United States Department of Agriculture

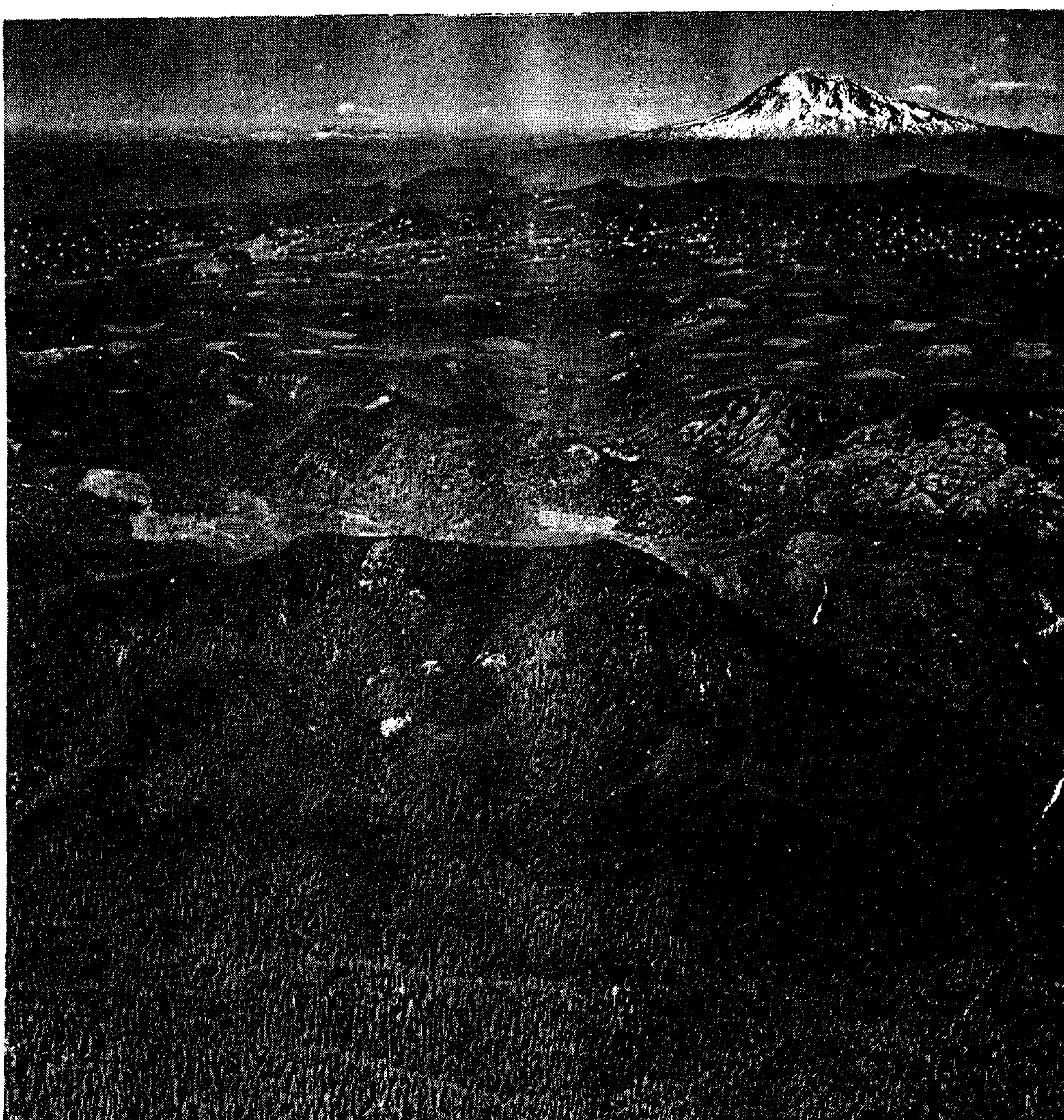
Forest Service

Pacific Northwest Region

R6-Ecol-130a-1983

Plant Association and Management Guide for the Pacific Silver Fir Zone

Gifford Pinchot National Forest



Plant Association and Management Guide for the Pacific Silver Fir Zone

Gifford Pinchot National Forest

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R6-Ecol-130a-1983
June 1983

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Introduction

The study of plant communities provides useful information about the environment in which they occur. Communities are a product of long term interaction between factors in the physical environment and the organisms present. Environmental factors such as temperature, moisture, light and nutrients act as selective influences on plant populations, favoring species best adapted to a particular type of site. While random chance and genetic adaptation within species are also important in the development of community composition and structure, research by Waring (1969) and Zobel et al. (1976) has documented the relationship between plant communities and the complex of environmental factors which influence them.

Although discontinuities may be found (Whittaker 1962), generally the composition of vegetation varies continuously over the landscape (Ramensky 1924, Gleason 1926, McIntosh 1967). As a management convenience, vegetation can be aggregated into discrete units (associations) based on dominant overstory, understory and indicator species which characterize environmental conditions on similar sites. This concept is similar to that of habitat type (Daubenmire 1968, Franklin 1966, Pfister et al. 1977) except that the land area upon which the association occurs is not included.

An understanding of the basic environmental factors that operate in an association allows better prediction of the results of natural processes and management actions. Sites occupied by similar plant associations may be expected to respond similarly to silvicultural treatment. Management considerations such as frost, snowpack, soil compactability, drought, regeneration potential, productivity and susceptibility to perturbation can be related to plant associations.

This guide is intended for use by forest land managers of the Gifford Pinchot National Forest. It is designed to help classify stands or sites into associations so that previous research and management experience pertinent to that plant community can be implemented. Specifically, it can be used as an aid in (1) identifying plant associations in the field during project level work, (2) stratifying future inventory sampling and (3) future mapping activity required for land management planning decisions. Its contents include (1) a summary of associations and their characteristic environments, (2) a discussion of association management considerations, (3) a key to the associations which can be used for field identification and (4) detailed descriptions of the physiography, soils, vegetation, regeneration and productivity of each association which should be used to verify identification and develop management options. For convenient field use, the major aspects of this guide have been condensed into pocket sized format (Brockway et al. 1983). Additional copies of these publications are available through the Forest Supervisor's Office in Vancouver, Washington.

The plant associations described in this guide are important tools for the land manager. They provide a basis for communicating research information and management experience and for choosing among management alternatives. These associations are useful as activity planning and land allocation decision tools because knowledge of the important environmental factors influencing various types of sites aids in prediction of long term trends on undisturbed areas as well as responses following management operations.

Methods and Nomenclature

Methods

The vegetation, soil and site data used in formulation of this guide were collected throughout the forested portion of the Pacific silver fir (ABAM) zone (Franklin and Dyrness 1973, Franklin 1966) and the lower portion of the mountain hemlock (TSME) zone of the Gifford Pinchot National Forest. Future editions of this guide will include ecological information collected in the remaining portion of the mountain hemlock series, subalpine fir (ABLA2) forests and parkland, non-forest vegetation, grand fir (ABGR) series, western hemlock (TSHE) series and riparian vegetation.

The major objective of our sampling was to include a wide variety of long term stable plant communities throughout the middle to upper elevations of the forest. Circular 0.05 acre (0.02 ha) plots were established in selected undisturbed stands occurring on a variety of aspects, elevations and slopes. Sampled stands met the following criteria: (1) at least 75 years old, (2) relatively undisturbed and (3) relatively uniform in vegetation composition and cover within the area sampled. This guide is based upon data from 318 reconnaissance plots, 101 of which were intensively sampled to obtain production estimates (Figure 1).

Data collection consisted of (1) ocular estimates of tree, shrub and herb cover by species, (2) height, diameter (dbh) and radial growth measurements of dominant and codominant trees, (3) basal area determination of stand and of each species by diameter class, (4) soil surface and soil profile description and (5) assessment of site location, elevation, aspect, slope, landform and microtopography. A summary of detailed sampling procedures is available from the Forest Ecologist, USDA Forest Service, Vancouver, Washington. Data collected from field plots were evaluated using standard computational techniques and procedures in Region 6 Ecological Programs (Volland and Connelly 1978). Procedures included association tables, similarity index and cluster and discriminate analyses.

Nomenclature

Although the plant associations described here are discussed as though they are discrete units, it is important to bear in mind that they represent conceptual abstractions. Their description as discrete units is a management convenience. Ecotones of transition vegetation may be frequently encountered when assessing composition in the field.

We have classified long term stable vegetation on two basic levels: series and association (Table 1). The "long term stable state" is the stand condition which is normally achieved following 300 years without disturbance. The Pacific silver fir series exists wherever the long term stable vegetation will have at least 10% cover of Pacific silver fir. This criterion effectively separates the Pacific silver fir series from the western hemlock series and subalpine fir series wherever they interface. The mountain hemlock series exists wherever the long term stable vegetation will have at least 10% mountain hemlock. This criterion separates the mountain hemlock series from the Pacific silver fir series where they interface. Stand development is usually sufficient to allow series identification between 50 and 100 years after stand formation. Series may also be inferred from adjacent stands. The series corresponds to the first two digits of the six digit TRI ecoclass code.

Series are divided into associations based on the dominant species in the understory which are indicative of the ambient environmental conditions. These may be shrub or herb species which exhibit prominent indicator value. An example of an association described by tree/shrub/herb assemblage would be Pacific silver fir/big huckleberry/beargrass (ABAM/VAME/XETE). An example of the singular importance of an herb in association nomenclature would be Pacific silver fir/coolwort foamflower (ABAM/TIUN). The association corresponds to the last four digits in the TRI ecoclass code.

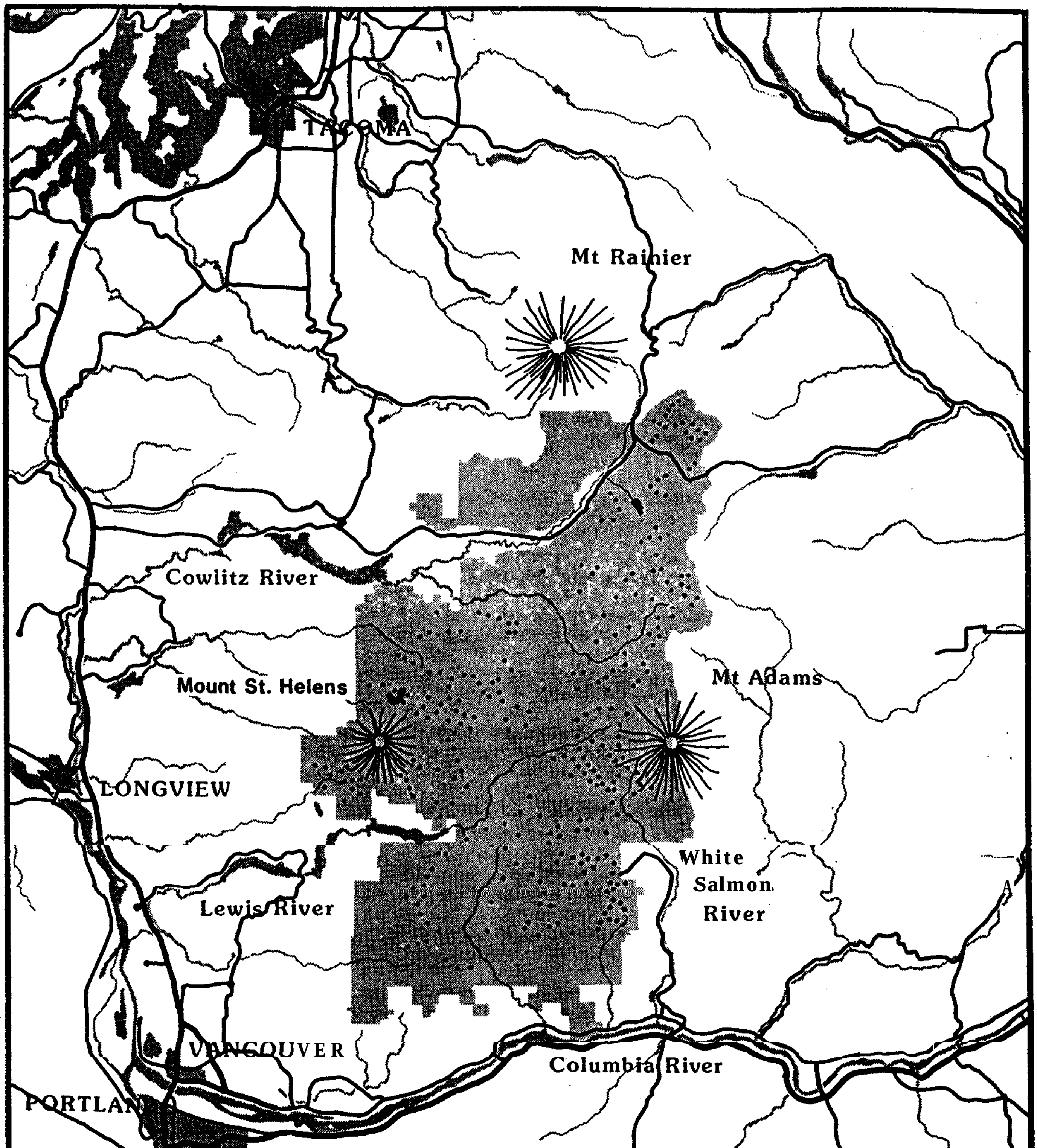


Figure 1: Pacific silver fir and mountain hemlock plot locations

Table 1: Names, abbreviations and ecoclass codes of the upper elevation associations of the Gifford Pinchot National Forest

Association	Scientific Name	Abbreviation and Ecoclass Code
Pacific silver fir/ salal association	Abies amabilis/ Gaultheria shallon	ABAM/GASH CF S1-52
Pacific silver fir/dwarf Oregon grape association	Abies amabilis/ Berberis nervosa	ABAM/BENE CF Sl-51
Pacific silver fir/ vanillaleaf-queencup beadlily association	Abies amabilis/ Achlys triphylla- Clintonia uniflora	ABAM/ACTR-CLUN CF F2-53
Pacific silver fir/Alaska huckleberry association	Abies amabilis/ Vaccinium alaskense	ABAM/VAAL CF S2-57
Pacific silver fir/Alaska huckleberry-salal association	Abies amabilis/ Vaccinium alaskense- Gaultheria shallon	ABAM/VAAL-GASH CF S2-55
Pacific silver fir/coolwort foamflower association	Abies amabilis/ Tiarella unifoliata	ABAM/TIUN CF Fl-52
Pacific silver fir/devil's club association	Abies amabilis/ Oplopanax horridum	ABAM/OPHO CF S3-51
Pacific silver fir/Cascades azalea association	Abies amabilis/ Rhododendron albiflorum	ABAM/RHAL CF S5-50
Pacific silver fir/fool's huckleberry association	Abies amabilis/Menziesia ferruginea	ABAM/MEFE CF S2-54
Pacific silver fir/big huckleberry/queencup beadlily association	Abies amabilis/Vaccinium membranaceum/Clintonia uniflora	ABAM/VAME/CLUN CF S2-56
Pacific silver fir/big huckleberry/beargrass association	Abies amabilis/Vaccinium membranaceum/Xerophyllum tenax	ABAM/VAME/XETE CF S2-51
Mountain hemlock/big huckleberry association	Tsuga mertensiana/ Vaccinium membranaceum	TSME/VAME CM S2-10
Mountain hemlock/fool's huckleberry association	Tsuga mertensiana/ Menziesia ferruginea	TSME/MEFE CM S2-21
Mountain hemlock/Cascades azalea association	Tsuga mertensiana/ Rhododendron albiflorum	TSME/RHAL CM S2-23

Plant Associations

An Overview

The plant associations present on the Gifford Pinchot National Forest are typical of the vegetation assemblages occurring in southern Washington Cascades physiographic region bounded by Mt. Adams to the east, Mount St. Helens to the west, Mt. Rainier to the north and the Columbia River to the south. A generalized east-west transect through the Columbia Gorge (Figure 2) shows the spatial arrangement of the major vegetation series present in this area. Environmental gradients in moisture from east (dry) to west (moist) and temperature from low elevation (warm) to high elevation (cold) are readily apparent from occurrence of various series. The western hemlock series occupies the lower elevations (below 3000 feet) generally to the west of the Cascade crest (warm and moist). While the ponderosa pine series also occurs at lower elevations, it is located further to the east (warm and dry). The Pacific silver fir series occupies sites of upper elevation (approximately 3000 to 4300 feet) generally west of the Cascade crest (cool and moist), however, may intergrade to the east with its elevational equivalent, the grand fir series (cool and dry). The mountain hemlock series is present at even higher elevations (approximately 4300 to 5600 feet) throughout the forest (cold environments). The subalpine fir series occurs at the highest elevations (above 5600 feet) where forest may be found upward to the tree line (very cold environments). Non-forested alpine communities occur at elevations above the tree line.

The acreage breakdown of the above series taken from forest TRI records is seen in Table 2. The largest area is occupied by the western hemlock series, 531,792 acres or 40 percent of the total national forest land. At 495,832 acres or 38 percent of the total, the Pacific silver fir zone represents the second largest series present. The grand fir series at 61,278 acres or 5 percent and the subalpine fir series at 51,335 acres or 4 percent of the total are the next largest groups. The mountain hemlock at 8440 acres and the ponderosa pine series at 129 acres represent less than 1 percent of the total.

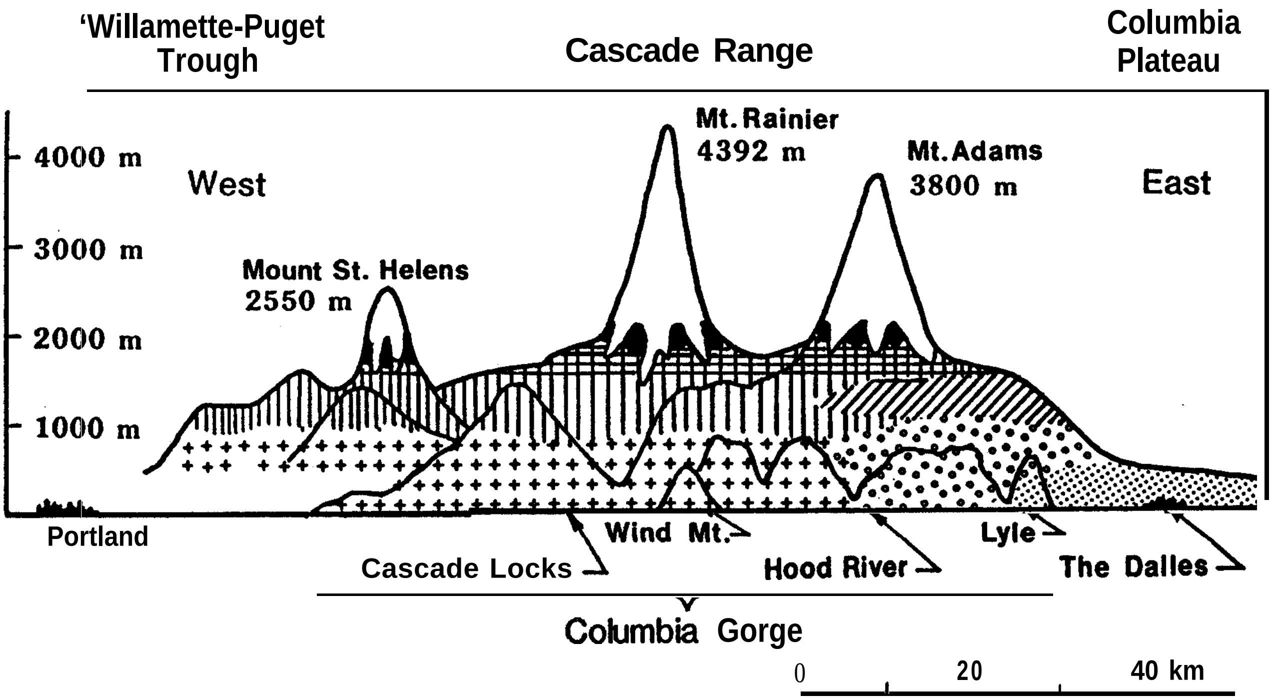
Ecological interpretation

The environmental gradients of moisture and temperature, as we have seen, have a major influence upon the occurrence of the various forest series present on the Gifford Pinchot Natfonal Forest. Within that broader context of environmental gradients influencing the occurrence of each series is a subset of more subtle environmental gradients which largely determine the occurrence of the various plant associations. Again moisture and temperature are prominent influences at this level, but other atmospheric or edaphic factors may be locally important. Figure 3 shows the annual precipitation for the locale. Although precipitation is abundant throughout the forest, variation in the proportion incident as snow versus rafn and variation in soil and air temperatures (Table 3) resulting from elevation, aspect and soil drainage characteristics produces different environmental conditions and the corresponding diversity of plant associations. The plant associations occurring in the upper elevations are shown in Figure 4. Their relationship to one another and to the remaining series on the Gifford Pinchot National Forest is represented along moisture and temperature gradients.

Indicator species have been a useful tool in determining the relative environmental relationship among the various plant associations. Knowledge of the habitat preferences of one plant species or a co-occurring group of species in a particular plant association, can aid in characterizing the environmental conditions of a site occupied by the association. Since associations are identified by their dominant understory vegetation, shrub distribution is of interest (Figure 5). Note that devil's club, Cascades azalea, salal and to some degree fool's huckleberry have limited distribution and are

Table 2: Acreage breakdown of forest series on the Gifford Pinchot National Forest (Forest TRI records 1982)

Series	Acres Occupied	% of Total Area
Western hemlock	531,792	40
Pacific silver fir	495,832	38
Grand fir	61,278	5
Subalpine fir	51,335	4
Mountain hemlock	8,440	0.6
Ponderosa pine	129	0.01
Non-forest	171,547	12.4
Total	1,320,353	100.01



Forests of *Pseudotsuga menziesii* with *Tsuga heterophylla* and *Thuja plicata*

Forests of *Pinus ponderosa* and *Quercus garryana*

Prairie (bunchgrass steppe of *Agropyron spicatum*)

Forests of *Abies amabilis*, *A. procera*, *Pinus monticola*, *Tsuga heterophylla* and *Chamaecyparis nootkatensis*

Forests of *Abies grandis*, *Pinus monticola*, *P. contorta*, P. *ponderosa*, *Larix occidentalis* and *Pseudotsuga menziesii*

Subalpine forests of *Tsuga mertensiana*, *Abies lasiocarpa* and *Pinus albicaulis*

Alpine communities

Snowfields and glaciers

Figure 2: Vegetation profile through the Columbia Gorge and Cascade Range (Troll 1955)

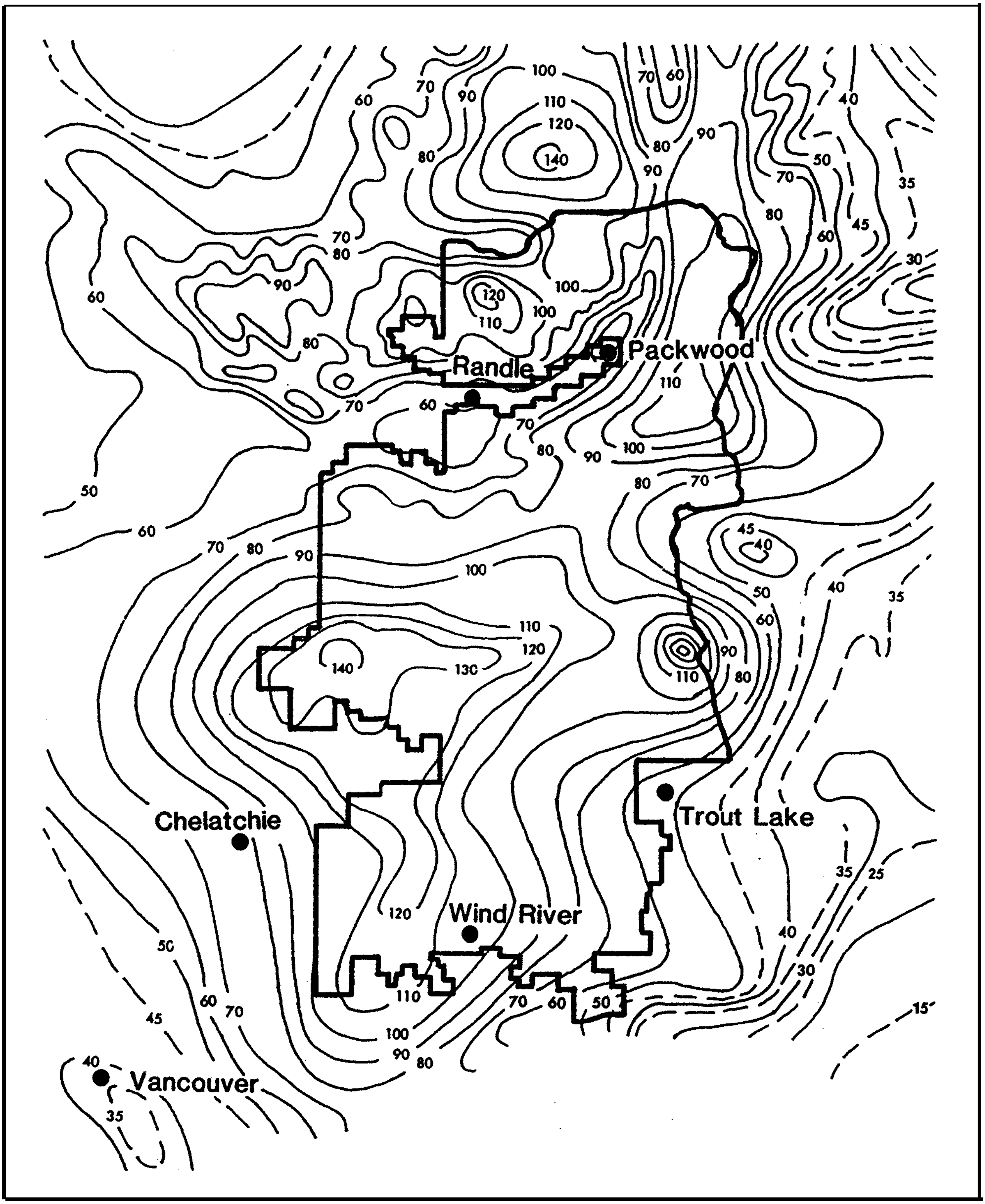


Figure 3: Annual precipitation for the Gifford Pinchot National Forest (U.S. Weather Bureau 1965)

Table 3: Mean air and soil temperatures for selected plant conmunfties in the Pacific silver fir series[1]

Mean Air Temperature (°C) 1978-1980

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Max	Min	Max	Min	Max	Mfn	Max	Min	Max	Min	Max	Mfn	Max	Min	Max	Min	Max	Mfn	Max	Mfn	Max	Min	Max	Min
ABAM/VAME	-2.7	-4.8	•	•	•	•	•	•	7.0	2.2	11.9	4.4	19.6	9.3	17.5	9.8	12.3	6.1	12.5	5.2	4.1	-0.8	0.4	-3.1
ABAM/RHAL	-2.2	-7.6	2.3	-1.8	4.3	-0.4	7.7	2.0	10.8	4.7	13.1	6.0	18.4	10.0	16.6	9.4	14.6	a.1	12.8	6.3	5.0	0.7	2.5	-1.5
ABAM/OPHO	1.5	-2.4	3.9	1.0	5.7	2.0	10.0	5.0	13.3	6.2	16.6	9.0	20.4	11.9	18.8	11.1	16.0	10.2	12.6	7.5	6.5	3.0	3.1	-0.3
ABAM/TIUN	2.6	-1.1	•	•	•	•	•	•	9.7	4.4	15.4	a.0	18.6	10.5	17.8	11.0	15.5	9.1	13.3	7.3	6.7	1.4	3.2	-0.4
ABAM/VAAL	0.3	-4.1	3.2	-0.5	5.4	0.8	8.8	2.2	13.2	5.2	14.9	6.8	19.8	10.3	17.8	10.0	15.8	a.7	14.0	7.2	5.9	1.7	2.9	-1.1
ABAM/BENE	-1.4	-6.2	2.0	-1.7	4.0	-0.9	8.7	1.4	11.4	3.2	15.4	7.0	20.5	9.6	la.1	a.8	13.7	7.0	12.3	4.3	3.3	-1.3	-2.3	-6.9

Mean Soil Temperature (°C) 1978-1980

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ABAM/VAME	1.3	•			1.6	6.1	a.5	9.7	7.7	6.8	2.6	2.7
ABAM/RHAL	2.4	2.4	2.1	2.2	2.8	7.0	11.3	10.3	10.4	a.3	3.9	2.2
ABAM/OPHO	2.2	1.6	1.4	4.0	5.3	a.3	10.6	12.0	11.3	9.4	5.4	2.4
ABAM/TIUN	1.6		•	•	5.4	a.0	10.2	11.2	10.1	a.9	5.1	2.1
ABAM/VAAL	1.8	1.8	1.8	2.0	5.6	7.8	10.9	12.0	10.5	9.0	4.2	2.5
ABAM/BENE	1.0	2.4	1.6	3.0	5.4	7.8	11.0	11.1	9.3	7.8	3.9	1.8

[1]Greene, S. and J. F. Franklin. 1982. Unpublished air and soil temperature data in Pacific silver fir communities of Nfsqually River drainage, Mt. Rainier National Park. (Personal comnuniction). USDA Forest Service. Corvallfs, OR 97331.

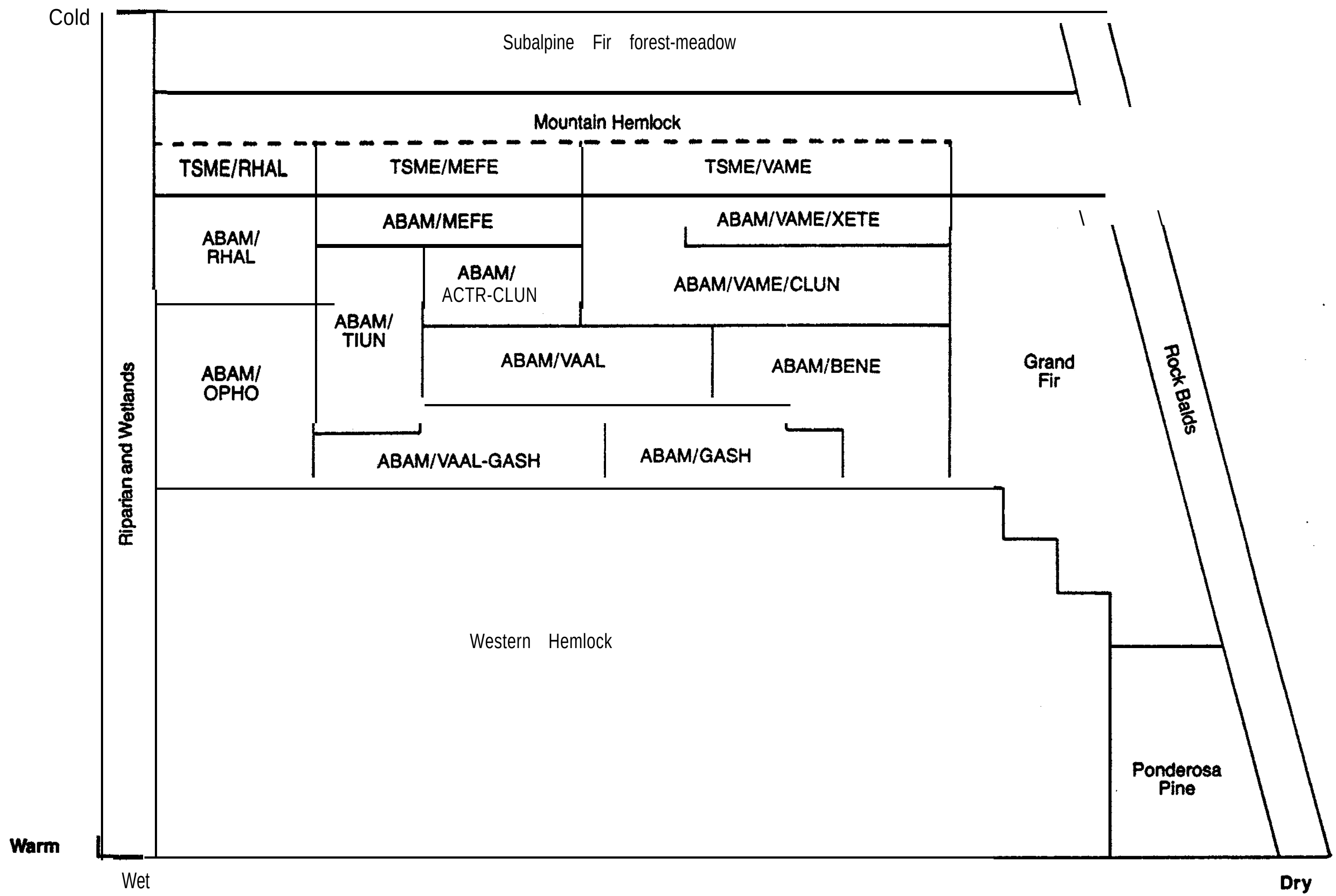


Figure 4: ENVIRONMENTAL RELATIONSHIPS AMONG THE SERIES AND ASSOCIATIONS OF THE **GIFFORD PINCHOT** NATIONAL FOREST

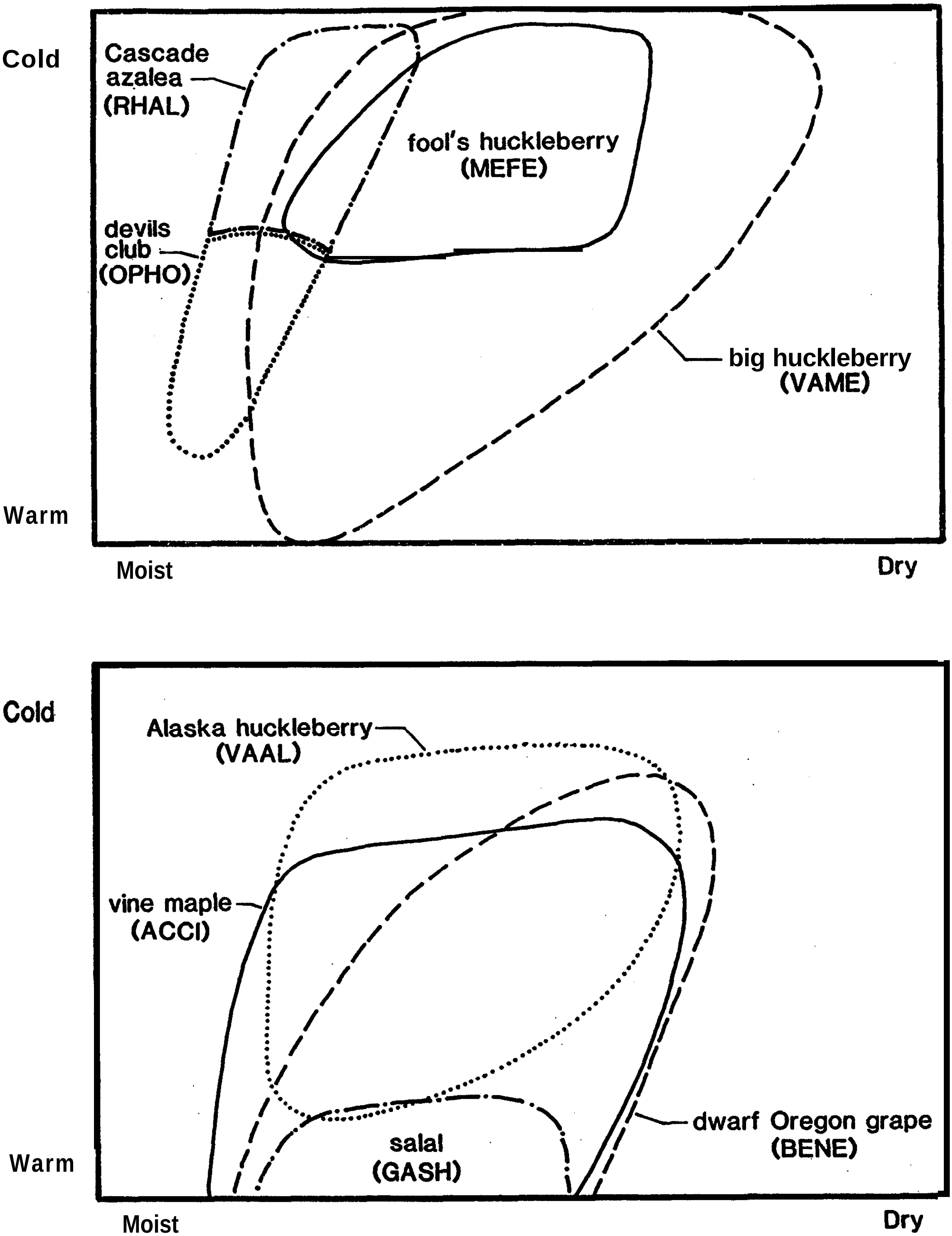


Figure 5: Relative environmental distribution of several shrubs on the Gifford Pinchot National Forest

therefore diagnostic for the types named for them. Several more widespread shrubs, big . huckleberry, dwarf Oregon grape, vine maple and Alaska huckleberry, are less diagnostic because they are more widely distributed and occur frequently outside the associations which bear their names.

The warm shrub group includes baldhip rose (ROGY), trailing snowberry (SYMO), red huckleberry (VAPA), vine maple (ACCI), dwarf Oregon grape (BENE), salal (GASH) and prince's pine (CHUM) and is often associated with good sites for Douglas-fir and noble fir. Salal occurs only at lower elevations on fairly warm sites. Dwarf Oregon grape and prince's pine occur in a wide variety of environments with highest cover on relatively dry, warm areas. Trailing snowberry only occurs on the warmest, driest sites in the Pacific silver fir zone where soils are deep and well-drained. Vine maple occurs in very rocky, dry areas such as talus slopes or rockslides and on relatively moist sites.

Cascades azalea (RHAL) indicates a cold, moist site and does not occur outside of areas where there is a heavy snowpack. Fool's huckleberry (MEFE) and Alaska huckleberry (VAAL) are favored by cool sites which have relatively good drainage. Fool's huckleberry is more narrowly restricted to cooler locales. Devil's club (OPHO) is confined to sites with abundant water during the growing season and generally occurs at lower elevations than Cascades azalea.

Warm site herbs in the Pacific silver fir series include fairybells (DIHO), Oregon bedstraw (GAOR), white hawkweed (HIAL), twinflower (LIBO2), strawberry (FRAGA), western swordfern (POMU) and Pacific trillium (TROV). Western swordfern, twinflower and Pacific trillium are also widespread in the western hemlock zone. Herbs typical of mesic sites, with deeper soils and moderate temperatures, include vanillaleaf (ACTR), white inside-out flower (VAHE), pioneer violet (VIGL), sweetscented bedstraw (GATR), threeleaf anemone (ANDE) and starry solomonplume (SMST). Rosy twistedstalk (STRO), sitka valerian (VASI) and coolwort foamflower are herbs which indicate cooler, moist sites within the Pacific silver fir zone. Very moist site species which are generally associated with abundant moisture and rich soils include oak fern (GYDR), Siberian montia (MOSI) and, on warm sites, Oregon oxalis (OXOR), baneberry (ACRU), brewer miterwort (MIBR), ladyfern (ATFI) and deerfern (BLSP). Siberian montia also occurs in places where there is a high water table during the early part of the growing season, especially at lower elevations. Horsetail (EQAR) indicates a high water table and may invade disturbed areas. Geargrass (XETE) is very widespread, but attains its highest coverage on cold and dry habitats. It is nearly ubiquitous in the Pacific silver fir associations except for very rich and moist sites.

Douglas-fir (PSME) and noble fir (ABPR) are the most common seral species on warmer, well-drained sites (Table 4). Douglas-fir is found in all associations within the Pacific silver fir zone and therefore has little indicator value. Its long life span, light seed and adaptiveness have insured widespread distribution. Noble fir is erratic in its distribution because of its heavy seed and relatively short life span. It is a seral tree species, generally dropping out of stands after they reach 350 years of age.

Western hemlock (TSHE) and Pacific silver fir (ABAM) are the most widespread trees in the Pacific silver fir zone. They are typically thought of as climax species because they both are tolerant. Because Pacific silver fir is more frost hardy and resistant to snow breakage than western hemlock (Thornberg 1969), it will dominate on cooler habitats. Given a site with sufficient moisture, both western hemlock and

Table 4: Distribution of tree species by association*

Association	ABAM	ABPR	TSME	TSHE	PSME	PIEN	ABLA2	PIMO	PICO	LAOC	THPL	CHNO
TSME/RHAL	C		C	c	s	s	s			s		c
TSME/MEFE	C	s	C	c	s	s	s		S			
TSME/VAME	C	s	C	c	s	s	s	S	S	s		
ABAM/VAME/XETE	C	S	c	c	s	s		S	s			
ABAM/VAME/CLUN	C	S	c	c	S	s			s			
ABAM/MEFE	C	s		c	S	s		s	s			
ABAM/RHAL	C	S	c	c	S	s			s			
ABAM/OPHO	C	S		c	S						c	c
ABAM/TIUN	C	S		C	S						c	
ABAM/VAAL	C	S		C	S						c	
ABAM/ACTR-CLUN	c	S		c	S						c	
ABAM/VAAL-GASH	C	s		c	S						C	
ABAM/BENE	C	s		C	S						c	
ABAM/GASH	C	s		C	S						C	

*C = major climax species
c = minor climax species
S = major seral species
s = minor seral species

Pacific silver fir can play a seral role. In the Pacific silver fir zone of the Cascades, western hemlock often has played a pioneer role in older stands which now have little western hemlock regeneration. It appears to have moved upslope as a pioneer in open areas. This may be explained by the greater moisture supply and lower evaporative demand found at the higher elevations.

Mountain hemlock (TSME), when found in abundance in the overstory and the regeneration layer, indicates a cold site. Alaska yellow-cedar (CHNO) is found at high elevations on moist sites. Both mountain hemlock and Alaska yellow-cedar occur up to timberline, indicating they are highly adapted to cold, extreme environnments. Lodgepole pine (PICO) and western larch (LAOC) are early succession invaders on the eastern side of the Cascades where the rain-shadow effect creates a drier environment. Lodgepole pine also pioneers on deep pumice or lava flows and may persist there for hundreds of years.

Several other tree species occur in a more or less predictable pattern. Western redcedar (THPL,) is a warm site indicator within the Pacific silver fir zone, occurring only in the lower elevation warmer associations. Western white pine (PIMO) occurs sporadically in many types:, having been greatly reduced in importance by white pine blister rust. Subalpine fir (ABLA2) regenerates best at the upper margin of the closed forest stands, although it may occur occasionally in other locations. Engelmann spruce (PIEN) is generally found in frost pockets, either on flat ridgetops or in moist depressions. It is capable of developing a spreading root system, suiting it to sites with high water tables.

Table 5 summarizes the descriptive characteristics of the environments occupied by the various associations of the upper elevations. The mountain hemlock/Cascades azalea (TSME/RHAL) association, mountain hemlock/fool's huckleberry (TSME/MEFE) association, mountain hemlock/big huckleberry (TSME/VAME) association and Pacific silver fir/big huckleberry/beargrass (ABAM/VAME/XETE) association are typically encountered at high elevations on sites with-north tending aspects. This results in cold temperatures, heavy snowpacks and occasionally high water tables. Sites occupied by ABAM/VAME/XETE have southerly aspects and are slightly warmer and drier than those of the TSME associations. The Pacific silver fir/Cascades azalea (ABAM/RHAL), Pacific silver fir/devil's club (ABAM/OPHO), Pacific silver fir/big huckleberry/queencup beadlily (ABAM/VAME/CLUN) and Pacific silver fir/fool's huckleberry (ABAM/MEFE) associations are characterized by cool environments on sites tending to north aspects, positioned on benches to upper slopes. The Pacific silver fir/coolwort foamflower (ABAM/TIUN), Pacific silver fir/Alaska huckleberry (ABAM/VAAL) and Pacific silver fir/vanillaleaf-queencup beadlily (ABAM/ACTR-CLUN) associations occupy mesic sites which are influenced by moderate environmental conditions. The Pacific silver fir/Alaska huckleberry-salal (ABAM/VAAL-GASH), Pacific silver fir/dwarf Oregon grape (ABAM/BENE) and Pacific silver fir/salal (ABAM/GASH) associations are found at lower elevations on warm sites bordering the western hemlock series.

The above associations are readily identified in the field by the presence of indicator plant species. With continued use of the key and increased familiarity with the associations, identification of the associations should require only a few minutes. Generally associations on the warmer end of the environmental spectrum offer the best opportunity for intensive management, while those occupying the environmental extremes require the greatest care to insure that application of silvicultural treatments does not lead to management problems.

Management Considerations

Management characteristics unique to each association are summarized in Table 6. Hazards to regeneration success are subjective estimates of relative severity. The frost hazard is relative assuming other factors such as slope and topographic position are equal. Associations with the lowest frost hazard can, however, develop an increased frost hazard if clearcutting is done in a topographic depression where cold air can accumulate. The snowpack hazard combines snow depth and duration of the snowpack. The drought hazard reflects each association's soil moisture holding capacity and. evaporative demand and the resultant likelihood of drought occurrence affecting planted tree seedlings. Selection of the suitable regeneration species in each association is based on matching the physiological characteristics of the species with the stress factors likely to be important in the ambient environment. Since frost is an important environmental influence on survival and growth, recommendations are provided for slopes less than and exceeding 15 percent. The soil compaction hazard is an expression of each association's tendency to occur on soils susceptible to compaction. Opportunity for intensive management is based on relative productivity, risks to regeneration and soil compactability. Sites in the Pacific silver fir zone and mountain hemlock zone present opportunities for intensive management ranging fromgoodto poor. Sites offering excellent opportunity for intensive management are found only in the lower elevation, more productive western hemlock zone on the Gifford Pinchot National-Forest.

Soils

The soils present in the upper elevations of the Gifford Pinchot National Forest have developed by a variety of processes. Bedrock materials which may function as parent materials are most typically andesite and basalt. Soil profiles are dominated by layers of volcanic ash and pumice from the eruptions of Mt. Rainier, Mt.

Tabie 5: Environmentaf characteristics of tne upper eievation associations of the Gifford Pinchot National Forest

Group	Association	Number of Samples	Vegetation: Tree Cover (%)	Vegetation: Shrub Cover (%)	Vegetation: Herb Cover (%)	Physiography: Elevation Mean (Feet)	Physiography: Elevation Range (Feet)	Physiography: Aspect	Physiography: Slope Mean (%)	Physiography: Slope Range (%)	Physiography: Landform and Slope Position	Soil: Total Depth Mean (Inches)	Soil: Total Depth S.D. (Inches)	Soil: Effective Rooting Depth* Mean (Inches)	Soil: Effective Rooting Depth* S.D. (Inches)	Soil: Litter Depth Mean (Inches)	Soil: Litter Depth S.D. (Inches)
Cold																	
	TSME/RHAL	9	61	68	19	4644	(4000-5300)	NW,N,NE	29	(8-68)	Upper slopes and flats	53	13	37	14	1.9	0.8
	TSME/MEFE	10	58	65	36	3955	(3300-4400)	NW,N,NE,E	12	(2-43)	Upper slopes, ridges and flats	61	22	46	13	2.3	2.3
	TSME/VAME	13	63	42	29	4362	(3300-5700)	W,NW,N,NE	22	(11-49)	Upper to lower slopes	43	22	33	12	1.3	0.9
	ABAM/VAME/XETE	13	61	37	29	3831	(2900-4800)	W,SW,S, SE,E	18	(O-55)	Middle slopes, ridges and flats	50	14	33	10	1.7	1.6
Cool																	
	ABAM/OPHO	25	60	67	68	3728	(2600-4600)	Variable	36	(2-67)	Lower slopes and benches	60	18	43	16	2.4	2.3
	ABAM/RHAL	18	67	64	38	4272	(3600-5300)	NW,N,NE	28	(4-63)	Upper slopes and benches	49	19	30	11	1.7	1.1
	ABAM/MEFE	37	66	58	30	3673	(2900-4500)	NW,N,NE	25	(O-66)	Middle to upper slopes	64	22	39	13	1.8	1.0
	ABAM/VAME/CLUN	26	69	31	40	3781	(3100-4900)	W,SW,S, SE,E	21	(O-75)	Middle slopes and benches	46	14	33	10	1.3	0.6
Mesic																	
	ABAM/TIUN	36	71	39	44	3342	(1500-5000)	Variable	36	(O-80)	Upper slopes and flats	62	16	39	31	1.7	1.2
	ABAM/ACTR-CLUN	42	73	56	50	3426	(2700-4500)	W,SW,S,SE	34	(2-76)	Middle slopes and flats	53	18	33	16	1.5	0.7
	ABAM/VAAL	42	69	44	13	3355	(2500-4200)	W,SW,S, SE,E	24	(2-75)	Middle slopes	58	18	37	15	2.1	2.0
Warm																	
	ABAM/GASH	13	74	50	27	2631	(1100-3600)	SW,S,SE,E	33	(O-66)	Middle to lower slopes	60	18	37	14	1.2	1.1
	ABAM/BENE	17	77	40	26	3459	(2600-4600)	W,SE,S,SE	36	(13-70)	Middle to lower slopes	48	16	26	19	1.6	0.8
	ABAM/VAAL-GASH	17	69	66	17	2806	(1900-4700)	Variable	22	(2-45)	Middle to lower slopes	61	24	44	23	1.8	1.0

*Calculated by plot as the sunation of (100 - % Coarse Fragments) X (Horizon Thickness) X 0.01

Adams, Mt. St. Helens and local cinder cones. The other major influence on soil profiles has been colluvial deposition of a mixture of materials from the normal erosion process. Colluvium is often interbedded with pumice. Alluvial and glacial deposits are also locally important. Soils are moderately deep, averaging 50 inches or more in total depth. Fairly high proportions of coarse fragments are present in the profiles, limiting rooting space and the soil water holding capacity.

In the area northeast of Mount St. Helens, large amounts of lapilli compose the entire soil profile. The 1980 eruptions of Mount St. Helens have deposited additional pumice 'and ash layers of variable thickness in this area covering the former soils and, in the case of deep deposits, burying the vegetation present. These ash and lapilli deposits are characterized by coarse particle sizes, relatively high bulk densities and low nutrient content (Klock 1981). They are also subject to substantial sheet and rill erosion (Swanson et al. 1982) in the absence of stabilizing vegetation. Of local importance are pyroclastic flows, debris flows and mudflows which are also low in nutrients and quite variable in their respective stratigraphy, texture and moisture holding properties.

Compaction is the foremost soil related management problem in the Pacific silver fir zone and mountain hemlock zone. Compaction is a long lasting problem, the effects of which may require many years to diminish. Susceptibility to compaction is dependent upon the proportion of clay and silt sized particles in the soil and the moisture content of the soil at the time traffic occurs. Equipment design such as catapillar tracks or high flotation tires will abate the compacting load influence to some degree, but conventional wheels can cause 90 percent of the total potential compaction damage to a susceptible soil during the first pass over a skid trail. The TSME/RHAL, ABAM/RHAL, ABAM/OPHO and ABAM/TIUN associations generally occur on soils which are moist during a significant portion of the year and therefore susceptible to compaction. Compaction in the relatively productive associations can greatly reduce establishment success, growth and yield. High water tables characteristic of these associations, coupled with compaction, could lead to overland runoff and severe erosion problems.

Nutrient Cycling

Plant nutrients, particularly nitrogen, may be limiting to growth in many of the shallow, coarse textured or rocky soils in the Pacific silver fir zone and mountain hemlock zone. Nitrogen capital on sites with cindery andeptics developed from recent volcanic ejecta deserve particular concern in this regard. These soils occur widely in the high Cascades of western Washington and are characterized by low colloidal content, thus a low ability to retain site nutrients. Many of the associations do not include nitrogen fixing plants, such as Ceanothus velutinus, during early succession.

Analysis of the forest floor along an elevation transect in the western Cascades has revealed a linear correspondence between elevation and forest floor weight (Topik 1982). At lower elevations (western hemlock series) warmer temperatures have resulted in more rapid decomposition rates and a lower accumulation of organic matter upon the mineral soil (Figure 6, Topik 1982). At higher elevations (Pacific silver fir series and mountain hemlock series) colder temperatures resulted in very slow decomposition rates and a greater accumulation of organic matter upon the mineral soil. As elevation increases, the forest floor becomes the primary reservoir for site nitrogen, thus the importance of the forest floor and the need for its protection becomes greater (Figure 7, Topik 1982).

Nitrogen capital of Pacific silver fir and mountain hemlock sites is concentrated primarily in the forest floor and above ground vegetation. As a result, 60 percent of the fine (feeder) roots of an upper elevation stand are concentrated in the forest floor organic horizons which generally range from 2 to 4 inches in depth (Grier et al. 1981). Cold temperatures and excessive moisture in many upper elevation associations result in very slow rates of nitrogen mineralization and cycling.' Intensified management practices which extract biomass from these types at an accelerated rate, such as whole tree harvesting, or destroy the organic horizons of the forest floor, such as . slash disposal by burning, are likely to deplete site nitrogen reserves at a pace which could lead to decreased site productivity (Swank and Waide 1980).

Harvest of tree boles in upper elevation associations generally results in a small nitrogen loss which can generally be sustained, occurring once in each 110 to 150 year rotation. The presence of shrubs such as Alnus sinuata, which can fix 30 lbs. of nitrogen per acre per year, may aid in site recovery (Binkley 1982). If harvest, however, is followed by fire which destroys the forest floor and residual slash, 60 to 80 percent of the site's nitrogen capital may be lost (DeBell and Ralston 1970) amounting to 1000 to 1400 pounds of N per acre[1]. Nitrogen loss through volatilization during burning is proportional to the amount of organic matter consumed. Losses as modest as 200 to 500 lbs. per acre, common during slash burning, while not as critical in more productive associations, can result in N deficiency and a depression in productivity on more severe sites. Slash disposal on clearcut units where fuels have had opportunity to dry may produce fires of greater local intensity on

[1] Grier, C. C. 1982. Unpublished data (personal communication). University of Washington. Seattle, WA 98195.

Table 6: Management characteristics of the upper elevation associations of the Gifford Pfnchot National Forest

		Regeneration						
		Relative Hazards			Suitable Species			
Group	Association	Frost Hazard	Snow Pack	**Drought Hazard**	**Less than 15% Slope**	Over 15% Slope	**Soil Compaction** Hazard	**Opportunity for** Intensive Management
Cold								
	TSME/RHAL	**High**	**High**	**Low**	**PIEN TSME*** LAOC **PIMO** PICO **CHNO* ABAM***	**PIEN LAOC TSME* PIMO ABAM***	Moderately high	Poor
	TSME/MEFE	High	High	Moderately low	**PIEN TSME* ABAM* LAOC PICO PIMO**	PIMO LAOC **TSME* ABAM***	Moderate	Poor
	TSME/VAME	High	High	**Moderately** high	PIMO **PICO LAOC TSME* ABAM* PIEN**	**PIMO LAOC TSME* ABAM***	Moderately low	Poor
	ABAM/VAME/XETE	High	Moderately high	Moderately high	**PIMO PICO TSME* ABAM*** LAOC PEIN	ABPR **PIMO ABAM* TSME* LAOC**	Moderately low	Moderate
Cool								
	ABAM/MEFE	Moderately high	Moderately high	Moderately low	**PIMO** ABPR **ABAM*** LAOC **TSME***	ABPR **ABAM* PIMO**	Moderate	Moderate
	ABAM/VAME/CLUN	Moderately high	Moderate	Moderate	PIMO ABPR **PIEN** ABAW	ABPR **PSME PIMO**	Moderately low	Moderate
	ABAM/RHAL	Moderately high	High	**Low**	**PIMO PIEN TSME*** MAW **CHNO***	**PIEN PIMO** ABPR **ABAM***	Moderately high	Poor
	ABAM/OPHO	Moderately high	Moderately high	Low	**ABPR PIEN THPL* ABAM* CHNO***	**PIEN** ABPR **PSME**	High	**Poor**
Mesic								
	ABAM/TIUN	Moderately high	Moderately high	Moderately low	**PIMO PIEN** ABPR **ABAM***	ABPR **PIMO PSME**	Moderately high	Good
	ABAM/VAAL	Moderate	Moderate	Moderate	ABPR **PIMO ABAM***	ABPR **PSME**	Moderate	Good
	ABAM/ACTR-CLUN	Moderate	Moderately low	Moderate	ABPR PIMO **ABAM***	ABPR PSNE	Moderate	Good
Warm								
	ABAM/VAAL-GASH	Moderately **low**	**Moderately** low	Moderate	ABPR **ABAM***	**PSME** ABPR THPL*	Moderately low	Good
	ABAM/BENE	Moderately low	Moderately low	Moderately high	ABPR **ABAM***	ABPR **PSME**	Moderately low	Moderate
	ABAM/GASH	Moderately low	Moderately low	Moderate	ABPR **ABAM***	PSME ABPR **THPL***	Moderately low	Good

*Useful as advanced regeneration

Adams, Mt. St. Helens and local cinder cones. The other major influence on soil profiles has been colluvial deposition of a mixture of materials from the normal erosion process. Colluvium is often interbedded with pumice. Alluvial and glacial deposits are also locally important. Soils are moderately deep, averaging 50 inches or more in total depth. Fairly high proportions of coarse fragments are present in the profiles, limiting rooting space and the soil water holding capacity.

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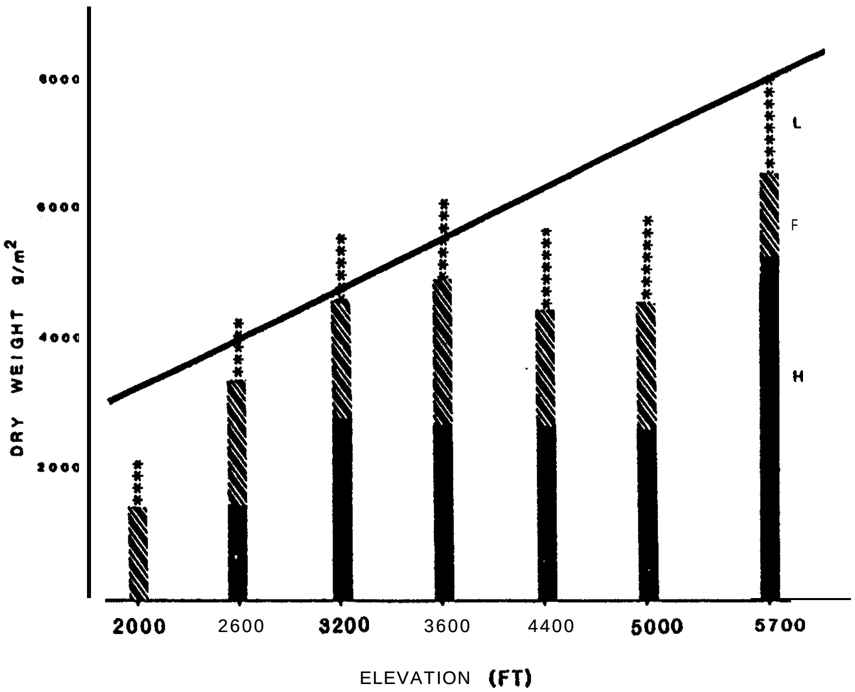

Figure 6: Forest floor dry weight with increasing eievatfon (Topik 1982)

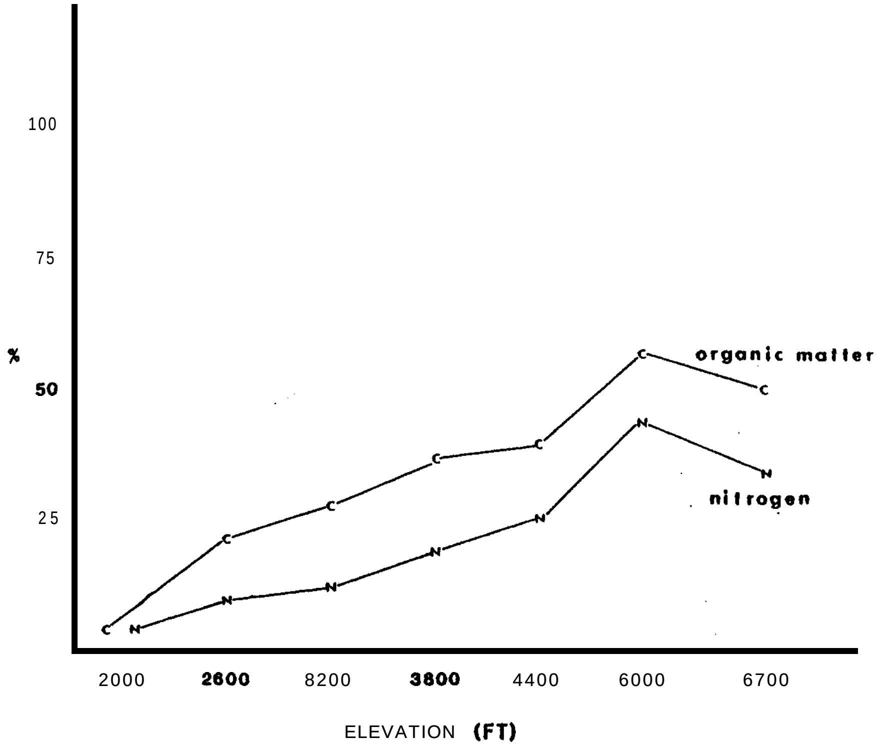

Figure 7: Percent of total soil organic matter and nitrogen 'contained in the forest floor with increasing elevation (Topik 1982)

the forest floor than does wildfire in a natural stand (**Lotan** et al. 1981).

Reducing fire hazard from slash, obtaining prompt regeneration and maintaining site productivity are objectives which seemingly conflict. An evaluation of the environmental conditions in the upper elevation associations reveals the fire hazard in these types to be relatively modest when compared to the heavier fuel loadings of lower elevation forest series. The TSME associations, **ABAM/RHAL** and **ABAM/MEFE** associations appear to be very fire resistant and function as effective fuel breaks (Hemstrom 1982). Moist conditions in the upper elevations further abate the fire hazard here. Burning in the **TSME/RHAL, TSME/MEFE, TSME/VAME, ABAM/VAME/XETE, ABAM/VAME/CLUN, ABAM/RHAL** and **ABAM/MEFE** associations which represent the cooler sites, where soils are relatively less fertile, nutrient cycling proceeds at a slow rate and tree growth modest, is likely to result in diminished site fertility and productivity. Even light burns here may seriously decrease nitrogen capital as well as kill advanced regeneration. The option to burn in the remaining associations, although potentially less harmful to site nitrogen reserves, should be considered on a site by site basis and using a fire intensity not exceeding "light" as defined in Table 7 by Boyer and Dell (1980).

Table 7: Relationship of site nutrient loss and burn intensity (Boyer and Dell 1980)

Burn Intensity	Surface Temperature (°C)	Nitrogen Lost (%)
Light	Less than 200	Trace
Moderate	200 to 400	50 to 75
Severe	400 to 500	75 to 100
Very Severe	Greater than 500	100

Light burn: The surface duff layer is often charred by fire but not removed. Duff, crumbled wood or other woody debris partly burned, logs not deeply charred.

In clearcuts: Surface **temperature** of less than **200°C** (3900F).
In underburns: Surface **temperature** of less than 1800C **(350°F).**
Surface temperature of 1770C produced soil **temperature** of 710C at 2.5 cm (1 in) depth.

Moderate burn: Duff, rotten wood or other woody debris partially consumed or logs may be deeply charred but mineral soil under the ash not appreciably changed in color.

In clearcuts: Surface **temperature** of **200°C** to **500°C** (390oF to **930°F).**
In underburns: Surface **temperature** of 1800C to **300°C (350°F** to **590°F).**
Surface **temperature** of **400°C** produced soil **temperature** of 1770C at 2.5 cm (1 in) depth.

Severe burn: Top layer of mineral soil **significantly changed** in color, usually to reddish color; next one-half inch blackened from organic matter charring by heat conducted through top layer.

In clearcuts: Surface temperature of greater than 500oC (930oF).
In underburns: Surface temperature of greater than **300°C (590°F).**
Under.piles: Surface temperature of greater than 650oC (1200oF).
Wildfire: Surface temperature of greater than 7600C **(1400°F).**
Surface temperature of **500°C** produced soil temperature of 2880C at 2.5 cm (1 in) depth.

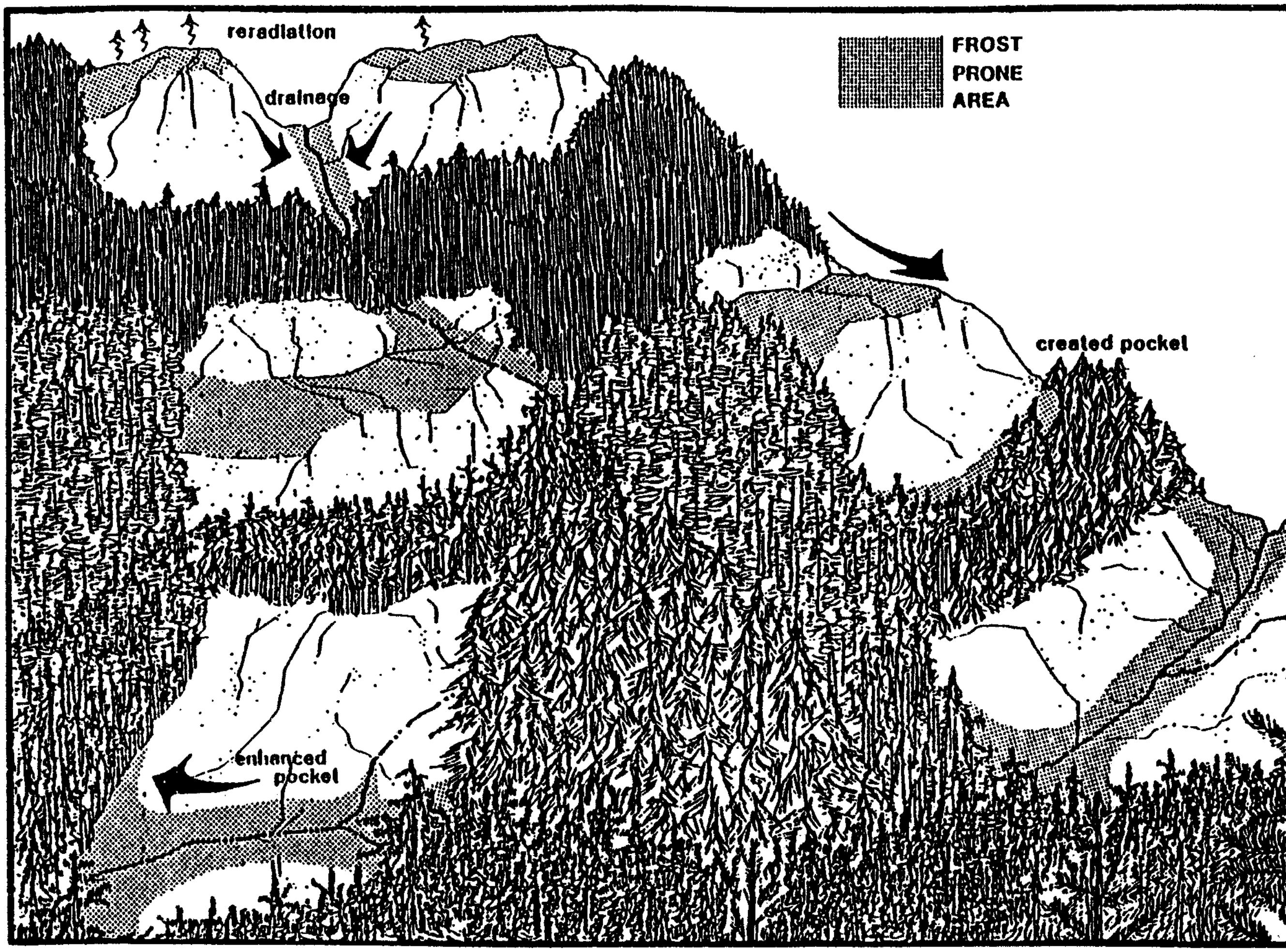

Figure 8: Frost prone areas of the upper elevations in the Cascade Range

Regeneration

Frost is the single most important factor affecting plantation establishment in the upper elevations. Frost severity and frequency are influenced by site factors such as elevation, aspect, slope, topography and residual thermal cover. Figure 8 illustrates areas subject to frequent and severe frost in the upper elevations of the Cascade Range. As elevation increases the probability of early or late season frosts occurring generally increases. On sites where slope exceeds 15%, frost hazard decreases as cold air drainage from a site is improved. Flat topography retards air circulation at night and cold air accumulates in even the slightest depression. At lower elevations where frost is less common, frost pockets may be formed by concave topography or created by logging which leaves a stand of timber blocking the drainage of cold air along a slope. Reradiation of energy to the open sky on clear nights is critically important and, combined with cold air drainage, may create frost pockets in unusual topographic positions such as mid-slope benches or smooth hillsides with less than 15 percent slope. Temperature inversions occurring in valleys can also result in prolonged periods of frost.

The presence of certain associations can provide clues to the potential frost hazard (Halverson and Emmingham 1982). Beargrass is an extremely frost tolerant species and severe frost problems can be anticipated where it dominates the herbaceous layer on ridgetops, benches and slopes less than 15%. The ABAM/VAME/XETE association is the most frost prone in the Pacific silver fir series. The TSME/VAME, TSME/MEFE and TSME/RHAL associations are also found on the highest frost hazard sites. The ABAM/RHAL, ABAM/MEFE and ABAM/VAME/CLUN associations occur on sites with a moderately high frost hazard as do the ABAM/TIUN and ABAM/OPHO associations where elevations exceed 3500 feet. Meeting the five year post-harvest regeneration objective in these associations is most easily achieved through management practices which protect natural advanced regeneration, minimize reradiation by maintaining adequate thermal cover and allow cold air drainage away from newly reforested sites. The remaining associations, while not as frost prone, may occasionally occur on sites which are difficult to regenerate. Protection of advanced regeneration may here be appropriate as well.

Choice of reproduction method may effect regeneration success by influencing the degree of post-harvest protection afforded young seedlings. In associations indicative of moderate environments (ABAM/GASH, ABAM/BENE, ABAM/VAAL-GASH, ABAM/VAAL, ABAM/OPHO, ABAM/TIUN and ABAM/ACTR-CLUN) the clearcut method may be generally practiced with reasonable assurance of subsequent regeneration success. Where frost prone areas occur within these associations, clearcut unit dimensions may be reduced to a value not exceeding twice the height of the adjacent standing trees to enhance effective thermal cover (Cochran 1969). This recommendation is also broadly applicable to the ABAM/MEFE, ABAM/RHAL and ABAM/VAME/CLUN associations which occupy more rigorous environments. Associations which are found on sites of severe environment (TSME/RHAL, TSME/MEFE, TSME/VAME and ABAM/VAME/XETE) may not be practical candidates for clearcutting if the five year post-harvest regeneration target is to be met.

Indiscriminant application of the clearcut method may further complicate reforestation efforts by stimulating growth of competing vegetation. When applied below elevations of 3800 feet in associations indicative of moderate environments, clearcutting should be promptly followed by tree planting to prevent site occupation by proliferating brush. If high elevation associations, which indicate severe environments, are clearcut, the opportunity for site occupation by beargrass or sedge dramatically increases, often accompanied by increased pocket gopher activity.

The use of the shelterwood method has been successful in many instances in permitting the attainment of harvest goals on severe sites while assuring regeneration success (Hughes et al. 1979). Its use has also been effective in decreasing brush invasion, preventing increases in forb production, discouraging pocket gopher activity and preventing saturated soil conditions from developing on areas where high water tables persist. Other advantages of this method include (1) providing a guaranteed local seed source, (2) providing site amelioration for early and abundant regeneration, (3) affording protection to young seedlings which enhances their development prior to full exposure, (4) obtaining genetic improvement through proper seed tree selection without special investments, (5) providing natural regeneration on high elevation, severe sites which frequently fail when planted with seedlings of nursery origin and (6) retarding the rate at which fuels may dry on the forest floor (Jaszkowski et al. 1975).

The forests of the Pacific silver fir zone are well suited to the use of the shelterwood method (Hoyer 1980). Good regeneration is obtained on all aspects if canopy removal is limited to no more than 50 percent (Williamson 1973). Besides the biological benefits, shelterwood reproduction appears more economical on severe sites where long regeneration delays occur following clearcutting. Shelterwood has also proven successful in and is often required for reproduction of the mountain hemlock, subalpine fir and drier portions of the grand fir and western hemlock series (Hoyer 1980).

Regeneration in associations typical of moderate sites can be effectively protected by leaving about 25 percent of the initial stand basal area on site following the shelterwood seed cut. Seedlings in associations occupying severe sites require more protection which could be provided by leaving up to 50 percent of the inital stand basal area (see individual association descriptions for details). Associations occupying severe sites (TSME/RHAL, TSME/MEFE, TSME/VAME and ABAM/VAME/XETE) may require the shelterwood method to achieve compliance with the 5 year post-harvest regeneration directive. On sites containing a significant cover of beargrass, planting of seedlings promptly following shelterwood harvest may be required as added insurance against site occupation by competing vegetation (Jaszkowski et al. 1975). The ABAM/RHAL, ABAM/MEFE and ABAM/VAME/CLUN associations may frequently require the shelter-wood method where they occur on frost prone sites. The remaining Pacific silver fir associations will only infrequently require shelterwood application, perhaps only in localized frost pockets.

The shelterwood method may not. be practical on sites prone to windthrow such as exposed ridgetops or in stands dominated by Engelmann spruce which are indicative of high water tables, hence shallow rooting systems (Hoyer 1980). Disadvantages of this method included (1) possible higher costs and harvesting difficulty, (2) undesirable damage to seedlings, during removal cuts, (3) restricted fuel management alternatives and (4) a required greater level of expertise on the part of the land manager, as well as increased manpower needs in the field (Jaszkowski et al. 1975).

Group selection and single tree selection may provide the greatest degree of protection for the site while encouraging stand regeneration on a continuous basis. Pacific silver fir seedlings, being tolerant, have demonstrated good growth responses following overstory removal (Halverson and Emmingham 1982). The growth response of advanced Pacific silver fir regeneration to release is highly dependent upon stem size at the time of canopy removal and the intensity of competition in the ambient post-harvest environment. While larger diameter trees generally respond with the greater growth, they are also more susceptible to infection by decay fungi such as <u>Echinodontium tinctorium</u>. By retaining advanced Pacific silver fir on site which are under 6 feet in height, less than 2 inches in diameter and younger than 60 years old, a healthy and vigorous regeneration layer can be assured (Herring and Etheridge 1976). Group selection will likely favor less tolerant noble fir and Douglas-fir. Damage to residual trees and economics will of necessity be considered in prescribing selection cutting alternatives. Given adequate care during harvest, the forest species in the upper elevations possess the biological capacity to produce on a sustained yield basis under the selection system.

In addition to standing trees, slash materials left on site may act as effective thermal cover for the severe environments in the upper elevations. The use of broadcast or other burning techniques here will likely diminish regeneration success (Sullivan 1978). In the less severe associations, where regeneration is easier and fewer management problems occur, greater flexibility exists in the use of fire, choice of reproduction method, size and shape design of harvest units and selection of other silvicultural options.

Another major factor determining regeneration success is tree species selection for reforestation. Since plant associations indicate environmental conditions, they may be useful in matching tree species to sites on which they can best perform. The

Table 8: Regeneration characteristics of upper elevation conifer species

Species	Suitable associations	Remarks
Douglas-fir	ABAM/GASH, ABAM/BENE,ABAM/TIUN, ABAM/VAAL, ABAM/VAAL-GASH, ABAM/ACTR-CLUN, ABAM/VAME/CLUN.	Good early growth. Slower diameter growth in dense stands than noble fir. Frost sensitive. Do not plant on slopes less than 15% in frost prone associations.
Noble fir	All ABAM associations.	Slow early growth. Good sustain diameter growth in dense stands. Do not plant on slopes less than 15% in frost prone associations.
Western white pine	All associations except ABAM/OPHO.	Rapid early growth. May be planted on frost prone sites. Use rust resistant stock.
Engelmann spruce	ABAM/TIUN, ABAM/OPHO, ABAM/RHAL, ABAM/VAME/CLUN, ABAM/VAME/XETE and TSME associations.	Good growth on sites with abundant soil moisture. Highly frost tolerant.
Western larch	ABAM/VAME/XETE, ABAM/MEFE and TSME associations.	Probably widely adapted to upper elevations. Rapid early growth. Highly frost tolerant.
Lodgepole pine	ABAM/VAME/XETE and TSME associations.	May be planted on frost prone sites or' sites or sites requiring rehabilitation.
Pacific silver fir	ABAM/RHAL, ABAM/MEFE, ABAM/TIUN, ABAM/OPHO, ABAM/VAME/CLUN, ABAM/VAME/XETE and TSME associations.	Useful advanced regeneration on cool or frost prone sites. A major component of all ABAM associations.
Mountain hemlock	ABAM/VAME/XETE, ABAM/MEFE, ABAM/RHAL and TSME associations.	Useful advanced regeneration on frost prone sites. Slow early growth. Can tolerate heavy snowpack conditions.
Alaska yellow-cedar	TSME/RHAL, ABAM/RHAL, and ABAM/OPHO.	Useful advanced regeneration on frost prone sites. Requires abundant soil moisture.
Western hemlock	ABAM/GASH, ABAM/VAAL, ABAM/VAAL-GASH, ABAM/TIUN, ABAM/OPHO, ABAM/RHAL, ABAM/VAME/CLUN.	May be useful advanced regeneration. Intolerant of heavy snowpack conditions.
Western redcedar	ABAM/OPHO and warmer ABAM associations.	Useful advanced regeneration. Requires adequate soil moisture. Relatively slow growth.
Grand fir	None.	A species adapted to environmental conditions of the grand fir series east of the Cascade crest.

Table 9: Productivity summary for upper elevation associations of the Gifford Pinchot National Forest

Plant association	No. of plots	Stand age (Yrs.) Mean	Stand age (Yrs.) S.D.	Trees per acre in current Stand Mean	Trees per acre in current Stand S.D.	Quad. mean diameter (in.) Mean	Quad. mean diameter (in.) S.D.	Stand basal area ($ft.^2/A$) Mean	Stand basal area ($ft.^2/A$) S.D.
TSME/RHAL	4	250	13	194	46	16	2	258	55
TSME/MEFE	4	364	128	140	84	19	5	232	59
TSME/VAME		222	116	158	55	16	3	221	66
ABAM/RHAL	3	387	126	99	31	22	5	233	22
ABAM/MEFE	7	462	70	131	51	19	3	249	47
ABAM/VAME/XETE	5	436	153	160	53	18	3	285	71
ABAM/VAME/CLUN	9	419	210	156	123	21	7	272	49
ABAM/OPHO	8	554	305	116	41	24	4	325	39
ABAM/TIUN	8	330	168	142	51	21	4	305	62
ABAM/ACTR-CLUN	6	381	340	152	126	21	7	269	38
ABAM/VAAL	15	483	149	162	71	18	4	259	40
ABAM/VAAL-GASH	10	508	199	254	150	16	5	295	66
ABAM/BENE	5	312	128	141	34	19	3	256	49
ABAM/GASH	6	391	187	217	149	18	7	271	80

characteristics of several conifer species and the associations for which they are best suited are listed in Table 8. While Douglas-fir is a widely adapted tree species, it is a more successful species in the western hemlock zone. When planted in the Pacific silver fir zone, it is best confined to lower elevation, warmer, south aspects and the less severe associations. Noble fir also does well in these associations and in many cases may be preferred over Douglas-fir. Noble fir is more frost tolerant than Douglas-fir and can also be planted at somewhat higher elevations. Noble fir is particularly suited to south aspect sites which are well drained with slopes exceeding 15 percent. Western white pine can be planted on flats or plateaus which are extremely frost prone. Rust resistant planting stock should be utilized. Engelmann spruce may be planted on frost prone areas or on sites with a high water table Western larch is a fast growing and frost-resistant species which may be planted in a number of upper elevation associations. Lodgepole pine is extremely frost hardy species which may be planted on areas requiring rehabilitation. Pacific silver fir is valuable as advanced regeneration on a variety of sites. Mountain hemlock may also be useful as advanced regeneration and can tolerate heavy snowpacks and extreme cold. Alaska yellow-cedar may be infrequently useful as advanced regeneration in associations which occupy moist sites. Western hemlock can be useful as advanced regeneration on moist north aspects. Western redcedar is useful advanced regeneration in warmer Pacific silver fir associations. Grand fir is a species poorly adapted to the environmental conditions of the Pacific silver fir zone.

Productivity and Stocking

Productivity varies considerably among the plant associations in the upper elevations (Table 9). Stand production data collected during the 1982 field season were based on measurements of dominant and codominant trees. Three independent methods were employed to estimate stand productivity: volume index, SDI volume increment and current volume increment.

Volume index (VI) is computed as a product of site index (SI) and growth basal area (GBA): $VI = SI \times GBA \times 0.005$. Since both SI and GBA are indexed to age 100 (Hall 1983), volume index is an expression of potential volume growth for normally stocked, even aged stands at age 100. While not a precise estimator of volume growth, it serves as an index of relative production among associations.

SDI volume increment is computed by a series of equations which relate the actual production (Pa) of a sampled stand to the production (Pn) of a "normally" stocked stand[1]: $Pa = Pn\ (SDI_a/SDI_n)$. This method was developed to discriminate between stands which are commercial (20 $ft.^3/A/yr$) and those which are not.

The final method used to estimate volume production, current volume increment, is based on tree growth regression equations[2]. Briefly, volume for overstory trees is estimated

[1] Knapp, W. A. 1981. Unpublished in-house paper on file with USDA Forest Service, Pacific Northwest Region. Portland, OR 97208. 6 pp.

[2] Hemstrom, M. A. 1982. Unpublished growth simulation model for upper elevation conifers (personal communication). USDA Forest Service. Eugene, OR 97401.

Stand Density Index (trees/A)		SDI Volume Increment (ft.^{3}/A/yr)		Current Volume Increment (ft.^{3}/A/yr)		ABAM Volume Index (ft^3/A/yr)		ABAM Growth Basal Area (ft.^{2}/A)		Herbaceous Production (lbs/A)	
Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
396	81	80	35	69	12	113	44	245	61	678	373
338	111	75	22	57	28	99	26	211	58	350	351
333	93	73	20	70	28	108	42	246	104	507	485
317	36	75	16	66	28	100	22	214	21	337	178
354	68	104	28	45	16	158	42	285	49	258	179
411	97	111	55	61	17	134	39	253	61	255	319
380	62	101	25	61	15	122	62	253	109	514	276
428	63	166	41	75	29	227	67	343	82	1132	514
421	69	147	54	88	40	189	60	322	83	1068	955
375	57	140	31	105	36	146	21	259	13	488	226
379	71	105	24	50	9	126	33	250	63	202	191
451	75	131	39	58	22	161	77	293	105	206	246
367	59	73	29	50	12	117	--	252	--	576	404
408	120	100	29	93	20	167	84	324	124	162	141

by equations of the form $V = a(D^2H)^k$ where V is volume, D is diameter at breast height, H is tree height and a and k are empirically derived constants specific to each species. Volume increment during the last decade is estimated by subtraction of present overstory volume and overstory volume ten years ago. Understory volume is estimated from the relationship $CG_u = BA_u (CG_o/BA_o)$ where CG_u and CG_o are last ten years radial increment and BA_u and BA_o are the mean diameter at breast height of understory and overstory, respectively. The stand volume is determined by summation of the component estimates. Current volume increment is an estimate of the mean annual volume increment over the past 10 years of sampled stands. The values computed by this model are estimates of net production, not including mortality, of natural, mixed species stands. Since most of our sampled stands were old (i.e., over 250 years), mean values for current growth (Table 9) represent growth rates of older stands.

These three volume estimates, can be arrayed along the temperature and moisture gradients which influence the distribution of plant associations (Figure 9). Volume index values generally exceed those for SDI volume increment; they both represent potential production near culmination. Current volume increment values, on the other hand, are lower than SDI volume increments and volume index because they represent volume production in stands (of age 222 to 554 years) which are past culmination age.

Generally, no matter which volume growth estimator is employed, plant associations may be grouped into three productivity classes. High production is observed in the ABAM/TIUN, ABAM/OPHO and ABAM/ACTR-CLUN associations where a favorable environment occurs, as characterized by adequate moisture, deep soils and a rich herb cover. Low production is observed in the TSME/RHAL, TSME/MEFE, TSME/VAME and ABAM/RHAL associations where cold soil and air temperatures, heavy snowpacks and shorter growing seasons limit growth and in the ABAM/BENE association where shallow, rocky soils on southern exposures may contribute to growing season drought stress. Moderate production levels observed in the ABAM/MEFE, ABAM/VAME/XETE, ABAM/VAME/CLUN, ABAM/VAAL, ABAM/VAAL-GASH and ABAM/GASH represent a broad range of intermediate environments. These groupings are relative to the Pacific silver fir zone and do not directly correspond to the national standard.

The height growth patterns of the major tree species vary considerably among the above productivity groups (Figure 10). Although some stands were 500 or more years old, most future stands will be managed.on rotations of 150 years or less. Stand volume production is not only a result of height growth patterns, but is also greatly influenced by stand density and diameter growth. Growth performance of different tree species seems to be well related to plant association. This point is further illustrated by the empirically derived height-age curves in Appendix II. From data collected on the forest, these curves were developed using a nonlinear polynomial curve fitting technique (Dixon 1981) for the natural growth function $f(x) = a(1-e^{-bx})$ where x is tree age, f(x) is tree height, a is the maximum value for height, b is the rate at which tree height approaches the maximum and e is the natural log constant (Parton and Innis 1972). Note that the empirically derived curves do not fit many of the height-age curves currently in use. The shape of height-age curves also changes within species over different plant associations. Our conclusion is that the shape of a height growth curve for a species will change as environmental factors become more severe.

Data for annual volume increment plotted against stand age paralled trends for height growth in Appendix II. Volume increment during the recent

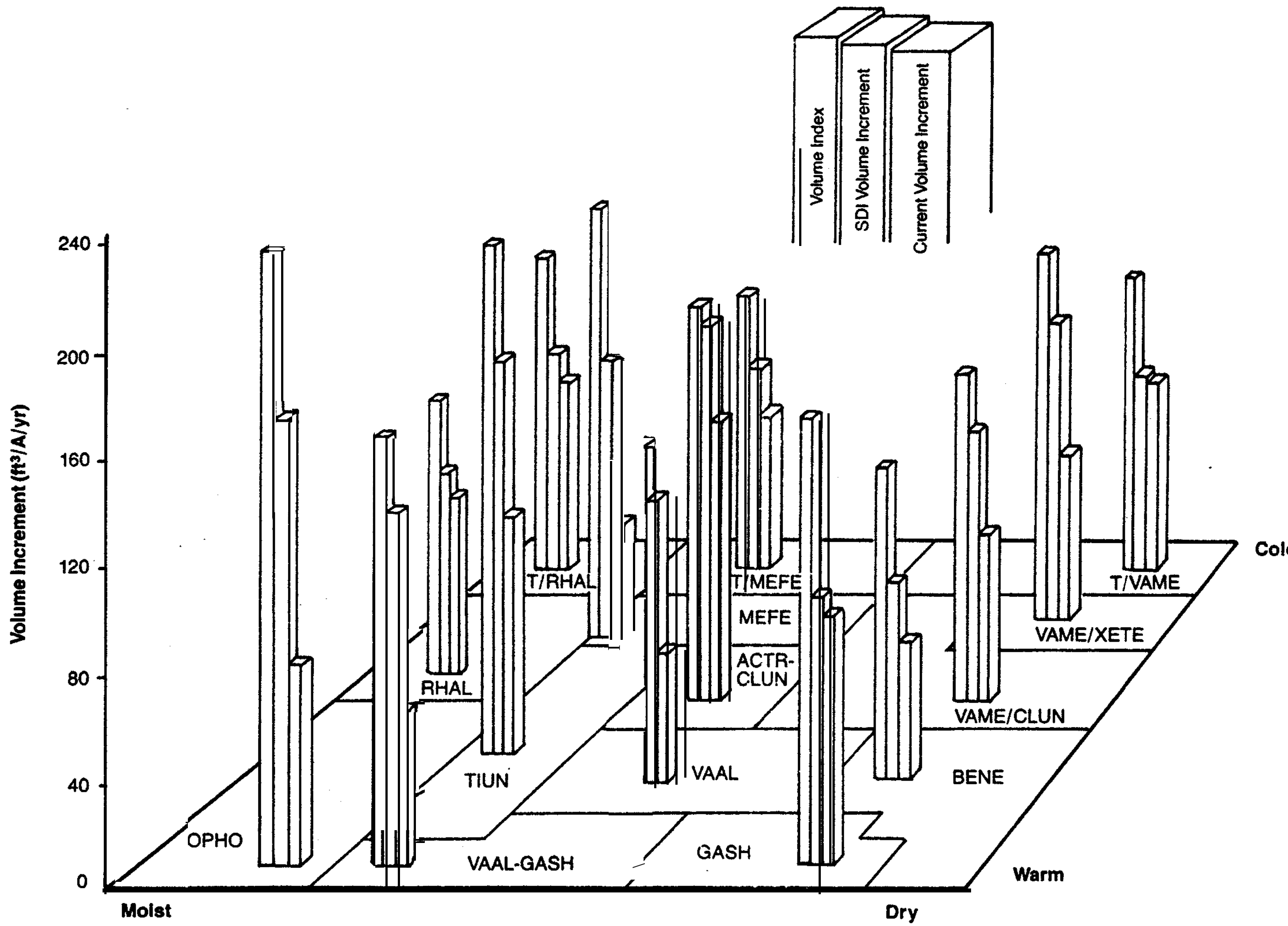

Figure 9: COMPARISON OF THREE PRODUCTION INDICES AMONG UPPER ELEVATION ASSOCIATIONS

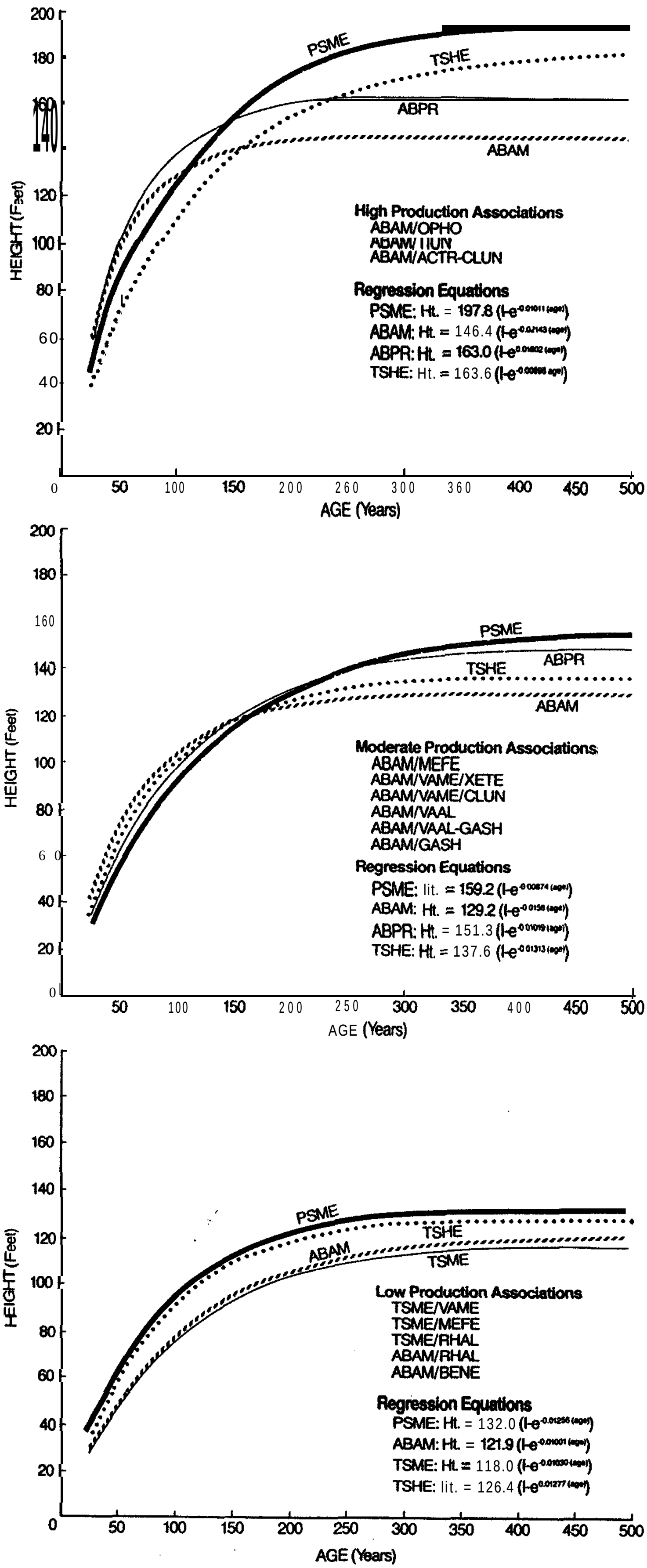

Figure 10: HEIGHTGROWTH COMPARISON AMONG IMPORTANT TIMBER SPECIES IN HIGH, MODERATE AND LOW PRODUCTION UPPER ELEVATION ASSOCIATIONS

decade was computed using the method of Hemstrom[1] and graphed against stand age for each sampled plot. The resulting curves were hand fitted to the data to obtain estimates of volume growth over a broad range of stand ages. Volume production for all species combined in the high production associations culminates at an average of 140 $ft.^3/A/yr$ at age 110. Culmination averages 95 $ft.^3/A/yr$ at age 125 in the moderate production associations and 75 $ft.^3/A/yr$ at age 150 in the low production associations. As site severity increases overall production decreases and age to culmination increases.

The following should be considered in interpreting the seeming similarity in productivity for the many upper elevation associations. (1) The similarity in productivity estimates among associations may be a result of the similar nature of the soils and climate. (2) Estimates were based on trees averaging over 250 years old, which may not directly reflect the conditions present in the managed stands of the future. Better estimates of actual productivity may be obtained by measuring somewhat younger, more vigorously growing stands. (3) The standard (height over age) growth curves available may give erroneous indication of similarities among the associations. The volume index and SDI volume increment estimates both rely on site index curves constructed with data from a wide geographical area. Studies have shown that height growth patterns of Douglas-fir (Means 1980) and mountain hemlock (Johnson 1980) differ with environmental factors associated with elevation and moisture. (4) Natural lags in regeneration may produce apparent similarities in productivity. There may be little difference among associations once stands become established, however, delay time required for regeneration to become established may vary by association. Lower elevation sites are more likely to regenerate within a five year period with trees growing well immediately following establishment. On upper elevation sites regeneration establishment may be delayed for up to 10 to 20 years and seedling growth may be very slow for the first 20 to 50 years following establishment. This slow period of growth may result in lower stand performance than would be predicted by currently available computer growth simulation models, necessitating longer rotations in associations characteristic of the more severe sites. Growth may increase on high elevation sites once tree crowns attain a position above the winter snowpack. Neither the delay time for establishment nor the time to reach breast height or overtop the winter snowpack were here considered in estimating productivity.

Stocking naturally varies among sites of differing environmental severity. Management practices which lead to degradation of site quality may lead to a reduction in stocking. Factors such as effective rooting depth, degree of exposure, prevalence of brush and occurrance of fire are among the factors which may influence post-harvest stocking. Sullivan (1978) reported post-harvest stocking rates on sites occupied by the severe ABAM/VAME/XETE and TSME associations to be half of those found on sites characterized by warmer associations. This was a result of the heightened environmental severity of clearcut high elevation sites.

Stocking differences among associations may also be related to planting stock selection. Certain tree species, such as noble fir, demonstrate the ability to grow better in closed canopy situations than do others, such as Douglas-fir. Selecting species which are physiologically adapted to the environmental conditions indicated by various associations will be a critical step in the management process leading to adequate stocking, successful regeneration and sustained timber production on upper elevation sites.

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[1] Hemstrom, M. A. 1982. Unpublished growth simulation model for upper elevation conifers (personal communication). USDA Forest Service. Eugene, OR 97401.

Key to Plant Associations

Use of ttie Key

The following key was designed as an aid in identifying the upper elevation associations of the Gifford Pinchot National Forest and vicinity. Environmental and management information applicable to a given site is accessed by identifying the association using the key, then referring to the detailed association description.

The steps in using the key are

1. Select a vegetationally uniform area about 25 feet (8 meters) in radius or 0.05 acre (0.02 ha) in size. The plot should be representative of a larger area of reasonably homogeneous vegetation.
2. First identify and list tree, shrub and herb species, then estimate the cover of each. Cover is estimated to the nearest percent, up to 10 percent cover and to the nearest 5 percent thereafter. Walk around the plot area.
3. Work step by step through the association key to a preliminary identification.
4. Review the association description to verify the identification.
5. Only after verification, note the management considerations for the association.

It is important to follow these steps rigorously since misidentification may lead to the wrong management considerations. The key is designed to be used in sequence. Always start at the beginning of the key and work systematically through.

The associations described in this guide are based on plot data collected throughout the forest and represent conceptual abstractions. In practice, few stands will conform exactly to the typical association description. Because vegetation varies continuously over the landscape, ecotones of transitional composition, which do not fit neatly into any described association, will be encountered. Suc'h ecotones should be managed according to the characteristics of the associations between which they fall. In most cases, adjacent associations have similar management properties. There are about 50 common herb and shrub species used in the key and association descriptions. Table 10 contains the abbreviations, scientific and common names used in this guide.

Key to the plant associations and ecoclass codes for the upper elevation series, Gifford Pinchot National Forest

	Lead	Result	Ecoclass
1.	Tree cover in stand projected to stable state* contains less than 10% ABAM and less than 10% TSME	not included in key	
1'.	Tree cover in stand projected to stable state contains at least 10% ABAM and/or 10% TSME	2	
2.	Tree cover in stand projected to stable state contains at least 10% TSME	Mountain Hemlock Series 3	
2'.	Tree cover in stand projected to stable state contains less than 10% TSME	Pacific Silver Fir Series 6	
3.	RHAL cover 5% or more	TSME/RHAL Association	CM S2-23 (page 70)
3'.	RHAL cover less than 5%	4	
4.	MEFE cover 5% or more	TSME/MEFE Association	CM S2-21 (page 69)
4'.	MEFE cover less than 5%	5	
5.	VAME cover 5% or more	TSME/VAME Association	CM S2-10 (page 68)
5'.	VAME cover less than 5%	undescribed TSME Association	
6.	OPHO cover 5% or more	ABAM/OPHO Association	CF S3-51 (page 62)
6'.	OPHO cover less than 5%	7	
7.	RHAL cover 5% or more	ABAM/RHAL Association	CF S5-50 (page 63)
7'.	RHAL cover less than 5%	8	
8.	MEFE cover 5% or more	ABAM/MEFE Association	CF S2-54 (page 64)
8'.	MEFE cover less than 5%	9	
9.	TIUN cover 5% or more; or TIUN cover at least 1% along with at least two wet site herbs	ABAM/TIUN Association	CF F1-52 (page 61)
9'.	TIUN cover less than 5% and less than two wet site herbs present	10	
10.	VAAL plus VAOV cover 5% or more	11	
10'.	VAAL plus VAOV cover less than 5%	12	
11.	GASH cover 2% or more	ABAM/VAAL-GASH Association	CF S2-55 (page 60)
11'.	GASH cover less than 2%	ABAM/VAAL Association	CF S2-57 (page 59)
12.	GASH cover 2% or more	ABAM/GASH Association	CF S1-52 (page 55)
12'.	GASH cover less than 2%	13	
13.	BENE cover 5% or more	ABAM/BENE Association	CF S1-51 (page 56)
13'.	BENE cover less than 5%	14	
14.	VAME cover 5% or more	15	
14'.	VAME cover less than 5%; cover of herb layer at least 10% including ACTR	ABAM/ACTR-CLUN Association	CF F2-53 (page 57)
15.	Several herbs other than XETE present, usually including CLUN and ACTR	ABAM/VAME/CLUN Association	CF S2-56 (page 65)
15'.	XETE most prominent herb; other herbs inconspicuous	ABAM/VAME/XETE Association	CF S2-51 (page 66)

*Stand conditions at age 300 or more.

Table 10: List of TRI abbreviations, scientific and common names of trees, shrubs and herbs used in the key and association descriptions1

Trees

TRI codes	Scientific name	Common name
ABAM*	Abies amabilis	Pacific silver fir
ABGR	Abies grandis	Grand fir
ABLA2	Abies lasiocarpa	Subalpine fir
ABPR	Abies procera	Noble fir
CHNO	Chamaecyparis nootkatensis	Alaska yellow-cedar
LAOC	Larix occidentalis	Western larch
PIEN	Picea engelmannii	Engelmann spruce
PICO	Pinus contorta	Lodgepole pine
PIMO	Pinus monticola	Western white pine
PSME	Pseudotsuga menziesii	Douglas-fir
TABR	Taxus brevifolia	Pacific yew
THPL	Thuja plicata	Western redcedar
TSHE	Tsuga heterophylla	Western hemlock
TSME*	Tsuga mertensiana	Mountain hemlock

Shrubs

TRI codes	Scientific name	Common name	Indicator value
ACCI*	Acer circinatum	Vine maple	warm
ACGLD	Acer glabrum var. douglasii	Douglas Rocky Mt. maple	
ARNE	Arctostaphylos nevadensis	Pinemat manzanita	warm, dry
BENE*	Berberis nervosa	Dwarf Oregon grape	warm
CEVE	Ceanothus velutinus	Snowbrush	
CHME	Chimaphila menziesii	Little prince's pine	
CHUM	Chimaphila umbellata	Prince's pine	
COCOC	Corylus cornuta var. californica	California hazel	warm, dry
CONU	Cornus nuttallii	Pacific dogwood	
GAOV	Gaultheria ovatifolia	Wintergreen	
GASH*	Gaultheria shallon	Salal	warm, dry
HODI	Holodiscus discolor	Ocean-spray	warm, 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	Pacific rhododendron	
RHDI	Rhus diversiloba	Poison oak	warm, dry
RILA	Ribes lacustre	Prickly currant	
ROGY*	Rosa gymnocarpa	Baldhip Rose	warm
RULA	Rubus lasiococcus	Dwarf bramble	
RULE	Rubus leucodermis	Whitebark raspberry	
RUN1	Rubus nivalis	Snow dewberry	
RUPA	Rubus parviflorus	Western thimbleberry	
RUPE	Rubus pedatus	Five leaf bramble	
RUSP	Rubus spectabilis	Salmonberry	warm, wet
RUUR	Rubus ursinus	Trailing blackberry	warm
SOS1	Sorbus sitchensis	Sitka mountain ash	cool
SYMO	Symphoricarpos mollis	Trailing snowberry	warm
VACCI*	Vaccinium species	Huckleberry species	
VAAL*	Vaccinium alaskense	Alaska huckleberry	
VAME*	Vaccinium membranaceum	Big huckleberry	cool
VAOV*	Vaccinium ovalifolium	Ovalleaf whortleberry	
VAPA*	Vaccinium parvifolium	Red huckleberry	warm
VASC	Vaccinium scoparium	Grouse huckleberry	cold, dry

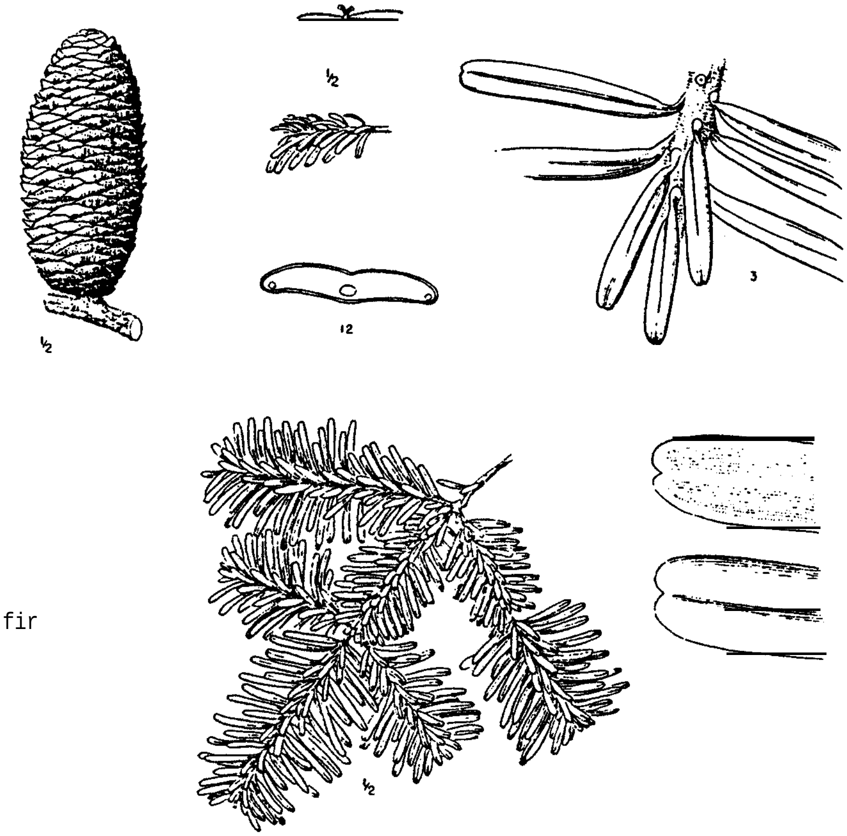
Herbs	TRI codes	Scientific name	Common name	Indicator value
	ACTR*	Achlys triphylla	Vanillaleaf	warm, mesic
	ACRU	Actaea rubra	Baneberry	
	ADBI*	Adenocaulon bicolor	Pathfinder	
	ADPE*	Adiantum pedatum	Maidenhair fern	wet
	ANDE	Anemone deltoidea	Threeleaf anemone	moist
	ANLY2	Anemone lyallii	Nine leaved anemone	
	AQFO	Aquilegia formosa	Sitka columbine	
	ARCA3	Aralia californica	California aralia	moist
	ARMA3	Arenaria macrophylla	Bluntleaf sandwort	
	ARLA	Arnica latifolia	Broadleaf arnica	
	ASCA3	Asarum caudatum	Wildginger	
	ATFI*	Athyrium filix-femina	Ladyfern	moist
	BLSP*	Blechnum spicant	Deerfern	moist
	CABU2	Calypso bulbosa	Calypso orchid	
	CASC2	Campanula scouleri	Scouler's bluebell	
	CIAL	Circaea alpina	Alpine circaea	
	CIRSI	Cirsium species	Thistle	
	CLUN*	Clintonia uniflora	Queencup beadlily	moist, cool
	COLA	Coptis laciniata	Cutleaf goldthread	
	COMA3	Corallorhiza maculata	Coralroot	
	COCA*	Cornus canadensis	Dogwood bunchberry	
	DIFO	Dicentra formosa	Pacific bleedingheart	
	DIHO	Disporum hookeri	Fairybells	
	EQAR*	Equisetum arvense	Common horsetail	moist, disturbed
	FRAGA	Fragaria species	Strawberry	
	GAOR	Galium oreganum	Oregon bedstraw	
	GATR*	Galium triflorum	Sweetscented bedstraw	
	GOOB	Goodyera oblongifolia	Rattlesnake plantain	
	GYDR*	Gynmocarpium dryopteris	Oak fern	moist
	HIAL	Hieracium albiflorum	White hawkweed	
	HYCA	Hydrophyllum capitatum	Ballhead waterleaf	
	HYMO	Hypopitys monotropa	Pinesap	cool
	IRTE	Iris tenax	Oregon iris	warm
	LIBO2*	Linnaea borealis	Twinflower	warm
	LIBO	Listera borealis	Twayblade	
	LUZUL	Luzula species	Luzula	
	MIBR*	Mitella breweri	Brewer miterwort	moist
	MOSI*	Montia sibirica	Siberian montia	moist
	OSCH	Osmorhiza chilensis	Sweet cicely	
	OXOR*	Oxalis oregana	Oregon oxalis	moist
	PERA	Pedicularis racemosa	Sickletop pedicularis	
	POA	Poa species	Bluegrass	
	POMU*	Polystichum munitum	Western swordfern	warm, mesic
	PTAQ	Pteridium aquilinum	Bracken fern	disturbance
	PYPI	Pyrola picta	Whitevein pyrola	
	PYSE	Pyrola secunda	Sidebells pyrola	
	PYAS	Pyrola asarifolia	Alpine pyrola	
	SAME3*	Saxifraga mertensiana	Mertens saxifrage	
	SMRA*	Smilacina racemosa	Feather solomonolume	
	SMST	Smilacina stellata	Starry solomonpiume	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
	VAHE*	Vancouveria hexandra	White inside-out flower	moist, warm
	VECA	Veratrum californicum	California falsehellebore	moist
	VIGL	Viola glabella	Pioneer violet	
	VIOR2	Viola orbiculata	Vetch violet	moist
	VISE	Viola senipervirens	Redwoods violet	
	XETE*	Xerophyllum tenax	Beargrass	cold, dry

[1]"Northwest Plant Names and Symbols for Ecosystem Inventory and Analysis" Garrison et al. (1976) and "Vascular Plants of the Pacific Northwest" Hitchcock et al. (1977).

*Diagnostic, used in key as an important indicator plant (see following illustrations).
**Also referred to as TITRU Tiarella trifoliata var. unifoliata.

Figure 11:

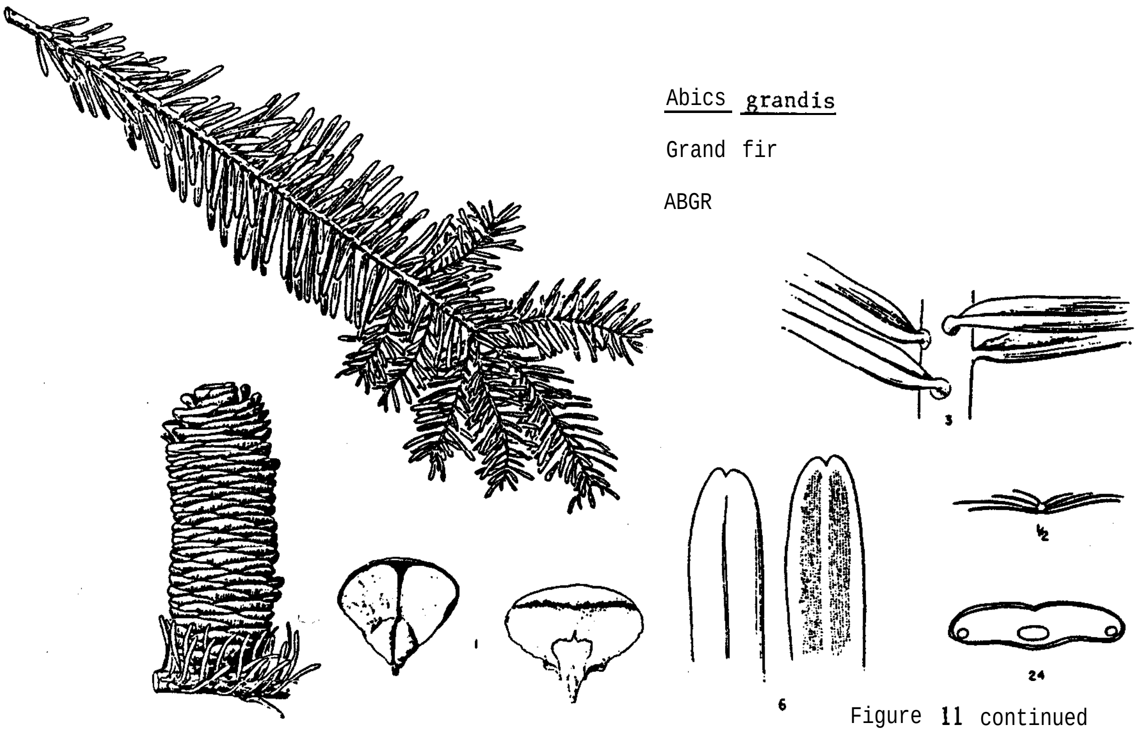
On the following pages are found the important timber and indicator plants commonly found in the upper elevations of the Gifford Pinchot National Forest (PLANT ILLUSTRATIONS REPRODUCED WITH PERMISSION FROM HITCHCOCK ET AL. VASCULAR PLANTS OF THE PACIFIC NORTHWEST. Copyrights: 1969 Part 1, 1964 Part 2, 1961 Part 3, 1959 Part 4, 1955 Part 5).



<u>Abies amabilis</u>

Pacific silver fir

ABAM

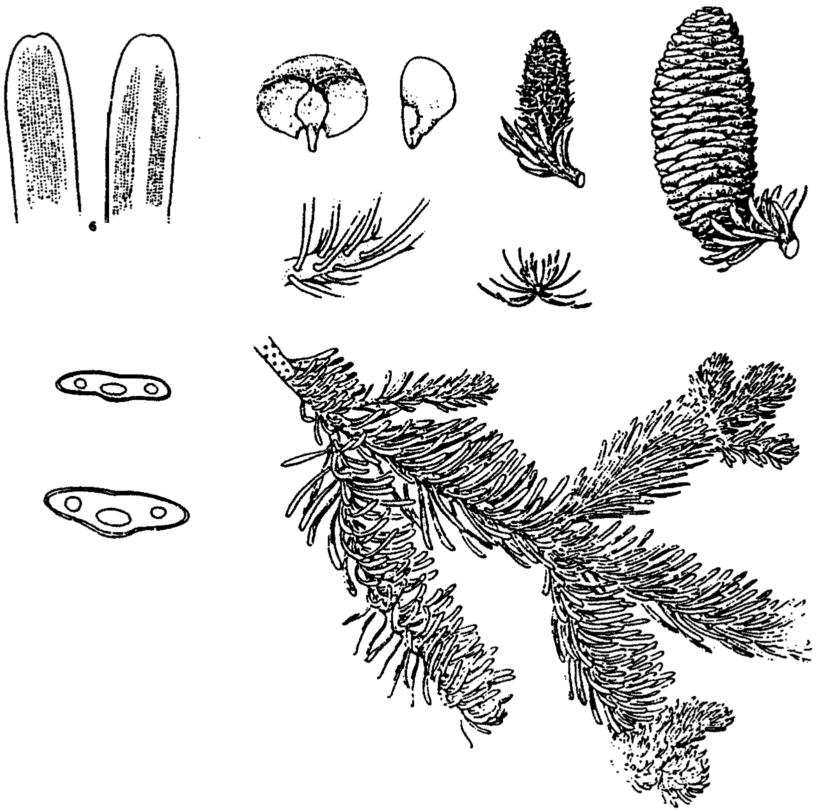


<u>Abics grandis</u>

Grand fir

ABGR

Figure 11 continued



Abies lasiocarpa

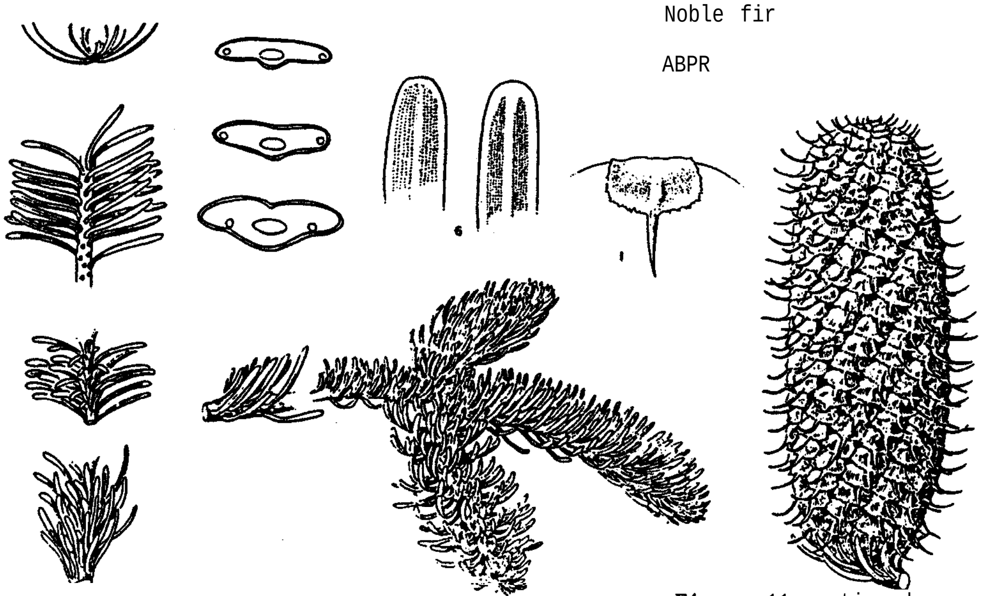
Subalpine fir

ABLA

Abies procera

Noble fir

ABPR



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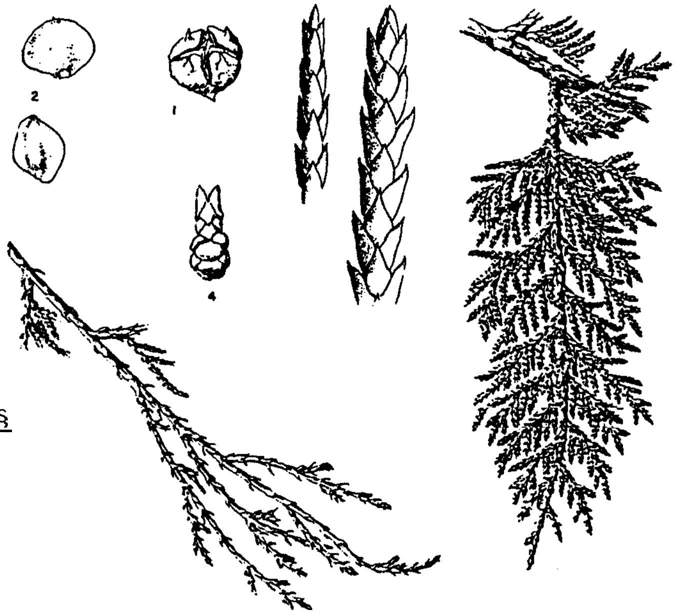
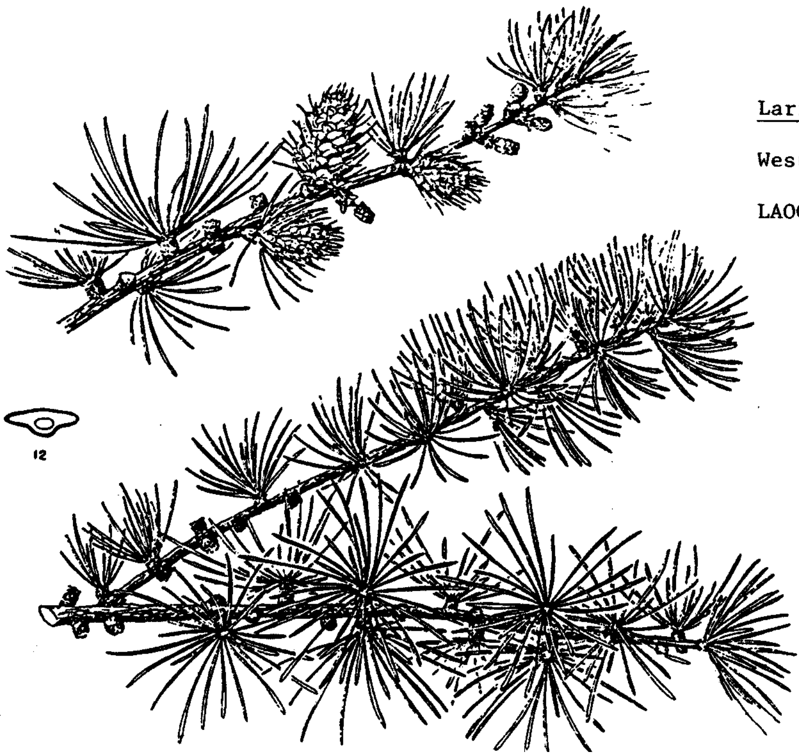


Chamaecyparis nootkatensis

Alaska yellow-cedar

CHNO

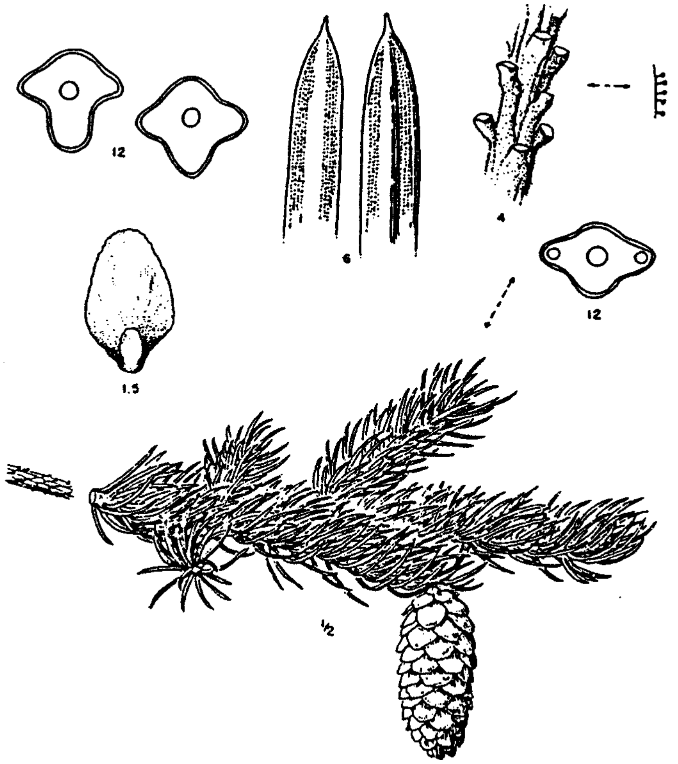


Larix occidentalis

Western larch

LAOC

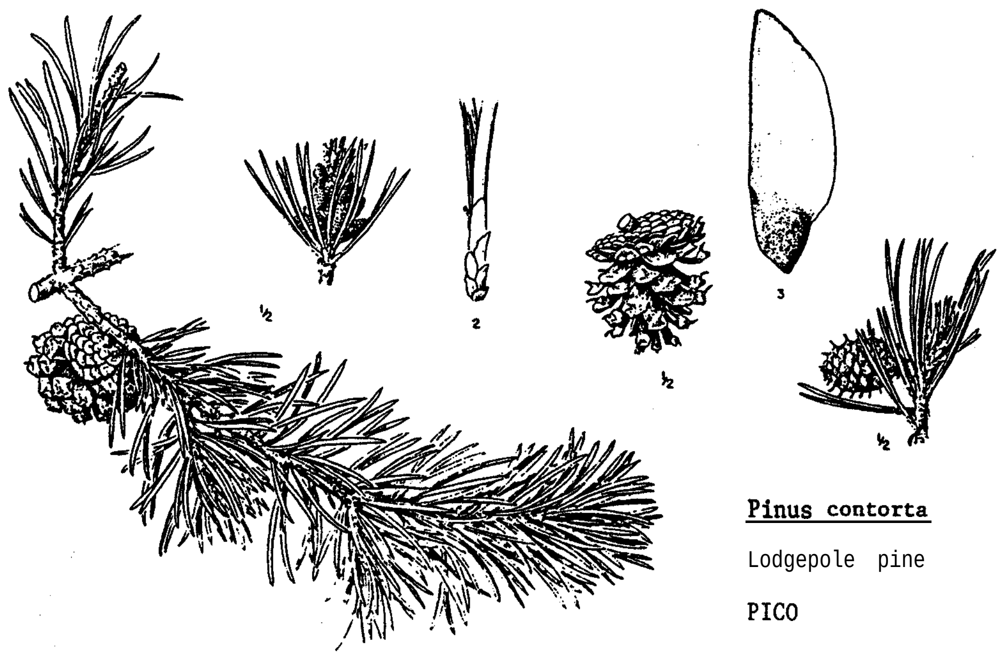
Figure 11 continued



Picea engelmannii

Engelmann spruce

PIEN



Pinus contorta

Lodgepole pine

PICO

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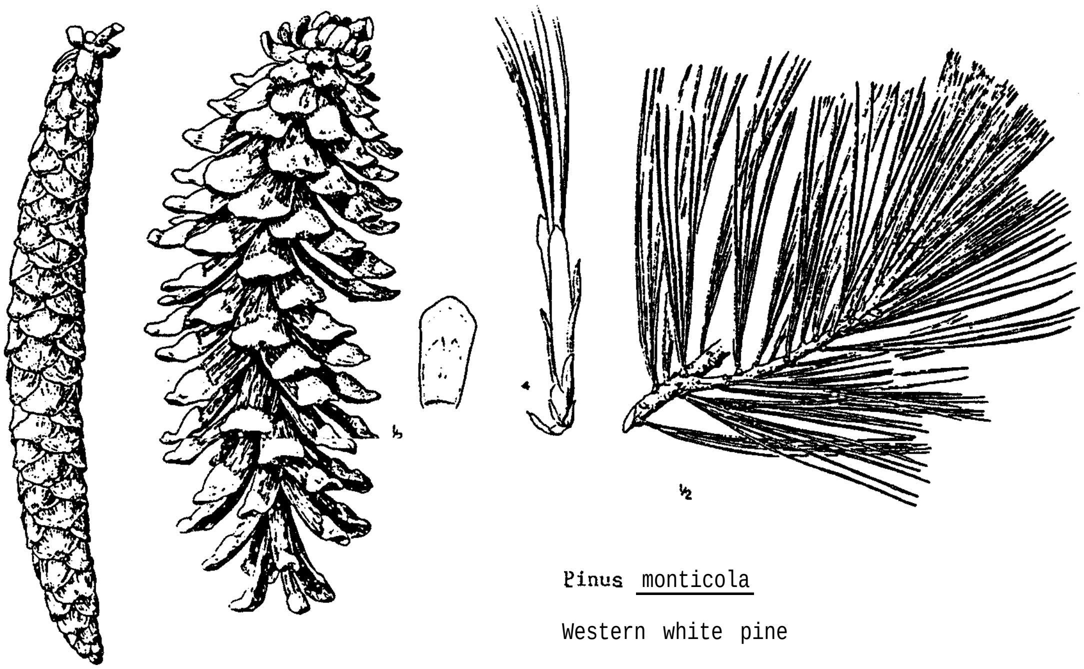


Pinus monticola

Western white pine

PIMO

Pseudotsuga menziesii

Douglas-fir

PSME

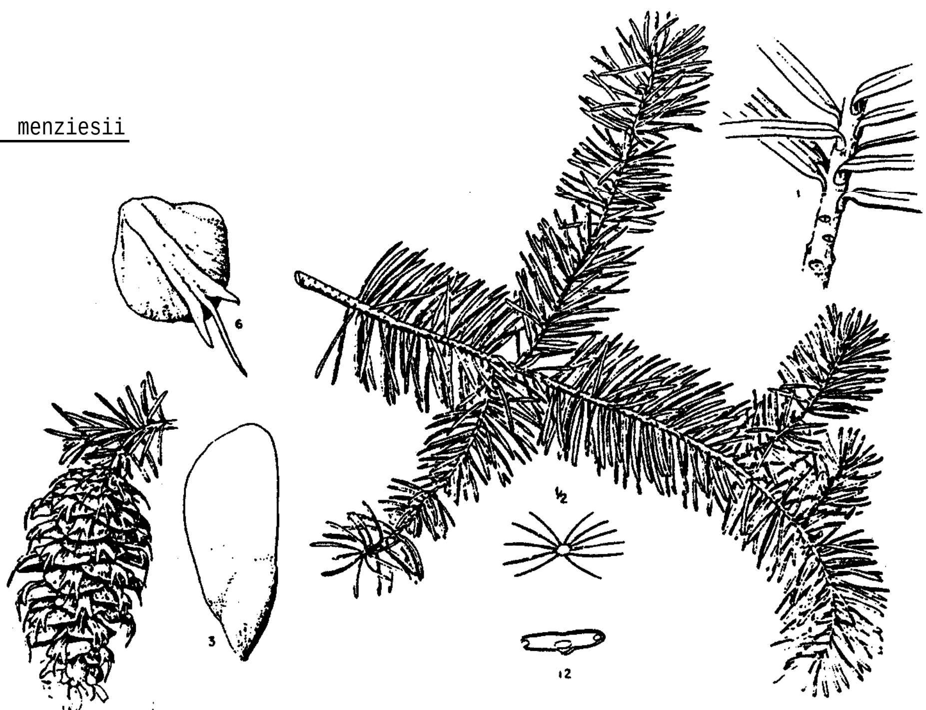
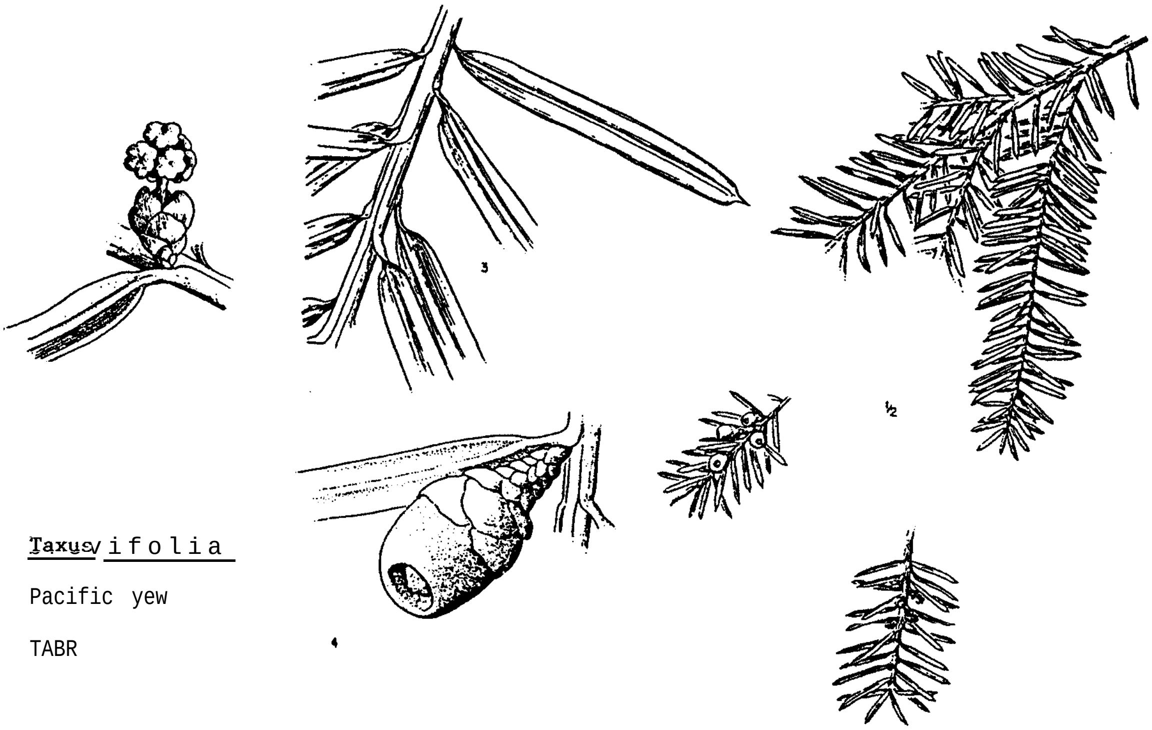


Figure 11 continued



Taxus vifolia

Pacific yew

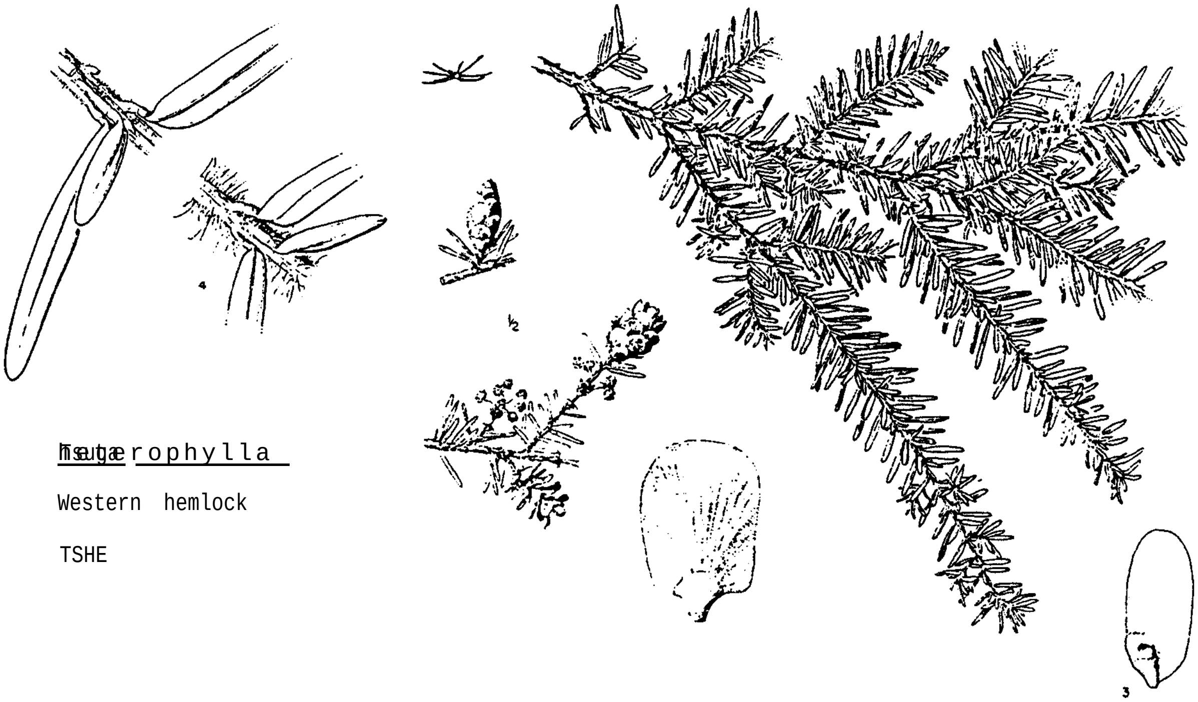
TABR

Thuja plicata

Western redcedar

THPL

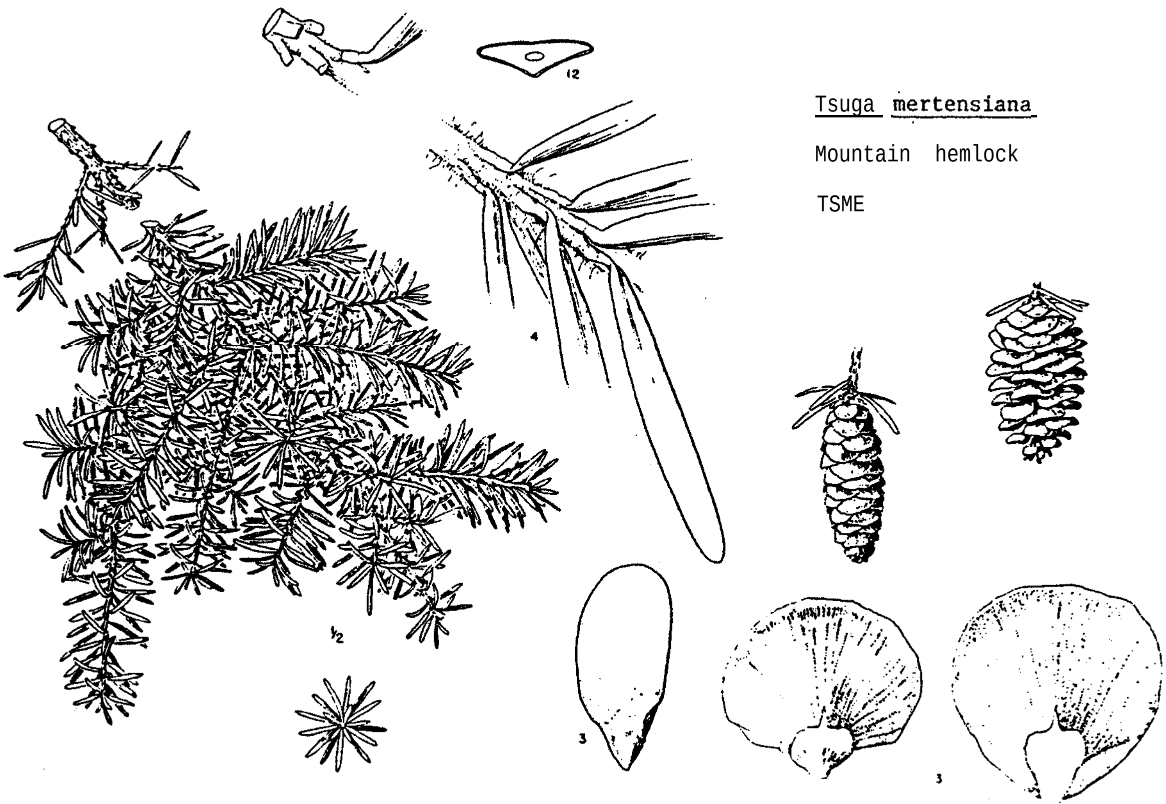
Figure 11 continued



Tsuga heterophylla

Western hemlock

TSHE



Tsuga mertensiana

Mountain hemlock

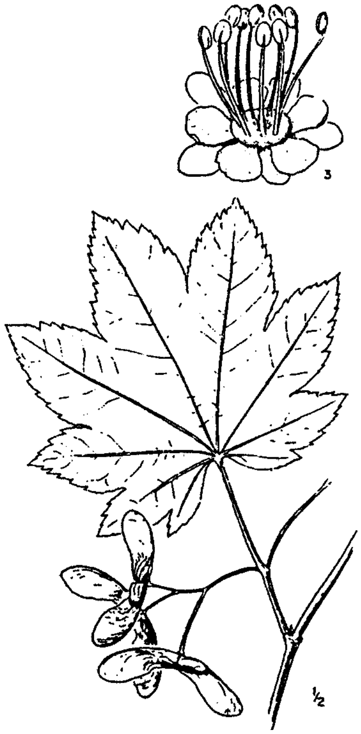
TSME

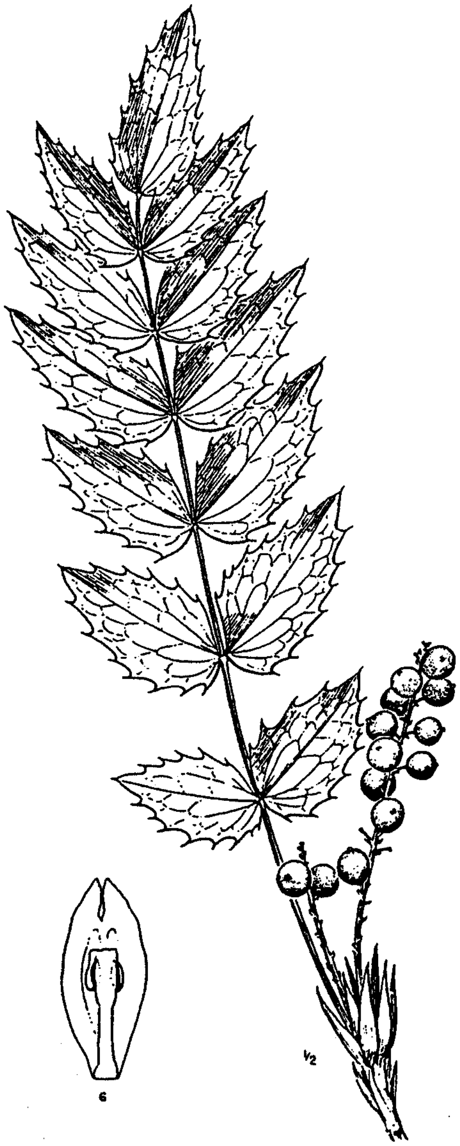
Figure 11 continued

Acer circinatum

Vine maple

ACCI





Berberis nervosa

Dwarf Oregon grape

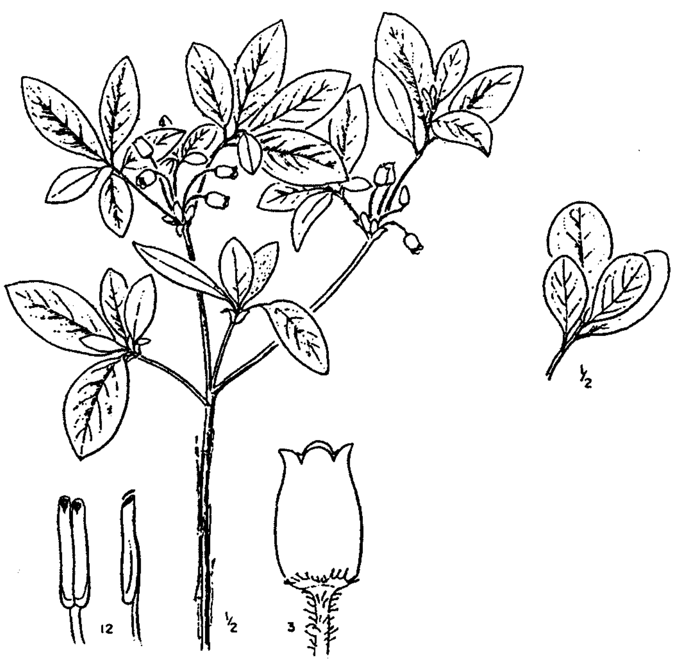
BENE

Figure 11 continued

Gaultheria shallon

Salal

GASH



Menziesia ferruginea

Fool's huckleberry

MEFE

Figure 11 continued

Oplopanax horridum

Devil's club

OPHO

Rhododendron albiflorum

Cascades azalea

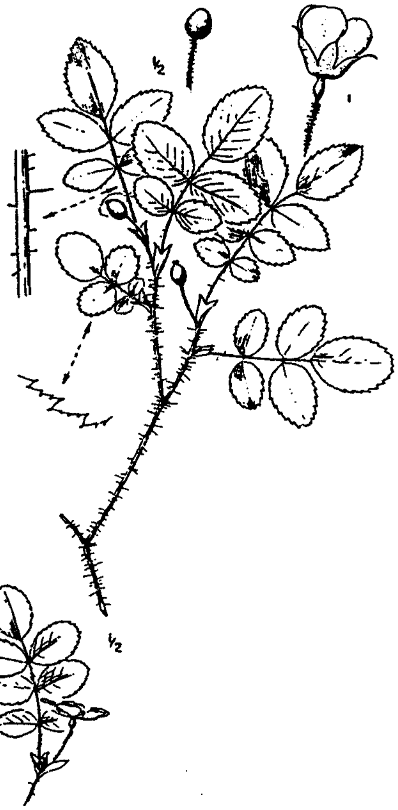
RHAL

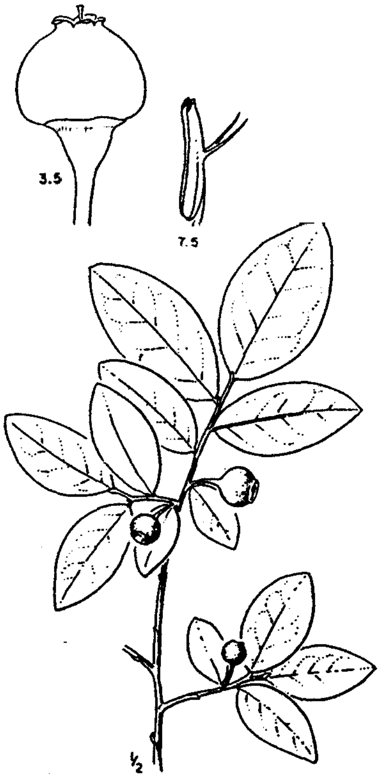
Figure 11 continued

Rosa gymnocarpa

Baldhip rose

ROGY





Vaccinium alaskense

Alaska huckleberry

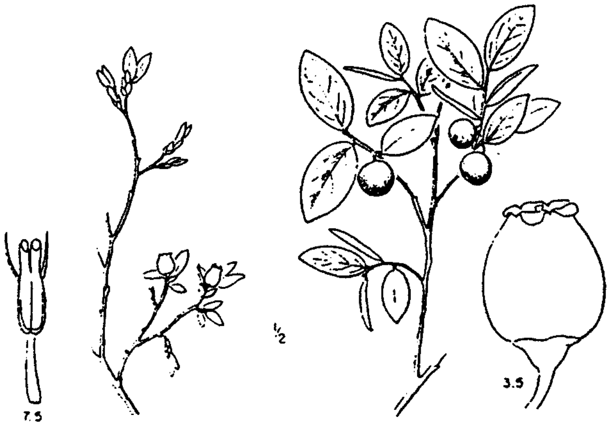
VAAL

Figure 11 continued

Vaccinium membranaceum

Big huckleberry

VAME



Vaccinium parvifolium

Red huckleberry

VAPA

Vaccinium ovalifolium

Ovalleaf whortleberry

VAOV

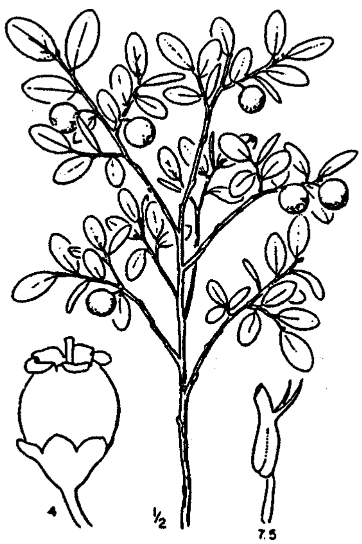
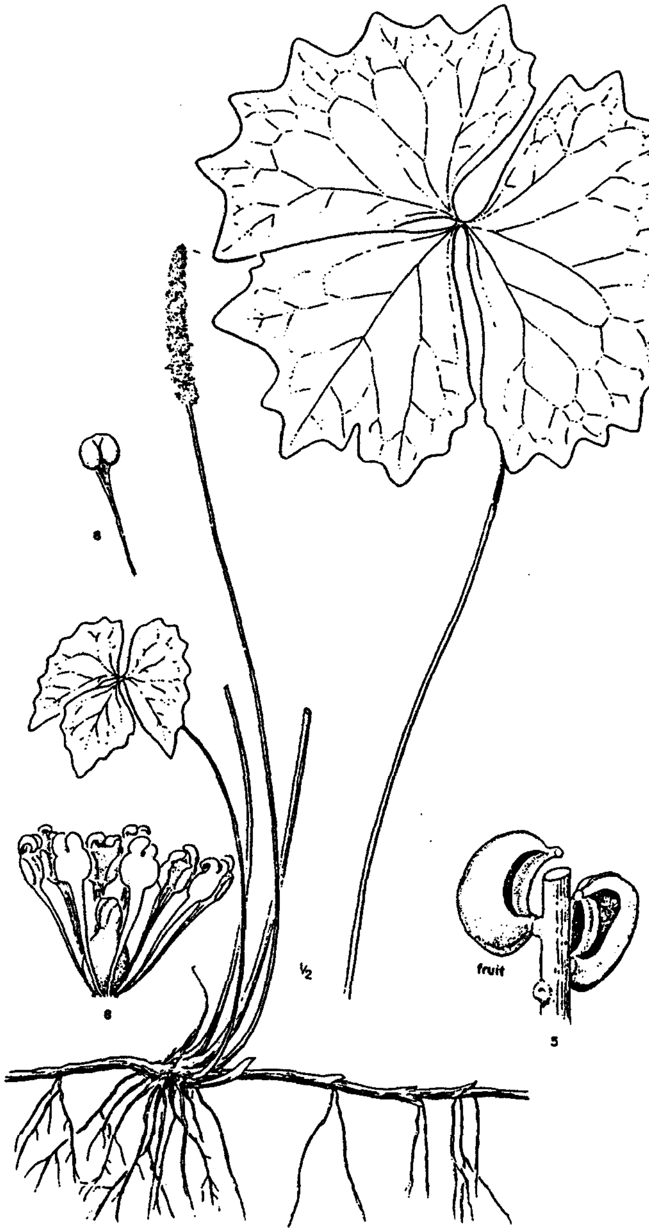


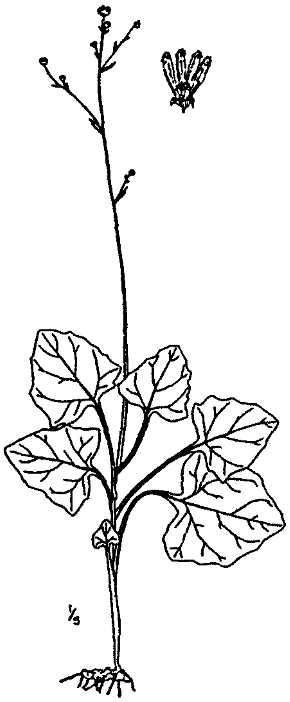
Figure 11 continued

<u>Achlys hylla</u>

Vanillaleaf

ACTR



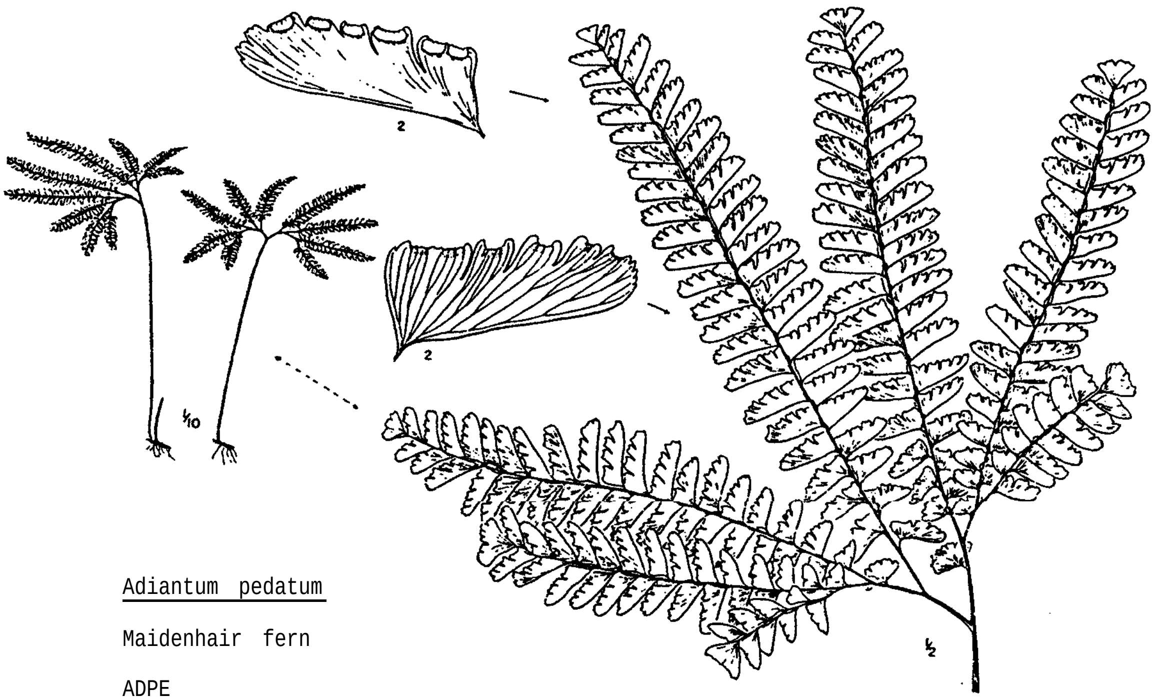


<u>Adenocaulon</u> <u>bicolor</u>

Pathfinder

ADBI

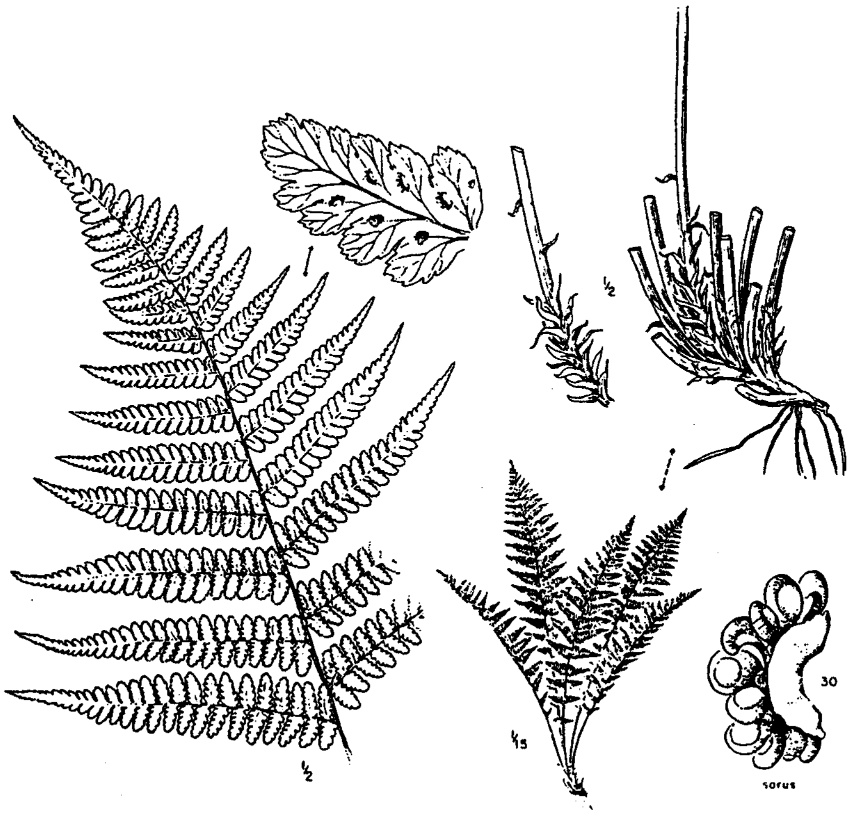
Figure 11 continued



Adiantum pedatum

Maidenhair fern

ADPE



Athyrium filix-femina

Ladyfem

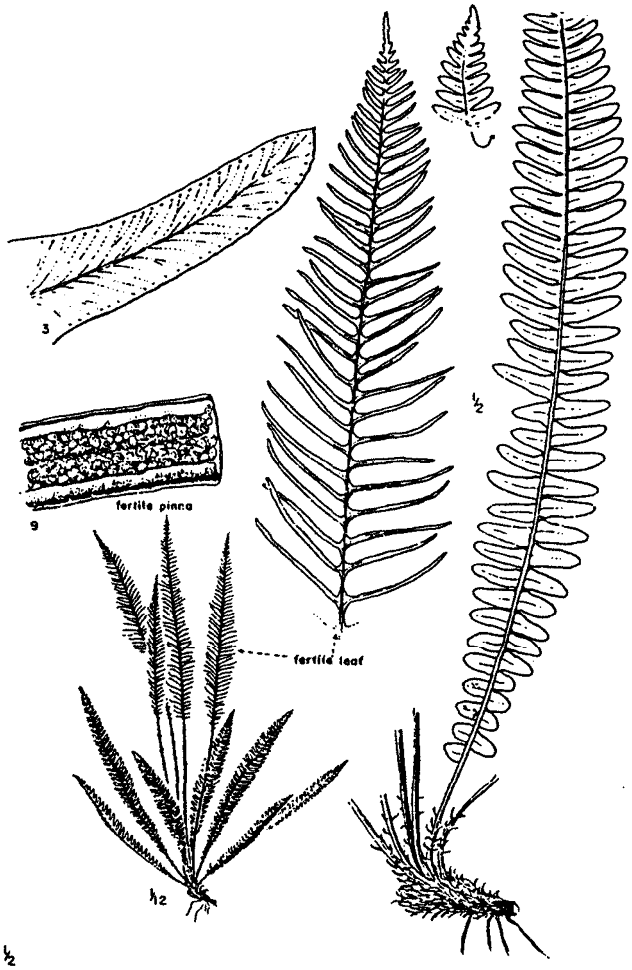
ATFI

Figure 11 continued

Blechum spicant

Deerfern

BLSP



Clintonia uniflora

Queencup beadlily

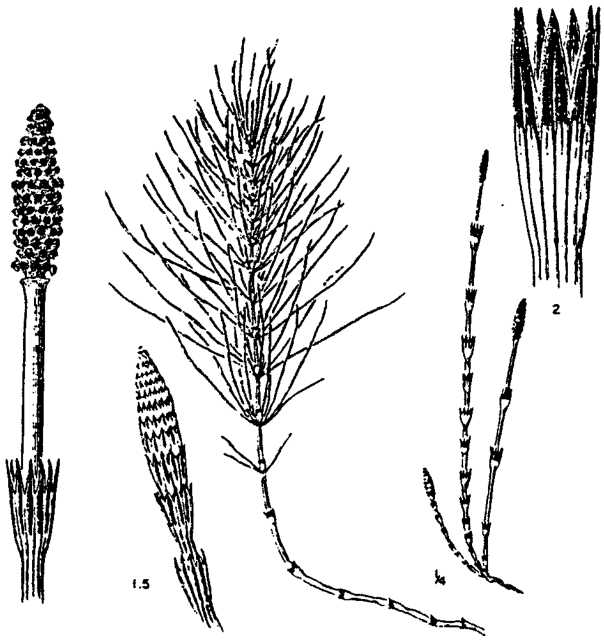
CLUN

Figure 11 continued

Cornus canadensis

Dogwood bunchberry

COCA



Equisetum arvense

Common horsetail

EQAR

Galium triflorum

Sweetscented **bedstraw**

GATR

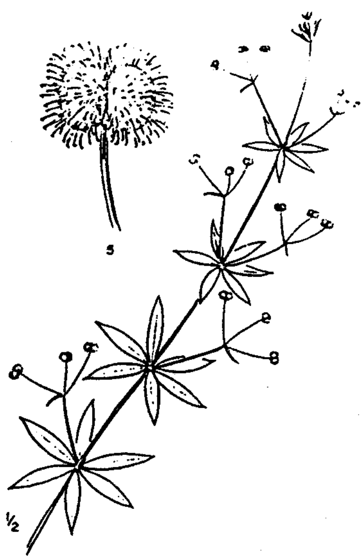
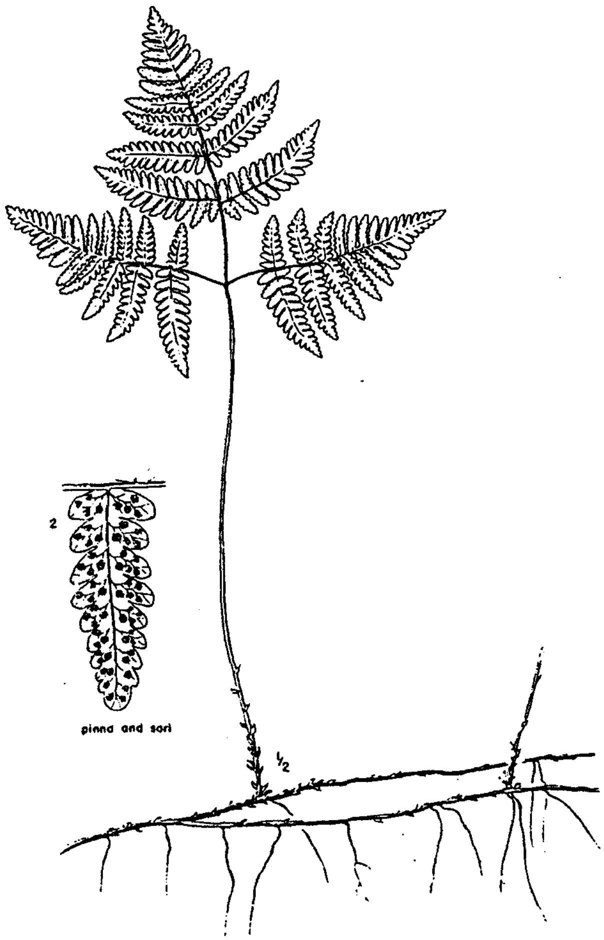


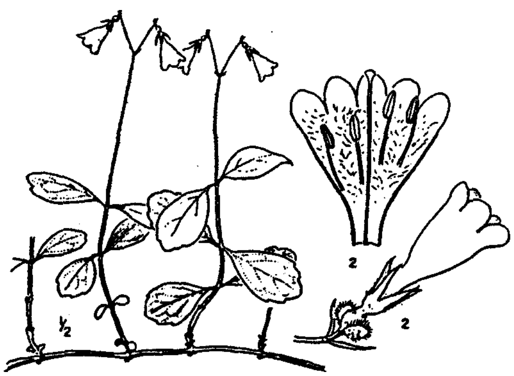
Figure 11 continued



Gymnocarpium dryopteris

Woodfern

GYDR



Linnaea borealis

Twinflower

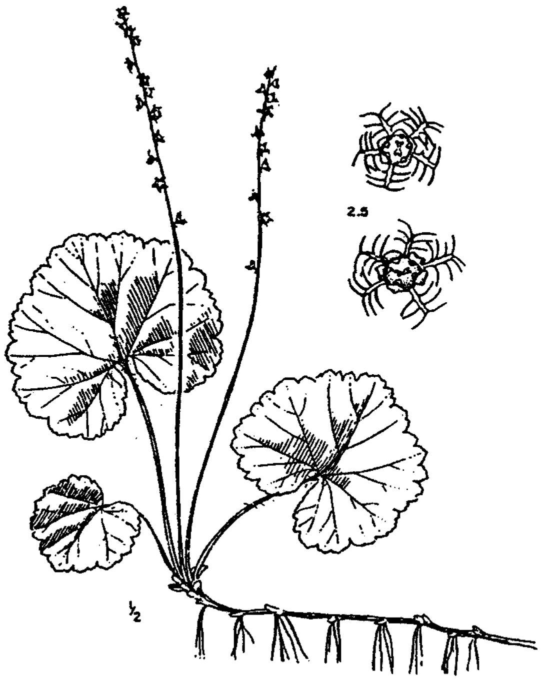
LIB02

Figure 11 continued

Mitella **breweri**

Brewer miterwort

MIBR



Montia sibirica

Siberian montia

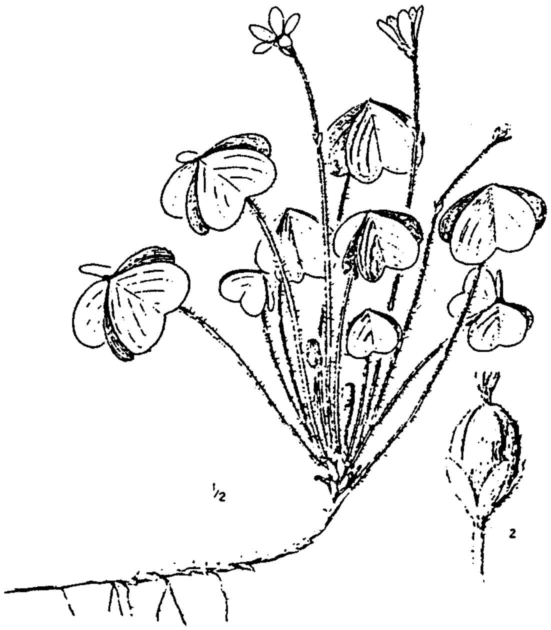
MOSI

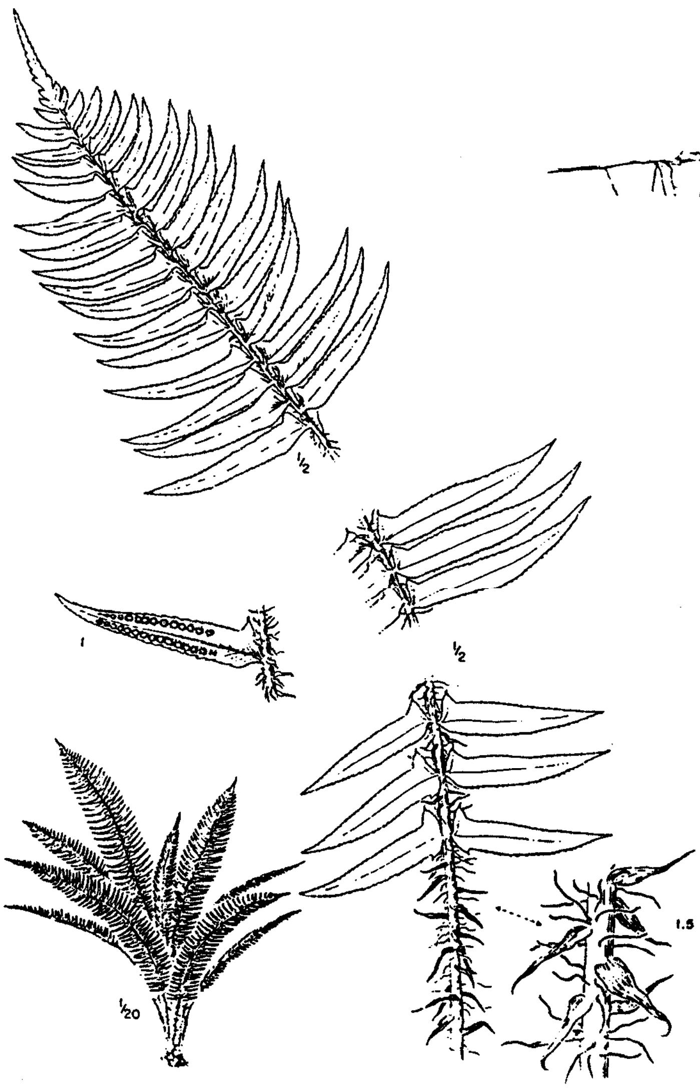
Figure 11 continued

Oxalis oregana

Oregon oxalis

OXOR





Polystichum munitum

Western swordfern

POMU

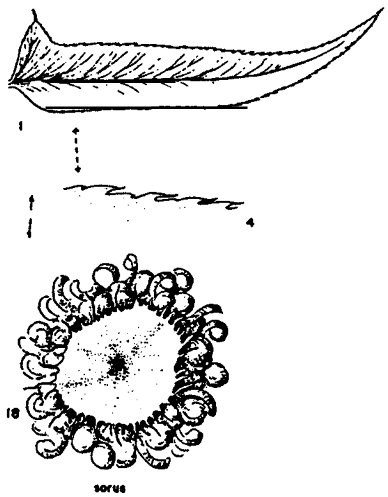
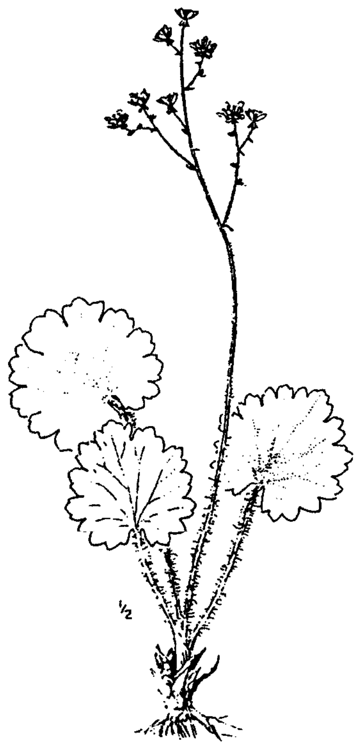


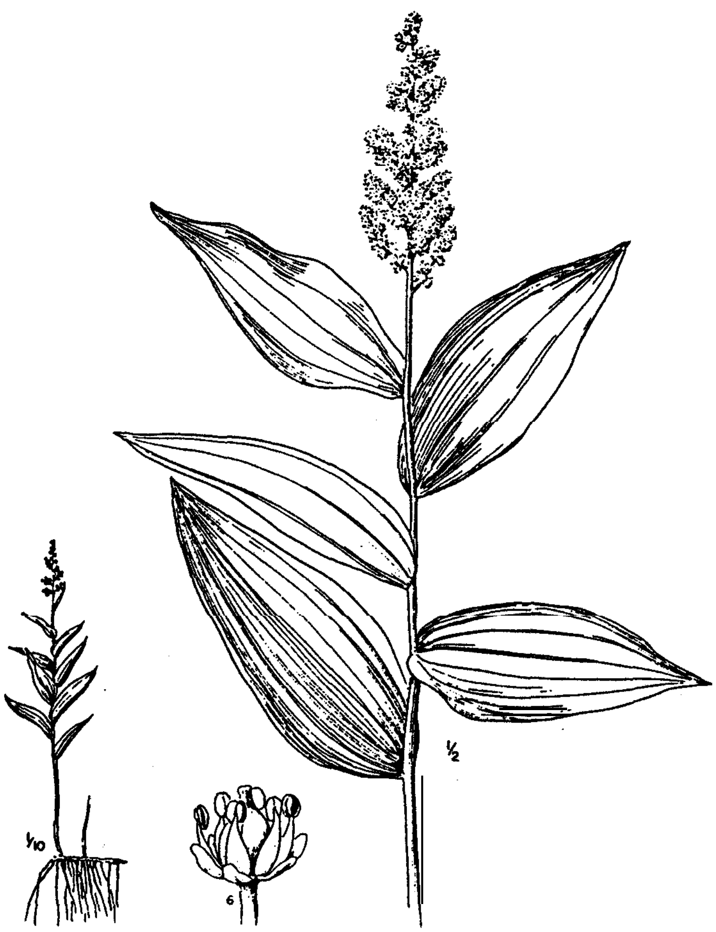
Figure 11 continued

Saxifraga mertensiana

Mertens saxifrag

SAME3



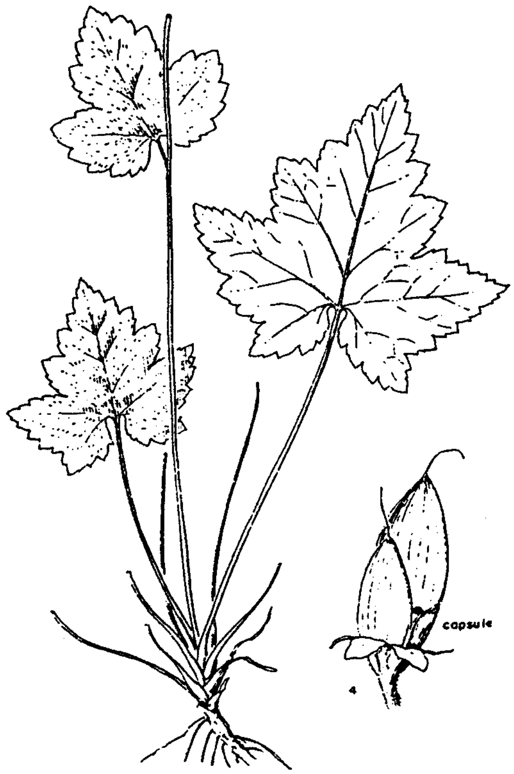


Smilacina racemosa

False **solomonseal**

SMRA

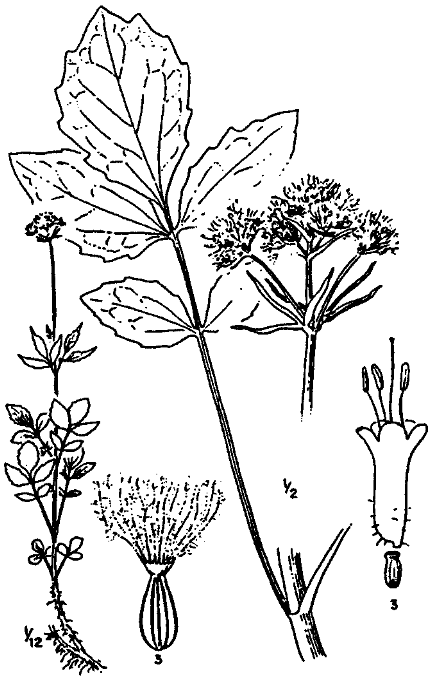
Figure 11 continued



Tiarella unifoliata

Coolwort foamflower

TIUN

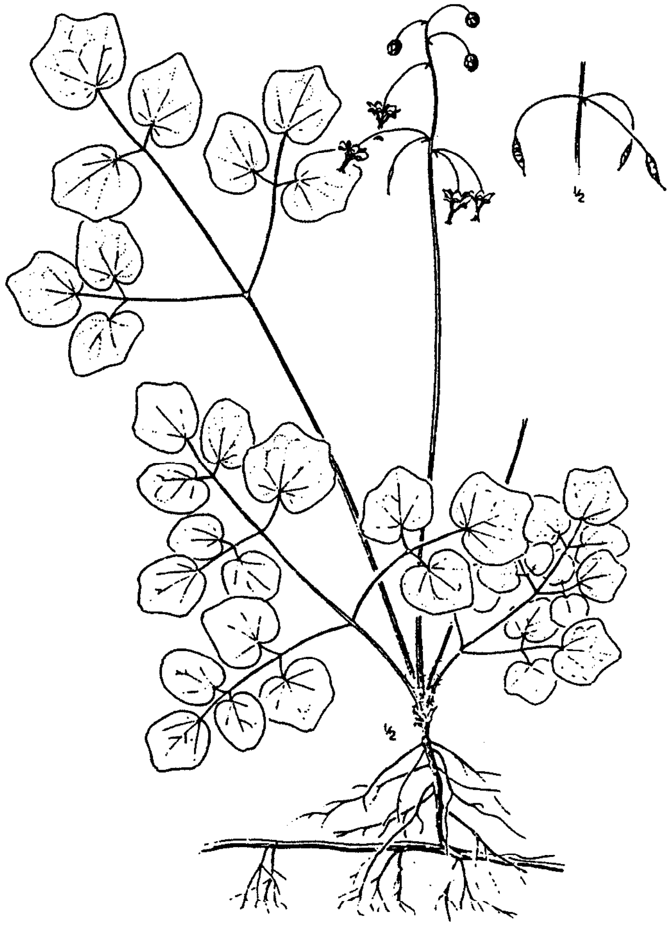


Valeriana sitchensis

Sitka valerian

VASI

Figure 11 continued



Vancouveria hexandra

White inside-out flower

VAHE

Xerophyllum **tenax**

Beargrass

XETE

Figure 11 continued

Terms used include cover and constancy. Cover is the percent of the ground area covered by the leaves of the species within the 0.05 acre (0.02 ha) plot. Constancy is the percentage of plots in that type which contained the species. Thus, 50 percent cover of VAME with 75 percent constancy means that VAME was present on 75 percent of the plots in the association and on those plots, it has an average of 50 percent cover.

Productivity for each tree species found to occur in an association is expressed in terms of volume index and current volume increment. Volume index (VI), a relative measure of species growth performance, is a product of species site index (SI) or height at age 100 and growth basal area (GBA) which is the basal area ($ft.^2/A$) of living trees at which dominants radially grow 10/20ths inch per decade at age 100 (Hall 19883): VI = SI x GBA x 0.005. Volume index is an estimate of the relative growth potential of a stand composed of a single tree species at age 100, adjusted for stocking levels, and is an indicator of the relative productivity among different tree species on the same site. Current volume increment is an expression of the recent 10 year growth of each species, given the relative species stocking proportions which currently exist. The sum of individual species volume growth values is an estimate of the current volume growth for a typical stand in a given association. Ages of the populations measured ranged from 82 to 565 years. Current volume increments were computed using a method adapted from Hemstrom[1] based on regression equations developed for tree species in the Cascade Range. It should be noted that current volume increment varies with stand age, species composition and stocking level on a given site, thus the data presented for one species is not directly comparable to others. These values do, however, present a breakdown of the relative contribution of each species to stand volume growth on upper elevation sites as they currently exist in the field. The remaining species characteristics of age, diameter at breast height, site index, growth basal area and current radial increment are listed to provide the manager a more detailed description of stands found in each plant association.

Pacific Silver Fir/Salal Association (CF S1-52)
ABAM/GASH

The Pacific silver fir-salal association occurs near the transition zone where both Pacific silver fir and western hemlock successfully regenerate. It is characterized by a prominent shrub layer composed mainly of the warm site shrubs. This association generally occurs at lower elevations on south-facing slopes and presents good management opportunities except on steep slopes.

Composition and Structure

Douglas-fir, western hemlock and Pacific silver fir dominate the overstory, averaging 28, 21 and 14 percent cover respectively (Table 25). Mature western redcedar is present in over half of the stands, generally with about 15 percent cover. Noble fir is present in small amounts at elevations generally above 3000 feet. Pacific silver fir and western hemlock dominate the regeneration layer, averaging about 10 percent cover each.

Presence of both salal (GASH) and dwarf Oregon grape (BENE) characterize this association. Other warm site shrubs are also characteristic, including one or more of the following: baldhip rose (ROGY), red huckleberry (VAPA), vine maple (ACCI), trailing blackberry (RUUR) and prince's pine (CHUM). Together with BENE and GASH the warm site shrubs average about 50 percent cover. Although other species of Vaccinium may be present, they generally average less than 5 percent cover.

In the herb layer, twinflower (LIBO2) is the most constant species, ranging between 2 and 10 percent cover. Vanillaleaf (ACTR) also occurs regularly and averages about 3 percent cover. Other herbs which occurred in nearly 50 percent of the stands sampled were western swordfern (POMU), beargrass (XETE), rattlesnake plantain (GOOB), alpine pyrola (PYAS), Pacific trillium (TROV) and dogwood bunchberry (COCA). The average total herb cover is 27 percent. The moss layer occupied an average of 30 percent cover.

Physiography and Soils

Generally occurring on 0 to 66 percent slopes (Table 31), this association is found most often on south or east-facing slopes at lower elevations. Over 70 percent of the plots were below 3000 feet (average elevation 2631 feet). Soils averaged 60 inches in total depth. Effective rooting depth averaged 37 inches. The average profile had one or more pumice layers on top of colluvial or glacial deposits. Only 20 percent of the soil profiles had developed in place. Extrusive igneous rocks, such as andesite and basalt, were the bedrock in three-quarters of our plots. Typically

[1] Hemstrom, M.A. 1982. Unpublished growth simulation model for upper elevation conifers (personal communication). USDA Forest Service. Eugene, OR 97401.

Table **11**: Productivity of the Pacific silver fir/salal association

Tree Species	Number of Cored Trees	**Site Index (ft)** Mean	SD	Current Radial Incre- **ment (20ths/ 10 yrs)** Mean	SD	Growth **Basal Area (ft^2/A)** Mean	SD	Volume **Index (ft^3/ A/yr)** Mean	SD	Current Volume Incre- **ment (ft^3/ A/yr)** Mean	SD	**D.B.H. (in)** Mean	SD	**Tree Age (yrs)** Mean	SD
Noble fir	**19**	**99**	2	12	4	389	211	180	93	**8**	6	25	3	178	6
Pacific silver fir	**25**	**99**	16	10	7	324	124	167	84	**26**	16	**19**	4	152	**46**
Western hemlock			14	**11**	4	290	59	142	20	40	13	22	6	171	**58**
Douglas-fir	30	**91**	**15**	**6**	4	253	104	116	49	35	16	28	8	276	142

encountered TRI soil mapping units included 34, 43, 57, 378 and 412.

Productivityand Management Considerations

Overall productivity is **moderate** for stands in the Pacific silver **fir/salal** association. The site index values are highest here for western **hemlock** (99) and Pacific silver fir (99) while **those** for noble fir (93) and Douglas-fir **(91)** are somewhat lower (Table **11).** Although current **volume** in most of these stands is dominated by **western** hemlock, Douglas-fir and noble fir, a **comparison** of volume index data indicates that **noble** fir is potentially the most productive species in this association. Noble fir **maintains** good rates of diameter growth at **relatively** high stocking levels.

This association has good potential for intensive timber management, except on steep slopes in dissected topography. Clearcutting may be widely used. Where frost pockets develop **on** sites with slopes less than 15 percent, a shelterwood leaving about 25 percent of the initial basal area (or 70 to **80 ft^2/A)** should provide adequate protection for seedlings. Generally, however, shelterwood is not needed to successfully regenerate this association. Both Douglas-fir and noble fir are suitable timber **species** in this type. At lower elevations on slopes greater than 15 percent, Douglas-fir could be planted exclusively without fear of frost. At elevations above 3000 feet, noble fir and Douglas-fir may be planted in equal amounts **where** there is no frost danger.

Comparisons

The ABAM/GASH association most closely resembles **the ABAM/GASH** habitat type described by Franklin et al. **(1979)** for Mt. Rainier National Park. Vine maple is important here, but was not at Mt. **Rainier.** Franklin **(1966)** described an **ABAM/GASH** type in the Mt. Rainier Province, which-is also similar. Beargrass is not as consistent or as important in the association described here as it was in either of the previous classifications. Henderson and Peter **(1981)** described a similar ABAM/GASH type for the northern Washington Cascades. Appendix IV contains floristic data averaged for the Mt. Baker-Snoqualmie and Gifford Pinchot National Forests for this association.

Pacific Silver Fir/Dwarf Oregon Grape Association (CF S1-51) ABAM/BENE

The Pacific silver fir/dwarf Oregon grape association is similar to the Pacific silver **fir/salal** association except that **salal** is either lacking or inconspicuous. Warm site shrubs dominate the shrub layer and the herb layer is usually minor. In spite of its relatively low productivity (Table **12),** this association should respond well to moderately intensive **timber** management and produce good stands of Douglas-fir and noble fir.

Composition and Structure

Stands are dominated by western hemlock, Douglas-fir and Pacific silver fir with 32, 25 and 15 percent average cover, respectively (Table 25). Noble fir occurs in about 30 percent of the stands with **10** percent average cover and western **redcedar** in about 50 percent of the stands with 7 percent cover. Pacific silver fir and western hemlock generally reproduce about equally well, averaging **11** percent cover each. Western **redcedar** regenerated **sporadically** in 41 percent of our stands.

Warm site shrubs dominate the shrub layer, which averages 40 percent total cover. Dwarf Oregon grape (BENE) cover is often **10** to 20 percent. Prince's pine (CHUM), vine maple (ACCI), **baldhip** rose-(ROGY), red huckleberry (VAPA) and Oregon boxwood **(PAMY)** are other shrubs from the warm group which occur more or less frequently. CHUM and **ACCI** occurred in over 75 percent of our plots and together comprised 15 to 20 percent cover. Vaccinium species are often present, especially big huckleberry (VAME) and **ovalleaf** whortleberry (VAOV), but generally occupy less **than** 5 percent cover. Trailing blackberry (RUUR), dwarf bramble (RULA) and little prince's pine (CHME) are common with less than 2 percent average cover.

The herbaceous layer averages 26 percent cover. Twinflower (LIB02) is the most characteristic **herb** with 82 percent constancy and 4 percent average cover. Dogwood bunchberry (COCA) and sidebells pyrola (PYSE) are frequently present in small amounts and beargrass (XETE), vanillaleaf (ACTR), **queencup beadlily** (CLUN), Pacific trillium (TROV) and alpine pyrola (PYAS) all occur in more than 50 percent of the plots, but only COCA, ACTR and XETE have more than 5

Table 12: Productivity of the Pacific silver fir/dwarf Oregon grape association

Tree Species	Number of Cored Trees	Site Index (ft)		Current Radial Increment (20ths/10 yrs)		Growth Basal Area (ft²/A)		Volume Index (ft³/A/yr)		Current Volume Increment (ft³/A/yr)		D.B.H. (in)		Tree Age (yrs)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pacific silver fir	5	89	-	6	-	252	-	117	-	10	-	19	-	269	-
Western hemlock	13	92	2	9	3	243	42	113	19	15	4	23	5	220	i14
Noble fir	5	68		7	-	283	-	96	-	26	-	31	-	322	
Douglas-fir	25	78	15	5	1	210	47	82	27	26	12	29	6	275	11;

percent average cover. Other **common** herbs include rattlesnake plantain (GOOB), coolwort foamflower (TIUN) and **vetch** violet (VIOR2). The moss layer is often lush and averages 23 percent cover.

Physiography and Soils

Occurring on slopes averaging 36 percent between 2600 and 4600 feet elevation (Table **31),** most plots had south to west aspects. Few were north-facing. About half the plots were on steep, dissected terrain while the other half were on more gentle, rolling topography. The soils averaged 48 inches in **total depth.** Effective rooting depth averaged 26 inches. The most common profiles were pumice layers mixed with colluvium or glacial till over andesite or basalt bedrock. Typically encountered TRI soil mapping units included 25, 26, 31, 41 and 92.

Productivityand Management Considerations

Overall **productivity** is low for stands in the Pacific silver fir/dwarf Oregon grape association. Site index values are highest here for western hemlock (92) and Pacific silver fir (89) while those for Douglas-fir (78) and noble fir (68) are lower (Table 12). Current volume *in* these stands is generally dominated by noble fir and Douglas-fir. At higher elevations in this association, Pacific silver fir may be quite productive.

Relatively low productivity and steep, dissected terrain indicate less adaptability to **intensive** silvicultural treatment than other associations in the Pacific silver fir zone. Generally occurring on slopes greater than **10** percent at elevations generally less than 4000 feet, there should be few frost problems. Clearcutting may be widely used. Where shallow, rocky soils or frost problems occur, a shelterwood leaving about 30 percent of'the initial basal area (or 75 to 85 ft^2/A) should provide adequate protection for seedlings. Generally shelterwood is not required to regenerate this association. Douglas-fir and noble fir may be the best species for regeneration efforts.

Comparisons

Althawgh vine maple is more prominent in the **ABAM/BENE association,** it is otherwise similar to **the ABAM/BENE** habitat type described by Franklin et al. **(1979)** for Mt. Rainier National Park. This association, although similar to the **ABAM/BENE** habitat type described by Franklin **(1966)** for the Mt. Rainier Province, does not contain **salal** and Alaska huckleberry is much less comnon. The average cover of beargrass is consistently higher in Franklin's habitat type. **Hemstrom** et al. **(1982),** working in the Oregon Cascades, described an essentially identical type to our **ABAM/BENE** association. Henderson and Peter **(1981)** described a similar association for the northern Washington Cascades. Appendix IV contains average floristic and productivity values for this association in the western Cascades.

Pacific Silver Fir/Vanillaleaf-Queencup Beadlily Association (CF F2-53) ABAM/ACTR-CLUN

The Pacific silver **fir/vanillaleaf-queencup beadlily** association is **noted** for good stands of Douglas-fir and noble fir. In most stands Douglas-fir and noble fir codominate with Pacific silver fir and western hemlock. Pacific silver fir is usually twice as abundant as western hemlock in the regeneration layer. Both the shrub and herb layer are very diverse, with many species occurring at over 50 percent constancy.

Composition and Structure

The overstory is composed of Douglas-fir, Pacific silver fir, western hemlock, noble fir and western **redcedar** (Table 25). Douglas-fir generally dominates stands with 35 percent average cover. Pacific silver fir and western hemlock are present in over 85 percent of the stands with an average cover of about 16 percent each. While noble fir is present in only about 50 percent of the stands, its average cover is 17 percent. Western **redcedar** occurs in about 30 percent of the plots with 7 percent average cover. Pacific silver fir is the *major* climax tree species in this association, regenerating in **100** percent of the plots with about **10** percent cover. Western hemlock seedlings occurred in about 65 percent of the stands and had an average cover of 5 percent. Western **redcedar** regenerated in nearly 30 percent of the stands with an average cover of 4 percent.

Vine maple (ACCI) dominates the shrub layer, averaging between 20 and 30 percent cover. **Baldhip** rose (ROGY) and prince's pine (CHUM) occurred in over 70 **percent of** the stands sampled. Big huckleberry (VAME) averaged about

Table 13: Productivity of the Pacific silver fir/vanillaleaf-queencup beadlily association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft^2/A) Mean	Growth Basal Area (ft^2/A) SD	Volume Index (ft^3/A/yr) Mean	Volume Index (ft^3/A/yr) SD	Current Volume Increment (ft^3/A/yr) Mean	Current Volume Increment (ft^3/A/yr) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
Noble fir	15	134	16	18	5	415	99	286	95	52	46	26	4	93	36
Douglas-fir	25	119	17	9	4	326	38	195	43	57	42	36	16	330	305
Western hemlock	15	120	13	8	5	324	90	195	48	21	22	37	7	309	126
Pacific silver fir	10	112	10	7	1	259	13	146	21	18	8	25	6	234	26

10 percent cover in 83 percent of the stands. Dwarf Oregon grape (BENE), dwarf bramble (RULA), little prince's pine (CHME) and sitka mountain ash (SOSI) occurred in over 50 percent of the sampled stands. Other common shrubs included trailing blackberry (RUUR), trailing snowberry (SYMO), Oregon boxwood (PAMY), western thimbleberry (RUPA), ovalleaf whortleberry (VAOV) and red huckleberry (VAPA).

The herb layer is rich and diverse with an average cover of 50 percent. Vanillaleaf (ACTR), the characteristic species, averages about 14 percent cover. Sidebells pyrola (PYSE), twinflower (LIBO2), queencup beadlily (CLUN) and starry solomonplume (SMST) occurred in 70 percent of the plots. Twinflower, with 8 percent average cover, is the most prominent of these. CLUN and SMST averaged about 5 percent cover. Herbs with over 50 percent constancy included fairybells (DIHO), rattlesnake plantain (GOOD), Pacific trillium (TROV), coolwort foamflower (TIUN) and dogwood bunchberry (COCA). COCA was the most prominent of these with almost 10 percent average cover. There were 10 other herbs which occurred with over 30 percent constancy, including beargrass (XETE), white inside-out flower (VAHE) and threeleaf anemone (ANDE). Bracken fern (PTAQ) occurred in about 33 percent of the stands. This is the only association in the Pacific silver fir zone where bracken fern occurred regularly.

Physiography and Soils

ABAM/ACTR-CLUN association is found on slopes averaging 34% (Table 31) in topographically favorable positions for deep soil accumulation. About 40 percent of the stands sampled were on southerly aspects. Fewer than 15 percent were on north aspects. Although the elevation range in our plots is nearly 2000 feet, 60 percent were between 2900 and 3900 feet elevation.

Generally occurring on moderate to deep, well drained soils, mean soil depth was 53 inches. Effective rooting depth averaged 33 inches. Soils were dominated by pryoclastic and extrusive igneous materials. Three-quarters of all profiles had a pumice layer and most were underlain by extrusive igneous rock. Andesite was the most common parent material but basaltic tuffs and breccias were also found. Thirty percent of our soil profiles had colluvial layers which either dominated or were mixed with the pumice. Only about 10 percent of the plots were on residual soils. Typically encountered TRI soil mapping units included 17, 28, 41, 45 and 95.

Productivity and Management Considerations

Overall productivity is high for stands in the Pacific silver fir/vanillaleaf-queencup beadlily association. Site index values for noble fir (134), western hemlock (120) and Douglas-fir (119) were substantially higher than that for Pacific silver fir (1.12). Current volume increment in these stands is dominated by noble fir and Douglas-fir (Table 13). Volume index values indicate that noble fir, and to a somewhat lesser degree, Douglas-fir and western hemlock are potentially the most productive species in this association. Again, noble fir's position as the most productive species is a result of its ability to grow well at higher stocking levels, as can be seen from the growth basal area data.

This association offers good opportunities for intensive timber management. Clearcutting may be widely used. Where frost pockets develop on sites with slopes less than.15 percent, a shelterwood leaving about 30 percent of the initial basal area (or 80 to 90 ft^2/A) should provide adequate protection for seedlings. Generally, however, shelterwood is not required to regenerate this association. Noble fir and Douglas-fir can be planted on slopes over 15 percent with southerly aspects. Planted pure noble fir stands would probably contain naturally seeded Douglas-fir, western hemlock and Pacific silver fir.

Comparisons

The ABAM/ACTR-CLUN association is similar to Franklin's ABAM/ACTR association (1966), but has greater cover of ACCI, lower cover of VAME and a slightly less rich herb layer. The understory of the TSHE/ACTR type described by Franklin et al. (1979) for the Ohanapecosh drainage of Mt. Rainier National Park is similar to this association except ABAM/ACTR-CLUN seems to indicate cooler and perhaps drier sites. Their type has a richer herbaceous layer and is a western hemlock climax. The ABAM/ACTR-CLUN association is most similar to the ABAM/ACTR habitat type described by Dyrness et al. (1974) and the ABAM/ACCI/TIUN association described by Hemstrom et al. (1982) in'the Oregon Cascades.

Table 14: Productivity of the Pacific silver fir/Alaska huckleberry association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	SD	Current Radial Increment (20ths/10 yrs) Mean	SD	Growth Basal Area (ft^2/A) Mean	SD	Volume Index (ft^3/A/yr) Mean	SD	Current Volume Increment (ft^3/A/yr) Mean	SD	D.B.H. (in) Mean	SD	Tree Age (yrs) Mean	SD
Western hemlock	51	102	12	8	2	293	59	148	34	33	17	31	7	332	103
Douglas-fir	27	111	14	6	2	264	66	146	37	12	7	44	13	456	205
Noble fir	7	104	28	10	5	256	43	138	62	2	-	28	6	240	190
Pacific silver fir	58	102	11	7	2	250	63	126	33	15	9	24	4	287	47

Pacific Silver Fir/Alaska Huckleberry Association (CF S2-57) ABAM/VAAL

The Pacific silver fir/Alaska huckleberry association is widespread on environmentally moderate sites. Timber stands are dominated by Pacific silver fir, western hemlock and Douglas-fir. Pacific silver fir is the climax dominant often associated with western hemlock. Douglas-fir up to 500 years old and 50 inches in diameter are common.

Composition and Structure

Pacific silver fir and western hemlock dominate (29 percent cover) the canopy (Table 26). Douglas-fir occurs in about 79 percent of the stands and averages 16 percent cover. Western redcedar occurs in only 38 percent of the stands and averages 7 percent cover. Although western hemlock regeneration is found in about 79 percent of the stands, Pacific silver fir regeneration is usually more than twice as abundant and is clearly dominant.

The ABAM/VAAL association is characterized by a prominent Vaccinium layer and lacks salal. Alaska huckleberry (VAAL) cover is generally greater than 20 percent with big huckleberry (VAME) and ovalleaf whortleberry (VAOV) cover between 5 and 10 percent. Warm site shrubs are generally inconspicuous.

The herb layer is highly variable containing queencup beadlily (CLUN), sidebells pyrola (PYSE), dogwood bunchberry (COCA), beargrass (XETE), Pacific trillium (TROV), twinflower (LIBO2), rattlesnake plantain (GOOB), vanillaleaf (ACTR) and alpine pyrola (PYAS). Herbaceous cover averages 14 percent. Where pumice deposits are a major portion of the soil profile, the herb layer is especially depauperate, generally including only PYSE and PYAS.

Physiography and Soils

The mean elevation is 3355 feet and all aspects are well represented (Table 32). About one-third of the plots fell on flats, benches or terraces with less than 15 percent slope. The plots averaged 24 percent slope and ranged from 2 to 75 percent slope. Soils are dominated by pumice. In over half of the stands, pumice or cinders comprised the entire rooting medium. In the remaining plots, volcanic ejecta (pumice, ash and cinders) were interbedded with colluvial, glacial or alluvial material. Soil depth ranged from 18 to 100 inches and averaged 58 inches (Table 32). Effective rooting depth averaged 37 inches. One-quarter of the plots had a layer with over 40 percent coarse fragments. Especially in the pumice soils, there is a tendency for an abnormal decrease in roots at about 15 inches depth. Typically encountered TRI soil mapping units included 20, 21, 26, 31, 34, 37, 65, 83, 92, 95 and 310.

Productivity and Management Considerations

Overall productivity is moderate for stands in the Pacific silver fir/Alaska huckleberry association. The site index value for Couglas-fir (111) was higher than values for noble fir (104), western hemlock (102) and Pacific silver fir (102). Current volume increment in these stands is dominated by western hemlock, Pacific silver fir and Douglas-fir (Table 14). However, volume index data indicated that western hemlock, Douglas-fir. and noble fir are potentially the most productive species in this association.

This association offers good opportunities for intensive timber management. Clearcutting may be widely practiced. Where frost pockets develop on sites with slopes less than 15 percent, a shelterwood leaving about 25 percent of the initial basal area (or 70 to 80 ft^2/A) should provide adequate protection for seedlings. Generally, however, shelterwood is not needed to successfully regenerate this association. Regeneration of noble fir and Douglas-fir are both possible outside of frost prone areas.

Comparisons

Several -authors have described Alaska huckleberry types but direct comparisons are difficult to make because this widespread type has been defined in various ways. The ABAM/VAAL association is close to that described by Dyrness et al. (1974) for the Central Cascades of Oregon and is similar to the ABAM/VAAL/BENE habitat type described by Franklin (1966) for the Mt. Rainier Province. Franklin's type is dominated by Douglas-fir, western hemlock, western redcedar and Pacific silver fir with an understory of red huckleberry (VAPA), dwarf Oregon grape (BENE), VAAL, VAOV, vine maple (ACCI) and salal (GASH). His type had a richer herb layer and often included coolwort foamflower (TIUN) and vanillaleaf (ACTR). The **ABAM/VAAL** association is also similar to the more herb rich **ABAM/VAAL(BENE)** type described in the Mt. Rainier study (Franklin et al. 1979). The **ABAM/VAAL/COCA** association described by **Hemstrom** et al. (1982) is similar to our **ABAM/VAAL** association. Henderson and Peter (1981 and 1982) describe an **ABAM/VAAL** association which is similar to that described here. Appendix IV contains floristic averages for this association where it has been described in the western Cascades.

Pacific Silver Fir/Alaska Huckleberry-Salal Association (CF S2-55) ABAMIVAAL-GASH

The Pacific silver fir/Alaska **huckleberry-salal** association is widespread and characterizes warmer middle elevation sites of moderate environment. Timber stands are dominated by Pacific silver fir, western hemlock and Douglas-fir. Western **redcedar** frequently can be found in abundance in this association.

Composition and Structure

The ABAM/VAAL-GASH association typically has **salal** and other warm site shrubs in addition to a prominent Vaccinium layer (Table 26). Found at lower elevations on moderate slopes, Douglas-fir, western hemlock and Pacific silver fir codominate in the overstory, each averaging about 20 percent cover while western **redcedar** is generally present at about 10 percent cover. Although Pacific silver fir dominates, both western hemlock and western **redcedar** are well represented in the regeneration layer.

Huckleberry species dominate the shrub layer. Alaska huckleberry (VAAL) is most important, with about 26 percent cover, and big huckleberry (VAME) and **ovalleaf** whortleberry (VAOV) usually combine for about 13 percent cover (Table 26). Total cover of the warm shrubs, dwarf Oregon grape (BENE), **salal** (GASH), prince's pine (CHUM), red huckleberry (VAPA) and vine maple (ACCI) is about 35 percent.

The herb layer is usually inconspicuous (17 percent average cover). The most common herbs are rattlesnake plantain **(GOOB)**, Pacific trillium (TROV), twinflower **(LIBO2)**, alpine pyrola (PYAS) and dogwood bunchberry (COCA). Of these, only LIBO2 and COCA generally have significant amounts of cover, averaging 5 and 7 percent, respectively. Other less common herbs include beargrass (XETE), sidebells pyrola **(PYSE), queencup beadlily** (CLUN) and vanillaleaf **(ACTR)**.

Physiography and Soils

This association is found on all aspects with slopes averaging 22 percent (Table 32) and between 1900 and 4700 feet elevation. Soils are quite similar to those in the **ABAM/VAAL** association. Effective rooting depth averaged 44 inches. Soil depth was over 60 inches in 70 percent of the plots, averaging 61 inches. Typically encountered TRI soil mapping units included 17, 37, 54, 56, 63, 81, 84, 412 and 561.

Productivity and Management Considerations

Overall productivity is moderate for stands in the Pacific silver fir/Alaska **huckleberry-salal** association. Site index values are highest for Pacific silver fir **(107)**, western **redcedar** **(103)**, western hemlock (101) and Douglas-fir (98) and lowest for noble fir (87). Current volume increment in most stands is largely dominated by western hemlock and Pacific silver fir (Table 15); however, volume index data indicate that Douglas-fir, Pacific silver fir and noble fir are potentially the most productive species in this association.

This association offers good opportunities for intensive timber management. Clearcutting may be widely applied. Where frost pockets develop on sites with slopes less than 15 percent, a shelterwood leaving about 25 percent of the initial basal area (or 70 to 80 ft^2/A) should provide adequate protection for seedlings. Generally, shelterwood is not required to successfully regenerate this association. Both Douglas-fir and noble fir may be used in regeneration efforts. The high shrub cover (66 percent average) indicates that shrub competition may become a problem following clearcutting.

Comparisons

The ABAM/VAAL-GASH association is similar to the **ABAM/VAAL** type of Dryness et al. **(1974)**, the **ABAM/VAAL/BENE** habitat type described by Franklin (1966) and the **ABAM/VAAL** (BENE) type identified by Franklin et al (1979). The **ABAM/VAAL-GASH** association has, however, a

Table 15: Productivity of the Pacific silver fir/Alaska **huckleberry-salal** association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft^2/A) Mean	Growth Basal Area (ft^2/A) SD	Volume Index ($ft^3/A/yr$) Mean	Volume Index ($ft^3/A/yr$) SD	Current Volume Increment ($ft^3/A/yr$) Mean	Current Volume Increment ($ft^3/A/yr$) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
		98		6											
Douglas-fir	39	107	24	8	1	339	69	171	67	16	8	40	14	451	147
Pacific silver fir'	35		17		3.	293	105	161	77	29	16	22	4	206	50
Noble fir	4			10	-	359	-	156			-	25	-	206	-
	6	87	28						-	2	7	31			30
Western redcedar	18	103	20	6	1	260	66	153	74	14	20	23	6	321	60

Table 16: Productivity of the Pacific silver **fir/coolwort** foamflower association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft²/A) Mean	Growth Basal Area (ft²/A) SD	Volume Index (ft³/A/yr) Mean	Volume Index (ft³/A/yr) SD	Current Volume Increment (ft³/A/yr) Mean	Current Volume Increment (ft³/A/yr) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
	10				1	480	84	338	95	71	30	34	9	233	126
Western hemlock	10	117 141	39 15	11 14	6	472	235	303	228	27	4	35	10	187	39
Noble fir	13			7					-	42	-	43			
Douglas-fir **Western redcedar**	40	130	15	7	3	303	81	302	80	30	35	50	22	398	236
Pacific silver fir		117	19	8	4	322	83	189	60	34	28	28	5	198	52

greater number of warmer site **indicator** species. **Hemstrom** et al. **(1982)** described an **ABAM/VAAL-GASH** association in the Oregon Cascades which is essehtfally identical to ours. Appendix IV contains florfstfc and productivity averages for this association where it has been described in the western Cascades.

Pacific Silver Fir/Coolwort Foamflower Association (CF F1-52) ABAM/TIUN

Tne **Pacific** silver **fir/coolwort** foamflower association is characteristic of moist to mesfc sites. Soils are generally deep and relatively **fertile compared** to other associations. This association **is** characterized by high cover and diversity in the herb layer, which generally includes coolwort foamflower (TIUN), vanillaleaf (ACTR), **queencup** beadlfly (CLUN) and Oregon oxalfs **(OXOR).**

Composition and Structure

The mature tree layer of stands up to 400 years old is dominated by either Douglas-fir or noble fir (Table 27). Both Pacific silver fir and western hemlock are common overstory codomfnants and are more important in older stands. Pacific silver fir is the dominant regenerating tree species. Mature and regenerating western **redcedar** may also be present. Western hemlock regeneration was low (7 percent) and its constancy was high (69 percent).

Average shrub cover was 39 percent (Table 27). None of the shrubs, except vine maple **(ACCI)**, are particularly dominant in this type. Dwarf **bramble** (RULA) has the highest constancy (72 percent) but low average cover (5 percent). Other shrubs with high constancy include **ovalleaf** whortleberry (VAOV), Alaska huckleberry (VAAL), big huckleberry (VANE), little prince's pine (CHME) and red **huckleberry** (VAPA).

The rich and diverse herb layer is most **characteristic** of this association. **The** presence of moisture indicating herbs such as coolwort foamflower (TIUN), Oregon oxalfs **(OXOR),** sfberfan montfa **(MOSI), ladyfern** (ATFI), **deerfern** (BLSP) and oak fern **(GYDR) is** the major **diagnostic feature** for the **type.** The most common herb is TIUN which has a constancy of 89 percent. Plants which **exhibit** constancy greater than 50 percent are **GYDR,** sidebells pyrola (PYSE), dogwood bunchberry (COCA), starry **solomonplume (SMST), queencup** beadlfly **(CLUN),** vanillaleaf (ACTR), Pacific trillium (TROV) and western swordfern (POMU). ACTR, COCA and **OXOR** may be quite abundant. Nearly every herb **found** in the **Pacific** silver fir zone occurs in this **association.**

Physiography and Soils

Although the elevation range in the **ABAM/TIUN** association ranges **from 1500** feet to 5000 feet, it is most **commonly** found between 3000 and 4000 feet (Table 33). Slopes range from nearly level to 80 percent. This association is generally **found** from upper slopes to benches or alluvial **flats.** Effective rooting depth averaged 39 **inches.** The soils of the **ABAM/TIUN** type are among the deepest of all associations. Andesite is the most common bedrock material present. Soils are developed in either colluvfum or complex layers of volcanic **ejecta.** Eighty-nine percent of the study plots had a thin layer of ash or pumice at the soil surface. Soils in these plots typlcally'had several layers of pumice or cinders in various stages of weathering. Forty percent of the plots were northeast of Mount St. Helens where there is a 5 to 15 inch thick layer of lapfllf in the soil profile. Typically encountered TRI soil **mapping** units **included** 15, 17, **41,** 63, 81, 92 and 312.

Productivity and Management Considerations

Overall productivity is high for stands in the Pacific silver **fir/coolwort** foamflower association. Site index values for western hemlock (141) and western **redcedar** (130) are higher than those for **Douglas-fir (122),** noble fir (117) and Pacific **silver** fir (117). Current **volume** production in most stands is dominated by western hemlock (Table 16). Volume index data indicate that **western** hemlock, noble fir and western **redcedar** are potentially the most productive **species** in this association.

The **environmental** factors (mesfc climate, moisture **availability** and deep soils) that enable this **association** to be rich in **species** and **high in** production should also **favor** rapid regeneration, but **competing** vegetation may be a problem. As is true anywhere in the Pacific silver fir zone, frost could be a problem on benches or gentle slopes. Problems from **competing** vegetation may **be** avoided by preserving advanced Pacific silver fir and western hemlock regeneration and planting immediately after harvest. This association affords good opportunities for intensive timber management. Clearcutting may be widely practiced. Where frost pockets develop on slopes less than 15 percent and at elevations approaching 4000 feet, a shelterwood leaving about 25 percent of the initial basal area (or 75 to 85 ft^2/A) should provide adequate protection for seedlings. Generally, however, shelterwood is not required to regenerate this association. Western hemlock, noble fir and Douglas-fir are suitable crop tree species on sites where frost is not a factor. Noble fir will produce greater harvest volumes in this type and will grow well in diameter at greater stocking densities than Douglas-fir. Since the soils are generally deep and hold moisture well into the growing season, compaction is a potential problem. Soil moisture content should be tested before entry with heavy equipment.

Comparisons

me ABAM/TIUN association is similar to the ABAM/TIUN type dexrfbed by Franklin (1966) for the Mt. Adams Province. Rich shrub and herb layers and a productive tree layer are common features, but our shrub layer is even mare diverse and has higher average cover. The ABAM/TIUN type Franklin et al. (1979) described at Mt. Rainier is more herb rich and slightly less shrubby than that described here. An essentially identical type was described by Hemstrom et al. (1982) for the Oregon Cascades. Appendix IV contains average floristic and productivity values for this association in the western Cascades.

Pacific Silver Fir/Devil's Club Association (CF S3-51)
ABAM/OPHO

The Pacific silver fir/devil's club association is found on the wettest forested sites occupied by the Pacific silver fir series. It is one of the easiest types to distinguish in the field because it is characterized by large amounts of devil's club and a rich herb layer. Stands may be found growing on terraces, river bottoms or slopes where they may be associated with the abundant moisture of seeps or springs.

Composition and Structure

The canopy composition in this association is variable and includes Douglas-fir, noble fir, Pacific silver fir, western hemlock, western redcedar and Alaska yellow-cedar (Table 27). Pacific silver fir and western hemlock dominate in most stands, but Douglas-fir and noble fir are important seral species. Western redcedar and Alaska yellow-cedar are generally minor species. Pacific silver fir regeneration is predominant with lesser amounts of western. hemlock, Both cedars also regenerate successfully in many devil's club communities.

Devil's club (OPHO) and several other shrubs dominate the shrub layer in this association. Ovalleaf whortleberry (VAOV), Alaska huckleberry (VAAL), five leaf bramble (RUPE) and dwarf bramble (RULA) are very common. A wide variety of shrubs occur with low constancy. The average shrub cover In this type is about 67 percent.

The herb layer in the ABAM/OPHO association contains a wide variety of wet site species including coolwort foamflower (TIUN), ladyfern (ATFI), deerfern (BLSP), oak fern (GYBR) and redwoods violet (VISE). TIUN and vanillaleaf (ACTR) are the most common plants with constancies of 100 and 96 percent, respectively. Other herbs with constancies greater than 50 percent include GYBR, Pacific trillium (TROV), ATFI, queencup beadlily (CLUN), starry solomonplume (SMST), sidebells pyrola (PYSE) and rosy twistedstalk (STRO).

Physiography and Soils

This association occurs in a variety of topographic positions betwen 2600 and 4600 feet. elevation (Table 33). Sites in middle to lower slope position contained stony soils of volcanic ash or pumice origin. On lower slope sites colluvium was often present in the soil profile. Effective rooting depth averaged 43. On very steep rocky slopes, thls association is present only where seeps or springs bring groundwater near the surface. Terraces, river bottoms and wet meadows contained soils developed from alluvium or glacial drift. Typically encountered TRI soil mapping units included 15, 16, 34, 39, 322, 418 and 420.

Table 17: Productivity of the Pacific silver fir/devil's club association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	SD	Current Radial Increment (20ths/10 yrs) Mean	SD	Growth Basal Area (ft^2/A) Mean	SD	Volume Index ($ft^3/A/yr$) Mean	SD	Current Volume Increment ($ft^3/A/yr$) Mean	SD	D.B.H. (in) Mean	SD	Tree Age (yrs) Mean	SD
		124	6				12	270	8	6			15	565	134
Alaska yellow-cedar	8	132	2	16	1	429	-	268	56	25	1	41	-	180	-
Douglas-fir Noble fir	2:	131	-	8	3	[illegible]	112	253	67	35	36	52	17	504	300
Pacific silver fir	35		19		2	343	82	227			20	29	7	216	38
Western hemlock	26	123	23	6	3	333	123	209	91'	20	16	35	12	305	142
Western redcedar	3	118	-	8	-	306	-	178	-	19	-	39	-	217	-

Productivity and Management Considerations

Overall productivity is high for stands in the Pacific silver fir/devil's club association. Site index values for noble fir (134), Douglas-fir (132) and Pacific silver fir (131) are higher than those for Alaska yellow-cedar (124), western hemlock (123) and western redcedar (118). Pacific silver fir, Douglas-fir and western hemlock are the highest contributors to current volume increment in stands of this association (Table 17). Volume index data indicate that Alaska yellow-cedar, noble fir and Douglas-fir are potentially the most productive species in this association. The high growth basal area values for Alaska yellow-cedar and noble fir indicate good diameter growth at higher stocking levels, thus a greater potential volume yield per acre.

This association does not cover large areas on the Gifford Pinchot National Forest but becomes more widespread further north. It often occurs in patches of less than five acres and is surrounded by more well drained types. Opportunities for intensive timber management are poor in this association. Clearcutting may. be practiced, but with caution. Where frost pockets develop on slopes under 15 percent as typically encountered on high elevation benches, a shelter-wood leaving about 25 percent of the initial basal area (or 75 to 85 ft^2/A) 'should provide adequate protection for seedlings. Shelterwood is generally not required to regenerate this association. Timber harvesting may be difficult because of wet soils. Soil compaction and erosion could be major problems. Where this type occurs in small patches, adverse impacts to soils may be minimized by felling trees toward more stable soils in surrounding associations.

This association provides diversity within the matrix of drier forest types and should be managed with care to prevent erosion of the deep soils which are often saturated with water. Since this type occupies a small fraction of the landscape, it could be considered a special habitat providing biotic diversity and managed for purposes other than timber production. It is also an important animal habitat since the leaves of devil's club provide a preferred forage for elk during the late summer and early fall. The substantial shrub cover and frequent proximity to riparian areas make this association an important protective cover for wildlife.

Comparisons

Franklin et al. (1979) described an ABAM/OPHO habitat type in Mt. Rainier National Park which is similar to that described here. They found some stands with very reduced shrub layer, which we did not. This may be a result of the abundance of elk within Mt. Rainier National Park and their preference for devil's club foliage. Franklin (1966) found CHNO to be more prevalent and PIEN and ABGR to be major seral species, in contrast to our association. The shrub and herb composition are comparable. Dyrness et al. (1974) described a CHNO/OPHO habitat type in the Central Oregon Cascades which is closely analogous to our ABAM/OPHO association. Hemstrom et al. (1982) described an association in the Oregon Cascades essentially identical to our ABAM/OPHO type. Henderson and Peter (1982) reported a similar type in the Northern Washington Cascades. Appendix IV contains average floristic and productivity values for this association in the western Cascades.

Pacific Silver Fir/Cascade Azalea Association (CF S5-50) ABAM/RHAL

Heavy snowpacks, short growing seasons, frequent frost and cold, often moist soils are typical of sites occupied by this association. Stands found on benches or terraces at lower elevations and those on high ridges are extremely frost-prone following clearcutting.

Composition and Structure

Pacific silver fir dominates the overstory along with mountain hemlock. Douglas-fir, noble fir, subalpine fir, western hemlock and Alaska yellow-cedar may be present to a lesser degree. The shrub layer is relatively diverse and characterized by Cascades azalea (RHAL) and several huckleberries (Table 28). The herb layer is moderately rich. Beargrass (XETE), sidebells pyrola (PYSE), vanillaleaf (ACTR), queencup beadlily (CLUN), Pacific trillium (TROV), rosy twistedstalk (STRO), sitka valerian (VASI) and coolwort foamflower (TIUN) occurred in over 30 percent of our plots. Average total herb cover is greater than 35 percent. CLUN, STRO, VASI and TIUN indicate a more favorable environment. Six or more herbs are usually present and the cover of herbs other than XETE averages 21 percent.

Physiography and Soils

Mostly found on gentle north slopes averaging 4247 feet elevation (Table 34), 33 percent of the stands were on slopes of 15 percent or less. Most plots were in upper slope position. Soils are generally composed of tephra deposits which are underlain by glacial or colluvial deposits. The soil profile is generally rocky compared to other associations, commonly containing one or more layers with over 40 percent coarse fragments. Effective rooting depth averaged 30 inches. Typically encountered TRI soil mapping units included 17, 34, 54, 57 and 310.

Productivity and Management Considerations

Overall productivity is low for stands in the Pacific silver fir/Cascades azalea association. Site index for western hemlock (107) is substantially greater than values for Pacific silver fir (93), Douglas-fir (91), mountain hemlock (87) and Engelmann spruce (82). Western hemlock makes the greatest contribution to current volume increment in stands of this association with mountain hemlock and Pacific silver fir ranking second and third, respectively (Table 18). Volume index data indicate that western hemlock and Pacific silver fir are potentially the most productive species

Table 18: Productivity of the Pacific silver fir/Cascades azalea association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft^2/A) Mean	Growth Basal Area (ft^2/A) SD	Volume Index ($ft^3/A/yr$) Mean	Volume Index ($ft^3/A/yr$) SD	Current Volume Increment ($ft^3/A/yr$) Mean	Current Volume Increment ($ft^3/A/yr$) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
	12		4												
Western hemlock	32	107	13	6	2	239	27	127	13	52	39	30	2	335	60
		93		6	2	214	21	100	22	21	12	23	4	268	79
Pacific silver fir	9	91	0	4	1	213	32	98	16	6	2	40	1	404	144
Douglas-fir / Mountain hemlock	20	87	14	7	3	219	45	94	15	30	25	24	4	273	101
Engelmann spruce	5	82	-	5	-	183	-	75	-	4	-	22	-	224	-

on this association; The productive potential of Engelmann spruce is best expressed on sites with high water tables, such as the edges of lakes and wet meadows. The persistent snowpack, typical of this association, commonly results in regeneration delays from slow early seedling growth.

Opportunities for intensive timber management are poor in this association. Clearcutting may be practiced, but with caution. Where shallow soils, high elevation and slopes less than 15 percent result in frost problems, a shelterwood leaving about 40 percent of the initial basal area (or 85 to 95 ft^2/A) should provide adequate protection for seedlings. Where this type is found on slopes greater than 15 percent, clearcutting may provide adequate protection for planted noble fir. On slopes less than 15 percent, frost problems should be expected and species such as Engelmann spruce, western white pine, Pacific silver fir and mountain hemlock will be more successful. Douglas-fir is poorly adapted to this environment. These sites will generally open up late and soil temperatures may remain cool inhibiting root growth. Soil temperature should be checked before planting to see that it is at least 410F (50C). Because of the late entry and cold soil problem, this association is an attractive candidate for fall planting, providing properly preconditioned nursery stock is available.

The preponderance of north-facing aspects and fairly moist conditions may make slash burning difficult. Heavy slash can be reduced by yarding unmerchantable material. Because soils in this association are not nutrient rich, as little organic matter as possible should be removed to maintain site fertility and productivity. Use of heavy ground-based equipment may cause soil compaction where high water tables persist.

Comparisons

Franklin (1966) viewed this association as a high elevation variant of the ABAM/MEFE habitat type. His CHNO/RHAL type is somewhat similar except that Alaska yellow-cedar is a major climax species along with Pacific silver fir. His CHNO/RHAL habitat type is also probably wetter than the ABAM/RHAL association. Franklin et al. (1979) described an ABAM/RHAL habitat type at Mt. Rainier that is also similar to the one described here. The major differences are that Alaska yellow-cedar as a major overstory constituent in their type and western hemlock is entirely lacking. Our ABAM/RHAL association is similar to the ABAM/RHAL/CLUN association described by Hemstrom et al. (1982) in the Oregon Cascades.

Pacific Silver Fir/Fool's Huckleberry Association (CF S2-54) ABAM/MEFE

The Pacific silver fir/fool's huckleberry association is characterized by a tall, dense shrub layer dominated by fool's huckleberry (MEFE) and several huckleberry species. The herb layer is fairly diverse. Pacific silver fir and western hemlock dominate the overstory, but Douglas-fir is often present.

Composition and Structure

The ABAM/MEFE association is dominated by Pacific silver fir (average cover 31 percent) and western hemlock (average cover 24 percent) with a lesser presence and cover (20 percent) of Douglas-fir (Table 28). Western redcedar, noble fir, Engelmann spruce and western white pine occurred less frequently in the overstory. The regeneration layer is dominated by Pacific silver fir (cover 18 percent) and western hemlock (cover 5 percent), with western redcedar and Alaska yellow-cedar occurring less frequently and at lower relative cover.

The most characteristic feature is the diverse and dominant shrub layer with an average cover of 62 percent and total shrub cover near 100 percent on some plots. Fools huckleberry dominates the shrub layer (5 to 15 percent cover) along with one of three Vaccinium species, big huckleberry (VAME), Alaska huckleberry (VAAL) or ovalleaf whortleberry (VAOV). Their combined cover averages 42 percent. Dwarf bramble (RULA). sitka mountain ash (SOSI) and five leaf bramble (RUPE) are present in most stands at low coverage. The warm site shrub group is represented with cover generally less than 10 percent.

Although the herbaceous layer is obscured by dense shrubs, its cover averages 34 percent. Dogwood bunchberry (COCA) and queencup beadlily (CLUN) were the most frequently encountered herbs (70 and 78 percent respective constancy) followed by sidebells pyrola (PYSE), Pacific trillium (TROV), coolwort foamflower (TIUN), vanillaleaf (ACTR), beargrass (XETE), twinflower (LIB02) and rosy twistedstalk (STRO). Average cover for CLUN, COCA, TIUN **and** XETE is over 5 percent.

Physiography and Soils

Slopes average 25 percent but range from nearly level to 66 percent (Table 34). Mean elevation is 3673 feet and aspects tend to be northerly. The soils on 50 percent of the plots contained a layer of lapilli and another 50 percent contained at least one layer with more than 50 percent rock. Effective rooting depth averaged 39 inches. Typically encountered TRI soil mapping units included 17, 18, 27, 41, 57, 92 and 561.

Productivity and Management Considerations

Overall productivity is moderate for stands in the Pacific silver fir/fool's huckleberry association. Values of site index for noble fir **(113),** western hemlock (113) and Pacific silver fir **(110)** were higher than that for Douglas-fir (103). Current stand volume increment was largely comprised of contributions from **Pacific** silver fir and western hemlock (Table **19).** Volume index data. indicated that Pacific silver fir, noble fir and western hemlock are' potentially more productive in this association than is Douglas-fir.

Opportunities for intensive timber management are moderate in this association. Clearcutting may be practiced. Where high elevations and slopes less than 15 percent produce frost pockets, a shelterwood leaving about 30 **percent** of the initial basal area (or 75 to 85 ft^2/A) should provide adequate protection for seedlings. Douglas-fir is a **common** high value timber species in this association; however, it will suffer frost damage on slopes less than **15** percent and snow creep deformation on steeper slopes. **It** is therefore not well suited for reforestation in this association. Pacific **silver** fir, western white pine and Engelmann spruce are better suited to gentler slopes and noble fir, while generally not present in the original stand, is well suited on slopes over 15 percent. This association occurs in locations where soil moisture is abundant early it the growing season. Stand entry at this time with heavy equipment could cause soil compaction problems.

Comparisons

The **ABAM/MEFE** association is similar to the ABAM/MEFE habitat type described by Franklin et al. (1979) for Mt. Rainier National Park. Their type is similar to ours in the relatively few herbaceous species which have high fidelity within the type. Although our **ABAM/MEFE association** contains **much** less Cascades azalea , it is similar to the **ABAM/MEFE** association described by Franklin **(1966)** for the Mt. Rainier Province. An analogous type was not described by Oyrness et al. **(1973)** for the Central Cascades of Oregon. However, **Hemstrom** et al. (1982) described an essentially identical type on the Mt. Hood National Forest. Henderson and Peter **(1981)** described a similar type in the northern Washington Cascades. Appendix IV contains average floristic and productivity values for this association in the western Cascades.

Pacific Silver Fir/Big Huckleberry/Queencup Beadlily Association (CF S2-56) ABAM/VAME/CLUN

The Pacific silver fir/big huckleberry/queencup beadliiy association is characterized by stands of Pacific silver. fir, western hemlock and Douglas-fir with an understory of big huckleberry, **queencup beadlily** and other herbs. This association, while often found on frost prone high elevation sites, is more environmentally moderate than the **ABAM/VAME/XETE** association.

Composition and Structure

Pacific silver fir (26 percent cover) dominates the overstory with Douglas-fir (22 percent cover), western hemlock (14 percent cover) and noble fir (22 percent cover) as major associates (Table 29). Mountain hemlock is present in the overstory in 35 percent of the plots with an average of 9 percent cover. Pacific silver fir dominates the regeneration layer with cover ranging from 5 to 25 percent. Mountain hemlock and western hemlock are occasionally present in the regenerating layer.

Big huckleberry dominates the shrub layer with **10** to 30 percent average cover. Prince's pine (CHUM) and dwarf bramble (RULA) occur in 65 to 85 percent of the stands with 3 and 4 percent

Table **19:** Productivity of the Pacific silver fir/fool's huckleberry association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft^2/A) Mean	Growth Basal Area (ft^2/A) SD	Volume Index ($ft^3/A/yr$) Mean	Volume Index ($ft^3/A/yr$) SD	Current Volume Increment ($ft^3/A/yr$) Mean	Current Volume Increment ($ft^3/A/yr$) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
				8											
Pacific silver fir	30	110	13	4	3	285	49	158	42	32	12	29	4	315	26
Noble fir	3	113			-	269	-	152	-	2	-	45	-	471	
Western hemlock	15	113	15	4	2	249	89	140	52	15	3	35	5	407	23
Douglas-fir	10	103	7	4	1	206	71	108	44	7	2	43	9	450	29

Table 20: Productivity of the Pacific silver fir/big huckleberry/queencup **beadlily** association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft^2/A) Mean	Growth Basal Area (ft^2/A) SD	Volume Index (ft^3/A/yr) Mean	Volume Index (ft^3/A/yr) SD	Current Volume Increment (ft^3/A/yr) Mean	Current Volume Increment (ft^3/A/yr) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
Western white pine		130	-	11	-	448	-	292	-	2		42	-	465	
Western hemlock	3:	103	13	8	3	307	65	160	38	28	13	29	5	307	106
			14	6	1	253	61	134	39	27	17	24	4	231	62
Douglas-fir / Pacific silver fir	30 / 40	193	15	5	2	269	92	128	57	13	8	36	8	357	183
Noble 'fir	5	89	-	7	-	285	-	126	-	5	-	24	-	229	-
Mountain hemlock	3	80	-	6	-	269	-	107	-	2	-	27	-	232	-

average cover, respectively. Besides sitka mountain ash (SOSI), these are the only other shrubs found in over 50 percent of the plots. Several shrubs occur with low cover in over 30 percent of the plots including **baldhip** rose (ROGY), **ovalleaf** whortleberry (VAOV) and Oregon boxwood **(PAMY).** Total shrub cover averages 31 percent with generally 5 or 6 shrub species present.

Average herb cover is 40 percent with over 30 species occurring. **Queencup beadlily** (CLUN), vanillaleaf (ACTR), beargrass (XETE) and sidebells pyrolla **(PYSE)** are generally present with a combined cover of 15 to 25 percent. Other **common** herbs are Pacific trillium (TROV), twinflower **(LIBO2),** rattlesnake plantain (GOOB), alpine pyrola (PYAS), threeleaf anemone (ANDE), sitka valerfan **(VASI),** coolwort foamflower (TIUN), dogwood bunchberry (COCA) and white inside-out flower (VAHE). The presence of moist site herbs such as TIUN, starry solomonplume (SMST), VASI, ANOE, **vetch** violet **(VIOR2),** Brewers mitewort (MIBR) and **ladyfern** (ATFI) indicates that this association is more **mesic** than the **ABAM/VAME/XETE** association.

Physiography and Soils

Stands in this association occur at elevations between 3100 and 4900 feet, 3781 feet being average (Table 35). Generally **occuring** on gentle slopes in middle to lower slope positions, about 77 percent of the plots were on less than 15 percent slopes. Over 60 percent of the plots were on east and south facing slopes. Effective rooting depth averaged 33 inches. Soils are dominated by pumice layers overlying residuum on sites less than 30 percent slope. Only about 10 percent of the plots do not have pumice or cinders in the upper foot of soil. In a few cases, the surface soil is colluvial and averages 20 percent rock content. Parent rock is extrusive igneous, chiefly andesite and occasionally basalt. Layers of lapilli were present in only a few plots. Typically encountered TRI soil mapping units included 17, 30, 154, 172 and 412.

Productivity and Management Considerations

Overall **productivity** is moderate for stands in the Pacific silver fir/big huckleberry/queencup **beadlily** association. Site index values for western white pine **(130),** Pacific silver fir (107) and western hemlock (103) are higher than those for Douglas-fir **(93),** noble fir (89) and mountain hemlock (80). Western hemlock and Pacific silver fir make the greatest contributions to current volume increment in stands of this association (Table 20). However, volume index data indicate western white pine is potentially the most productive species in this association, followed by western hemlock and Pacific silver fir. Engelmann spruce may be productive in this association on level sites with elevated water tables.

This association affords moderate opportunities for intensive timber management. Clearcutting may be practiced, but with caution. Where high elevation and slopes less than 15 percent result in frost problems, a shelterwood leaving about 30 percent of the initial basal area (or 80 to 90 **ft^2/A)** should provide adequate protection for seedlings. Western white pine, Pacific silver fir, **Engelmann spruce,** noble fir and Douglas-fir would be good regeneration choices in this association. Western white pine and Pacific silver fir are particularly well suited to slopes less than 15 percent where frost is a hazard. Douglas-fir and noble fir will establish more easily on steeper slopes where cold air drainage averts frost damage. **The** soils in this type are porous and well drained, making compaction an unlikely problem.

Comparisons

The **ABAM/VAME/CLUN** association is similar to the ABAM-TSHE/VACCINIUM Association of Franklin **(1966),** but has less ACCI and BENE. **Hemstrom** et al. (1982) described an essentially identical **ABAM/VAME/CLUN** association in the Oregon Cascades. The **ABAM/VAME** association described by Henderson and Peter (1981 and **1982)** for the northern Washington Cascades is similar. Appendix IV contains average florfstic and productivity values for this association in the western Cascades.

Pacific Silver Fir/Big Huckleberry/Beargrass Association (CF S2-51) ABAM/VAME/XETE

This association is an herb poor, high elevation community characterized by Pacific silver fir and western hemlock in the overstory. Big huckleberry and beargrass dominate the shrub and herb layers, respectively, indicating a highly frost prone environment where regeneration difficulties can be anticipated.

Composition and Structure

Pacific silver fir and western hemlock dominate the tree layer, each with 20 percent cover (Table 29). Douglas-fir is frequently present with about 11 percent cover. Pacific silver fir dominates the regeneration layer with 10 to 20 percent cover while western hemlock regeneration generally has less than 5 percent cover.

Big huckleberry dominates the shrub layer and averages about 18 percent cover. Sitka mountain ash (SOSI) and baldhip rose (ROGY) may be present. Warm site shrubs are generally absent except for prince's pine (CHUM). Small amounts of other Vaccinium species including red huckleberry, ovalleaf whortleberry (VAOV) and Alaska huckleberry (VAAL) may occur.

Herbs are inconspicuous except beargrass, which may have up to 80 percent cover. Sidebells pyrola (PYSE) and twinflower (LIBO2) occur frequently with lower cover. There are generally five or fewer herbs other than beargrass (XETE).

Physiography and Soils

This association generally occurs on southerly aspects. Although it may occur on ridgetops or thin-soiled bottomland, the ABAM/VAME/XETE association is usually found on slopes under 15 percent (Table 35). Elevation ranged from 2900 to 4800 feet. Underlying soils were composed of pumice layers over residuum, colluvium or glacial deposits. Soils were relatively shallow. Effective rooting depth averaged 33 inches. Upper slope, south aspect sites with soil less than 24 inches deep may be very droughty. Typically encountered TRI soil mapping units included 11, 17, 25, 31 and 34.

Productivity and Management Considerations

Overall productivity is moderate for stands in the Pacific silver fir/big huckleberry/beargrass association. Site index values for western hemlock (99) and Pacific silver fir (95) are higher than those for mountain hemlock (75) and Douglas-fir (73). Mountain hemlock, Pacific silver fir and western hemlock make the greatest contributions to current volume increment in stands of this association (Table 21). Volume index data indicate that western hemlock and Pacific silver fir are potentially the most productive species in this association, followed by mountain hemlock and Douglas-fir. Noble fir may be among the most highly productive species in this association, although it was rarely encountered in our older stands.

This association affords moderate opportunities for intensive timber management. While clearcutting may be practiced, alternative methods might be considered for these dry, high elevation, frost prone sites when slopes are less than 15 percent. A shelterwood leaving about 40 per2ent of the initial basal area (or 95 to 115 ft 2/A) should provide sufficient protection for seedlings. Protection of advanced regeneration will aid reforestation efforts. As Douglas-fir productivity is low, timber management emphasizing Pacific silver fir or noble fir will result in higher volume yields. Since this type is generally found on coarse textured soils with adequate drainage, compaction should not be a problem.

Comparisons

The ABAM/VAME/XETE association is similar to the ABAM/XETE (TSHE) habitat type described by Franklin et al. (1979) for Mount Rainier National Park. It is analogous to the ABAM-TSHE/VAME type described by Franklin (1966) for the Mount Rainier Province. Hemstrom et al. (1982) described an association essentially identical to this in the Oregon Cascades. Henderson and Peter (1981) described an ABAM/XETE type for the northern Washington Cascades which is similar, except that it contains much less VAME. Appendix IV contains average floristic and productivity values for this association in the western Cascades.

Mountain Hemlock Associations

At elevations above 4000 feet in the Pacific silver fir series, mountain hemlock becomes increasingly abundant in overstory and understory. Although Pacific silver fir may often be the most prominent regenerating species, mountain hemlock seedlings are common, indicating a significantly colder environment than those of previously described associations. It is at this point (10% projected canopy cover of TSME) that the mountain hemlock series begins. Annual

Table 21: Productivity of the Pacific silver fir/big huckleberry/beargrass association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/ 10 yrs) Mean	Current Radial Increment (20ths/ 10 yrs) SD	Growth Basal Area (ft^2/A) Mean	Growth Basal Area (ft^2/A) SD	Volume Index (ft^3/ A/yr) Mean	Volume Index (ft^3/ A/yr) SD	Current Volume Increment (ft^3/ A/yr) Mean	Current Volume Increment (ft^3/ A/yr) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
		99		6											
Western hemlock	19	95	12	5	2	284	i03	144	66	20	10	30	5	338	159
Pacific silver fir	5		17	7	2	253	109	122	62	29	18	22	4	247	54
Mountain hemlock	15	75	-	5	-	272	-	101	-	30	-	23	-	236	
Douglas-fir		73	5		2	213	41	79	17	8	4	30	7	355	175

Table 22: Productivity of the mountain hemlock/big huckleberry association

Tree Species	Number of Cored Trees	Site Index (ft) Mean	Site Index (ft) SD	Current Radial Increment (20ths/10 yrs) Mean	Current Radial Increment (20ths/10 yrs) SD	Growth Basal Area (ft²/A) Mean	Growth Basal Area (ft²/A) SD	Volume Index (ft³/A/yr) Mean	Volume Index (ft³/A/yr) SD	Current Volume Increment (ft³/A/yr) Mean	Current Volume Increment (ft³/A/yr) SD	D.B.H. (in) Mean	D.B.H. (in) SD	Tree Age (yrs) Mean	Tree Age (yrs) SD
Western larch		123		11	-	217	-	135	-	21	-	20	-	82	
	5	89	-	8	3	246	104	108	42	27	27	21	3	204	8;
Douglas-fir / Pacific silver fir	24	104	10	12	2	200	8	105	21	37	5	19	1	87	8
		82		7	2	221	72	90	23	31	18	22	4	210	93
Western hemlock / Mountain hemlock	23	89	6	4	-	185	-	82	-	2	-	28	-	355	-
Subalpine fir	5	35	-	5	-	260	-	46	-	4	-	19	-	203	-

precipitation at the higher elevations approximates 100 inches resulting in heavy winter snowpacks. This combination of cold temperatures and heavy snow accumulation leads to problems in regeneration from short growing seasons, frost and seedling deformation by snow. Timber productivity is lower than in the Pacific silver fir associations. Regeneration success is dependent on the use of frost hardy species for reforestation, preservation of advanced regeneration and maintaining thermal protection for seedlings through partial cutting practices.

Mountain Hemlock/Big Huckleberry Association (CM S2-10) TSME/VAME

Mountain hemlock and Pacific silver fir are the primary regenerating species. Big huckleberry and beargrass dominate the shrub and herb layers. Otherwise there is little understory diversity. Productivity is relatively low. Short growing seasons and frost present regeneration problems.

Composition and Structure

The stands in the TSME/VAME association are dominated by Pacific silver fir and mountain hemlock which average 30 and 17 percent cover, respectively (Table 30). Canopy cover averages 63 percent. Cover of regenerating Pacific silver fir is generally greater than 10 and averages 16 percent. Mountain hemlock regeneration has less cover than Pacific silver fir. Douglas-fir is not a notable part of the stand, but Engelmann spruce and western white pine are sometimes present.

Big huckleberry (VAME) clearly dominates the shrub layer with between 10 and 50 percent cover (mean cover 34 percent). Other species of Vaccinium including ovalleaf whortleberry (VAOV) and red huckleberry (VAPA) are sometimes present in small amounts. Sitka mountain ash (SOSI) is occasionally present. The warm site shrub group is absent or inconspicuous. Dwarf bramble (RULA) is often present with 5 or more percent cover.

Beargrass (XETE) dominates the herb layer with 20 percent cover. There are generally fewer than 5 other herbaceous species present, The most common herbs are sidebells pyrola (PYSE) and queencup beadlily (CLUN) with 54 and 62 percent constancy and average cover of 2 or 3 percent.

Physiography and Soils

This association is usually found above 3300 feet elevation (mean elevation 4362 feet) on northerly aspects and generally occurs on upper slope sites (Table 36). Slopes are generally greater than 15 percent with an average of 22 percent. The only nearly flat areas occupied by this type were below 3500 feet elevation where cold air accumulates. Effective rooting depth averaged 33 inches. The soil profiles are dominated by pumice layers, often with high coarse fragment content. These pumice layers are generally underlain by residuum on upper slopes and colluvial or glacial deposits of andesite or basalt at the base of slopes. Typically encountered TRI soil mapping units included 17, 41, 45 and 95.

Productivity and Management Considerations

Overall productivity is low for stands in the mountain hemlock/big huckleberry association. Site index values for western larch (123), Douglas-fir (104), Pacific silver fir (89), western hemlock (89) and mountain hemlock (92) are higher than that for subalpine fir (35). Douglas-fir, mountain hemlock, Pacific silver fir and western larch contribute most to the current volume increment of stands in this association (Table 22). Volume index data indicate that western larch, Pacific silver fir and Douglas-fir are potentially the most productive species in this association. Although data were not available for noble fir and western white pine, their productivity is likely to be as high. Growth basal area data indicate that Pacific silver fir stocking on these sites is higher than any other species, except subalpine fir. Both productivity and stocking are limited in this rather severe, cold association.

This association affords poor opportunities for intensive timber management. Although clearcutting may be practiced with caution, high elevation and slopes less than 15 percent produce high frost hazard sites where alternative methods might be considered. A shelterwood leaving about 50 percent of the initial basal area (or 100 to 120 ft^2/A) should provide adequate protection for seedlings. The shelterwood method will probably produce a mixed stand of conifers, the species mix depending upon residual seed trees. If used on exposed ridgetops, this method may result in windthrow problems. Group selection harvest may be used to increase regeneration success.

The environment of this association is severe, with heavy winter snowpacks and possible frost during the growing season. Significant delays in regeneration are likely to reduce timber production. After disturbance, such as fire or clearcutting, beargrass and longstolen sedge can expand and dominate the herb layer, slowing or preventing conifer establishment. Western larch and western white pine are preferred species for planting in this association. Noble fir and Douglas-fir are not suitable species because of their susceptibility to frost damage. Engelmann spruce and lodgepole pine may seed into clearcuts from residual seed trees. The soils in this type are well drained and coarse textured. Compaction is usually not a problem.

Comparisons

The TSME/VAME association is similar to the ABAM/XETE (TSME) habitat type described by Franklin et al. (1979) for Mount Rainier National Park. It is also similar to the ABAM-TSME/VAME association in the Mt. Adams province reported by Franklin (1966). The TSME/VAME/XETE association described by Hemstrom et al. (1982) for the Oregon Cascades is similar, except that their XETE cover is over twice that of ours. The TSME/VAME association described by Henderson and Peter (1982) is also similar, except that VAME cover is higher and XETE cover is lower than in our association.

Mountain Hemlock/Fool's Huckleberry Association (CM S2-21) TSME/MEFE

The TSME/MEFE association is typical of high elevation sites where frequent frost, heavy snowpacks and short growing seasons are common. Generally occurring on gentle slopes these sites, which are dominated by Pacific silver fir and mountain hemlock, are difficult to regenerate following clearcutting.

Composition and Structure

In the TSME/MEFE association, mountain hemlock is codominant with Pacific silver fir. The cover of mountain hemlock and western hemlock, where they occur in the overstory, averages 15 and 9 percent, respectively. Subalpine fir and Engelmann spruce also occur in significant amounts. Douglas-fir occurs in only half of the stands at 5 to 10 percent cover. Pacific silver fir regeneration averages 25 percent cover and 100 percent constancy (Table 30). Seedlings of western and mountain hemlock both average less than 5 percent cover.

The shrub layer is dominated by fool's huckleberry (MEFE), big huckleberry (VAME), ovalleaf whortleberry (VAOV) and Alaska huckleberry (VAAL). Sitka mountain ash (SOSI) is often present in small amounts. The warm site shrub group is inconspicuous or absent.

Beargrass (XETE) occurs frequently in the herb layer with an average of 11 percent cover. Sidebells pyrola (PYSE) and queencup beadlily (CLUN) are highly constant herbs and average about 2 and 7 percent cover, respectively. Dogwood bunchberry (COCA) and coolwort foamflower (TIUN) occur in about 40 percent of the stands with an average cover of 8 and 2 percent, respectively. The average total herb cover is about 35 percent.

Physiography and Soils

Generally found on gentle slopes at elevations averaging 3955 feet (Table 36), 80 percent of the plots were located on slopes less than 15 percent. The TSME/MEFE association is most common on north-facing ridgetop or upper slope positions. None of the plots occurred on south aspects. Underlying soils are dominated by sand and sandy loam pumice layers to a depth of 15 inches. Only a third of the stands had total soil depths of less than 50 inches. Layers restricting root growth and high water tables are common enough that compaction or erosion causing activities should be carefully controlled. Effective rooting depth averaged 46 inches. Typically encountered TRI soil mapping units included 17, 20 and 37.

Productivity and Management Considerations

Overall productivity is low for stands in the mountain hemlock/fool's huckleberry association. Site index for Pacific silver fir

Table 23: Productivity of the mountain hemlock/fool's huckleberry association

Tree Species	Number of Cored Trees	Site Index (ft)		Current Radial Increment (20ths/10 yrs)		Growth Basal Area (ft^2/A)		Volume Index ($ft^3/A/yr$)		Current Volume Increment ($ft^3/A/yr$)		D.B.H. (in)		Tree Age (yrs)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	8	90	4							8					
Western hemlock	8	89	4	7	1	273	34	124	22	30	8	23	5	230	103
Douglas-fir		95		6	1	239	16	107	6		11	23	14	286	180
Pacific silver fir	20	87	11		1	211	58	99	26	16	13	25	5	286	79
Mountain hemlock	18		9	6	1	216	60	92	20	14			5	277	85

Table 24: Productivity of the mountain hemlock/Cascades azalea association

Tree Species	Number of Cored Trees	Site Index (ft)		Current Radial Increment (20ths/10 yrs)		Growth Basal Area (ft^2/A)		Volume Index (ft^3/A/yr)		Current Volume Increment (ft^3/A/yr)		D.B.H. (in)		Tree Age (yrs)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Noble fir	5	99	-	13	-	383	-	191	-	-	-	30	-	164	-
Douglas-fir	5	86	-	5	-	274	-	118		6	-	31	-	224	
Pacific silver fir	20	89	15	7	1	245	61	113	44	17	16	24	4	215	16
Mountain hemlock	18	76	12	7	2	236	46	91	28	13	6	23	3	219	3
Western larch	3	83	-	2	-	211		88		1	-	23	-	225	-
Engelmann spruce	8	81	8	3	0	184	69	76	35	1	0	23	-	217	5
Alaska yellow-cedar	3	62	-	5	-	156	-	49	-	5	-	19	-	183	-
Subalpine fir	3	56	-	3	-	134	-	38	-	4	-	18	-	191	-

(95) exceeds values for western hemlock (90), Douglas-fir (89) and mountain hemlock (87). Douglas-fir, Pacific silver fir and mountain hemlock account for the greatest contributions to current volume increment of stands in this association (Table 23). Volume index data indicate that western hemlock, Douglas-fir and Pacific silver fir are potentially the most productive species in this association, though the former would be very difficult to establish.

Opportunities for intensive timber management are poor in this association. Although clearcutting may be practiced with caution, high elevation and slopes less than 15 percent produce high frost hazard sites where alternative methods might be considered. A shelterwood leaving about 50 percent of the initial basal area (or 100 to 120 ft^2/A) should provide sufficient protection for regeneration. Group selection harvest would provide an added measure of seedling and site protection. The presence of mountain hemlock in this type indicates a cold environment. Also, an average elevation of 3955 feet and a general north aspect indicate heavy snow packs and frequent frost. Especially on slopes less than 15 percent, only frost resistant species such as mountain hemlock, Pacific silver fir, western larch, Engelmann spruce and western white pine may survive and grow. Noble fir and Douglas-fir are not suitable species in this association because of their susceptibility to frost damage.

Comparisons
The TSME/MEFE Association is most similar to the ABAM/MEFE habitat type described by Franklin (1966) for southern Washington and by Franklin et al. (1979) for Mt. Rainier National Park. Their habitat type represents a warmer site than the TSME/MEFE Association.

Mountain Hemlock/Cascade Azalea Association (CM, S2-23) TSME/RHAL

The mountain hemlock/Cascades azalea association is found in cool, high elevation sites where Pacific silver fir and mountain hemlock dominate the overstory. The dense shrub layer contains Cascades azalea and a variety of huckleberry species and the herb layer is low in diversity. Environmental factors important in this association are heavy snowpacks, short growing seasons and relatively cool temperatures throughout the growing season.

Composition and Structure

Pacific silver fir and mountain hemlock dominate this association, their cover averaging 26 and 24 percent, respectively (Table 30). Both act as seral species, indicating a cool, moist environment. Mature western hemlock occurs infrequently. Pacific silver fir regeneration averages between 10 and 35 percent cover. Mountain hemlock regeneration averages less than 5 percent cover. Seedlings of other species, including western hemlock and Alaska yellow-cedar, occasionally occur.

Cascades azalea (RHAL), fool's huckleberry (MEFE) and Vaccinium species dominate a very dense (mean cover 68 percent) shrub layer. RHAL cover varies between 5 and 30 percent, but the cover of other shrubs including MEFE and big huckleberry (VAME) may be higher. Other common shrubs include dwarf bramble (RULA), five leaf bramble (RUPE) and sitka mountain ash (SOSI). Only two or three herbaceous species are usually present. Beargrass (XETE) and sidebells pyrola (PYSE) are the most common herbs.

Physiography and Soils

This association generally occurs on gentle slopes or benches with north aspects (Table 36), but may also occur on very steep slopes. Elevation ranges from 4000 to 5300 feet. The soil profile is generally rocky compared to other associations, commonly containing one or more layers with over 40 percent coarse fragments. Average soil depth is 53 inches. Effective rooting depth averaged 37 inches. Pumice layers dominate, soil profiles but to a lesser extent than in the other upper elevation associations. Colluvial and glacial deposits occurred in the upper 12 inches of the soil in 60 percent of the plots. Typically encountered TRI soil mapping units included 17 and 34.

Productivity and Management Considerations

Overall productivity is low for stands in the mountain hemlock/Cascades azalea association. Site index values for noble fir (99), Pacific silver fir (89) and Douglas-fir (86) are higher than those for western larch (83), Engelmann spruce (81), mountain hemlock (76), Alaska yellow-cedar (62) and subalpine fir (56). Pacific silver fir and mountain hemlock account for the greatest contributions to current volume increment of stands in this association (Table 24). Volume index data indicate that noble fir is potentially the most productive species in this association, followed by Douglas-fir and Pacific silver fir. Growth basal area information here indicates that stocking is generally limited for most species, thus limiting overall volume production per acre. This association occurs at high elevations on northerly aspects and indicates a severe environment. The cold, wet environment may prevent Douglas-fir and noble fir from becoming established and may be responsible for the sparse herbaceous layer.

There may be delays in successful regeneration in this association. Only frost-resistant species such as Engelmann spruce, western white pine, Pacific silver fir and mountain hemlock may survive on sites with less than 15 percent slope. Regeneration success cannot be assured if Douglas-fir or noble fir are planted. Beargrass and sedges may quickly occupy openings and seriously delay conifer regeneration.

This association affords poor opportunities for Intensive timber management. Although clearcutting may be practiced with caution, the high elevation, gentle slopes less than 15 percent, cold soil temperatures, short growing season, heavy snowpack and high frost hazard (indicative of a severe environment for regenerating seedlings) together encourage the use of alternative methods. A shelterwood leaving about 50 percent of the initial stand basal area (or 110 to 130 ft^2/A) should provide adequate protection for seedlings. Group selection will provide an added measure of regeneration success, as well as increased site protection. Any advanced regeneration of mountain hemlock and Pacific silver fir which can be saved will help keep these sites occupied. Since this association is found on hfgh elevation, north aspects, fire hazard is not great. Slash could be left as added frost protection for small seedlings.

Comparisons

Franklin's (1966) CHNO/RHAL habitat type is somewhat similar except that Alaska yellow-cedar is the climax species. His CHNO/RHAL type is probably wetter than the TSME/RHAL association. Franklin et al. (1979) described an ABAM/RHAL habitat type at Mt. Rainier that is also similar to the TSME/RHAL association described here. The major differences are that Alaska yellow-cedar is a major overstory constituent in their type and western hemlock is entirely lacking. Henderson and Peter (1982) described a TSME/RHAL association similar to ours, except that their TSME cover was approximately twice that described here.

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Appendix I: Vegetation, Physiographic and Soil Characteristics of Each Association

Table 25: Plant cover of the Pacific silver **fir/salal,** Pacific silver fir/dwarf Oregon grape

	ABAM/ACTR-CLUN			**ABAM/BENE**			**ABAM/GASH**		
Number of Samples	42			17			13		
	Constancy*	Cover*	S.D.*	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Mature trees:									
ABAM	90	16	10	94	15	12	92	14	13
ABLA2	2		0	6	3	0			
ABPR	52	1:	15	29	10	4	15	10	7
PIEN	2	5	0	18	4	2			
PIMO	12	2		18	3	2	23	2	2
PSME	98	35	1:	100	25	15	100	28	16
TABR	7		2	6	3	0	23	1	1
THPL	29	3	5	53	7	6	77	15	13
TSHE	86	17	13	94	32	14	100	21	15
TSME	5	3	1	24	4	2			
Total	100	72	10	100	77	8	100	74	16
Regenerating trees:									
ABAM	100	10	8	100	11	8	100	10	9
CHNO							38	2	0
THPL	29	4	3	41	3		85	[illegible]	6
TSHE	67	5		76	11	1:			8
TSME	5	4	2	12	3	0			
Shrubs:									
RILA									
ROGY	79	3	3	65	2	3	38	2	1
SYMO	43	2	1	18	2	1	8	5	0
VAPA	29	9	9	53	4	3	92	12	6
ACCI	100	27	21	76	14	15	77		11
RUUR	48	2	1	59	2	1	62	1	0
ACGLD	17	3	2				8	1	0
BENE	60	5	5	100	12	9	100	11	6
GASH	5	2	1	12	7	5	100	13	16
CHUM	74	4	3	88	4	3	92	5	3
PAMY	40	3	3	35	1	1	23	2	1
RUN1	10	1	1				15	1	0
RUPA	45	3	7				8	1	0
RULA	69	3	2	59	2	2	23		1
VAME	83	10	8	76	6	5	62	3	5
VAOV	38	5	4	29	4		54	4	3
VAAL	14	7	8	18	14	2:	54	4	3
RUPE	10	4	4	24	3	2	15	2	1
CHME	62	2	1	47	1	1	54	2	1
GAOV	17	2	2	35	6		23	1	2
MEFE	10	3	3	18	3	3	8	1	0
SOS1	52	2	1	12	1	0	8		0
RHAL	5	4	2						
OPHO	5	1	0				8	2	0
Total	100	56	22	100	40	10	100	50	20

and Pacific silver fir/vanillaleaf-queencup beadlily associations

	ABAM/ACTR-CLUN			ABAM/BENE			ABAM/GASH		
Number of Samples	42			17			13		
	Constancy*	Cover*	S.D.*	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Herbs:									
PTAQ	33	3	1	24	3	2	8	2	0
XETE	38	6	8	71	7	4	46	8	9
DIHO	52	2	1	12	1	0			
POA	14	3	3	6	1	0			
CASC2	26	2	1	6	1	0			
GAOR	31	2	1	6	3	0			
GOOB	64	2	1	35	2	1	62	2	1
HIAL	43	1	1	18	1	1	31	2	1
PYSE	88	3	2	76	3	3	8	1	0
POMU	19	3	2	12	2	1	46	3	2
TROV	64	2	1	53	2	1	54	1	0
TRLA2	33	2	2	12	2	1	8	1	0
SMRA	33	2					15	1	0
LIB02	74	8	1:	82	4	3	85	7	11
FRAGA	5		0						
ACTR	100	1:	15	65	10	13	62	3	2
ADBI	31	2	2	18	2	1	15	2	1
VAHE	40	3	2	24	3	3	15	1	0
PYAS	40	2	1	59	2	2	46	2	1
VIGL	7	1	1						
PERA	12	1	1	12	2	1			
GATR	17	2	1	12	1	0			
ASCA3	10	1	1						
ANDE	50	3	3	12	1	0	38	1	0
PYPI	36	2	1	24	2	1	23	2	1
ANLY2	2	1	0						
OSCH	24	2	1	6	1	0			
CLUN	86	5	4	59	4	4	38	2	2
SMST	74	4	5	24	4	2	23	2	1
STRO	29	2	1	12	2	1	15	1	0
VASI	7	1	1						
VIOR2	17	3	1	29	3	2	8	4	0
VISE	21	3	3	24	3	1	8	2	0
TIUN	64	3	3	47	3	5	38	2	1
COCA	60	9	9	76	8	8	62'	7	6
GYDR	5	2	1						
OXOR									
MOSI	2	1	0						
ACRU	7	2	1						
ATFI	2	1	0						
BLSP	2	1	0	6	30	0	8	1	0
EQAR									
Total	100	50	24	100	26	26	100	27	16
Mosses: total	100	10	17	100	23	25	100	30	23

* Constancy is the percentage of the sample plots in this community which contained the species.
Cover is the mean of the cover observations for each species. The mean was computed using only the samples in which it occurred.
S.D. is the standard deviation of observations around the mean.

Table 26: Plant cover of the Pacific silver fir/Alaska huckleberry associations

	ABAM/VAAL			ABAM/VAAL-GASH		
Number of Samples		42			17	
	Constancy*	Cover*	S.D.*	Constancy	Cover	. .
Mature trees:						
ABAM	93	29	17	88	25	14
ABLA2						
ABPR	14	6	4	12	10	8
PIEN						
PIMO	7	4	3	12		0
PSME	79	16	9	100	15	10
TABR				12	5	3
THPL	38	7		82	10	6
TSHE	95	29	11	94	23	17
TSME	7	3	3	6	5	0
Total	100	70	13	100	69	13
Regenerating trees:						
ABAM	98	19	15	94	17	14
CHNO	5	3	1			
THPL	24	3	2	65	3	2
TSHE	79	7	6	76	6	7
TSME						
Shrubs:						
RILA	2	1	0			
ROGY	10	2	1	24	2	1
SYMO	7	1	1			
VAPA	64	5	4	88	6	4
ACCI	29	9	7	53	9	6
RUUR	14	2	1	35	2	1
ACGLD	7	3	2			
BENE	33	7	5	71	6	3
GASH	2	7	0	88	7	9
CHUM	62	5	4	82	7	7
PAMY	2	2	0	12	2	1
RUN1						
RUPA				6	5	0
RULA	60	3	2	35	2	1
VAME	67	6	7	76	7	6
VAOV	69	9	9	71	6	6
VAAL	95	26	17	100	26	12
RUPE	29	6	8	24	3	2
CHME	48	2	1	65	2	1
GAOV	17	3	2	71	3	2
MEFE	33	3	4	47	5	6
SOSI	26	2	1			
RHAL	2	2	0			
OPHO						
Total	100	44	22	100	66	21

	ABAM/VAAL			ABAM/VAAL-GASH		
Number of Samples		42			17	
	Constancy	Cover	S.D.	Constancy	Cover	. .
Herbs:						
PTAQ				6	1	0
XETE	31	9	a	41	8	7
DIHO						
POA	2	5	0			
CASC2	2	5	0			
GAOR	2	2	0			
GOOB	26	2	1	65	2	1
HIAL	7	1	1	6	1	0
PYSE	69	2	1	41	1	1
POMU	2	1	0			
TROV	29	1	0	47	2	1
TRLA2						
				6	3	0
E 1 2	45	5	7	a2	5	4
FRAGA						
ACTR	26	4	3	35	2	1
ADBI	2	5	0	6	3	0
VAHE	2	5	0	12	3	2
PYAS	29	2	1	65	2	1
VIGL	5	2	1			
PERA	12	1	1	24	7	4
GATR	2	3	0			
ASCA3				6	1	0
ANDE	2	2	0			
PYPI	12	2	1	la	1	0
ANLY2						
OSCH				6	1	0
CLUN	43	4	2	24	5	4
SMST	5	2	1	6	1	0
STRO	12	6	8	6	1	0
VASI	2		0			
VIOR2	2	3	0			
VISE	2	3	0			
TIUN	19	6	8	29	2	1
COCA	64	5	4	71	7	4
GYDR	5	2	0	a2	4	3
OXOR						
MOSI						
ACRU				6	1	0
ATFI	5	1	0			
BLSP	7	1	0	29	1	1
EQAR						
Total	100	14	16	100	17	13
Mosses: total	100	39	28	100	47	33

* Constancy is the percentage of the sample plots in this community which contained the species.
Cover is the mean of the cover observations for each species. The mean was computed using only the samples in which it occurred.
S.D. is the standard deviation of observations around the mean.

Table 27: Plant cover of the Pacific silver fir/devil's club and Pacific

	ABAM/OPHO			ABAM/TIUN		
Number of Samples		25			36	
	Constancy*	Cover*	. . *	Constancy	Cover	. .
Mature trees:						
ABAM	92	28	17	97	22	16
ABLA2				3	30	0
ABPR	48	13	7	42	16	12
PIEN				14	7	5
PIMO				6	4	
PSME	68	18	14	81	22	15
TABR				3	3	0
THPL	28		7	44	10	
TSHE	80	15	8	83	22	1:
TSME	12	3	2	11	4	3
Total	100	60	19	100	71	16
Regenerating trees:						
ABAM	100	13	11	97	13	9
CHNO	16	3		6	4	2
THPL	16	4	3	31	4	3
TSHE	80	6	3	69	7	6
TSME				6	3	3
Shrubs:						
RILA	9	4	1	6	2	1
ROGY	4	2	0	28	2	1
SYMO	4	1	0	3	3	0
VAPA	40	3	1	44	6	6
ACCI	32	4	5	42	19	23
RUUR	8	2	1	33	3	2
ACGLD	4	2	0	6	2	1
BENE	12	6	8	33	6	.7
GASH	4	7	0	11	2	
CHUM	16	3	2	39	3	3
PAMY	4	1	0	11	3	2
RUN1	4	1	0	6	2	1
RUPA	40	3	2	28	2	1
RULA	64	3	2	72	5	4
VAME	48	3	3	53	14	17
VAOV	76	4	3	67	6	5
VAAL	52	9	7	58	10	8
RUPE	60	6	6	33	6	7
CHME	36	2	1	61		1
GAOV	8	2	1	14	5	2
MEFE	36	5	6	25	4	6
SOS1	20	3	4	25	2	1
RHAL	4	3	0	3	1	0
OPHO	96	43	33	19	2	2
Total	100	67	28	100	39	22

silver fir/coolwort foamflower associations

	ABAM/OPHO			ABAM/TIUN		
Number of Samples	25			36		
	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Herbs:						
PTAQ	8	6	6	14	3	4
XETE	8	7	7	25	5	6
DIHO	40	2	1	28	2	1
POA	28	2	1	22	1	1
CASC2				17	2	1
GAOR	16	2	1	11	2	1
GOOB	20	1	1	47	1	0
HIAL	28	1	1	39	1	1
PYSE	52	2	1	61	3	2
POMU	32	2	2	58	3	2
TROV	80	2	1	72		1
TRLA2				3	5	0
SMRA	28	3	2	25	2	1
LIB02	28	5	5	42	4	3
FRAGA				6	2	0
ACTR	96	14	12	69	7	7
ADBI	36	2	1	19	2	1
VAHE	24	4	3	36	7	8
PYAS	28	3	2	36	4	5
VIGL	48	5	4	17	2	1
PERA				17	2	1
GATR	40	4	3	11	1	0
ASCA3	40	7	9	6		2
ANDE	36	4	3	50	2	1
PYPI	16	2	1	31	2	1
ANLY2				6	4	2
OSCH	12	1	1	8	1	0
CLUN	72	4	2	72	5	4
SMST	72	4	5	53	3	2
STRO	56	2	1	47	4	6
VASI	44	4	2	25	6	7
VIOR2	8	2	0	8	2	1
VISE	16	3	1	11	3	1
TIUN	100	13	13	89	6	7
COCA	40	5	3	53	7	8
GYDR	88	17	18	72	5	6
OXOR	16	20	23	17	16	27
MOSI	36	5	4	3	1	0
ACRU	8	2		8	1	0
ATFI	80	10	1:	31	3	3
BLSP	24	4	3	39	3	2
EQAR						
Total	100	68	26	100	44	27
Mosses: total	100	16	19	100	20	22

* Constancy is the percentage of the sample plots in this community which contained the species.
Cover is the mean of the cover observations for each species. The mean was computed using only the samples in which it occurred.
S.D. is the standard deviation of observations around the mean.

Table 28: Plant cover for Pacific silver fir/fool's huckleberry and Pacific

	ABAM/MEFE			ABAM/RHAL		
Number of Samples		37			18	
	Constancy*	Cover*	S.D.*	Constancy	Cover	. .
Mature trees:						
ABAM	97	31	15	100	34	17
ABLA2	3	1	0	6	10	0
ABPR	24	15	11	28	9	5
PIEN	3	10	0	17	5	2
PIMO	8	4	2	6	8	0
PSME	65	20	8	56	11	5
TABR	3	7	0			
THPL	24	8	4	17	12	8
TSHE	92	24	13	50	25	13
TSME				72	3	10
Total	100	73	9	100	66	12
Regenerating trees:						
ABAM	100	18	10	89	22	14
CHNO	5	3	0	6	1	0
THPL	14	4	4	17	4	1
TSHE	86	5	5	50	4	4
TSME				28	5	3
Shrubs:						
RILA				6	3	0
ROGY		2	0			
SYMO	5	1	0			
VAPA	35	6	6	11	4	1
ACCI	22	11	6			
RUUR	8	3	2	6	2	0
ACGLD	5	1	0			
BENE	22	6	4	11	13	17
GASH	11	2	2			
CHUM	43	4	2	22	5	2
PAMY	14	2	1	11	2	1
RUN1						
RUPA	5	1	0			
RULA	81	6	6	83	9	8
VAME	89	11	9	100	20	14
VAOV	84	11	11	83	9	7
VAAL	78	20	11	22	16	12
RUPE	57	7	7	61	6	6
CHME	49	2	2	17	2	1
GAOV	30	3	1	6	8	0
MEFE	95	8	6	67	10	7
SOSI	35	2	1	67	3	2
RHAL	8	2	1	94	12	11
OPHO	3	5	0	6	1	0
Total	100	62	19	100	64	17

silver fir/Cascades azalea associations

	ABAM/MEFE			ABAM/RHAL		
Number of Samples	37			18		
	Constancy	Cover	. .	Constancy	Cover	. .
Herbs:						
PTAQ	3	1	0	6	2	0
XETE	43	9	9	72	18	15
OIHO	5	2	1			
POA	16	2	1	6	1	0
CASC2	5	3	1			
GAOR						
GOOB	32	2	1	22	1	1
HIAL	14	2	1			
PYSE	68	2	1	78	3	2
POMU	14	2	1	6	2	0
TROV	59	2	2	39	2	1
TRLA2						
SMRA	8	2	1	6	3	0
LIB02	35	4	3	28	4	1
FRAGA						
ACTR	46	4	3	39	4	2
ADBI						
VAHE	16	2	1			
PYAS	30	2	2	22	2	1
VIGL						
PERA	8	1	1	11	2	1
GATR						
ASCA3						
ANDE	8	2	1			
PYPI	8	2	7	6	2	0
ANLY2	3	1	0			
OSCH						
CLUN	78	6	5	72	5	2
SMST	24	4	3	6	5	0
STRO	35	2	2	44	3	3
VASI	5	2	1	39	4	4
VIOR2	3	2	0	11	2	0
VISE	3	3	0	11	3	0
TIUN	57	6	6	39	3	3
COCA	70	6	3	17	9	6
GYDR	14	3	1	6	8	0
OXOR						
MOSI	3	1	0			
ACRU	3	1	0			
ATFI	16	3	1	6	5	0
BLSP	22	2	1	6	1	0
EQAR						
Total	100	34	22	100	39	28
Mosses: total	loo	26	22	100	30	19

* Constancy is the percentage of the sample plots in this community which contained the species.
Cover is the mean of the cover **observations** for each species. The mean was computed using only the samples in which it occurred.
S.D. is the standard deviation of observations around the mean.

Table 29: Plant cover of the Pacific silver fir/big huckleberry associations

	ABAM/VAME/CLUN			ABAM/VAME/XETE		
Number of Samples	26			13		
	Constancy*	Cover*	S.D *	Constancy	Cover	S.D.
Mature trees:						
ABAM	100	26	14	100	20	14
ABLA2						
ABPR	35	22	25	23	26	19
PIEN	12	4	4	8	3	0
PIMO	8			15	2	1
PSME	85	2:	1:	92	11	8
TABR	8	4	2			
THPL	8	6	6	15	5	4
TSHE	73	14	11	92	20	12
TSME	35	9	5	31	9	0
Total	100	69	10	100	61	15
Regenerating trees:						
ABAM	100	16	12	100	14	7
CHNO	4	3	0			
THPL	8	2	2	23	3	2
TSHE	50	3	2	77	4	3
TSME	19	3	2			
Shrubs:						
RILA						
ROGY	38	4	3	15	3	3
SYMO	15	3	1			
VAPA	15	4	3	23	2	1
ACCI	15	9	14			
RUUR	8	3	1			
ACGLD						
BENE	8	2	2	38	4	·3
GASH				8	1	0
CHUM	65		1	62	4	2
PAMY	35	3	3	23	2	1
RUN1						
RUPA	8	2	1	8	1	0
RULA	85	4	3	62	4	2
VAME	96	18	11	100	18	11
VAOV	42	6	5	54	5	5
VAAL		15	0	38	2	1
RUPE	11	2	1			
CHME	27	2	1	15	2	1
GAOV	8	5	0	23	3	2
MEFE	4	1	0	38	3	2
SOS1	54	2	1	31	1	1
RHAL						
OPHO						
Total	100	31	14	100	36	13

	ABAM/VAME/CLUN			ABAM/VAME/XETE		
kumber of Samples	26			13		
	Constancy	Cover	. .	Constancy	Cover	. .
Herbs:						
PTAQ	23	4	2	8	2	0
XETE	85	9	7	85	24	24
DIHO	19	2	1	8	1	0
POA	12	1	1			
CASC2	8	4	5	15	2	0
GAOR	12	2	1	8	1	0
GOOB	27	2	1	15	2	1
HIAL	8	1	0	8	1	0
PYSE	81	3	1	85	2	1
POMU				8	1	0
TROV	58	2	1	23	1	0
TRLA2						
SMRA	15	2	1			
LIB02	54	6	4	54	6	3
FRAGA	8	1	0			
ACTR	81	7	5	54	3	3
AD81						
VAHE	31	3	3			
PYAS	27	2	1	38	2	1
VIGL	8	2	0			
PERA	23	1	0	15	1	0
GATR						
ASCA3						
ANDE	27	5	4	15	2	1
PYPI	8	2	1	15	1	0
ANLY2	8	2	2			
OSCH	4	1	0	8	1	0
CLUN	88	6	3	54	4	3
SMST	15	2	1	8	17	0
STRO	23	4	5	8	1	0
VASI	35	2	2	8	1	0
VIOR2	19	2	1			
VISE	4	3	0	8	2	0
TIUN	31	6	7	23	2	1
COCA	54	7	6	38	4	2
GYDR						
OXOR						
MOSI						
ACRU						
ATFI	4	1	0			
BLSP				8	1	0
EQAR						
Total	100	40	23	100	30	20
Mosses: Total	100	8	11	100	20	23

* Constancy is the percentage of the sample plots in this community which contained the species.
Cover is the mean of the cover observations for each species. The mean was computed using only the samples in which it occurred.
S.D. is the standard deviation of observations around the mean.

Table 30: Plant cover of the mountain hemlock associations

	TSME/RHAL			TSME/MEFE			TSME/VAME		
#umber of Samples	9			10			13		
	Constancy*	Cover*	S.D.*	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Mature trees:									
ABAM	100	26	15	100	33	14	100	30	18
ABLA2	10	40	0	10	1	0	15	10	7
ABPR				10	15	0	15	16	20
PIEN				10	1	0	31	4	3
PIMO	22	2	1	10	8	0	31	4	1
PSME	33	3	2	50	9	4	62	11	7
TABR									
THPL									
TSHE	33	7	2	70	9	6	31	15	20
TSME	89	24	16	90	15	9	77	17	16
Total	100	60	8	100	57	14	100	63	19
Regenerating trees:									
ABAM	100	22	11	100	25	14	100	16	10
CHNO	33	5	5	10	10	0			
THPL									
TSHE	22		3	50	4	4	23	7	7
TSME	56	7	3	80	2	2	46	4	2
Shrubs:									
RILA				10	2	0			
ROGY							8	10	0
SYMO				10	2	0	8	1	0
VAPA				10	2	0	15	4	2
ACCI							8	8	0
RUUR									
ACGLD	11	1	0						
BENE				10	5	0			
GASH									
CHUM	22	2	0				31	6	9
PAMY							31	2	1
RUN1									
RUPA									
RULA	100	6	4	90	5	3	69	9	
VAME	100	19	9	100	32	17	100	34	2:
VAOV	78	6	6	90	14	11	15	4	1
VAAL	22	2	2	40	8	6			
RUPE	56	6	4	80		3	8	4	0
CHME	11	1	0	20	4	1	8	2	0
GAOV	11	1	0	20	1	0	8	2	0
MEFE	78	21	20	100	18	13	8	20	0
SOS1	56	4	4	60	2	1	62	3	3
RHAL	100	19	7	10	25	0	8	1	0
OPHO									
Total	100	68	16	100	65	19	100	42	24

	TSME/RHAL			TSME/MEFE			TSME/VAME		
Number of Samples	9			10			13		
	Constancy*	Cover*	S.D.*	Constancy	Cover	S.O.	Constancy	Cover	S.O.
Herbs:									
PTAQ							8	3	0
XETE	67	11	7	70	11	10	85	20	14
OIHO				10	2	0			
POA	11	5	0	10	3	0	8	1	0
CASC2									
GAOR									
GOOB	11	1	0				8	2	0
HIAL							8	2	0
PYSE	67	2	1	80	2	1	54	2	1
POMU									
TROV	22	1	0	30	2	1	15	1	0
TRLA2									
SMRA									
LIB02				30	3	1	8	5	0'
FRAGA									
ACTR	22	4	0	30	8	7	31	3	2
AOBI									
VAHE				10	1	0			
PYAS	11	1	0	10	1	0			
VIGL							8	1	0
PERA	11	1	0	20	2	0			
GATR									
ASCA3									
ANOE				20	2	0			
PYPI							15	3	0
ANLY2				10	2	0			
OSCH							8	1	0
CLUN	22	14	8	70	7	5	62	3	1
SMST	11	2	0	20	2	1	8	1	0
STRO	11		0	40	3	2	23	2	1
VASI	33	8	5	50	3	2	38	2	0
VIOR2				20	4	2	23	3	2
VISE				10	4	0	8	2	0
TIUN	22	2	0	40	2	1			
COCA				40	8	6			
GYOR									
OXOR									
MOSI				10	1	0			
ACRU									
ATFI									
BLSP				10	1	0			
EQAR									
Total	100	18	11	100	35	24	100	29	16
Mosses: total	100	9	9	100	18	21	100	3	2

* Constancy is the percentage of the sample plots in this community which contained the.species.
Cover is the mean'of the cover observations for each species. The mean was computed using only the samples in which it occurred.
S.O. is the standard deviation of observations around the mean.

Table 31: Physiographic and soil characteristics of the Pacific silver fir/salal, Pacific silver fir/dwarf Oregon grape and Pacific silver fir/vanillaleaf-queencup beadlily associations

	ABAM/ACTR-CLUN		ABAM/BENE		ABAM/GASH	
Number of Samples	42		17		13	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Physiography						
Elevation (feet)	3426	751	3459	460	2631	694
Aspect						
Percent North	14		12		23	
Percent East	16		29		8	
Percent South	40		24		54	
Percent West	28		35		15	
Slope (%)	34	21	36	18	33	20
Percent less than 15%	24		6		38	
Percent greater than 15%	76		94		62	
Landform						
Percent on Ridges	2		6		0	
Percent on Slopes	95		94		85	
Percent in Bottoms	3		0		15	
Soil						
Total depth (inches)	53	18	48	16	60	18
Litter depth (inches)	1		2	1	1	1
Percent litter cover	96	1:	98	4	99	1
Layer 1 Thickness (inches)	5	4	4	2	3	4
Coarse fragments (%)	26	30	20	22	42	52
Fragment size (inches)	1	1	1	0	1	0
Layer 2 Thickness (inches)	14	15	8	6	17	18
Coarse fragments (%)	34	28	44	36	23	32
Fragment size (inches)	2	1	1	1	1	1
Layer 3 Thickness (inches)	20	12	20	18	14	14
Coarse fragments (%)	36	29	44	34	30	32
Fragment size (inches)	2	2	2	1	1	1
Layer 4 Thickness (inches)	22	13	17	8	17	10
Coarse fragments (%)	40	35	36	37	29	30
Fragment size (inches)	.2	1	2	2	3	2

Table 32: Physiographic and soil characteristics of the Pacific silver fir/ Alaska huckleberry associations

	ABAM/VAAL		ABAM/VAAL-GASH	
Number, of Samples	42		17	
	Mean	. .	Mean	. .
Physiography				
Elevation (feet)	3355	476	2806	628
Aspect				
Percent North	26		29	
Percent East	19		24	
Percent South	38		12	
Percent West	16		35	
Slope (%)	24	17	22	14
Percent less than 15%	36		35	
Percent greater than 15%	64		65	
Landform				
Percent on Ridges	4		6	
Percent on Slopes	71		76	
Percent in Bottoms	23		18	
Soil				
Total depth (inches)	58	18	61	24
Litter depth (inches)	2	2	2	1
Percent litter cover	94	18	99	0
Layer 1 Thickness (inches)	4	4	4	7
Coarse fragments (%)	56	44	40	46
Fragment size (inches)	1	0	1	0
Layer 2 Thickness (inches)	10	12	7	8
Coarse fragments (%)	26	33	22	29
Fragment size (inches)	1	0	2	1
Layer 3 Thickness (inches)	20	21	18	14
Coarse fragments (%)	49	39	48	39
Fragment size (inches)	2	2	2	2
Layer 4 Thickness (inches)	16	15	8	6
Coarse fragments (%)	40	32	20	35
Fragment size (inches)	2	2	1	0

Table 33: Physiographic and soil characteristics of the Pacific silver fir/devil's club and Pacific silver fir/coolwort foamflower associations

	ABAM/OPHO		ABAM/TIUN	
Number of Samples	25		36	
	Mean	S.D.	Mean	. .
Physiography				
Elevation (feet)	3728	437	3342	748
Aspect				
Percent North	76		33	
Percent East	16		33	
Percent South	4		13	
Percent West	4		21	
Slope (%)	36	21	36	21
Percent less than 15%	20		20	
Percent greater than 15%	80		80	
Landform				
Percent on Ridges	0		8	
Percent on Slopes	84		66	
Percent in Bottoms	16		25	
Soil				
Total depth (inches)	2	18	62	16
Litter depth (inches)	98	2	2	1
Percent litter cover	6	2	98	2
Layer 1 Thickness (inches)	24	269	6	6
Coarse fragments (%)			29	38
Fragment size (inches)	1	0	1	0
Layer 2 Thickness (inches)	8	8	16	18
Coarse fragments (%)	29	36	34	36
Fragment size (inches)	2	1	2	2
Layer 3 Thickness (inches)	14	11	22	20
Coarse fragments (%)	33	34	38	34
Fragment size (inches)	2	2	2	1
Layer 4 Thickness (inches)	16	12	20	13
Coarse fragments (%)	25	30	29	31
Fragment size (inches)	2	1	2	0

Table 34: Physiographic and soil characteristics of the Pacific silver fir/fool's huckleberry and Pacific silver fir/Cascades azalea associations

	ABAM/MEFE		ABAM/RHAL	
Number of Samples	37		18	
	Mean	. .	Mean	. .
Physiography				
Elevation (feet)	3673	378	4272	395
Aspect				
Percent North	35		39	
Percent East	24		28	
Percent South	14		0	
Percent West	27		33	
Slope (%)	25	19	28	18
Percent less than 15%	43		33	
Percent greater than 15%	57		67	
Landform				
Percent on Ridges	0		0	
Percent on Slopes	76		94	
Percent in Bottoms	24		6	
Soil				
Total depth (inches)	64	22	49	19
Litter depth (inches)	2	1		
Percent litter cover	99	1	95	2:
Layer 1 Thickness (inches)	3	3	4	4
Coarse fragments (%)	41	42	29	40
Fragment size (inches)	1	0	1	0
Layer 2 Thickness (inches)	8	8	6	5
Coarse fragments (%)	36	37	29	34
Fragment size (inches)		1	1	1
Layer 3 Thickness (inches)	1:	9	10	11
Coarse fragments (%)	53	39	46	32
Fragment size (inches)	1			1
Layer 4 Thickness (inches)	15	1:	1:	10
Coarse fragments (%)	36	34	40	35
Fragment size (inches)	1	1	3	3

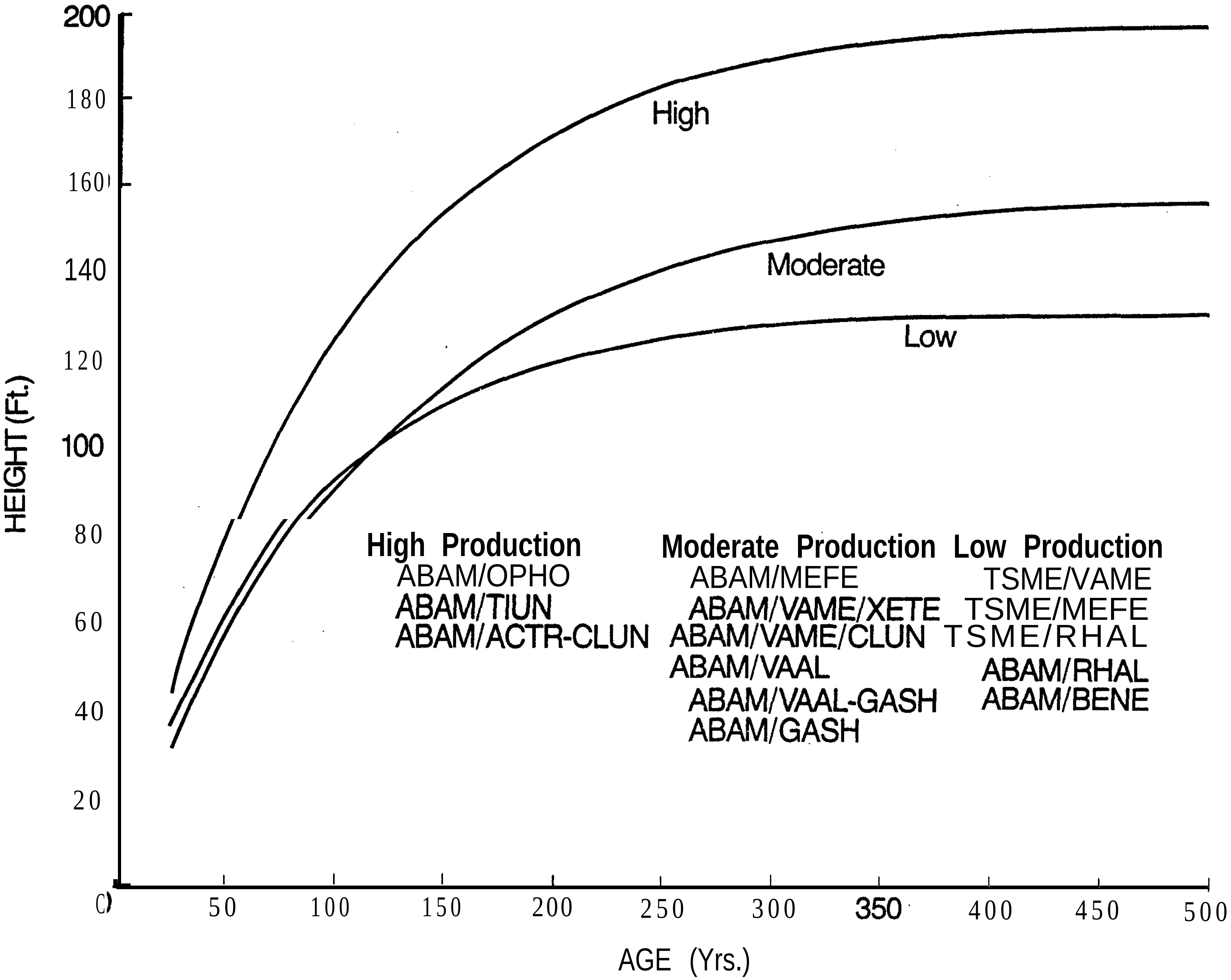
Table 35: Physiographic and soil characteristics of the Pacific silver fir/ big huckleberry associations

	ABAM/VAME/CLUN		ABAM/VAME/XETE	
Number of Samples	26		13	
	Mean		Mean	
Physiography				
Elevation (feet)	3781	475	3831	599
Aspect				
Percent North	12		17	
Percent East	27		33	
Percent South	34		33	
Percent West	27		17	
Slope (%)	21	21	18	19
Percent less than 15%	77		62	
Percent greater than 15%	23		38	
Landform				
Percent on Ridges	4		15	
Percent on Slopes	73		70	
Percent in Bottoms	23		15	
Soil				
Total depth (inches)	46	14	50	14
Litter depth (inches)	1	1	2	2
Percent litter cover	98	3	95	9
Layer 1 Thickness (inches)	5	4	4	3
Coarse fragments (%)	16		16	24
Fragment size (inches)		3	2	1
Layer 2 Thickness (inches)	1	6	16	12
Coarse fragments (%)	10	24	31	31
Fragment size (inches)	2	2	2	1
Layer 3 Thickness (inches)	13	10	14	6
Coarse fragments (%)	32	33	30	35
Fragment size (inches)	2	9	2	1
Layer 4 Thickness (inches)	15	35	24	28
Coarse fragments (%)	33		43	43
Fragment size (inches)	2	2	2	1

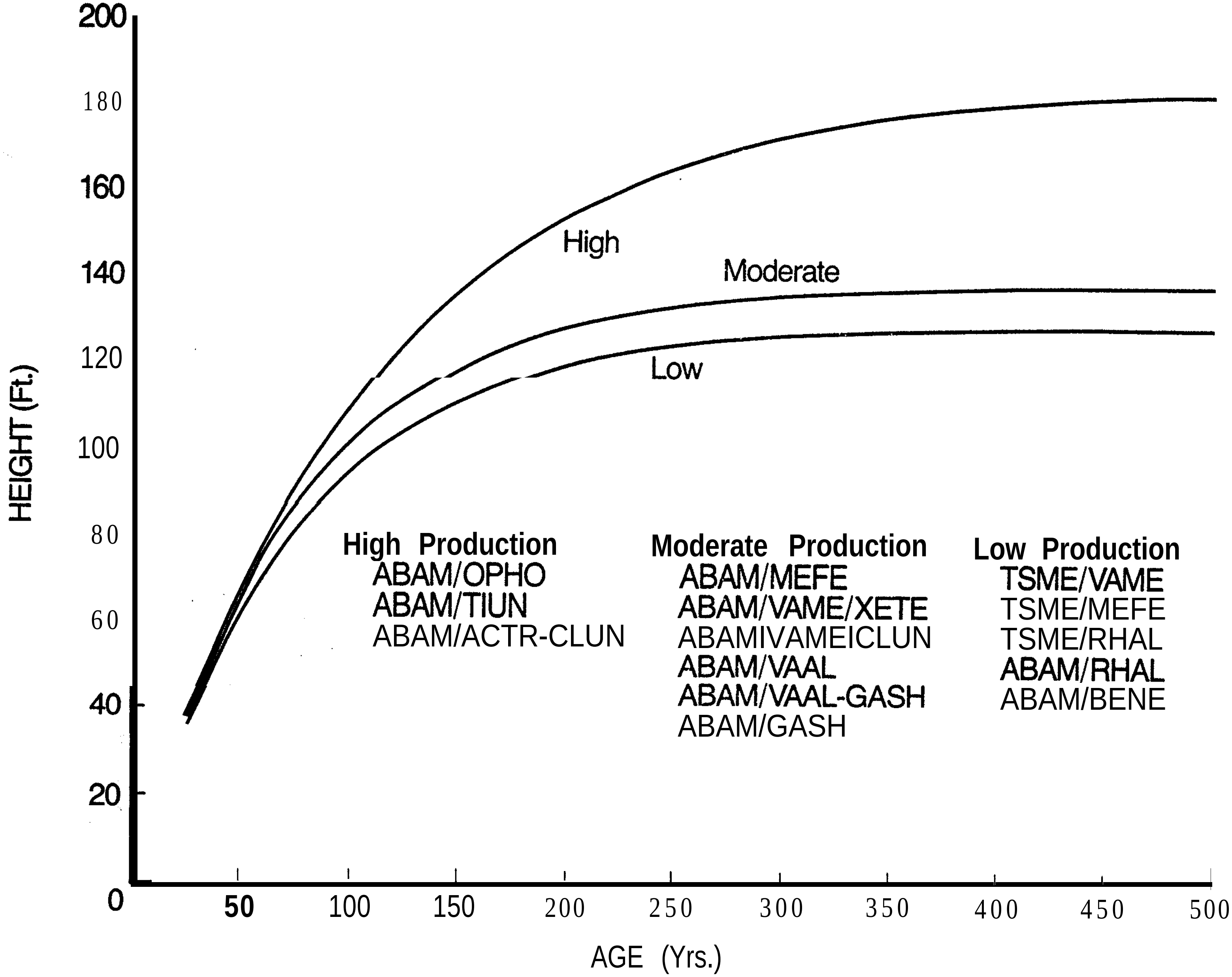
Table 36: Physiographic and soil characteristics of the mountain hemlock associations

	TSME/RHAL		TSME/MEFE		TSME/VAME	
Number of Samples	9		10		13	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Physiography						
Elevation (feet)	4644	416	3955	313	4362	710
Aspect						
Percent North	33		40		23	
Percent East	56		20		31	
Percent South	0		0		38	
Percent West	11		40		8	
Slope (%)	29	23	12	12	22	10
Percent less than 15%	56		80		38	
Percent greater than 15%	44		20		62	
Landform						
Percent on Ridges	11		20		31	
Percent on Slopes	66		70		54	
Percent in Bottoms	22		10		15	
Soil						
Total depth (inches)	53	13	61	22	43	22
Litter depth (inches)	2		2	2	1	1
Percent litter cover	98	1	99	0	92	23
Layer 1 Thickness (inches)	2	2	4	5	5	4
Coarse fragments (%)	26	41	56	48	18	33
Fragment size (inches)	1	0	1	0	1	1
Layer 2 Thickness (inches)	8	4	6	4	8	6
Coarse fragments (%)	10	8	28	30	26	29
Fragment size (inches)	1	0	1	0	1	1
Layer 3 Thickness (inches)	26	20	11	10	15	9
Coarse fragments (%)	44	35	29	27	38	33
Fragment size (inches)	2	2	1	0	2	1
Layer 4 Thickness (inches)	20	14	24	29	19	14
Coarse fragments (%)	13	10	38	46	35	33
Fragment size (inches)	2	2	1	0	2	1

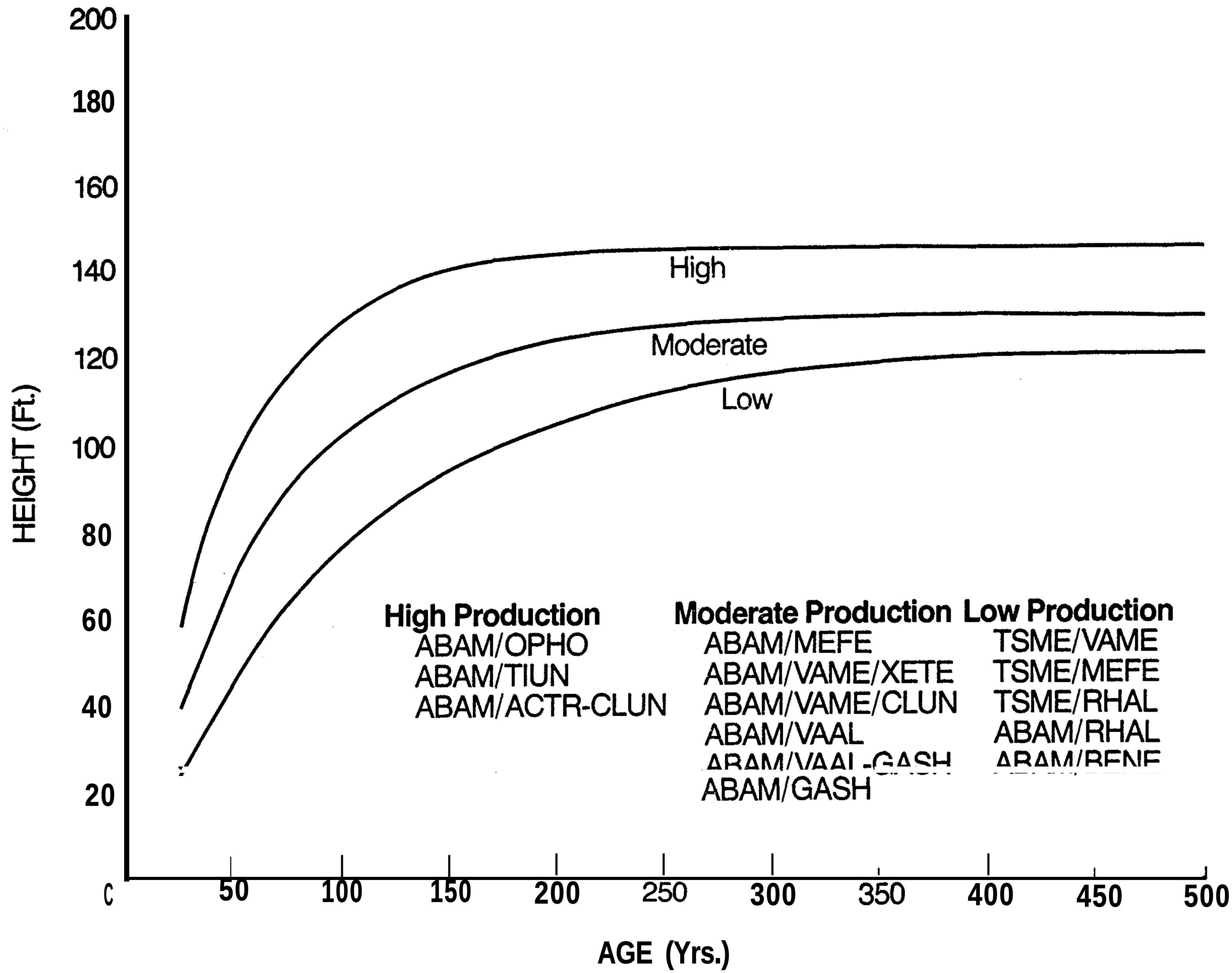
Appendix II: Empirical High Growth Curves and Volume Estimates



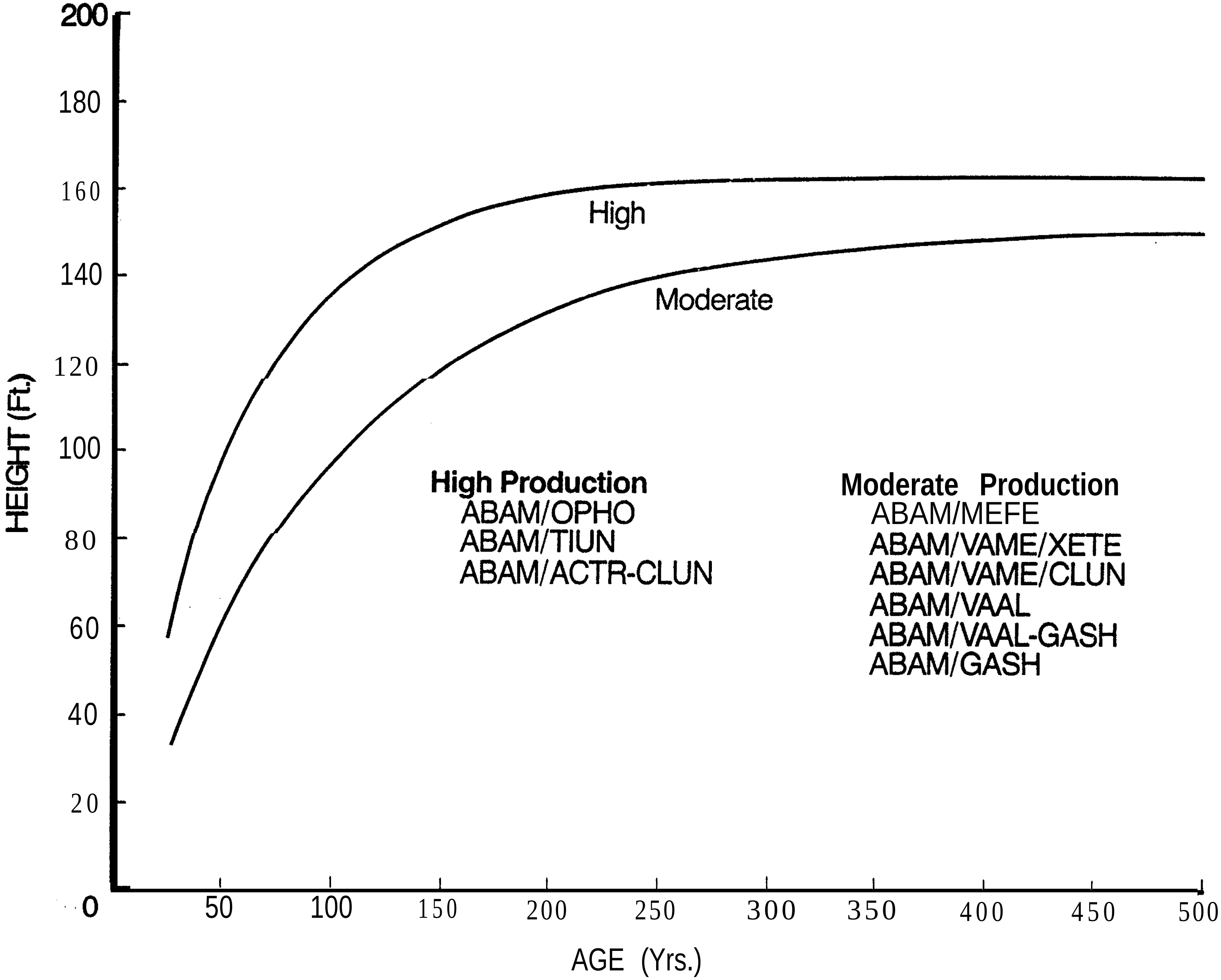
DOUGLAS-FIR HEIGHT GROWTH BY PRODUCTIVITY CLASS.



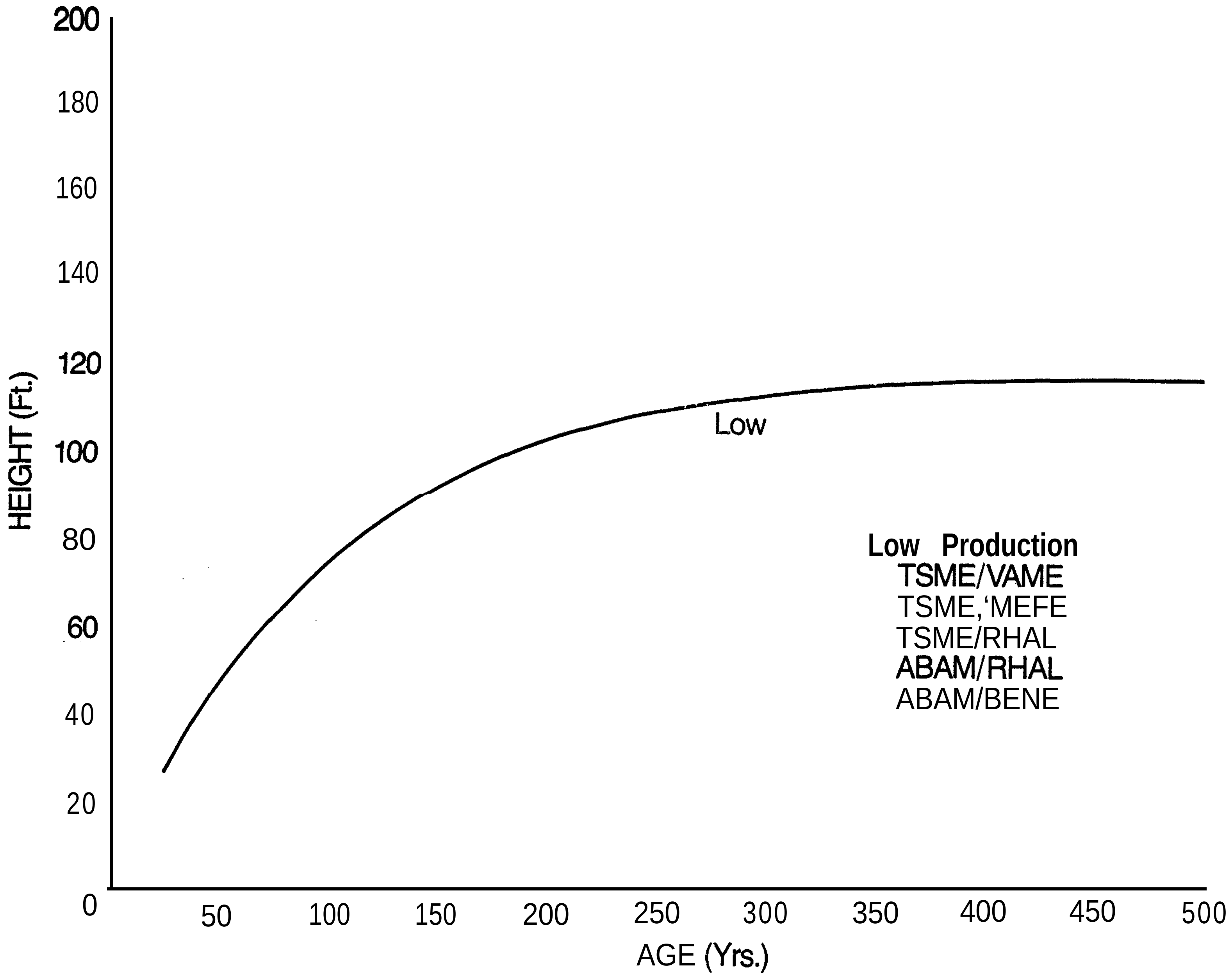
WESTERN HEMLOCK HEIGHT GROWTH BY PRODUCTIVITY CLASS.



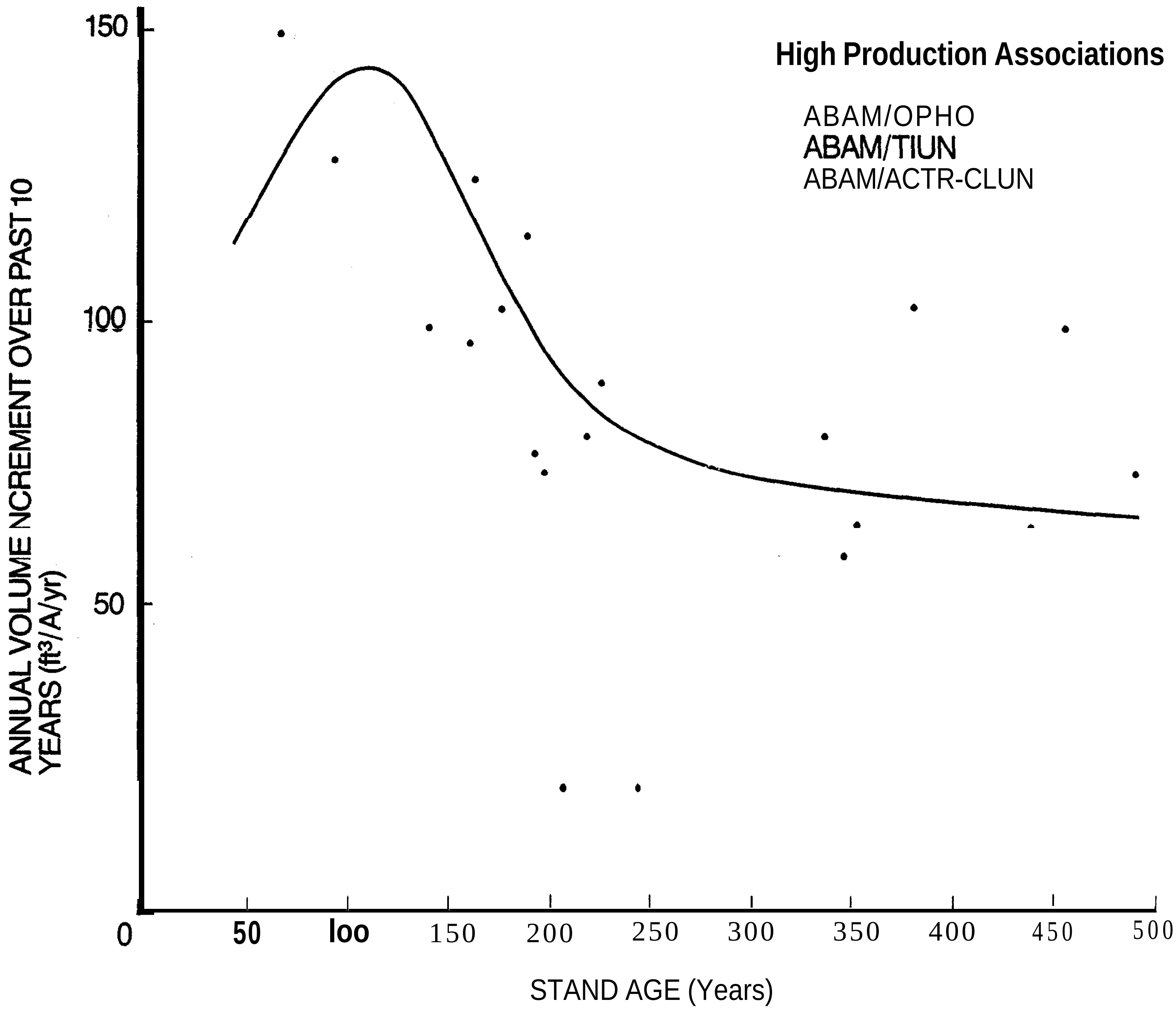
PACIFIC SILVER FIR HEIGHT GROWTH BY PRODUCTIVITY CLASS.



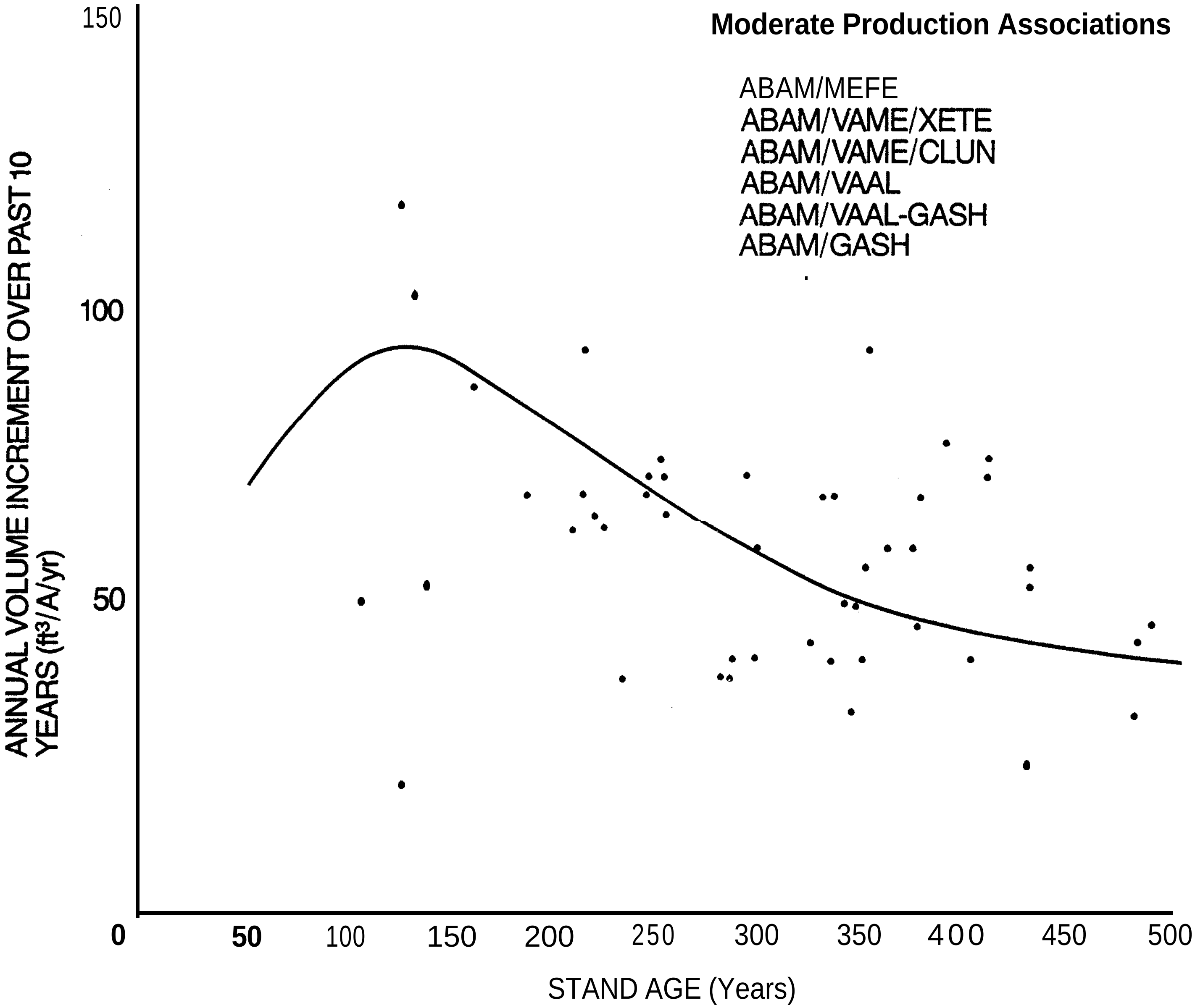
NOBLE FIR HEIGHT GROWTH BY PRODUCTIVITY CLASS



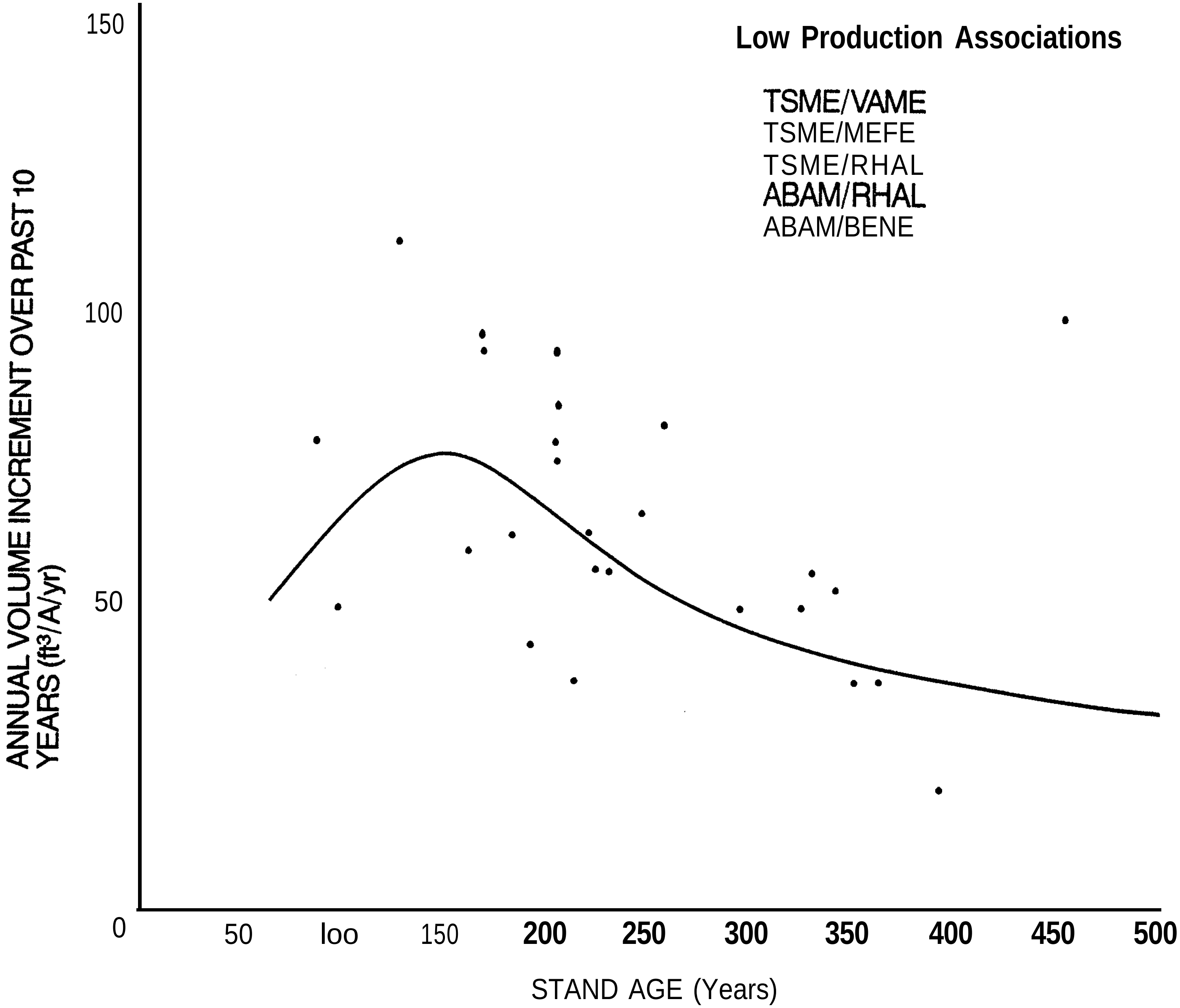
MOUNTAIN HEM-LOCK HEIGHT GROWTH BY PRODUCTIVITY CLASS.



ANNUAL VOLUME INCREMENT OVER PAST TEN YEARS FOR HIGH- PRODUCTION ASSOCIATIONS

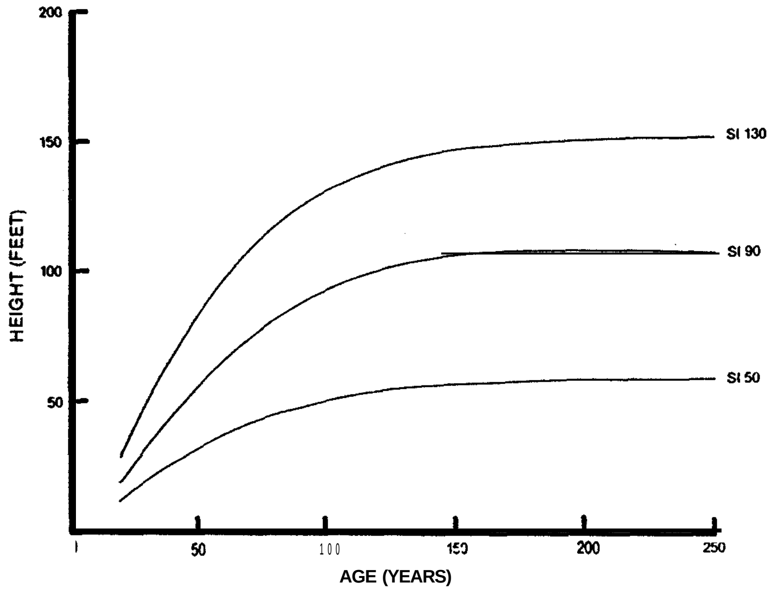


ANNUAL VOLUME INCREMENT OVER PAST TEN YEARS FOR MODERATE PRODUCTION ASSOCIATIONS'

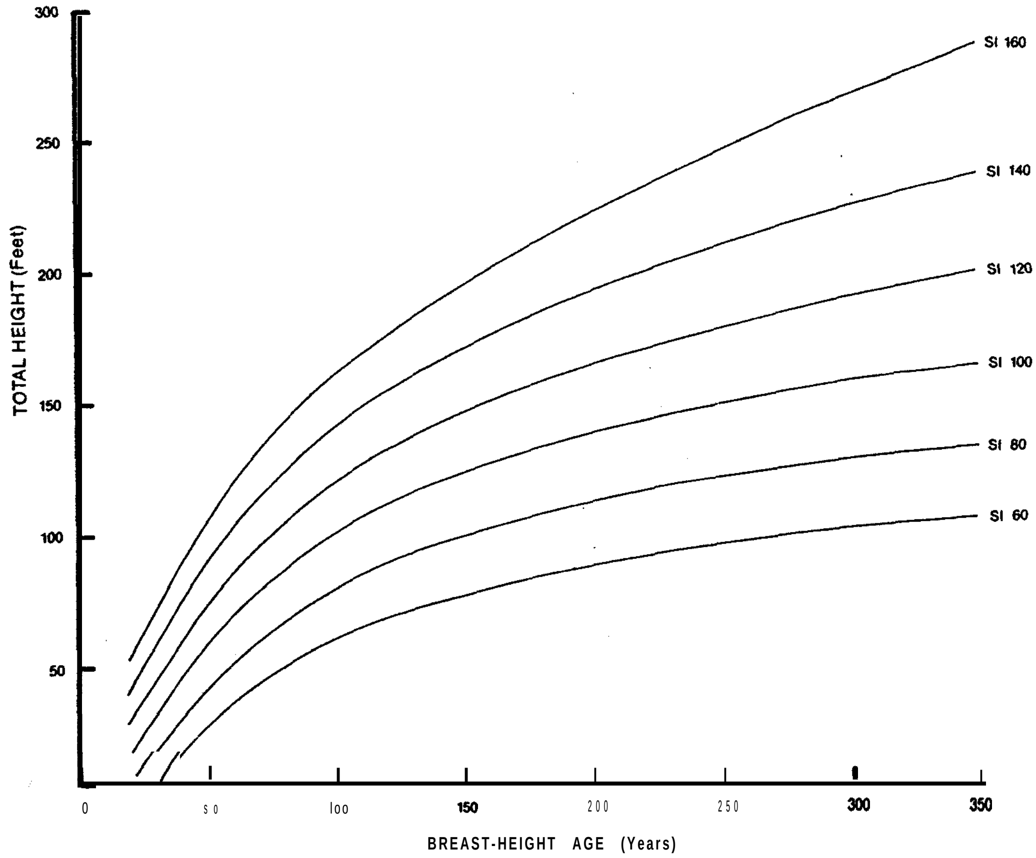


ANNUAL VOLUME INCREMENT OVER PAST TEN YEARS FOR LOW. PRODUCTION ASSOCIATIONS

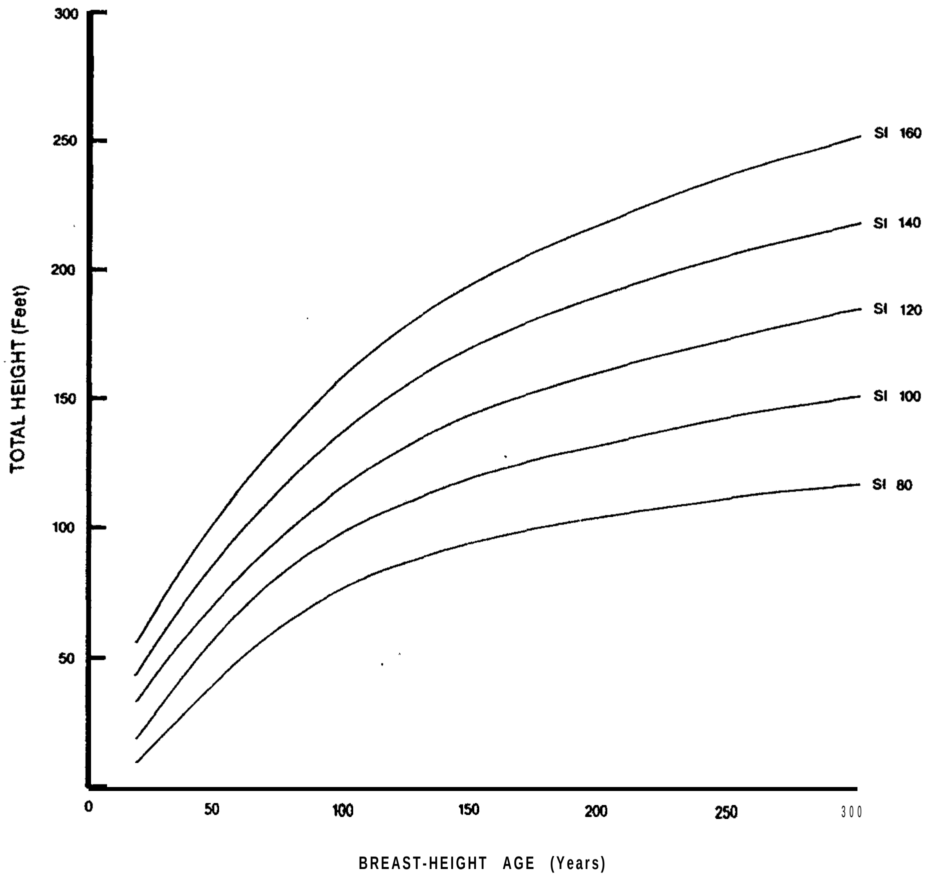
Appendix III: Curves for Site Index and Growth Basal Area



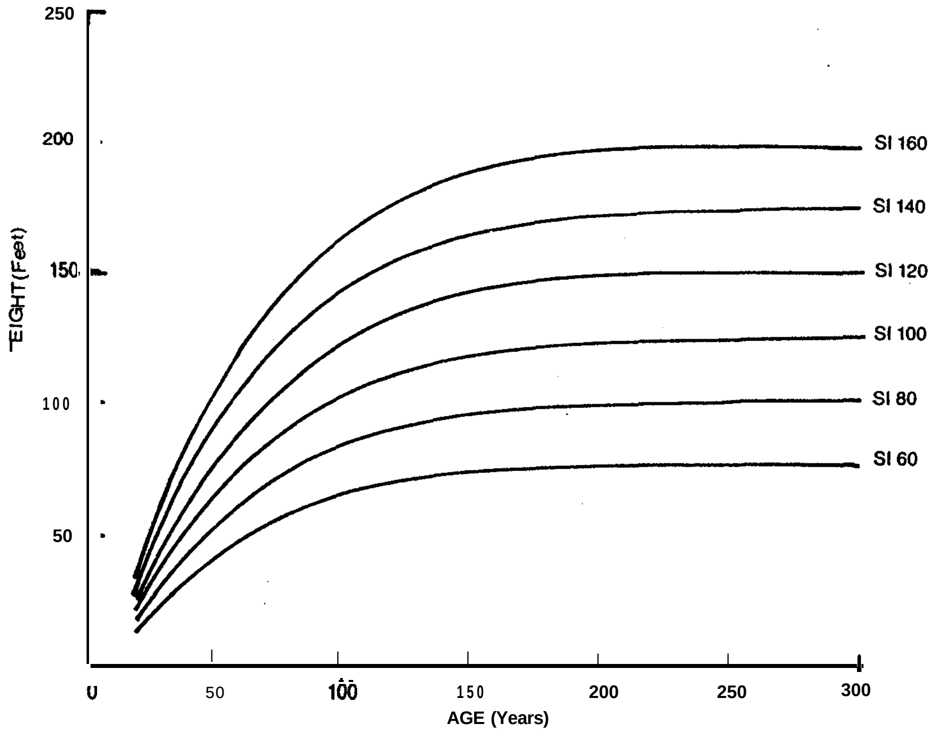
Site Index Curves for Pacific silver fir (Hegyi, et al. 1981)
Index Age 100.



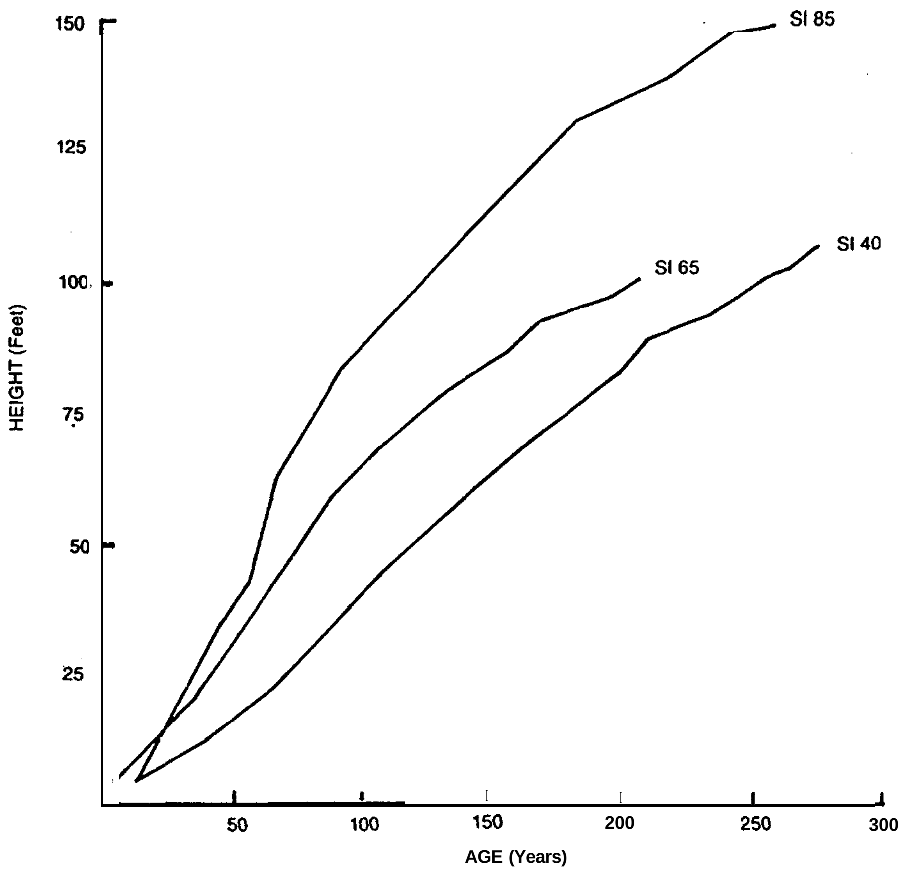
Site Index Curves for high-elevation Noble fir (Herman, et al. 1978).
Index Age 100.



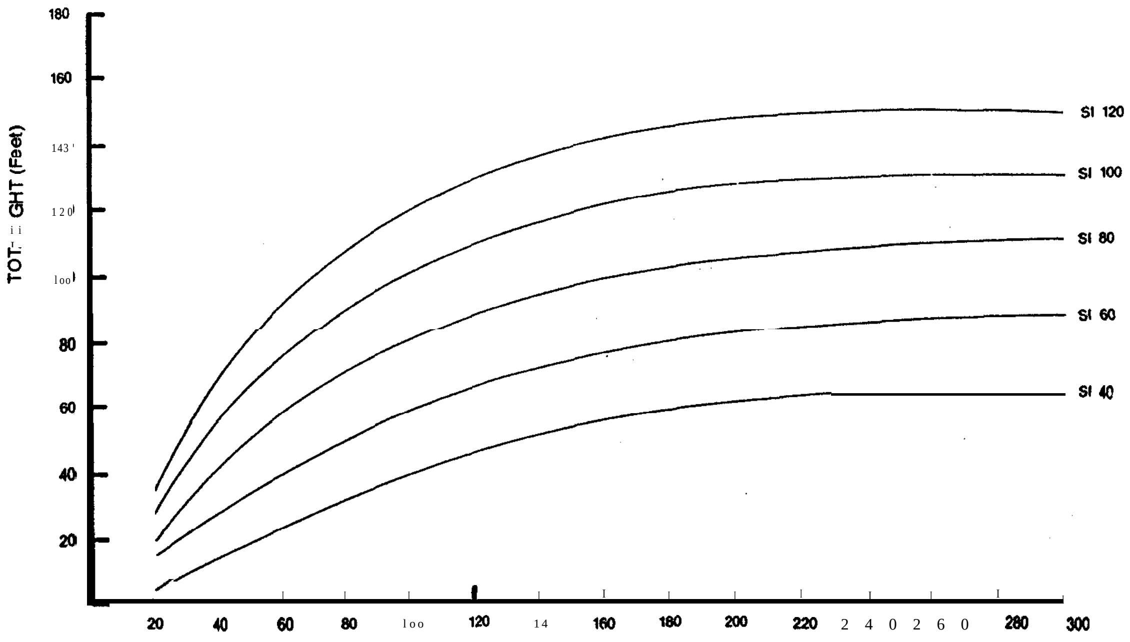
Site Index Curves for high-elevation Douglas-fir (Curtis, et al. 1974).
Index Age 100.



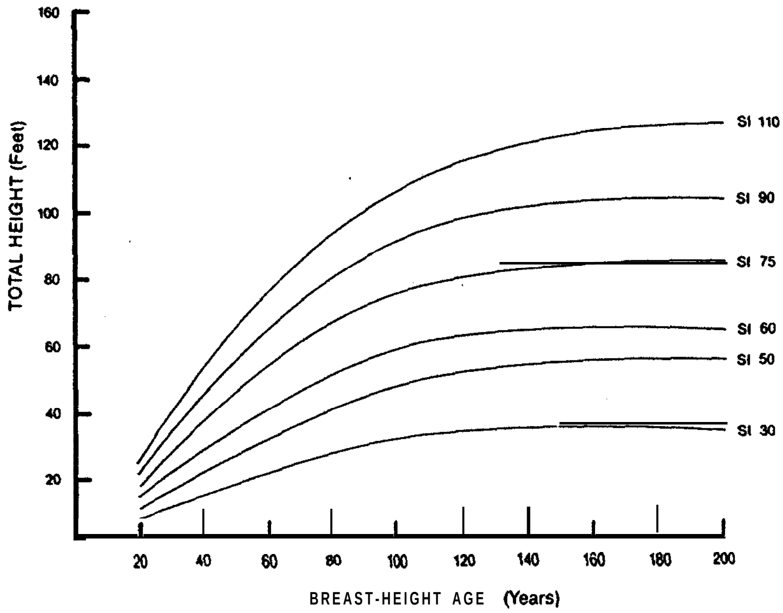
SITE INDEX CURVES FOR WESTERN HEMLOCK FROM SILVICULTURE PRACTICES HANDBOOK (FSH 2409.264.61.3). INDEX AGE 100.



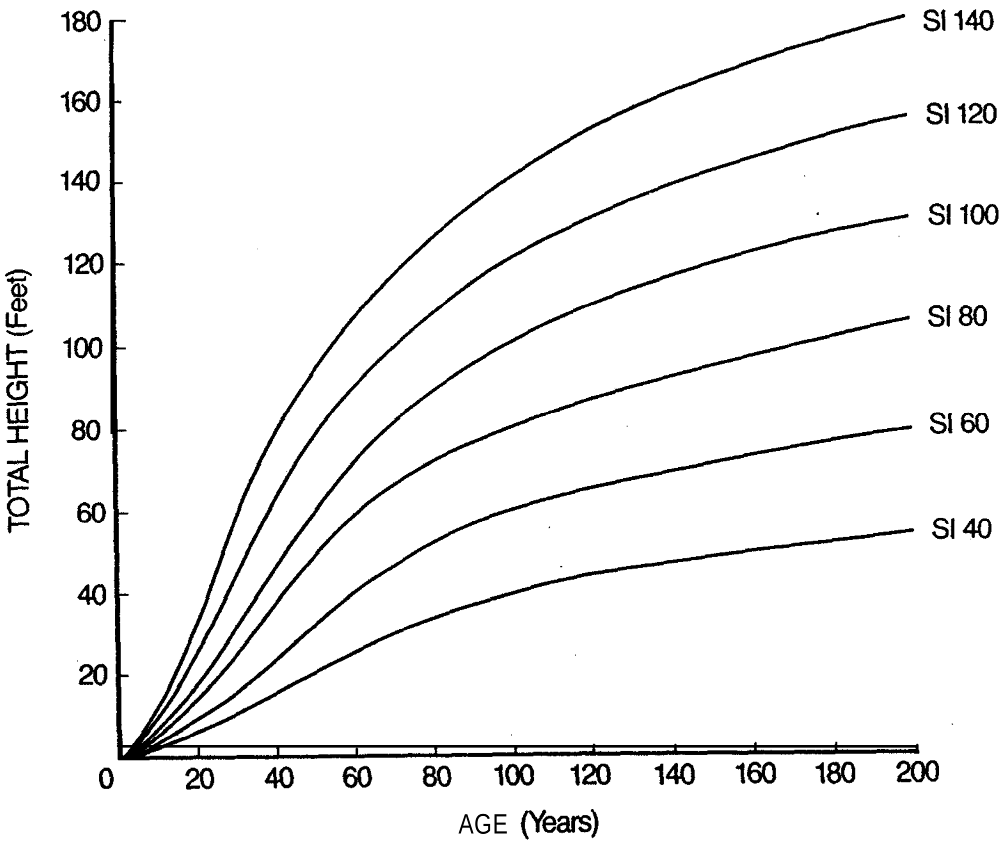
SITE INDEX CURVES FOR MOUNTAIN HEMLOCK. INDEX AGE 100. (HERMAN AND FRANKLIN 1976).



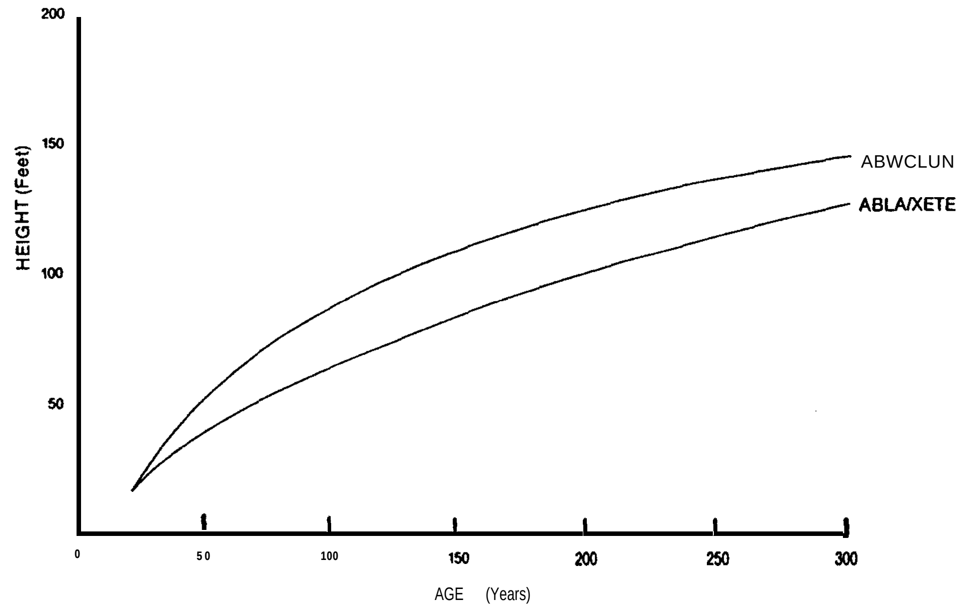
Site Index Curves for Engelmann spruce in Colorado (Alexander, 1967). Index Age 100.



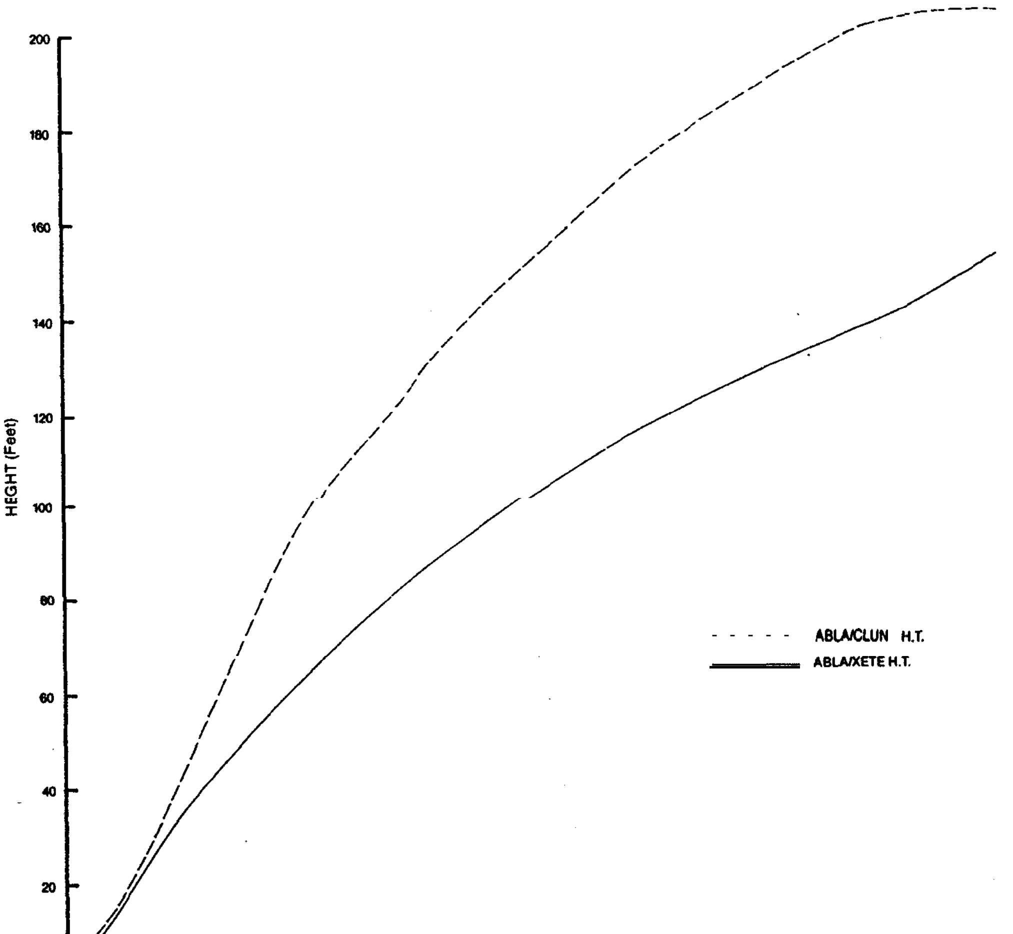
Site Index Curves for lodgepole pine (Dahms, 1964).
Index Age 100.



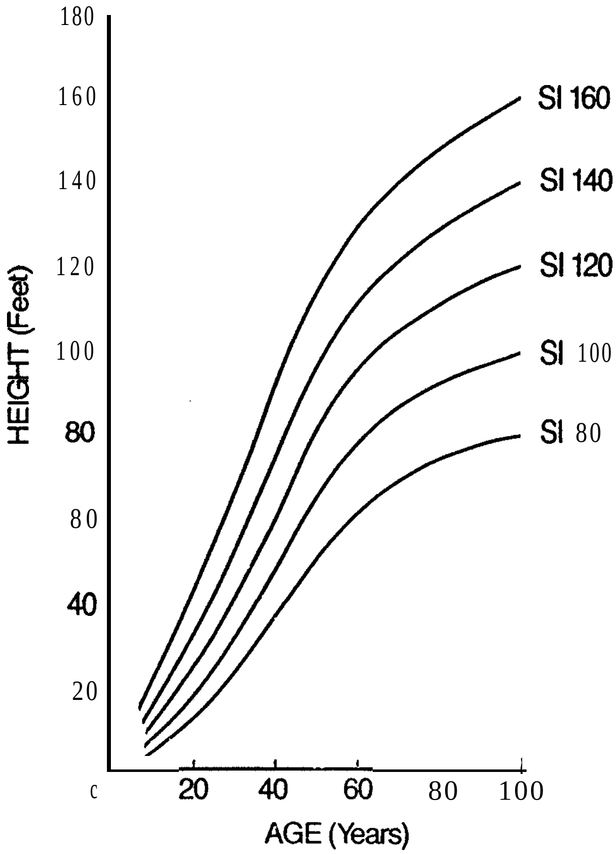
SITE INDEX CURVES FOR WESTERN LARCH (SCHMIDT ET AL. 1976). INDEX AGE 100.



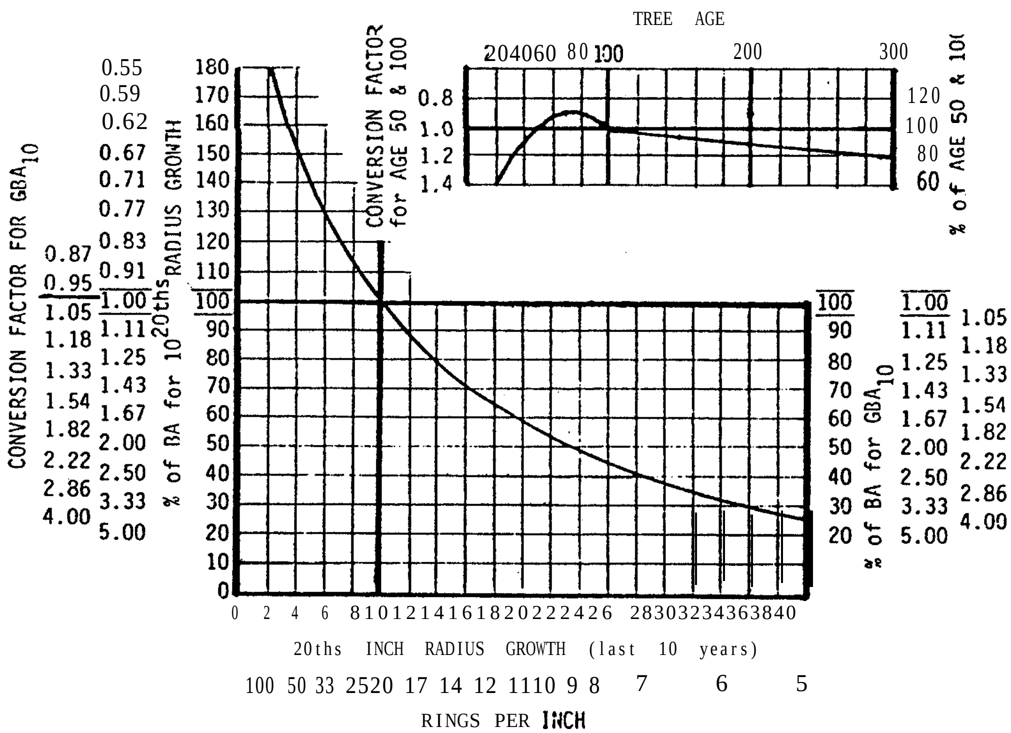
Predicted height growth of subalpine fir in two habitat types from the Clearwater National Forest (Intermountain Region) (Wykoff et al, 1981).



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



SITE INDEX CURVES FOR GRAND FIR (COCHRAN 1979). INDEX AGE 100.



Conversion factor curves for growth basal area (Hall 1983).

Appendix IV: Regional Characteristics of Each Association

Regional values for plant cover of the Pacific silver fir/salal, Pacific silver fir/

	ABAM/GASH			ABAM/BENE			ABAM/VAAL-GASH		
Number of Samples	20			112			20		
Gifford Pinchot	13			17			17		
Mt. Baker-Snoqualmie	7			10			0		
Mount Hood	0			25			3		
Willamette	0			60			0		
	Constancy	Cover	S.D.	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Trees:									
ABAM	100	23	20	98	26	18	100	37	19
ABLA2				2	2	1			
ABPR	20	6	6	33	12	17	20	5	7
CHNO	5	7	0	1	4	0			
PIEN				4	4	3			
PIMO	15	2		26	28	15	10	5	0
PSME	85	26	15	97			100	4	10
TABR	50		6	41	12	15	30	13	4
THPL	75	1:	15	33	13	10	85		9
TSHE	100	36	19	96	37	21	95	27	15
TSME	5	3	0	14	6	4	5	5	0
Shrubs:									
ROGY	25	2	1	46	3	3	25	2	0
SYMO				20	3	3			
VAPA	90		6	40	3	3	90		
ACCI	70	15	11	58	16	14	50	18	14
RUUR	40	1	0	55		2	30	2	1
BENE	100	8	6	100	1%	13	65	7	3
GASH	100	18	18	8	5	3	90	6	8
CHUM	85	4	3	86	7	6	80	2	7
PAMY	30	2	2	50	4	5	10	2	1
RULA	20	1	1	40	2	1	35	7	2
VAME	60	4		63	6	6	65	7	6
VAOV	35	4	5	12	5	5	65		6
VAAL	65	11	17	29	7	10	100	26	12
RUPE	15	1	1	9	3	1	25		2
CHME	50	1	1	38	2	1	65	3	1
GAOV	40	2	2	21	4	4	70	5	2
MEFE	25	1	1	9		2	40	5	6
SOS1	5	1	0	5	1	0			
RHAL				1	4	0			
OPHO	5	2	0						

dwarf Oregon grape and Pacific silver fir/Alaska huckleberry-salal associations.

	ABAM/GASH			ABAM/BENE			ABAM/VAAL-GASH		
	Constancy	Cover	S.D.	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Herbs:									
XETE	50	6	8	41	8	9	35	8	7
DIHO				7	1	1			
CASC2				4	3	3			
GAOR				3	2	1			
GOOB	50	2	1	54	2	1	65	2	1
HIAL	20	2	1	3	1	1	5	1	0
PYSE	5	1	0	59	3	2	40	2	1
POMU	30	3	2	18	2	2			
TROV	35	1	0	55	2	1	50	2	1
TRLA2	15	1	0	20	3	3			
SMRA	10	1	0	4	2	2	5	3	0
LIB02	90	6	9	69	8	12	75	6	4
ACTR	40	3	2	71	8	10	30	2	1
ADBI	10	2	1	12	2	1	5	3	0
VAHE	10	1	0	13	3	2	10	3	2
PYAS	40	1	1	33	3	2	65	2	1
VIGL				3	2	0			
PERA				6	5	4	25	6	4
ASCA3				6	2	1	5	1	0
ANDE	25	1	0	29	2	1			
PYPI	20	2	1	37	2	2	20	1	1
ANLY2				7	2	1			
OSCH				4	1	1	5	1	0
CLUN	35	2	2	51	4	4	20	5	4
SMST	15	2	1	27	3	1	10	16	21
STRO	10	1	0	8	2	2	5	1	0
VASI				1	1	0			
VIOR2	5	4	0	30	3	1			
VISE	5	2	0	29	3	3			
TIUN	25	2	1	29	3	3	30	2	1
COCA	50	6	5	67	8	8	75	7	4
GYDR				1	2	0			
OXOR									
MOSI				1	4	0			
ATFI				1	1	0			
BLSP	5	1	0	2	17	18	25	1	1

Regional values for plant cover of the Pacific silver fir/Alaska huckleberry, Pacific

	ABAM/VAAL			ABAM/TIUN			ABAM/OPHO		
Number of Samples	132			127			82		
Gifford Pinchot	42			36			25		
Mt. Baker-Snoqualmie	90			0			11		
Mount Hood	0			23			24		
Willamette	0			68			22		
	Constancy	Cover	S.D.	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Trees:									
ABAM	100	45	21	99	34	21	100	34	24
ABLA2				3	16	14			
ABPR	8	6		61	20	17	37	16	13
CHNO	8	13	13	5	6	6	11	15	17
PIEN				12	10	10	1	15	0
PIMO	4	3	2	17	3	2	1		0
PSME	48	16	10	84	28	19	67	2:	16
TABR	13	5	3	6	7	13	6	15	11
THPL	42	12	11	22	11		32	12	10
TSHE	100	44	23	82	21	19	95	25	16
TSME	8	6	8	23	7	6	7	4	3
Shrubs:									
ROGY	4	2	1	39	4	3	12	2	1
SYMO	2	1	1	18	4	3	6	2	2
VAPA	58	4	4	24		5	30	3	1
ACCI	23	10	12	35	11	15	39	14	16
RUUR	9	7	1	32	3		20		1
BENE	28	3	7	40	8		20	3	5
GASH	12	4	4	3	2	1:1	1	7	
CHUM	33	3		55	7	6	21	4	03
PAMY	8	2	4	16	3	2	4	1	1
RULA	44		1	64			48	6	2
VAME	46	12	125	69	9	1:	45	6	5
VAOV	42			33			50		5
VAAL	98	34	26	28	6	4	50	15	16
RUPE	57	5	9	14	11	106	41	4	5
CHME	29		1	47	5	1	24		1
GAOV	13	2	1	9	2	3	9	2	1
MEFE	49	3	3	9		6	23	4	5
SOS1	22	1	1	19	4	2	15	2	3
RHAL	4	3		1	1	0	2	4	1
OPHO	23	2	14	9	3	4	98	34	28

silver **fir/coolwort** foamflower and Pacific silver fir/devil's club associations.

	ABAM/VAAL			ABAM/TIUN			ABAM/OPHO		
	Constancy	Cover	S.D.	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Herbs:									
XETE	16	9	10	35	8	14	4	5	6
DIHO	4	1	0	29	4	5	38	3	4
CASC2	1	5	0	24	2	1	5	4	3
GAOR	1	2	0	31	5	9	18	4	3
GOOB	29	1	0	57	2	2	27	2	2
HIAL	2	1	1	11	1	1	9	1	1
PYSE	46	2	1	68	3	2	35	2	1
POMU	6	2	2	30	3	2	38	3	3
TROV	25	1	0	69	2	1	66	2	1
TRLA2	1	1	0	13	3	2	6	2	2
SMRA				13	2		17	4	4
LIB02	48	5	7	36	11	1:	24	7	
ACTR	23	4	6	89	13	11	a7	12	1:
ADBI	1	5	0	35	4	6	33	3	3
VAHE	1	5	0	36	7	8	35	9	9
PYAS	14	2	1	15	3	5	11	2	2
VIGL	5	1	0	22	2		32	4	3
PERA	4	1	1	20	6	1:	2	4	1
AScA3	2	1	0	28	4	4	49	5	6
ANDE	1	2	0	52	3	1	40	3	2
PYPI	a	1	1	28	2	1	10	2	1
ANLY2				18	3	2	10	3	2
OSCH	2	1	0	20	2	2	13	3	2
CLUN	67	4	4	82	7	7	85	6	6
SMST	18	2	2	78	7	6	77	12	17
STRO	24	3	5	24	4	5	51	3	3
VASI	5	3	3	16	4	5	22	4	3
vIOR2	1	3	0	31	4	4	12	3	2
VISE	6	2	1	34	4	3	18	3	2
TIUN	20	3	5	90	8	7	90	11	10
COCA	68	4	4	56	11	12	65	11	10
GYDR	12	2	2	20	5	6	41	14	16
OXOR				6	13	24	13	29	21
MOSI				12	6	a	32	6	
ATFI	17	2	2	17	3	3	74	10	1:
BLSP	40	5	6	13	3	2	21	5	3

Regional values for plant cover of the Pacific silver fir/fool's huckleberry, Pacific huckleberry/beargrass associations.

	ABAM/MEFE			ABAM/VAME/CLUN			ABAM/VAME/XETE		
Number of Samples	53			63			97		
Gifford Pinchot	37			26			13		
Mt. Baker-Snoqualmie	0			0			0		
Mount Hood	16			8			32		
Willamette	0			29			52		
	Constancy	Cover	S.O.	Constancy	Cover	S.O.	Constancy	Cover	S.O.
Trees:									
ABAM	98	48	17	100	43	23	99	39	24
ABLA2	2	1	0	3	14	2	2	16	20
ABPR	26	12	12	48	20	17	60	18	20
CHNO	6		2	5	4	1	3	14	10
PIEN	8	7	4	14	9	10	2	4	1
PIMO	8	4	1	19	6		30	4	3
PSME	62	18	a	79	22	1:	76	16	14
TABR	6	4		5	4	4	6	18	35
THPL	30	12	1:	8	6		13	5	3
TSHE	94	24	15	65	17	15	58	23	18
TSME	28	13	11	49	12	10	62	20	15
Shrubs:									
ROGY	8	2	1	27	3	3	16	2	2
SYMO	2	1	0	16	2	1	2	3	0
VAPA	25	6	6	8	3	3	11	2	1
ACCI	19	10	6	21	8	10	5	3	3
RUUR	8	3	2	17	3	1	6	1	1
BENE	17	6	4	14	2	1	27	5	5
GASH	8	3	2				2	1	0
CHUM	32	4	2	65	5	7	37	3	3
PAMY	11	2	1	25	3	3	14	2	1
RULA	81	5	5	81	4	5	60	3	2
VAME	91	14	13	98	18	16	98	16	16
VAOV	77	14	13	33	6	4	18	4	4
VAAL	70	19	11	10	6	5	9	4	3
RUPE	51	6	6	13	5	5	2	14	16
CHME	34	2		33	2	1	16	2	1
GAOV	34	4	5	13	3	2	20	2	2
MEFE	94	13	12	8	2	2	7	3	1
SOS1	42	2	1	38	2	1	11	2	1
RHAL	13	4	2	3	3	3	2	3	3
OPHO	a	4	2						

silver fir/big **huckleberry/queencup beadlily** and Pacific silver fir/big

	ABAM/MEFE			ABAM/VAME/CLUN			ABAM/VAME/XETE		
	Constancy	Cover	S.D.	Constancy	Cover	S.D.	Constancy	Cover	S.D.
Herbs:									
XETE	57	12	11	63	7	6	90	34	26
DIHO	4	2	1	8	2	1	1	1	0
CASC2	4	3	1	6	4	3	6	3	1
GAOR				10	2	2		1	0
GOOB	36	2	2	38	2	1	3:	2	1
HIAL	9	2	1	3	1	0		1	0
PYSE	55	2	1	79	3	3	6:	3	2
POMU	9	2	1	3	1	0	4	1	1
TROV	55	2	1	62		1	21	1	0
TRLA2	2	2	0	6	5	2	1	2	0
SMRA	9	2	1	10	2	1	2	1	0
LIB02		3	3	33	7	5	20	5	4
ACTR	3:	5	7	78	7	5	34	3	2
ADBI				8	1	1	1	1	0
VAHE	13	2	1	19	3	3	5	1	0
PYAS	23	2	2	17	2	1	12	2	1
VIGL	6	2	2	11	4	3	8	1	1
PERA	13	2	1	24	8	19	20	3	3
AScA3	4	2	1				1	1	0
ANDE	8	2	1	32	4	3	15	2	1
PYPI	8	2	1	16	2	1	8	2	1
ANLY2	2	1	0	19	2	1	5	3	1
OSCH	2	2	0	5	1	0			
CLUN	72	7	6	89	6	7	1	1	0
SMST	26	3	3	29	2	1	4	5	8
STRO	34		2	19	3	4	3	1	0
VAS I	9	3	4	21	3	2		1	0
VIOR2	8	2	1	30	3	2	2:	2	1
VISE	2	3	0	30	3	3	16	2	2
TIUN	51	6	5	37	4	5	10	2	1
COCA	72	7	5	51	10	10	28	4	4
GYDR	9	3	1						
OXOR									
MOSI	2	1	0						
ATFI	17	3	2	2	1	0			
BLSP	19	3	4				1	1	0

Regional stand productivity values by association

Association	Number of Plots				Quad Mean Diam (in.)	
	Gifford Pinchot	Mt. Hood	Willamette	Total	Mean	S.D.
ABAM/BENE	5	0	2	7	18	5
ABAM/VAAL-GASH	10	1	0	11	17	5
ABAM/TIUN	8	6	13	14	20	7
ABAM/OPHO	8	4	1	12	22	8
ABAM/MEFE	7	3	0	10	18	4
ABAM/VAME/CLUN	9	1	2	12	20	7
ABAM/VAME/XETE	5	5	3	13	15	5

Stand Basal Area (ft^2/A)		Stand Density Index (Trees/A)		SDI Volume Increment ($ft^3/A/yr$)		Current Volume Increment ($ft^3/A/yr$)	
Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
256	40	382	76	84	32	66	28
300	65	450	71	128	39	58	21
351	88	511	158	194	68	131	46
334	67	402	130	180	73	81	27
266	50	397	94	92	31	46	14
290	63	412	88	115	35	71	32
321	87	509	154	114	46	88	50

Regional species productivity values by association

Association	Volume Index (ft³/A/yr) Mean	. .	Growth Basal Area (ft³/A) Mean	. .	Site Index (ft) Mean	S.D.
ABAM/BENE						
Pacific silver fir	117		252		a9	
Noble fir	96		283		68	-
Douglas-fir	109	51	242	70	a7	21
Western hemlock	129	35	274	69	93	2
ABAM/VAAL-GASH						
Pacific silver fir	156	73	294	97	104	la
Noble fir	156		359		a7	
Douglas-fir	173	62	346	68	97	22
Western hemlock	154	68	312	74	96	27
ABAM/TIUN						
Pacific silver fir	178	52	315	84	113	17
Noble fir	307	107	460	125	130	18
Douglas-fir	268	69	427	a5	124	'15
Western hemlock	314	70	472	al	132	15
ABAM/OPHO						
Pacific silver fir	227	60	370	90	123	23
Noble fir	401	129	526	126	151	14
Douglas-fir	261	42	397	92	134	17
Western hemlock	253	99	400	138	125	26
ABAM/MEFE						
Pacific silver fir	128	57	278	68	94	27
Noble fir	152		269		113	
Douglas-fir	99	35	219		91	21
Western hemlock	139	40	262	5:	106	14
ABAM/VAME/CLUN						
Pacific silver fir	126	39	243	62	104	14
Noble fir	222	-	397	-	106	
Douglas-fir	139	58	272	86	100	19
Western hemlock	175	65	326	90	104	13
ABAM/VAME/XETE						
Pacific silver fir	123	51	286	111	85	15
Noble fir	153	35	362	68	84	10
Douglas-fir	106	29	256	46	80	8
Western hemlock	144	66	284	103	99	12