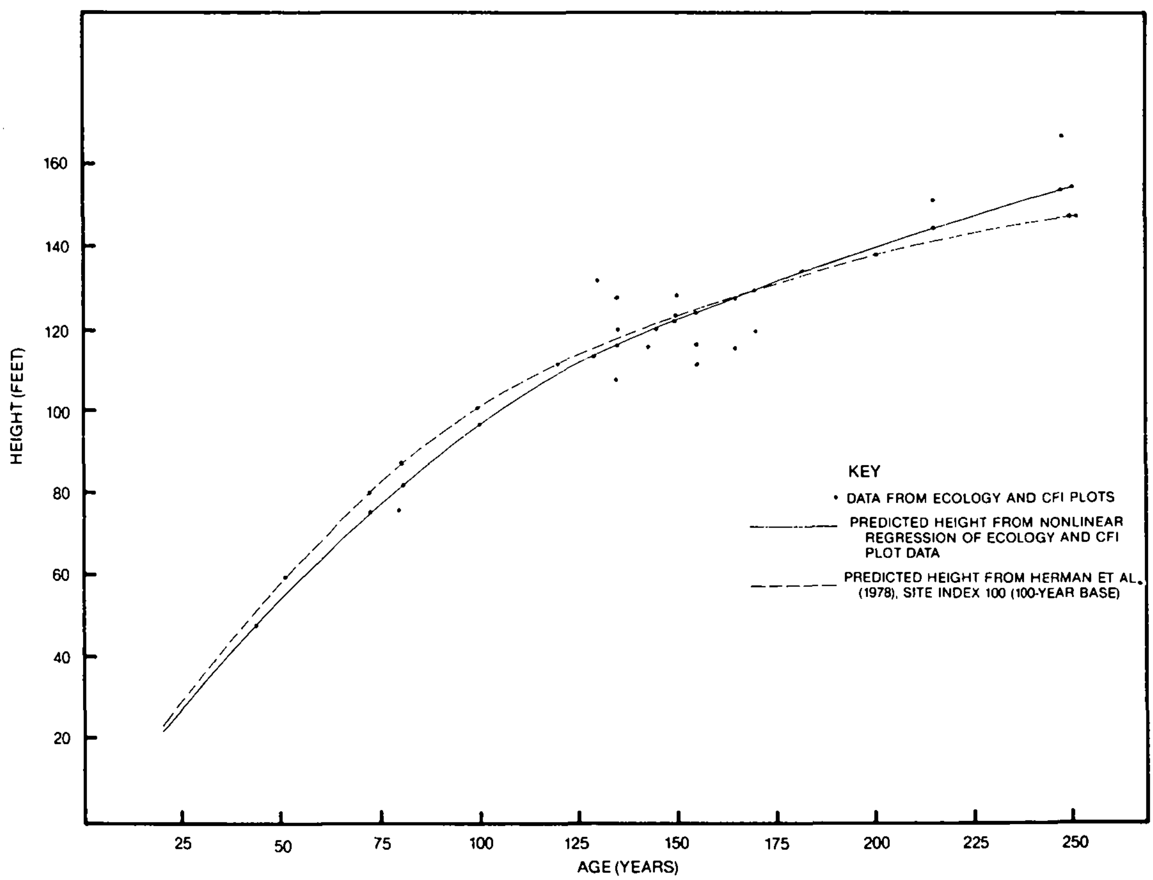
[1/] Soil layer designations do not refer to developmental horizons.

APPENDIX II

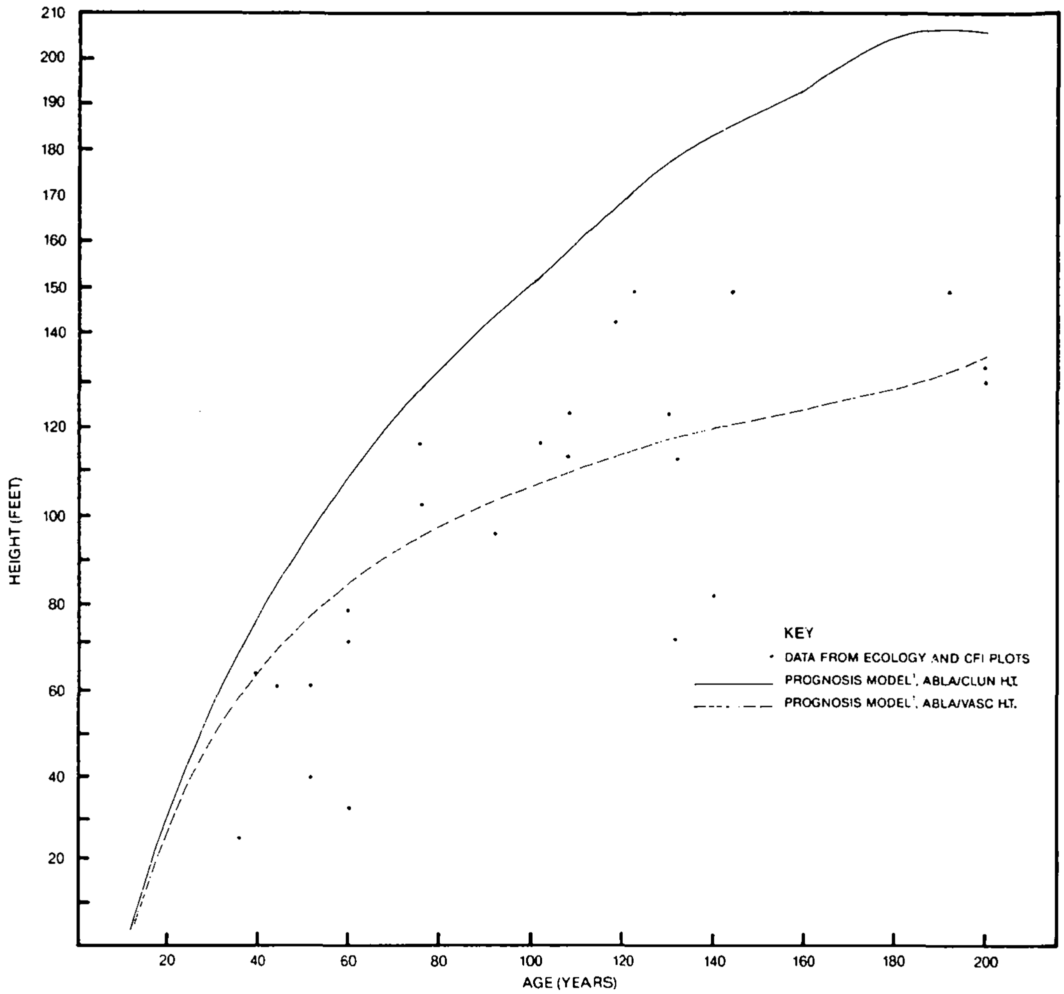
COMPARISON OF EMPIRICAL AND PUBLISHED HEIGHT GROWTH CURVES, EMPIRICAL VOLUME ESTIMATES



Pacific silver fir height/age relationships in the Pacific silver fir zone.

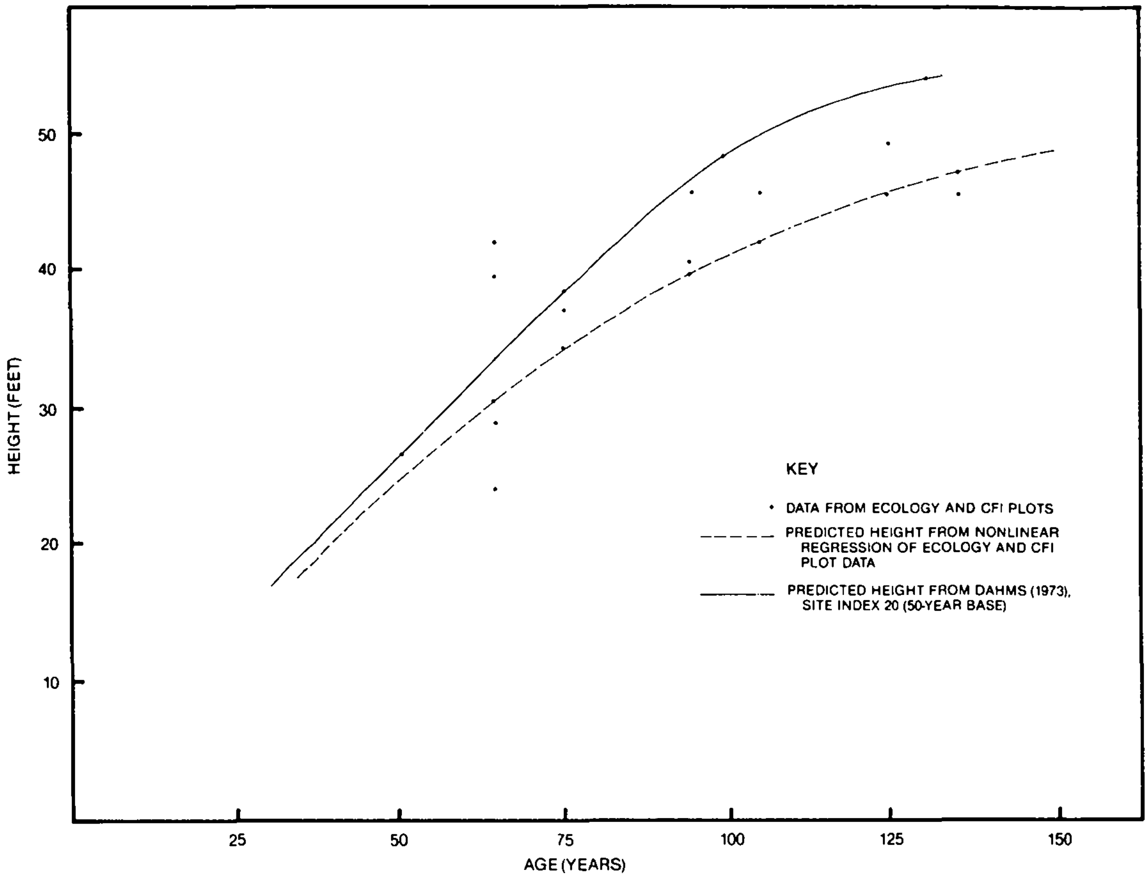


Noble fir height/age relationships on less productive sites in the Pacific silver fir zone.

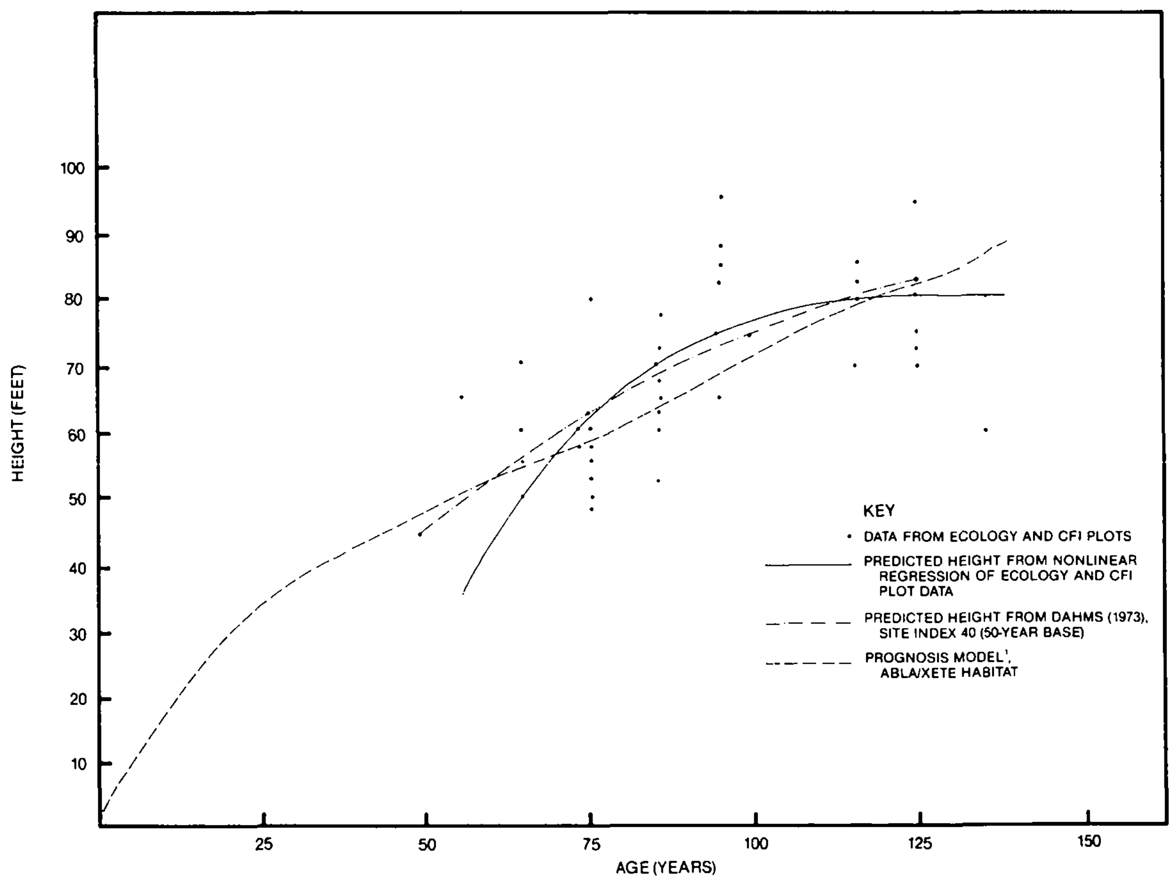


Western white pine height/age relationships in the Pacific silver fir zone.

Simulated height/age relationships of western white pine in two habitat types on the Clearwater National Forest (Intermountain Region). The Stand Prognosis model (Wykoff et al. 1981) was used to generate these curves

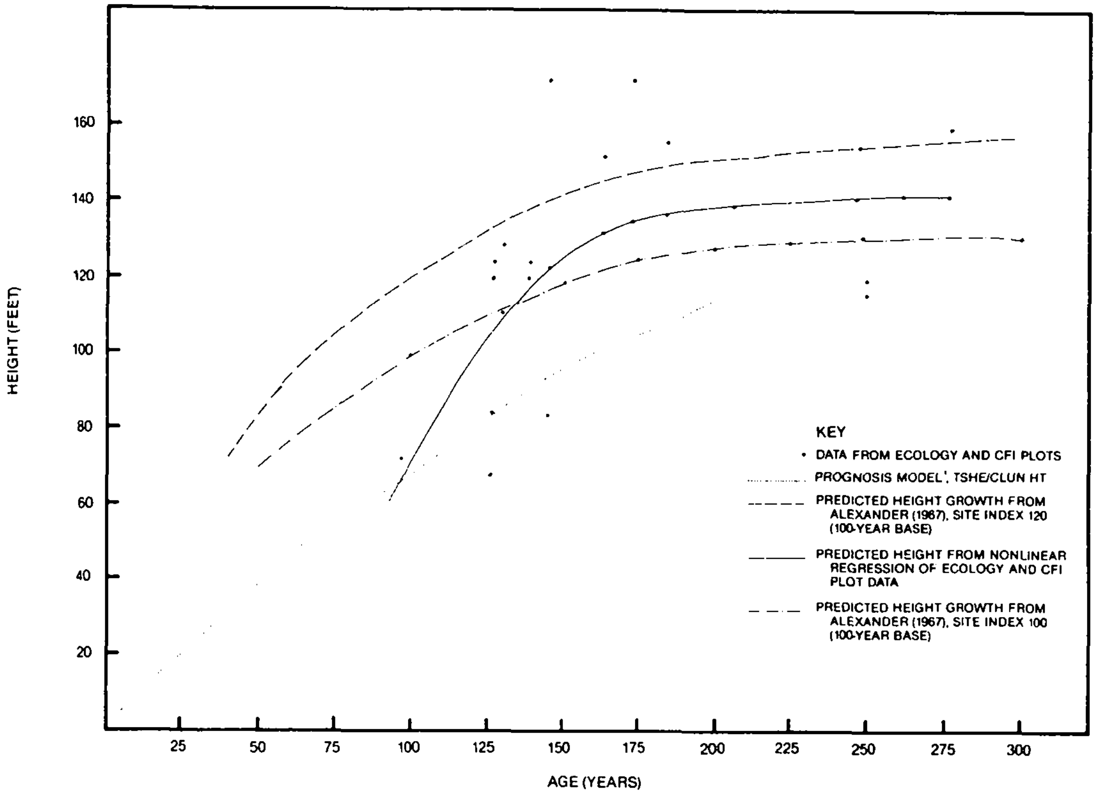


Lodgepole pine height/age relationships on less productive sites in the Pacific silver fir zone.



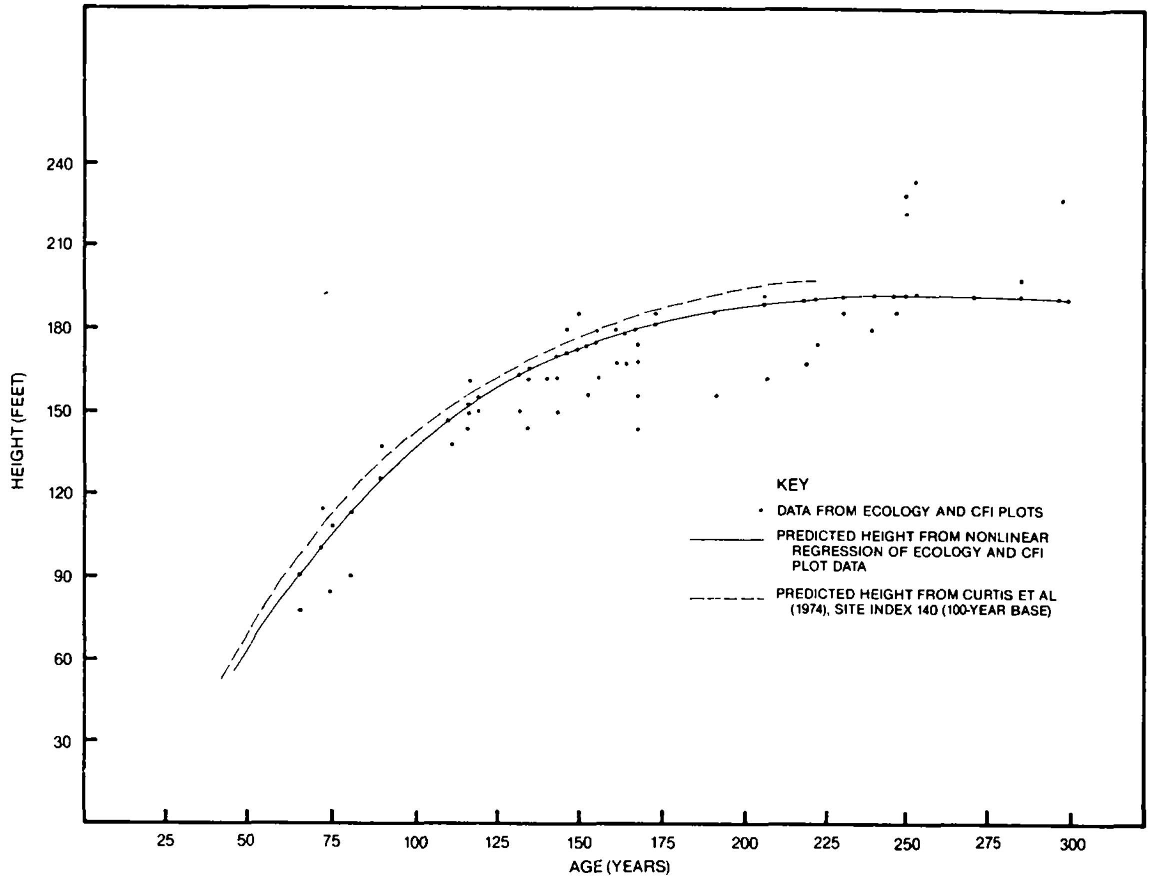
Lodgepole pine height/age relationships on more productive sites in the Pacific silver fir zone.

[1] Simulated height/age relationship of lodgepole pine on the ABLA/XETE habitat type on the Clearwater National Forest (Intermountain Region). The Stand Prognosis model (Wykoff et al. 1981) was used to generate the curve.

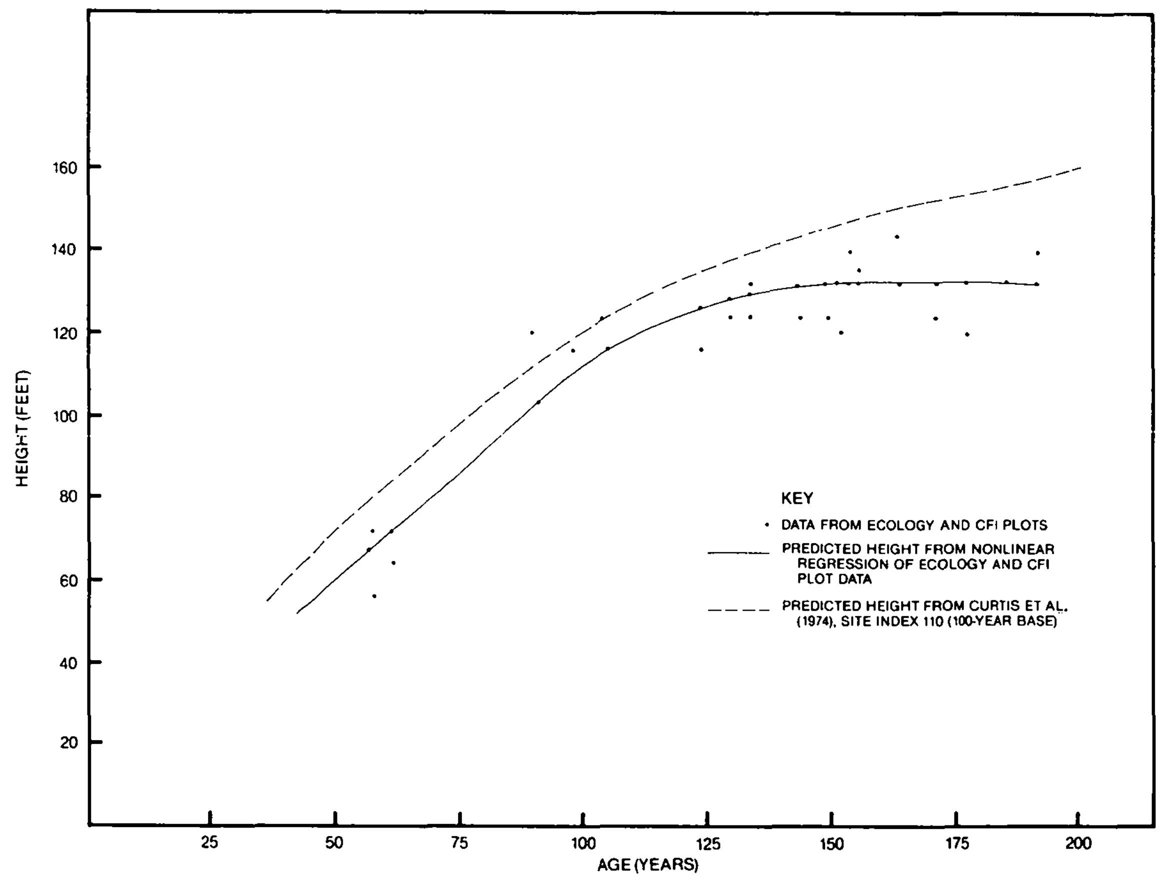


Engelmann spruce height/age relationships in the Pacific silver fir zone.

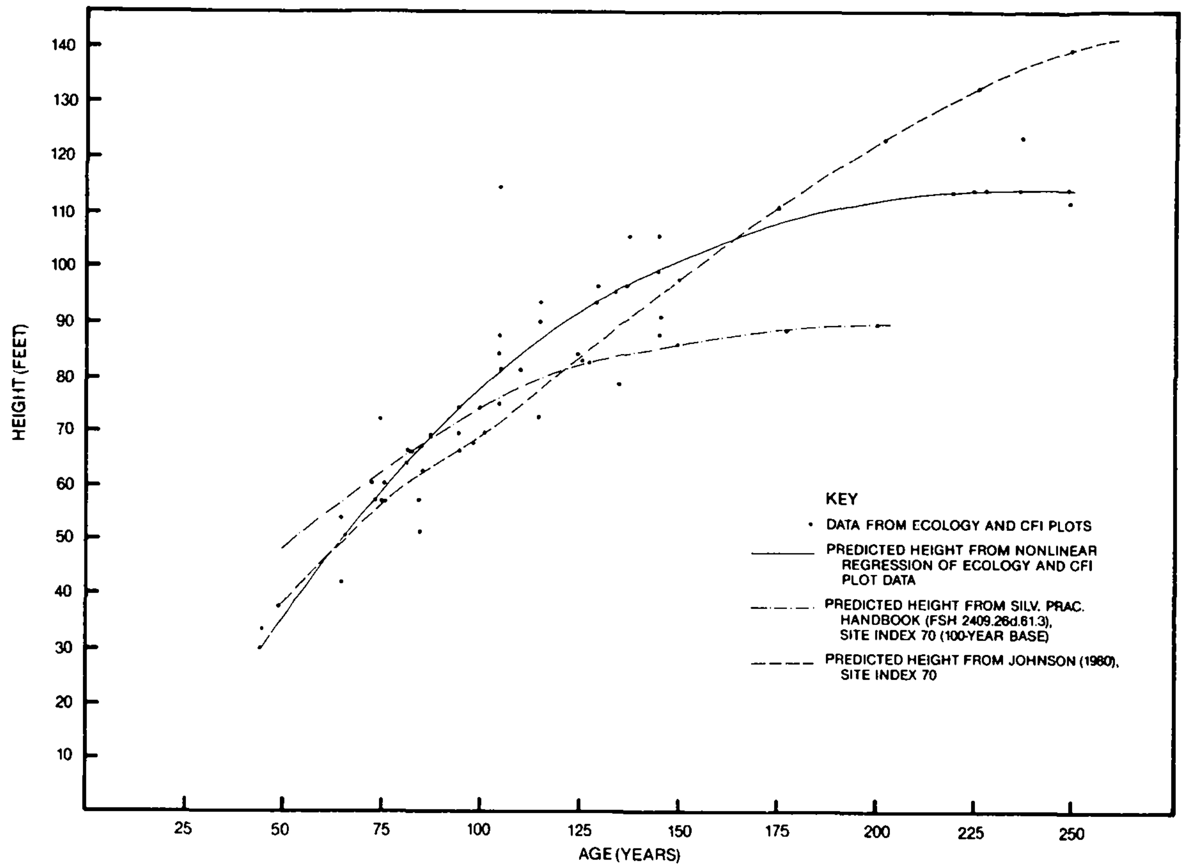
Simulated height/age relationship of Engelmann spruce in the TSHE/CLUN habitat type on the Clearwater National Forest (Intermountain Region). Productivity of Engelmann spruce in the Intermountain Region in maximum in the TSHE/CLUN type (Pfister et al. 1977), yet still is less than in the Cascade Pacific silver fir zone. The Stand Prognosis model (Wykoff, et al. 1981) was used to generate this curve.



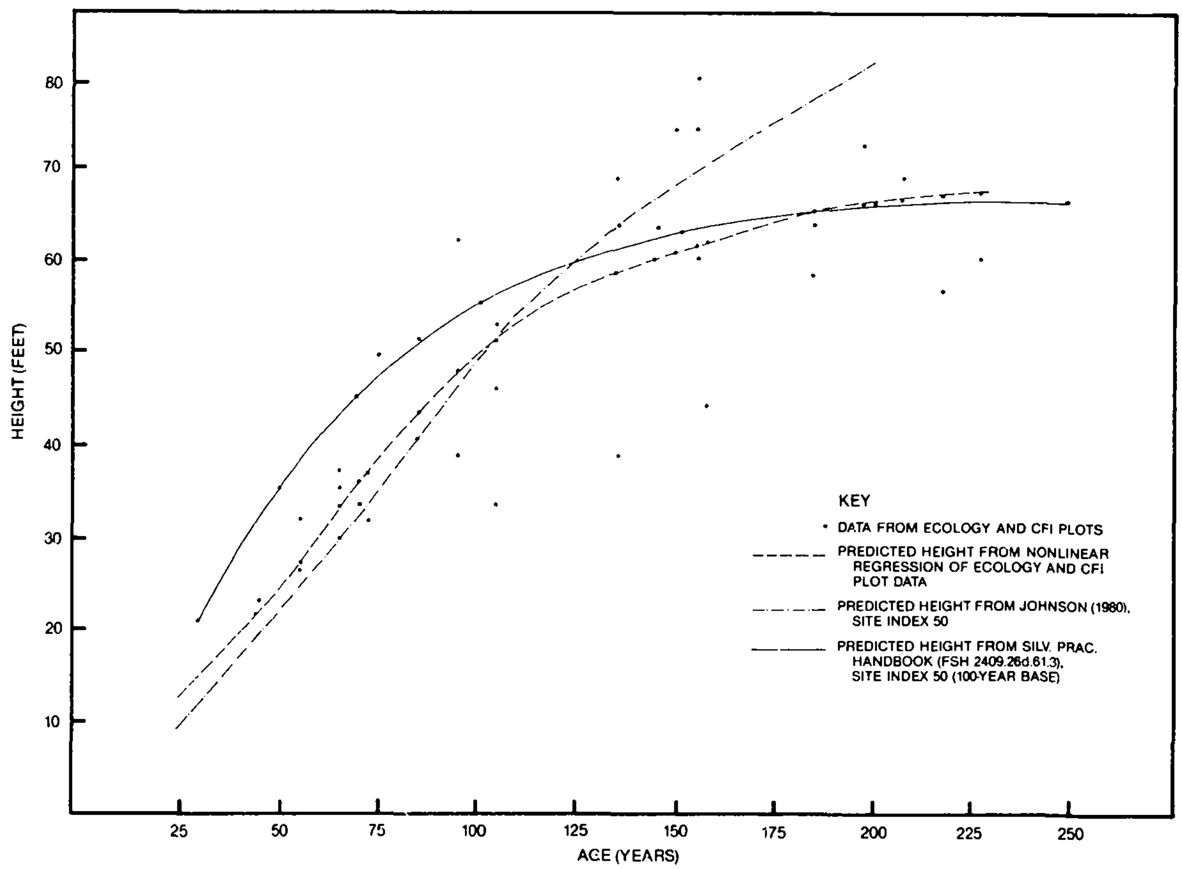
Douglas-fir height/age relationships on more productive sites in the Pacific silver fir zone.



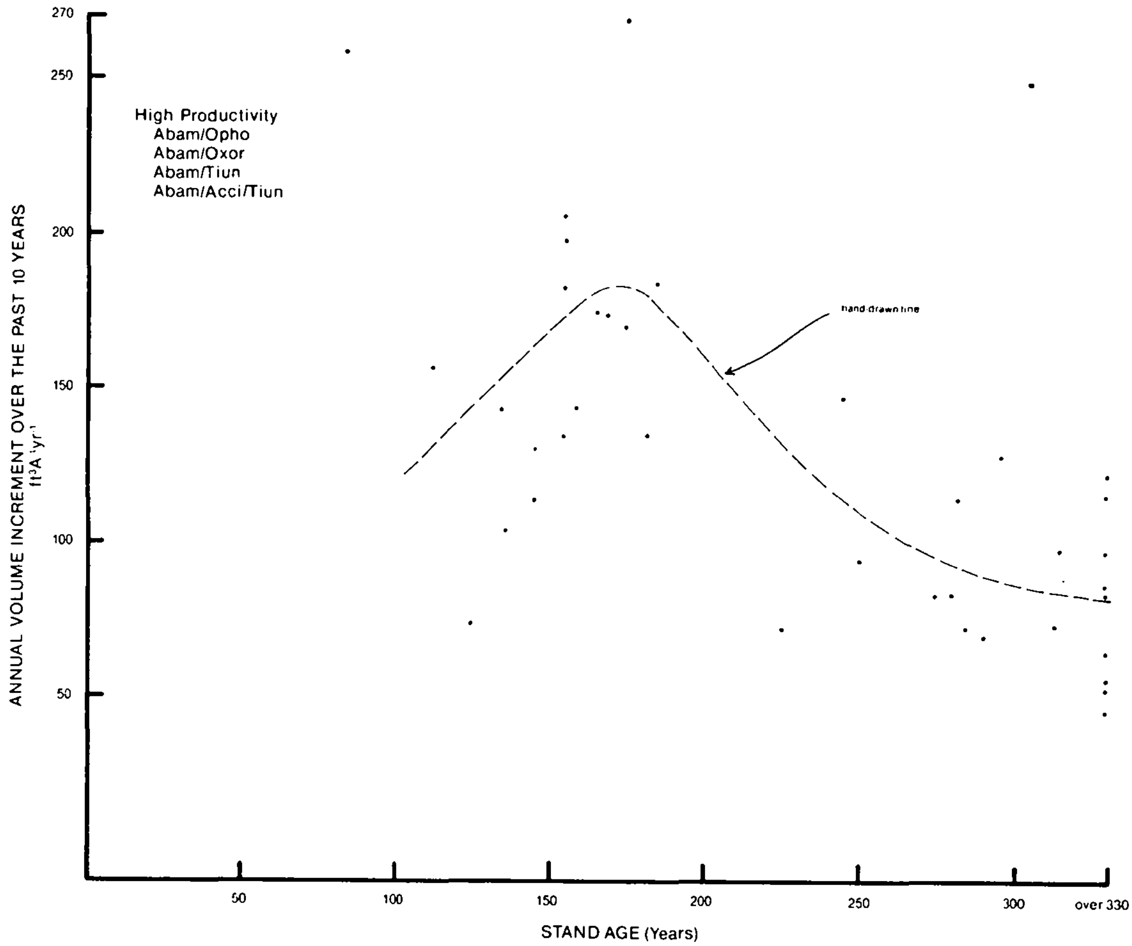
Douglas-fir height/age relationships on less productive sites in the Pacific silver fir zone.



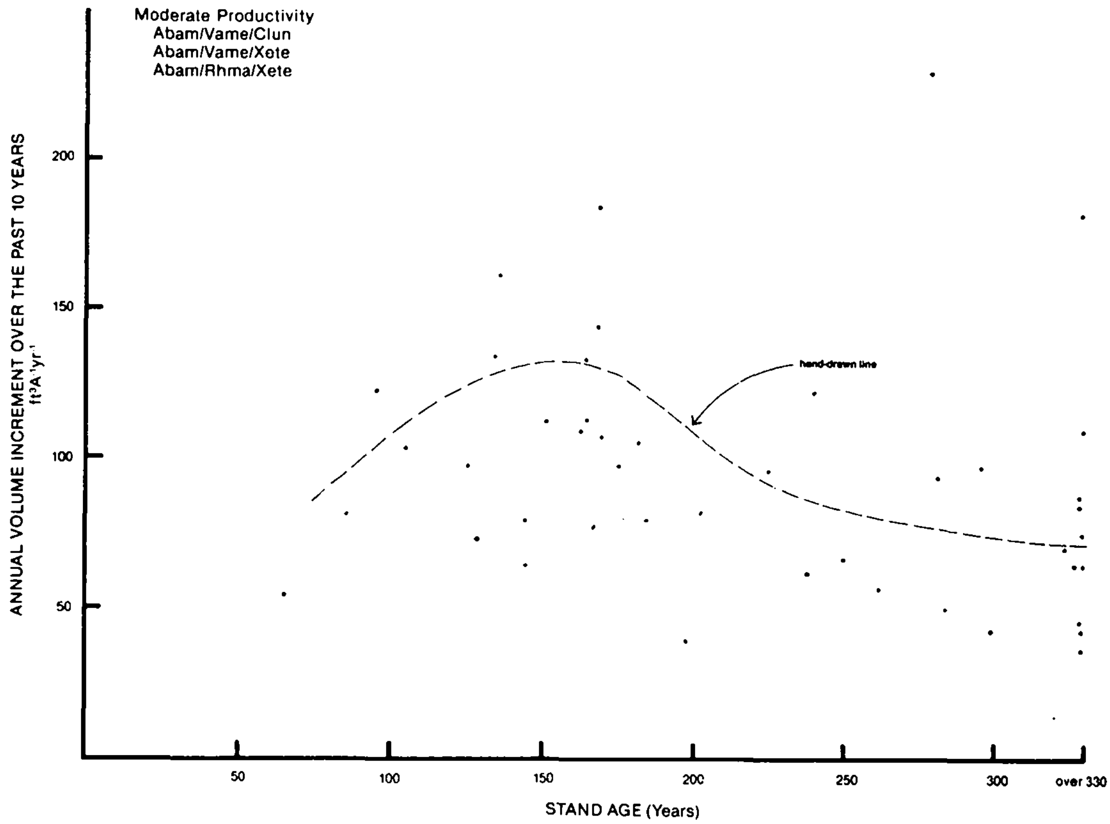
Mountain hemlock height/age relationships on more productive sites in the Pacific silver fir zone.



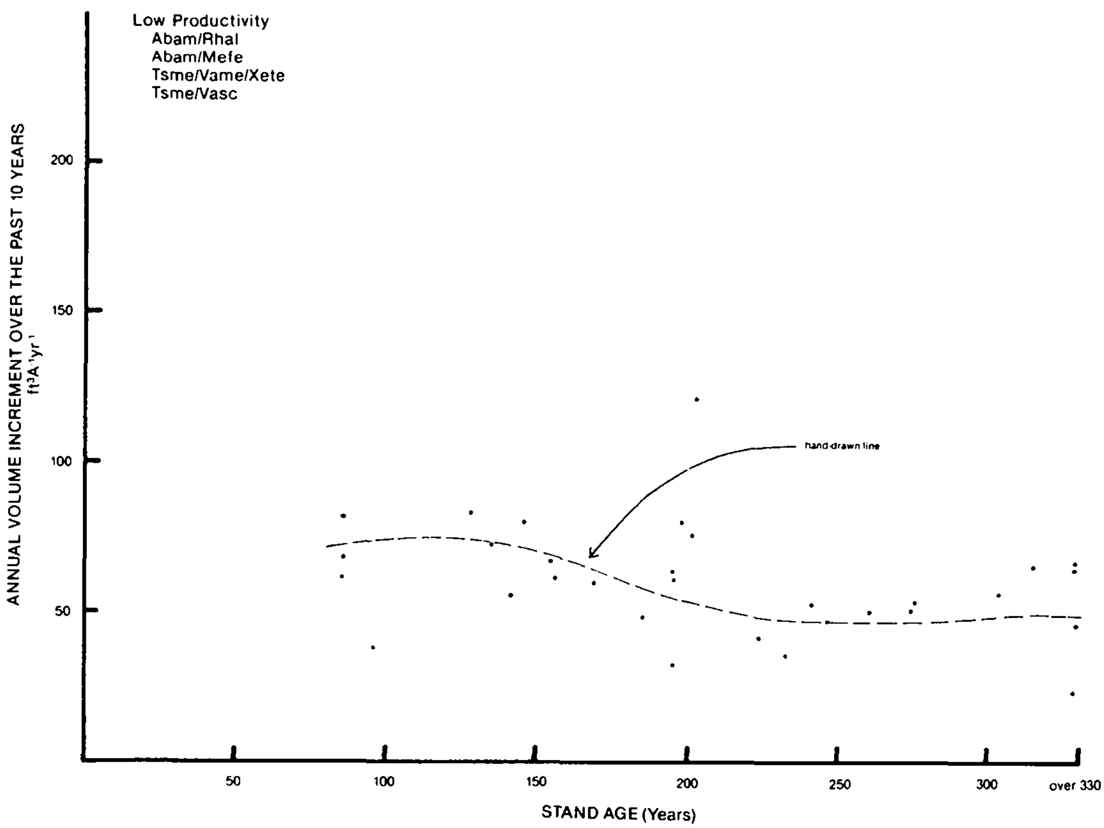
Mountain hemlock height/age relationships on less productive sites in the Pacific silver fir zone.



Annual volume increment over the past ten years for highly productive associations.



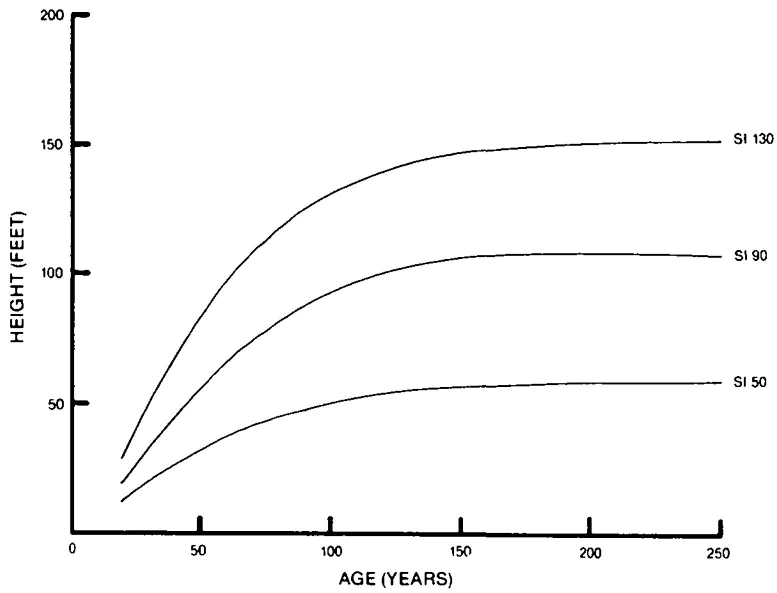
Annual volume increment over the past ten years for moderately productive associations.



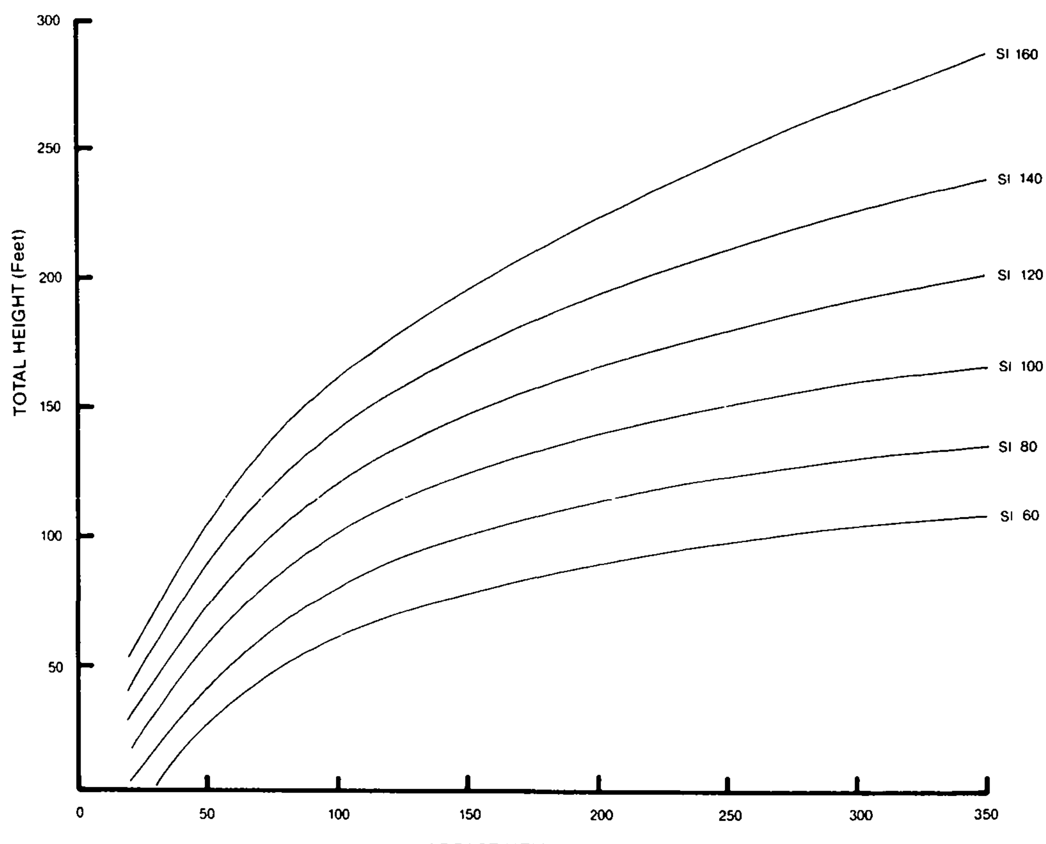
Annual volume increment over the past ten years for low productivity associations.

APPENDIX III

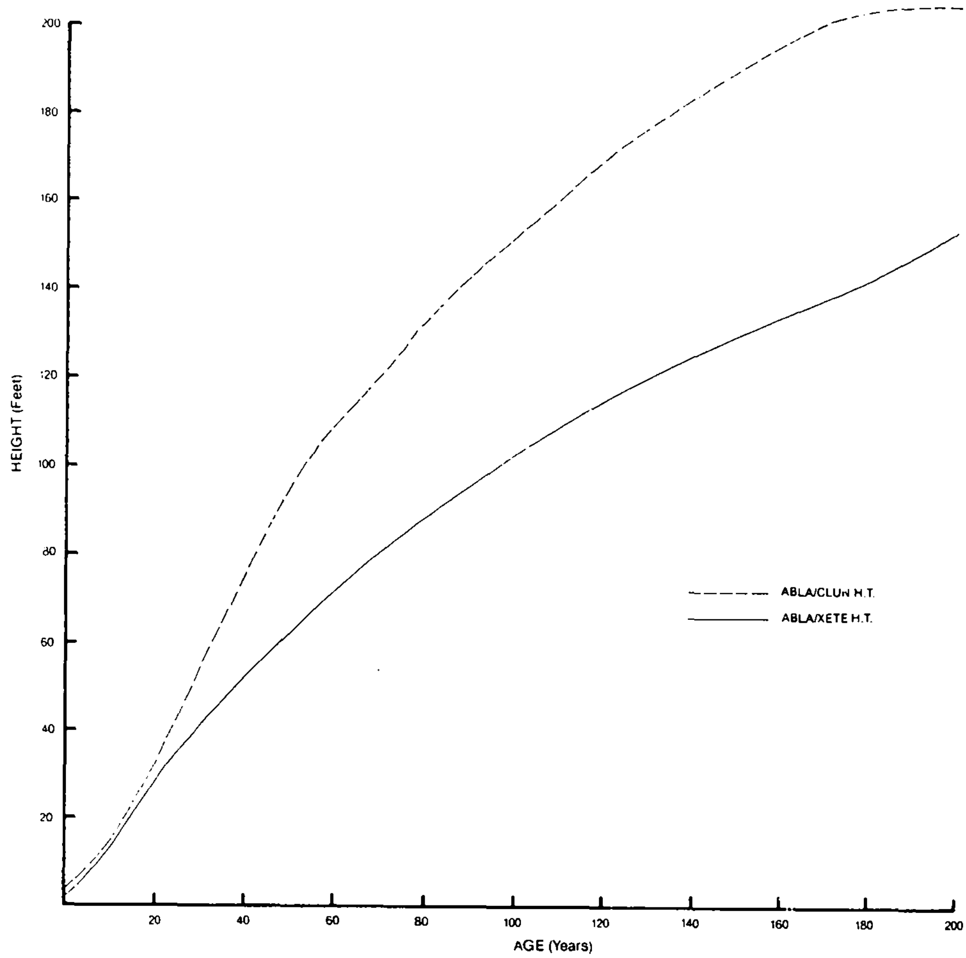
RECOMMENDED HEIGHT GROWTH CURVES



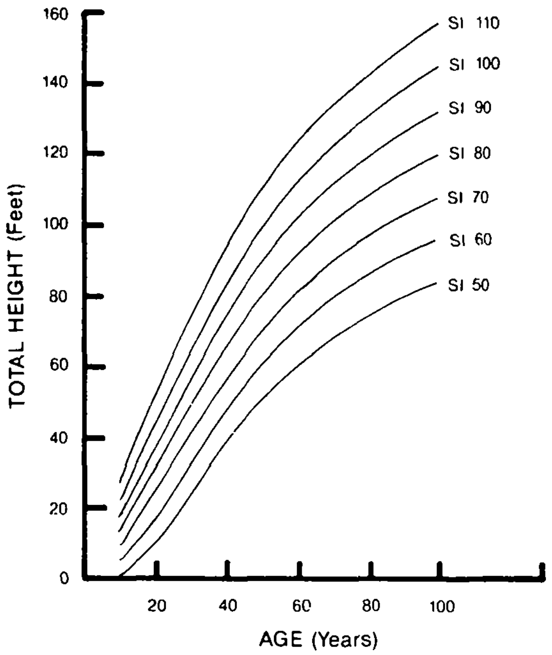
Site Index Curves for Pacific silver fir (Hegyi, et al. 1981).
Index Age 100.



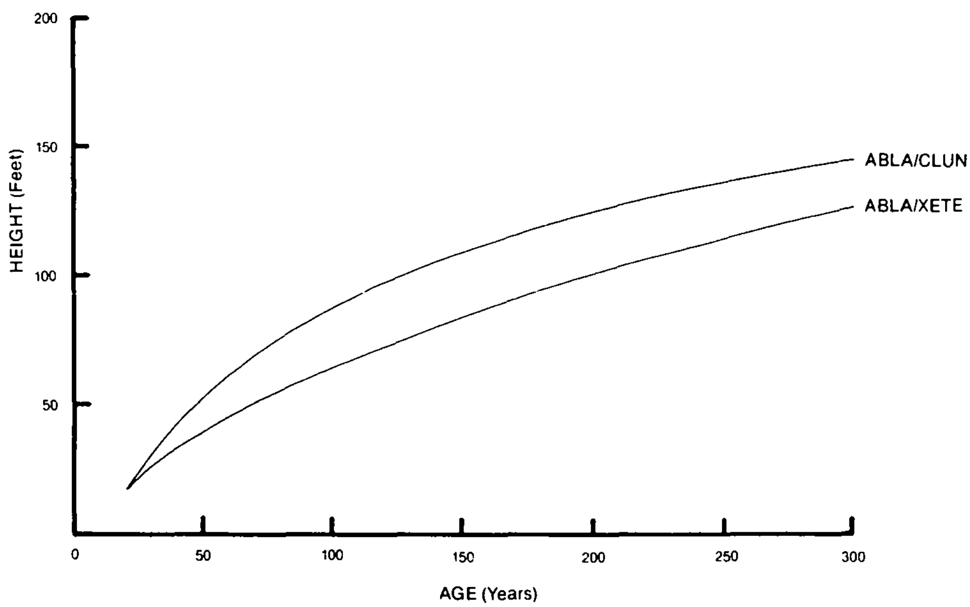
Site Index Curves for high-elevation Noble fir (Herman, et al. 1978).
Index Age 100.



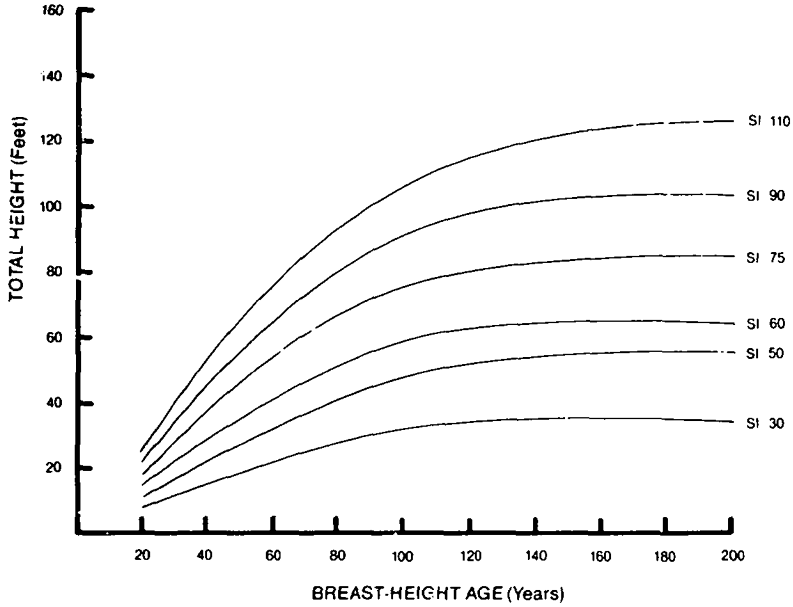
Predicted height growth of western white pine in two habitat types from the Clearwater National Forest (Intermountain Region) (Wykoff et al. 1981).



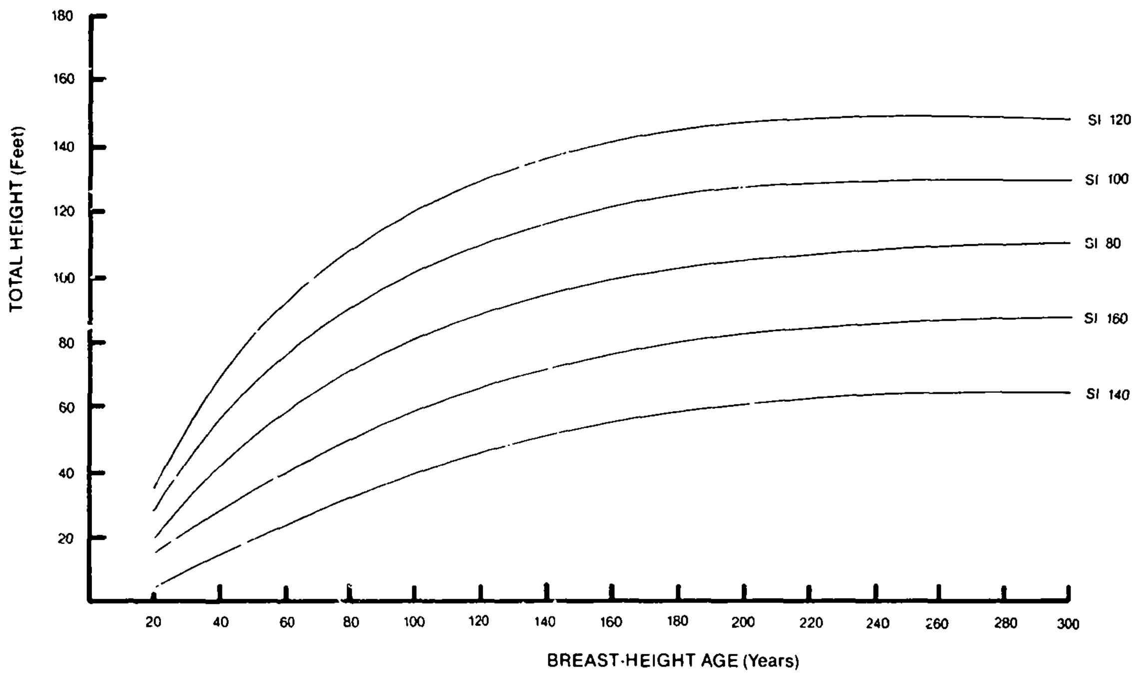
Site Index Curves for white or grand fir (Cochran, 1979). Index Age 100.



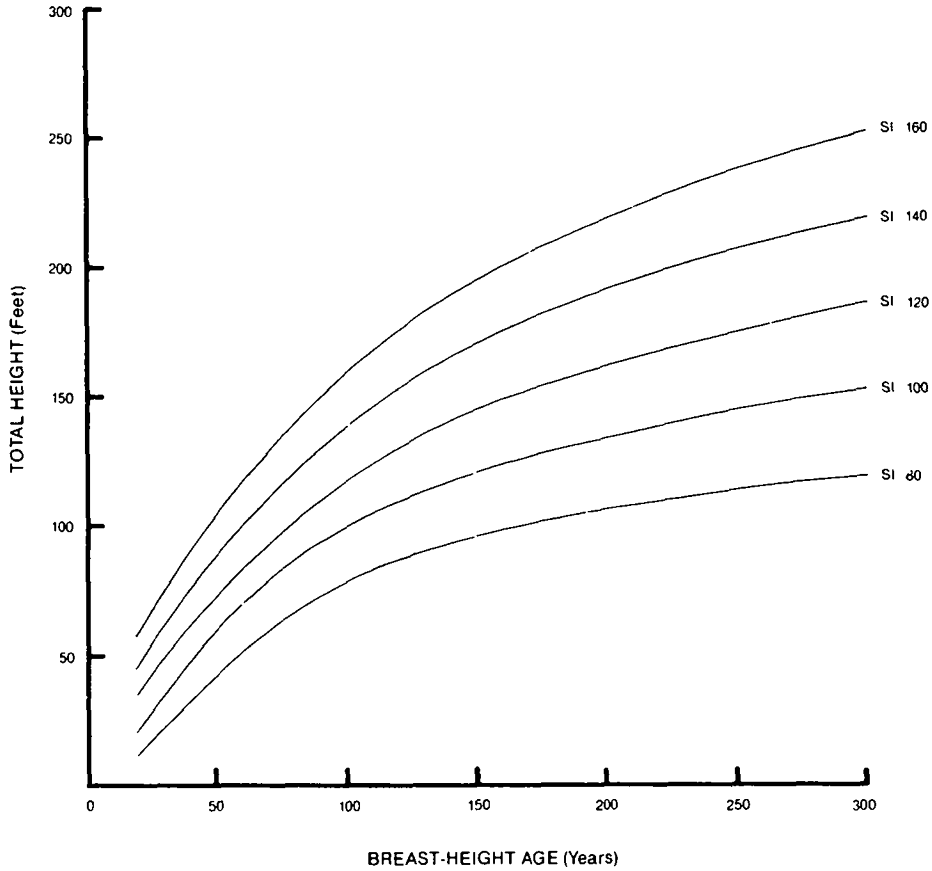
Predicted height growth of subalpine fir in two habitat types from the Clearwater National Forest (Intermountain Region) (Wykoff et al, 1981).



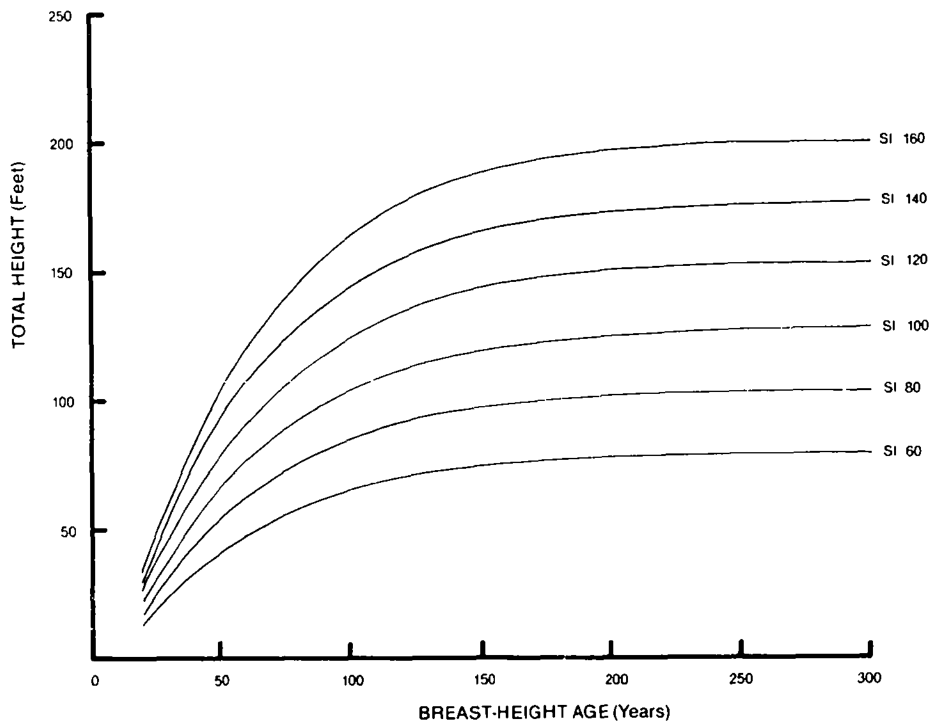
Site Index Curves for lodgepole pine (Dahms, 1964).
Index Age 100.



Site Index Curves for Engelmann spruce in Colorado (Alexander, 1967).
Index Age 100.



Site Index Curves for high-elevation Douglas-fir (Curtis, et al. 1974). Index Age 100.



Site Index Curves for mountain hemlock from Silviculture Practices Handbook (FSH 2409.26d.61.3). Index Age 100.