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Plant Association and Management Guide for the Western Hemlock Zone

Mt. Hood National Forest

CONTENTS

CHAPTER 1 INTRODUCTION

WHY WE CLASSIFY PLANT ASSOCIATIONS

Those who participate in management of National Forest lands, whether they are foresters, engineers, landscape architects, biologists, hydrologists, fuels managers, geologists, or any other specialists, must in reality function as applied ecologists a large part of the time. The reason is that all parts of the ecosystems we manage are linked, and any decision or recommendation made about one part produces impacts in the other parts when implemented. Thus, an understanding of the interrelationships between all the ecosystem components is essential to making good choices about land management.

One way to index the nature of ecosystem components is through vegetation. Over time, a relatively stable group of plants, or **plant association,** comes into equilibrium with the physical, chemical and biological environment on a given site (Daubenmire 1968). By knowing something about the habitat requirements of these plants, we can often infer a great deal about a site's characteristics, just by looking at the vegetation.

Williams and Lillybridge (1983) highlight three areas where plant associations are most useful:

1. In planning management strategies - evaluating productivity, resource condition and response to disturbance.

2. In communicating about our management experiences - successes and failures - by providing a common framework for describing forest stands.

3. In application of research - providing a direct link between research results and practical land management.

The goal of the Area Ecology Program is to help those who manage National Forests understand what the presence of different groups of plants, or plant associations, implies. We do this by classifying and naming the associations, by collecting data on their productivity and response to disturbance, by publishing this information and by providing ongoing training to those who use it.

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PLANT ASSOCIATION NAMES AND ECOCLASS

Throughout the text of this guide, plant associations will be referred to by their common names. To save space, alphanumeric codes (from Garrison et al. 1976) will be used for plant association names in tables and figures. These codes are based on latin scientific names, and consist of the first two letters of the genus, plus the first two letters of the species. For example, Tsuga heterophylla = TS + HE = TSHE.

We encourage our readers to become familiar with this system, as it is a good shorthand way to refer to plants, and avoids the redundencies and confusion associated with common names.

Table 10 lists species names and codes used in this Guide.

Ecoclass (Hall 1984) is a computer-based coding system used in the Pacific Northwest Region of the Forest Service for identifying plant associations. Ecoclass is used in large databases such as Stand Exam and Vegetative Resource Inventory.

Names and Ecoclass codes for Western Hemlock Zone plant associations are found in Table 1.

Table 1. Plant Associations of the Western Hemlock Zone, Mt. Hood National Forest

Alpha Code[1]	Common Name	Scientific Name	Page	Ecoclass
TSHE/ACCI/ACTR	Western hemlock/Vine maple/Vanilla leaf	Tsuga heterophylla/Acer circinatum/Achlys triphylla	56	CHS2-23
TSHE/ACTR	Western hemlock/Vanilla leaf	Tsuga heterophylla/Achlys triphylla	58	CHF2-21
TSHE/BENE	Western hemlock/Dwarf Oregongrape	Tsuga heterophylla/Berberis nervosa	60	CHS1-25
TSHE/BENE-GASH-MTH[2]	Western hemlock/Dwarf Oregongrape-Salal	Tsuga heterophylla/Berberis nervosa-Gaultheria shallon	62	CHS1-24
TSHE/BENE/POMU	Western hemlock/Dwarf Oregongrape/Swordfern	Tsuga heterophylla/Berberis nervosa/Polystichum munitum	64	CHF1-23
TSHE-PSME/HODI	Western hemlock-Douglas fir/Oceanspray	Tsuga heterophylla-Pseudotsuga menziesii/Holodiscus discolor	66	CHC2-12
TSHE/LYAM	Western hemlock/Skunkcabbage	Tsuga heterophylla/Lysichitum americanum	68	CHM1-21
TSHE/OPHO/OXOR	Western hemlock/Devil's club/Oxalis	Tsuga heterophylla/Oplopanax horridum/Oxalis oregana	69	CHS5-22
TSHE/OPHO/SMST	Western hemlock/Devil's club/Starry solomonplume	Tsuga heterophylla/Oplopanax horridum/Smilacina stellata	71	CHS5-23
TSHE/POMU-MTH[2]	Western hemlock/Swordfern	Tsuga heterophylla/Polystichum munitum	73	CHF1-23
TSHE/POMU-OXOR	Western hemlock/Swordfern-Oxalis	Tsuga heterophylla/Polystichum munitum-Oxalis oregana	75	CHF1-24
TSHE/RHMA-BENE	Western hemlock/Rhododendron-Dwarf Oregongrape	Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa	77	CHS3-28
TSHE/RHMA-GASH	Western hemlock/Rhododendron-Salal	Tsuga heterophylla/Rhododendron macrophyllum/Gaultheria shallon	79	CHS3-27
TSHE/RHMA-VAAL/COCA	Western hemlock/Rhododendron-Alaska huckleberry/Dogwood bunchberry	Tsuga heterophylla/Rhododendron macrophyllum-Vaccinium alaskaense/Cornus canadensis	81	CHS3-26
TSHE/RHMA/XETE	Western hemlock/Rhododendron/Beargrass	Tsuga heterophylla/Rhododendron macrophyllum/Xerophyllum tenax	83	CHS3-25
TSHE/VAAL/COCA	Western hemlock/Alaska huckleberry/Dogwood bunchberry	Tsuga heterophylla/Vaccinium alaskaense/Cornus canadensis	86	CHS6-15

Table 1. Cont'd.

Alpha Code[1]	Common Name	Scientific Name	Page	Ecoclass
TSHE/VAAL-GASH	Western hemlock/Alaska huckleberry-Salal	Tsuga heterophylla/Vaccinium alaskaense-Gaultheria shallon	88	CHS6-14
TSHE/VAAL-OPHO	Western hemlock/Alaska huckleberry-Devil's club	Tsuga heterophylla/Vaccinium alaskense/Oplopanax horridum	90	CHS6-11
TSHE/VAAL/OXOR	Western hemlock/Alaska huckleberry/Oxalis	Tsuga heterophylla/Vaccinium alaskaense/Oxalis oregana	91	CHS6-13
TSHE/VAME/XETE	Western hemlock/Big huckleberry/Beargrass	Tsuga heterophylla/Vaccinium membranaceum/Xerophyllum tenax	93	CHS6-12

1. Acronyms are from Garrison et al. 1976.

2. Associations ending in "-MTH" have names that are used elsewhere in the Pacific Northwest Region for plant associations that are <u>not</u> identical. Unless otherwise noted, the Forest suffix will not be used in this Guide.

CHAPTER 2 CONCEPTS

PLANT ASSOCIATIONS AS INDICATORS OF ENVIRONMENT

A mountain ecosystem is a mosaic of different environments, each having its own unique physical and biotic characteristics. Plant communities that occupy these different sites are a function of the land's topography and geology, climate, the habitat requirements of the plants available to vegetate the land, and the animals that play a role in their seed dispersal and reproduction.

In a sense, the environment acts as a screen (illustrated in Fig. 1) to prevent reproductive success of species unsuited to a given site. In a typical stream drainage for instance, seed from a wide variety of plants makes up the "seed rain" that falls on a given piece of ground. In extremely hot, cold, wet, dry or nutrient-poor sites, only those species that can tolerate such conditions survive to reproduce themselves. On the other hand, where more moderate conditions prevail, a larger number of species is able to reproduce, and competitive ability becomes more important in determining which species eventually become dominant.

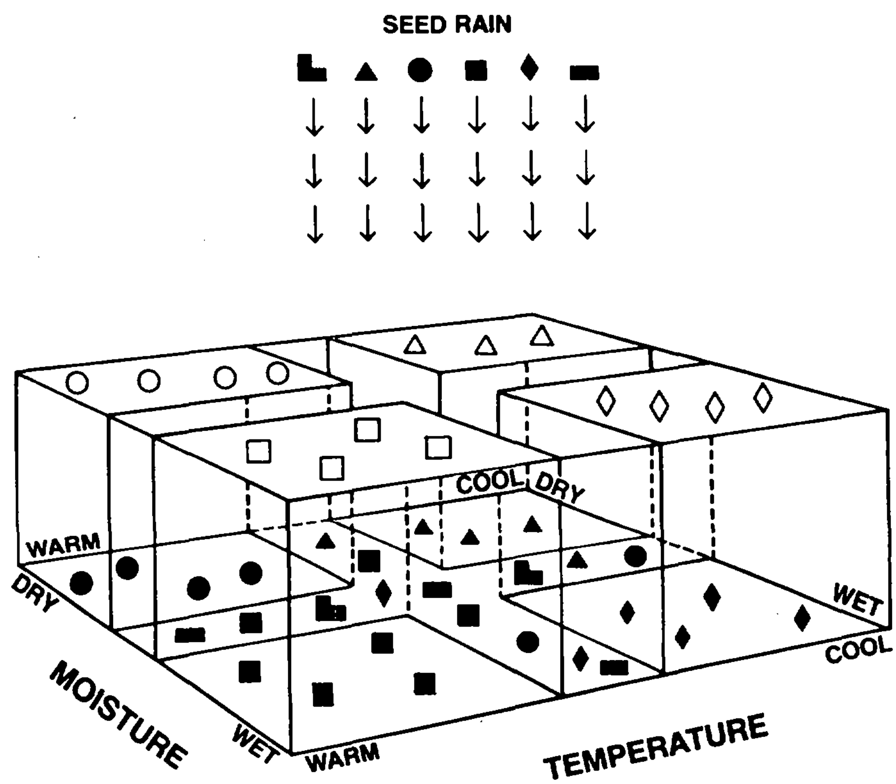

Fig 1. Only species suited to extreme conditions survive and reproduce in
environments at the ends of moisture and temperature gradients.

An extremely important concept follows from this perception of the environment as a screen to reproductive success: **Areas with an equivalent environment will, in general, eventually support roughly the same combination of plant species.** A corollary concept is that **the group of species that eventually becomes dominant on a site acts both as an _indicator_ of environmental conditions, and as a _means of comparing_ different sites to each other.** For these reasons, plant associations can be seen as one important tool in the prediction and control of effects of forest management activities.

ASSOCIATION BOUNDARIES:

IN SPACE AND TIME

It's fairly easy to see that plant associations have boundaries in **space,** since soil characteristics, topography and climate vary across the landscape. In most forested areas boundaries between areas having different plant associations are quite gradual, because environmental conditions change slowly over a relatively long distance. This often makes mapping distinct lines between communities virtually impossible. This "continuum" nature of vegetation on the west slope of the Cascades must be recognized by anyone trying to use this guide. There are many stands where the vegetation is transitional between two or more plant associations, and a judgment must be made as to which description fits best.

It is also true that plant communities have boundaries in **time.** Groups of different plant species succeed each other over time on a particular piece of ground because the physical and biological conditions of the land change temporally as well as spatially.

For example, in managed forests there are many different-aged communities of herbs and shrubs giving way to new stands of trees. As a young stand of trees grows, the ground surface becomes increasingly shaded and many light-loving species are eliminated from the plant community because they cannot perpetuate themselves.

As this development of vegetation in a disturbed area progresses, eventually the species composition stabilizes into a community that reproduces itself, rather than being replaced by something else. This ultimate community, which prevails unless it is disturbed again, is called the **_climax plant community_**, or **_plant association_**, and the process of different communities replacing each other until the climax community is reached is called **succession**. The plant communities that precede the climax association are called **seral stages**. Some readers may be familiar with the term **habitat type**. It is used to refer to the combination of a plant association and the physical/climatic habitat in which it occurs. A **zone** is the area within which a particular tree species is the stand dominant in the climax plant community. For example, the Western Hemlock Zone encompasses forests where western hemlock would eventually dominate the overstory (assuming no disturbance takes place). Forests that today have Douglas-fir in the overstory with western hemlock in the understory are considered to be within the Western Hemlock Zone because the Douglas-fir is not reproducing itself, while western hemlock is.

Vegetation zones are of interest because they generally represent major large-scale climatic differences within a region. A discussion of the forest zones found on the Mt. Hood National Forest is presented in Chapter 4 of this guide.

The complex of associations or communities that occur within a zone can be referred to as a series. Often we use the terms zone and series interchangeably.

Plant associations for forested areas must initially be identified in mature stands, since that is where the vegetation has more or less stabilized. In many cases, however, the climax plant association for earlier seral stages can be inferred from the presence of indicator plants. By this means, environmentally equivalent areas can be identified even though they may be at different places on the successional route. Conversely, the composition of seral stages can often be predicted from the climax plant association, making it possible to know whether undesirable species are likely to be present following disturbance.

SO WHAT? USES OF PLANT ASSOCIATIONS IN FOREST MANAGEMENT

Knowing plant associations and their management implications is useful in many of the activities we engage in as forest managers. The underlying value of plant association guides is that, because plant associations are indicators of their environment, they allow one to make inferences about a wide range of ecosystem factors (i.e., moisture, temperature, soil and hydrologic conditions, wildlife, etc.).

Engineers can use plant associations to locate high water table areas. Recreation planners can locate campsites in plant associations that quickly recover from trampling and resist soil compaction. Silviculturists can use them to help decide where shelterwood harvest rather than clearcutting will produce the best results, where severe brush competition may follow broadcast burning, or where cold-tolerant species should be used in reforestation. Plant associations differ in their ability to provide forage and hiding cover for wildlife, an important consideration in managing big game. Some associations are particularly prone to development of damage through disease or windthrow, indicating a possible need for attention from fuels managers.

At a broader level, plant associations provide a framework for storing and retrieving data on response of different kinds of sites to different forms of management, and for applying research results or recommendations to actual land areas. There are just a few of the uses previous guides have received. As our knowledge about plant associations increases, their value as tools for management will increase as well.

CHAPTER 3 THE WESTERN HEMLOCK ZONE

WHAT IS IT?

A zone consists of the area within which a particular tree species is dominant in the climax plant association. Thus, the Western Hemlock Zone is that area, where western hemlock is the major tree species that will replace itself over time. Figure 3 shows the location of the Western Hemlock Zone on the Mt. Hood National Forest.

To those familiar with our area, it will be immediately apparent that western hemlock is not currently the dominant species in the overstory in most of the Western Hemlock Zone; Douglas-fir is. But Douglas-fir, even though it is very long-lived, does not generally reproduce itself under a shaded canopy and would eventually (after many centuries) be eliminated from undisturbed stands. On this basis, we distinguish the Western Hemlock Zone from the climatically different true Douglas-Fir Zone, where Douglas-Fir does reproduce under its own canopy. The Douglas-Fir Zone occurs in dry sites, east of the Cascade crest, and on some hot south slopes bordering the Willamette Valley.

Fig. 2 shows a schematic view of the ecological position of the Western Hemlock Zone in relation to other zones found on the Mt. Hood National Forest. Above it, in generally

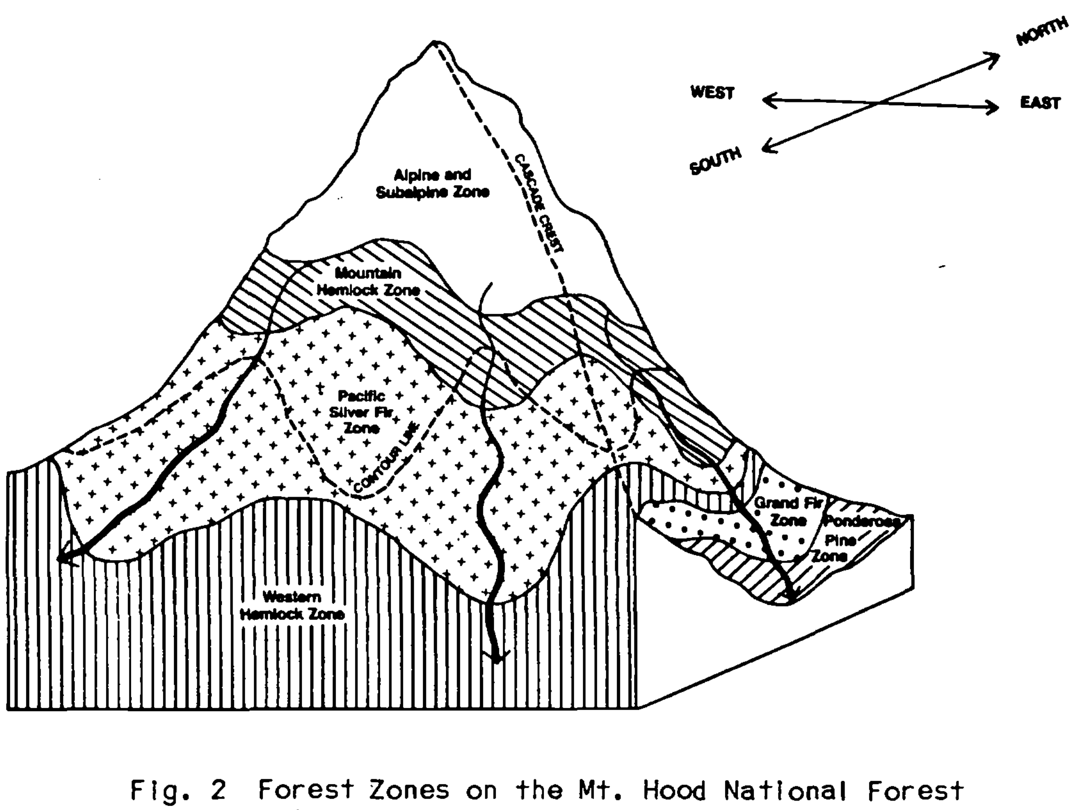

Fig. 2 Forest Zones on the Mt. Hood National Forest (schematic).

cooler and moister conditions, lies the Pacific silver fir zone. As in the Western Hemlock Zone, Douglas-fir is commonly a stand dominant in the Pacific Silver Fir Zone, but Pacific silver fir reproduces itself in the understory. Higher still lies the Mountain Hemlock Zone. A guide to the Pacific Silver Fir zone and a portion of the Mountain Hemlock Zone was published in 1982 by Hemstrom et al, and is available from the Area Ecologist at the address listed in the Introduction to this guide.

On the west side of the Cascade crest, the Western Hemlock Zone extends beyond the Mt. Hood National Forest Boundary. On the east side, however, precipitation drops off rapidly, producing conditions too dry for western hemlock to reproduce. Thus, below the Western Hemlock Zone on the east side we have the Grand Fir and Ponderosa Pine Zones.

More information about forest zones on the Mt. Hood National Forest can be found in Chapter 4.

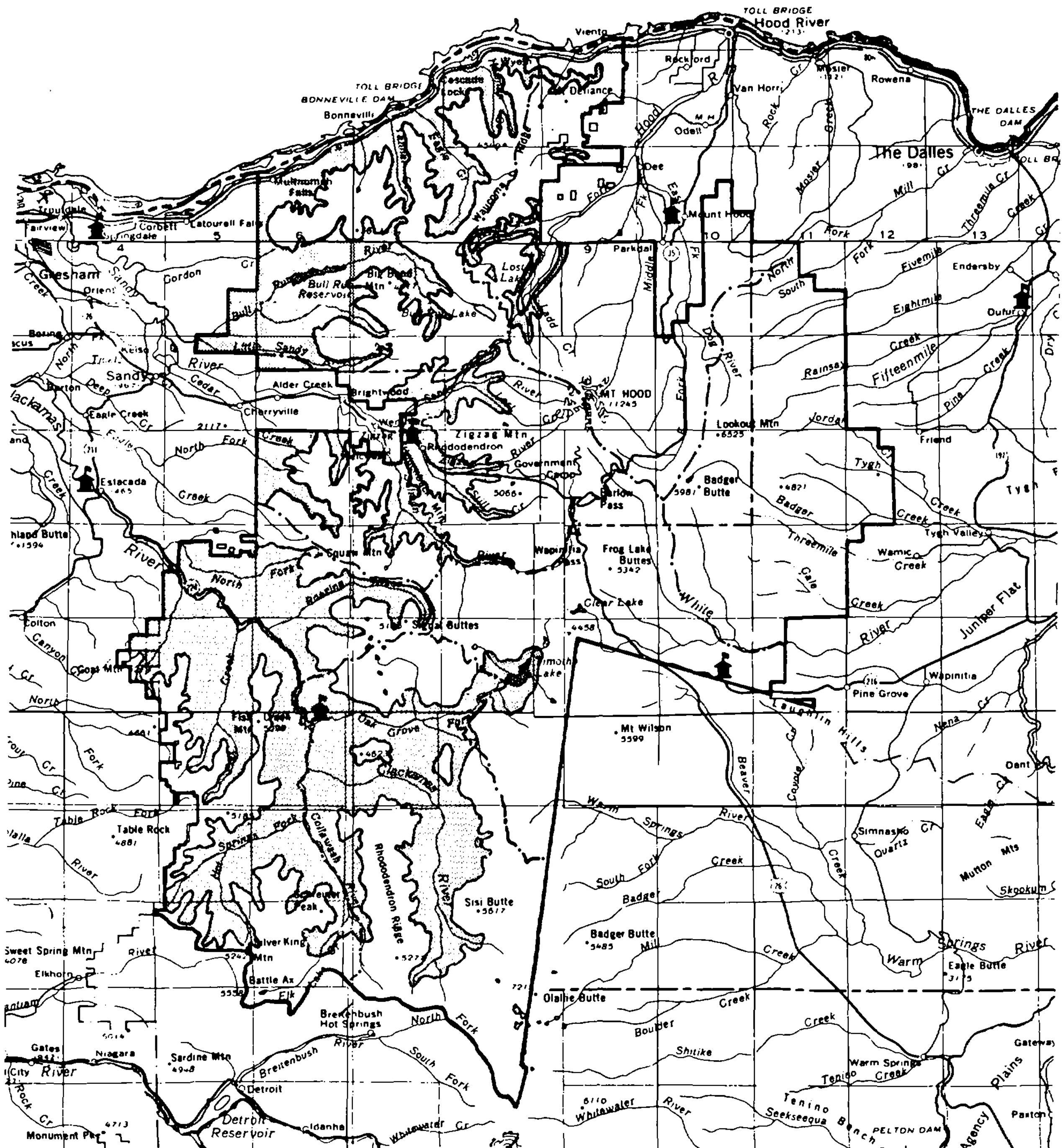

Fig. 3 The Western Hemlock Zone, Mt. Hood National Forest (generalized).

THE PHYSICAL SETTING

GEOLOGY

The Oregon Cascade Range is divided into two major geologic provinces: 1) the Oligocene to middle Pliocene Western Cascades and 2) the middle Pliocene to Quarternary High Cascades (Hammond et al 1982). The Western Cascades are composed mainly of basalt and andesite lava flows, pyroclastic flows, lahars, and minor sedimentary units of volcanic origin. These rock units form the bedrock of the western slopes and foothills of the Oregon Cascade Range. Western Cascades landforms are maturely dissected, with deeply incised valleys and sharp, steep-sloped ridges.

Geologic units of the High Cascades underly the higher elevation rolling plateaus, prominent volcanic peaks, and eastern slopes of the Cascade Range. This younger terrain is formed mainly of basalt and andesite lava flows. In many areas the High Cascades topography has been altered by Pleistocene alpine glaciation. Broad U-shaped valleys, glacial moraines, till, and glacial outwash deposits are commonly found in the High Cascade province. Small glaciers are still present at high elevations on Mt. Hood and other Cascade volcanos.

The Western Hemlock Zone occurs almost entirely within the Western Cascade Province. Units of the High Cascades tend to be present at altitudes above the upper temperature and elevation limits of the Western Hemlock Zone.

Bedrock of the Western Hemlock Zone involves five major geologic formations. These are:

1. Breitenbush Formation - Early Miocene pyroclastic flows interbedded with volcaniclastics and minor andesite lava flows.

2. Beds of Bull Creek Formation - Early to Middle Miocene interstratified thick laharic deposits, thinner fluvial volcaniclastic conglomerates and sandstones, and minor andesite and basalt lava flows.

3. Columbia River Basalt Group - Middle Miocene Basalt lava flows and very minor fluvial volcaniclastics

4. Rhodendendron Formation - Late Miocene to Early Pliocene andesite lava flows interbedded with coarse laharic deposits, pyroclastic flows and minor volcaniclastic sedimentary units.

5. Troutdale Formation - Middle Pliocene fluvial siltstones, sandstones, and conglomerates.

The Western Hemlock Zone can be divided into three district physiographic areas which result from the distribution of the geologic units listed above. These areas are the Clackamas River Drainage, the Columbia River Gorge and the Bull Run/Sandy Rivers Drainage.

In the Clackamas River drainage are four major geologic formations; Breitenbush Fm., Beds of Bull Creek Fm., Columbia River Basalt Group, and Rhodendendron Fm. Abundant faulting, hot springs activity and landslides occur in this area. Intrusive rocks (mostly dikes, thick sills, and small plugs with mineral compositions ranging from basalt to granodiorite) are also present. Landslides, some of which are quite large, are very common, especially in the upper Clackamas and Collawash River drainages. Most of the landslides involve units of the Breitenbush and Beds of Bull Creek formation which tend to be clay rich and unstable (Hammond et al. 1982). Additional instability results from the abundant fault zones and numerous dikes which have disrupted and altered the rock units. At higher elevations landslides also result from oversteepening of valley slopes caused by Pleistocene glaciation. The landslide activity has altered the normal topography of steep valleys and sharp ridges to more gradual concave benched slopes. Steep slopes with benches and rock cliffs are common where the rivers have cut through the Columbia River Basalt flows.

Topography in the Bull Run Watershed/Sandy River drainage area is dominated by steep-sloped drainages incised into the less resistant Troutdale and Rhododendron formations. Stream downcutting is retarded when streambeds reach the more-resistent flows of the Columbia River Basalt Group. On south aspects, tributaries are typically short with steep gradients, while on north aspects they are mostly longer with lower gradients. The overall drainage pattern is dendritic. Slopes in the western half of the area tend to be concave and benched due to mass wasting of the pyroclastic units of the Rhododendron formation. Abundant landslides, both active and inactive, have been mapped in this area (Shultz 1980).

Topography in the Columbia River Gorge area is controlled by the basalt flows of the Columbia River Basalt Group. The Columbia River has cut through the uplifted flows creating a steep gorge wall with a series of benches and rock cliffs. The slow weathering rock and steep slopes in this area cause soils to be poorly developed or absent in many locations. Northward-flowing tributaries have incised the gorge wall, forming tributaries with steep-walled, moderate gradient drainages. The Western Hemlock Zone extends south away from the gorge along these drainages.

SOILS

Nearly all of the opportunities and limitations we have for managing forests in the Western Hemlock Zone depend in some way on soils. Soils consist of two distinct, yet closely linked, components: the forest floor (also known as duff) and the mineral soil. The forest floor is composed of the surface organic horizons, through which most of the input of soil organic matter occurs. It is made up of plant residues in various states of decay, along with living fungal material and roots. It is the site of the most active decomposition and nutrient cycling in the ecosystem, and provides habitat for a large and diverse fauna of microorganisms and insects that mediate the incorporation of organic matter into mineral soil. Below the forest floor lies the mineral soil, which has its origin in decomposing rock, either weathering in place or transported from somewhere else by volcanos, glaciers, water or gravity. It too provides habitat for living things, perhaps most notably the roots of our diverse flora.

This discussion will emphasize the functional aspects, or links between ecosystem components of the soils of the Western Hemlock Zone. For more detailed descriptive information, see Howes 1979, Mt. Hood National Forest Soil Resource Inventory.

Forest Floor

The forest floor plays a crucial role in the function of coniferous forest ecosystems. Its chemical and physical characteristics have a profound effect on forest productivity (Lowe and Klinka 1981), since it provides the site for transfer of nutrients from plant residues back into the soil and plant roots. It provides habitat for the mycelium of mycorrhizal fungi that are essential to tree nutrition. And in mature stands, it is an important source of nutrients for the abundant feeder roots of trees (Vogt et al. 1983).

The forest floor is particularly important in poorer sites because it contains an even higher proportion of the ecosystem's nutrients relative to the mineral soil. Vogt et al. (1983) found significant differences between good and poor sites with respect to the amount of mycorrhizal tree roots present in the forest floor over time. Both types of sites had about the same proportion up to the time of forest canopy closure. Afterwards, the trends diverged. In better sites, tree roots were presumably better able to obtain nutrition from the mineral soil, either because 1) the mineral soil itself was higher in nutrients, or because 2) the organic material was incorporated more readily into the mineral soil. Thus, in better sites roots were found throughout the soil profile. In contrast, in poor sites the mycorrhizal tree roots remained distinctly concentrated in the forest floor as the stands matured. In either case, it seems clear that management activities which disturb the forest floor after canopy closure may affect future stand productivity. And the impacts will be worst in the poorer sites, because soil organic material, being concentrated in the forest floor, is more susceptible to loss.

Variations in the character and amount of forest floor within the Western Hemlock Zone are due to differences in temperature, moisture and input (both amount and type) of plant debris among different sites. Plant associations reflect these differences in the forest floor. Table 2 shows the thickness of the litter, fragmentation and humus horizons and the total forest floor (terminology follows Klinka and Lowe 1981). In general, associations that occupy warm, dry sites (Western hemlock-Douglas-fir/Oceanspray, Western hemlock/Dwarf oregongrape, Western hemlock/Dwarf oregongrape-Salal and Western hemlock/Vine maple/Vanillaleaf) have the thinnest forest floor layers. In these sites the warm temperatures hasten decomposition, and initial input of plant residues may be low because the canopies tend to be open. The thickest forest floors are found in sites with warm, moist conditions (Western hemlock/Devil's club/Oxalis, Western hemlock/Swordfern and Western hemlock/Swordfern-Oxalis). Although decomposition rates are high, initial input of litter is also very great in these highly productive sites. We infer that part of their high productivity is due to the rapid turnover of a large amount of organic material, which also is readily

Table 2. Summary of Soil Characteristics for Western Hemlock Zone Plant Associations

Plant Association	Average Total Depth (cm)	Average % Coarse Frags.	Effective Rooting Depth (cm)	% Cover Surface Rock & Gravel		Dominant Parent Material	Average Forest Floor Horizon Thickness (mm)			
				MRC[1]	CONS[1]		L[2]	F[2]	H[2]	Total
TSHE/ACCI/ACTR	95	38	60	30	83	Basalts & breccias	12	26		38
TSHE/ACTR	99	35	64	10	49	Basalts	13	31	4	45
TSHE/BENE	100	44	56	18	65	Basalts	10	26	1	37
TSHE/BENE-GASH	103	31	71	12	49	Basalts	11	24	2	37
TSHE/BENE/POMU	94	55	43	54	70	Basalts	11	25	1	37
TSHE-PSME/HODI	93	52	45	40	82	Breccias	15	15		30
TSHE/OPHO/OXOR	100	9	91	15	9	Basalts	20	40		60
TSHE/POMU	100	45	55	49	80	Breccias	18	36	3	57
TSHE/POMU-OXOR	99	28	73	15	31	Basalts	15	37	3	55
TSHE/RHMA-BENE	96	35	63	15	57	Basalts	13	30	3	46
TSHE/RHMA-GASH	93	36	62	26	69	Basalts & breccias	12	28	6	41
TSHE/RHMA-VAAL/COCA	100	32	68	12	38	Breccias	15	24	3	41
TSHE/RHMA/XETE	100	56	44	22	65	Basalts & breccias	11	29	10	44
TSHE/VAAL/COCA	96	26	71	7	50	Basalts	11	19	2	32
TSHE/VAAL/GASH	96	20	75	2	11	Basalts	15	35		50
TSHE/VAAL-OPHO	100	38	62	5	12	Basalts	25	27		52
TSHE/VAAL/OXOR	96	35	63	2	14	Basalts	15	25	8	43

1. MRC = Mean Relative Cover = Average % cover for those plots with surface rock or gravel.
CONS = Constance = % of the total number of plots with surface rock or gravel.

2. L = Litter; F = Fragmentation layer; H = Humus (Lowe and Klinka 1981).

leached into the mineral soil. Cool, moist sites (Western hemlock/Alaska huckleberry-Devil's club and Western hemlock/Alaska huckleberry-Salal) also may develop relatively thick forest floor layers, because decomposition is slowed by the lower temperatures.

Mineral Soil Horizons

The character of mineral soils is under the influence of a number of interacting factors. These can be grouped into six primary areas: parent materials, climate, vegetation, animals, time and topography.

In the Western Hemlock Zone, soils have developed under these influences in specific ways. Parent materials are constituted primarily from volcanic ejecta and lava flows, with a minor amount of glacial till. In our area these rocks have tended to produce well-drained soils. The climate is relatively moderate and rainy, with a decrease in precipitation during the growing season. The abundant rainfall plays an important role in movement of clay particles, organic compounds and mineral nutrients downward through the soil. The vegetation is dominated by conifer forests, contributing acidic organic matter to the soil. The increase in soil acidity affects movement of nutrients and clay particles. Animals - soil microorganisms and insects - are the primary agents causing organic matter to become incorporated into the soil. On a relative scale of time, Western Hemlock Zone soils are quite youthful. The geomorphic surfaces of the Cascades are relatively new, and given the climate, time has not been sufficient to develop deeply weathered, well-differentiated soil horizons. The configuration of the land, or topography, affects soil formation primarily by modifying climatic influences. By controlling runoff, topography inciuences the effectiveness of rainfall and the extent to which erosion removes the forming soil.

All of these interlocking factors have contributed to the large amount of diversity found in Western Hemlock Zone soils. But in general this diversity can be seen as variations on a central theme, that of the dominant soil-forming process.

The major controllers of soil formation in the Western Hemlock Zone are mild temperatures, abundant rainfall and coniferous vegetation. As precipitation falls on and through the slowly decomposing forest floor organic material, an acidic leachate is formed. As this leachate moves through the mineral soil profile, chemical reactions take place that causes a small amount of clay particles, some mineral nutrients and oxides of iron and aluminum to be removed from the upper part of the soil and redeposited at a greater depth.

Because of the relative youth of our soils and the generally mesic temperature regime, the results of this process are weakly expressed in the Western Hemlock Zone compared to coniferous forests at higher altitudes and latitudes. However, these soils do tend to have a distinct organic (forest floor) horizon of minimally-decomposed material, a somewhat coarse-textured upper mineral horizon (often high in organic content), and a weakly developed medium-textured subsoil. Most of the Western Hemlock Zone soils are classified as Umbrepts (have a dark-colored, organically-enriched upper horizon) or Ochrepts (dark horizon not developed).

The variations on this basic theme are due mainly to effective rooting depth (see Table 2). Effective rooting depth is a vital concept in understanding the relation between soil and plants. It is that portion of the soil occupied by small (<2 mm) soil particles. It is determined by subtracting that portion of the soil profile occupied by larger rock fragments (coarse fragments) from the total soil depth. Effective rooting depth is of interest because it indicates how much of the soil is potential habitat for plant roots, and is capable of retaining water for plant use.

On upper slopes and ridgetops, soils tend to be shallower and less productive. Plant associations dominated by rhododendron (Western hemlock/Rhododendron/Beargrass and Western hemlock/Rhododendron-Salal), a very conservative user of nutrients, are often found on these sites. On lower slopes, downward-moving, nutrient-laden water and fine soil particles accumulate, producing deep, productive soils. Sometimes these areas have impeded drainage, supporting plant associations dominated by devil's club (Western hemlock/Alaska huckleberry-Devil's club and Western hemlock/Devil's club/Oxalis). Other sites are well-drained and support herb-rich plant associations (Western hemlock/Swordfern-Oxalis and Western hemlock/Vanillaleaf). On old talus slopes or landslide areas, soils often have a very high rock content. The Western hemlock/Swordfern plant association often occurs in such sites.

Putting It All Together – Plant Associations, Soils and Management

In the Western Hemlock Zone, some generalizations can be made about the relationships between forest productivity and manageability, plant associations and soil characteristics, specifically: effective rooting depth, forest floor thickness and incorporation of organic matter and nutrients into the mineral soil.

On the average, the most productive conditions occur where effective rooting depth is greatest, the input of plant residues is high and the organic matter is decomposed and leached into the soil quickly. The Western hemlock/Devil's club/Oxalis, Western hemlock/Alaska huckleberry-Devil's club and Western hemlock/Swordfern-Oxalis associations evidence this relationship.

The least productive sites are those where effective rooting depth is limited by shallow soils or high rock content, and where cold temperatures limit the decomposition of organic matter and its movement into the mineral soil. Western hemlock/Big huckleberry/Beargrass and Western hemlock/Rhododendron/Beargrass are associations that typify these conditions.

Special nutrition problems (specifically low nitrogen) may be encountered in plant associations where the flora is dominated by broadleaf evergreen shrubs and conifer foliage, and where cool temperatures slow forest floor decomposition. This is particularly the case in the rhododendron-dominated associations (Western hemlock/Rhododendron-Salal, Western hemlock/Rhododendron-Dwarf oregongrape and Western hemlock/Rhododendron/Beargrass). In these sites nitrogen may be limited to begin with, and further may tend to be cycled slowly, with much of it bound in the evergreen shrub foliage at any one time. It is in these sites that special attention should be given to conservation of the forest floor, since the mineral soil may be minimally capable of sustaining productivity on its own (this speculation is supported by the widespread occurrence of chlorotic trees in plantations with rhododendron-dominated plant associations where broadcast burning has destroyed or reduced the existing forest floor).

Other soil factors influencing forest management include the presence of rock fragments that limit plantability, and the presence of high water table. Plant associations with a high surface rock content are: Western hemlock/Dwarf oregongrape/Swordfern, Western hemlock/Swordfern, Western hemlock/Vine maple/Vanillaleaf and Western hemlock-Douglas fir/Oceanspray. Impeded drainage can be inferred from the presence of associations dominated by devil's club: Western hemlock/Devil's club/Oxalis, Western hemlock/Alaska huckleberry-Devil's club and Western hemlock/Devil's club/Starry solomonseal. In these sites, tractor logging carries a severe risk of soil compaction and erosion, and root aeration is easily reduced.

More detailed, specific management recommendations are included in the descriptions of individual plant associations.

CLIMATE

The Western Hemlock Zone has a temperate, rainy climate with a warm, dry summer. Snow falls in winter, but deep snowpacks are not common, and accumulated snow can be melted by warm rain at any time during the cold season.

Topography exerts a major influence over local climate. Fig. 4 shows generalized precipitation amounts in the Western Hemlock Zone; it does not, however reflect the great local variation that exists. Table 3 shows precipitation amounts recorded at various stations within the Western Hemlock Zone during the growing season of 1983. It is apparent that during this period, significant differences in precipitatin occurred within the area..

In general, precipitation ranges between 60 and 130 inches annually. Rainfall is greatest in the Bull Run drainage, where the east-west orientation of the river allows penetration of eastward-moving cyclonic storms deep into the heart of the area. As the storms rise over the ridges surrounding the Bull Run drainage, they lose their moisture in the form of precipitation. This abundance of rainfall is a major contributor to the high productivity found in the Bull Run drainage.

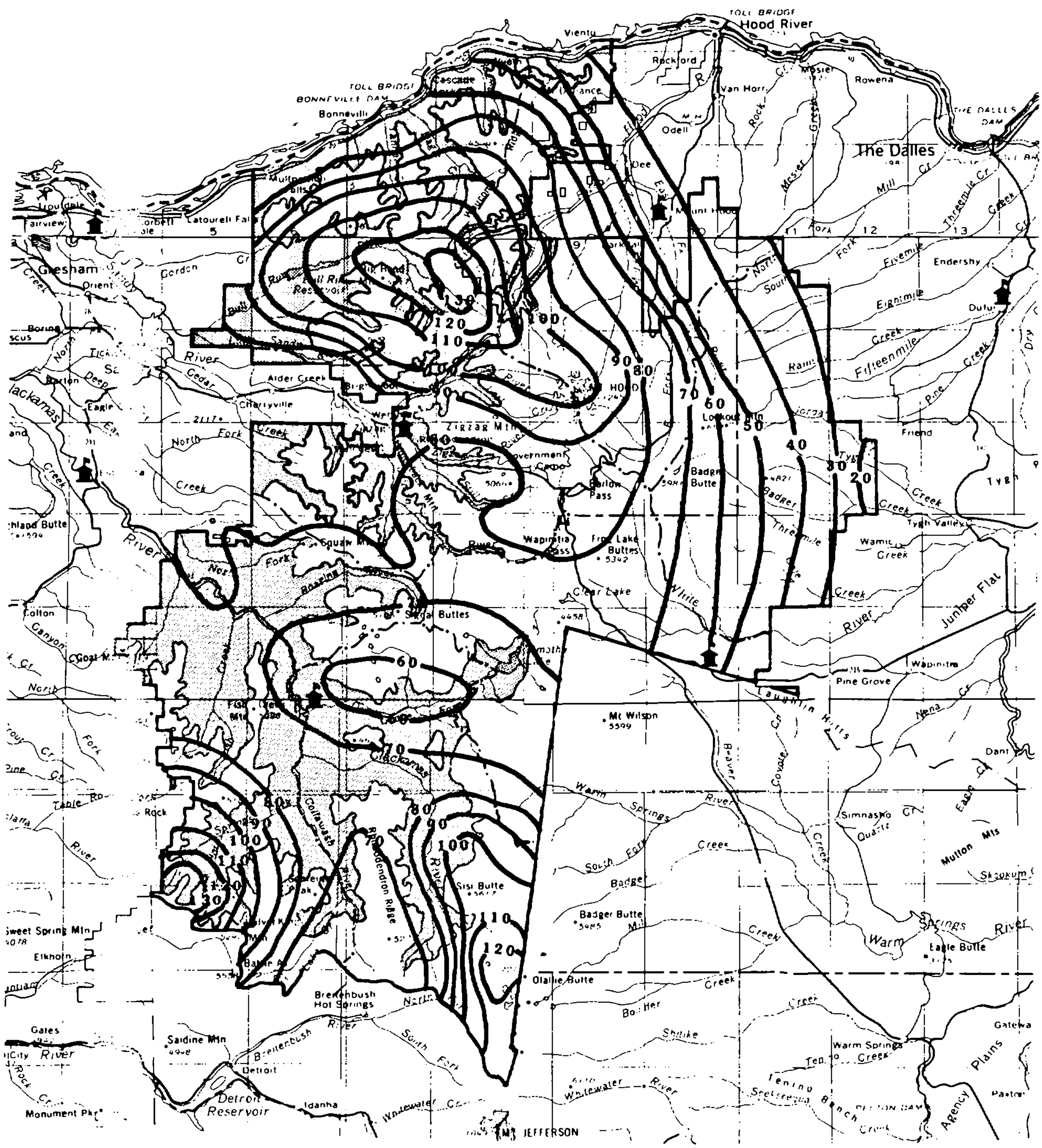

Fig. 4 Average Annual Precipitation - Mt. Hood National Forest.

Table 3. Mean Monthly Precipitation and Air Temperature at Western Hemlock Zone Stations - 1983.

Station	Location	Elev (ft)	Precip. (in.) June	Precip. (in.) July	Precip. (in.) Aug.	Precip. (in.) Sept.	Temp. (deg. F) June	Temp. (deg. F) July	Temp. (deg. F) Aug.	Temp. (deg. F) Sept.
Bull Run[1]	Lower Bull Run drainage, near river	1080	>7	>7	3.2	n.d.	53	57	59	55
Log Creek[2]	Upper Bull Run drainage, near river	2400	4.6	5.8	1.7	4.0	48	59	68	59
Wanderer's Peak[1]	West flank of Wanderer's Peak	3950	n.d.	>7	2.8	n.d.	49	66	56	51
Ripplebrook[2]	Near Ripplebrook R.S., mid-portion of Clackamas drainage, near river	1600	2.2	5.6	1.7	1.1	56	61	67	63
Redbox[2]	Upper Clackamas drainage on divide between Oak Grove Fork & Clackamas R.	3250	2.4	3.8	2.0	1.0	58	63	68	68
Rd. 4670[1]	East flank of Rho. Ridge	3600	2.4	4.0	1.6	n.d.	52	64	52	48

1. Ecology Program Stations.
2. Aviation/Fire Management Stations.

In the Clackamas River drainage, the situation is very different. There, a series of north-south-oriented ridges (Goat Mountain, Wanderer's Peak, Fish Creek Divide, Camelsback and Rhododendron Ridge) block the eastward-moving storms, and distinct rainshadow effects are produced. Precipitation decreases markedly from west to east in this part of the Western Hemlock Zone. Data collected by the Area 7 Ecology Program during the summer of 1983 suggest that considerably more rain fell on a site on the west side of the Clackamas River drainage than a site in the interior (compare the Wanderer's Peak and Rd. 4670 sites in Table 3).

Growing season temperature data for the Western Hemlock Zone is also presented in Table 3. In general, temperatures decrease with elevation. Diurnal fluctuation may be greatest in the interior of the Clackamas River drainage, where the number of cloud-free days is greatest.

Frost during the growing season is uncommon except at the highest elevations in the Western Hemlock Zone. Emmingham and Waring (1977) have shown that temperature conditions in the Western Hemlock Zone allow photosynthesis to continue well beyond the "growing season" (period of shoot elongation) for Douglas-fir, which greatly enhances the potential productivity of these sites.

VEGETATION OVERVIEW

In a general way, the environment of the Western Hemlock Zone can be arrayed as a two-dimensional grid, with temperature and moisture as axes (Fig. 5). Thus, some sites are cool and dry, some cool and wet, some warm and dry, and some warm and wet. Others fall in the middle ground, moderate in both temperature and moisture regime. These sites are termed **mesic**. In general, temperature is a function of elevation and aspect, with lower elevations and south-to-westerly slopes having the warmest temperatures year-round. Moisture regimes are affected by three factors: 1) moisture input from precipitation (predominantly a function of elevation, with precipitation increasing as elevation increases); 2) moisture retention capability of the soil (sandy, gravelly or rocky soils on slopes tend to be driest) and 3) potential evapotranpiration, which increases with higher temperatures.

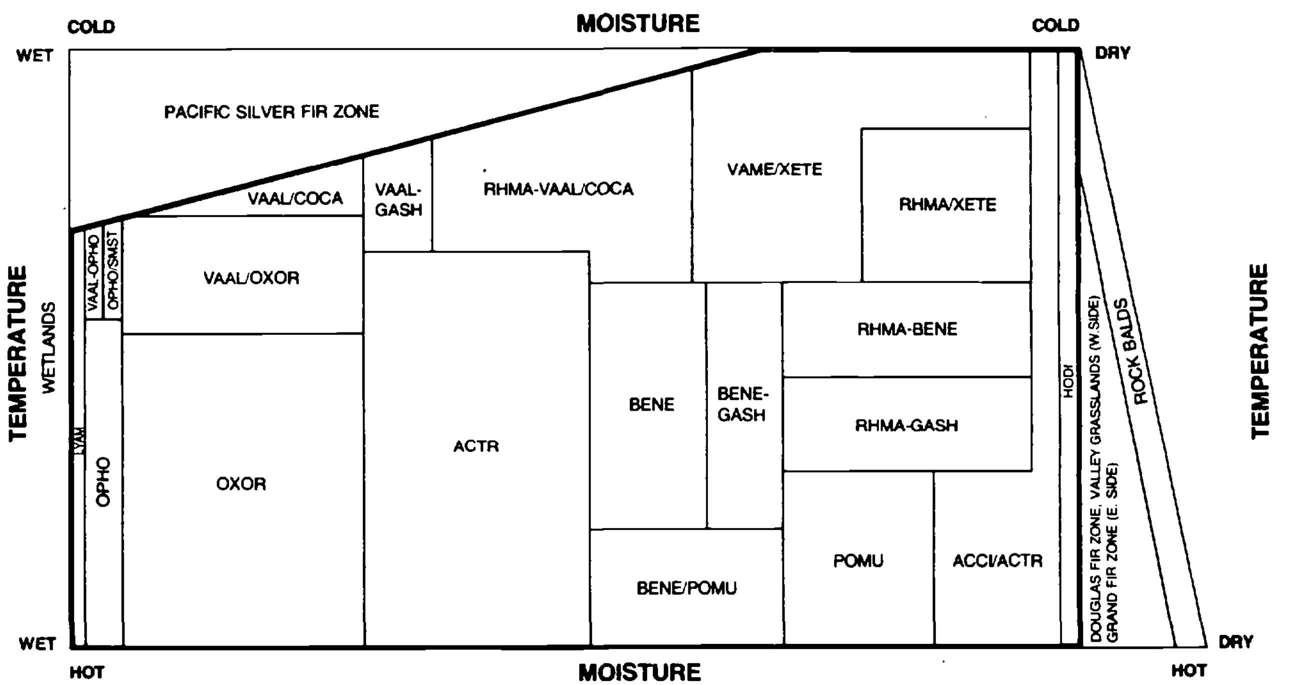

Fig. 5 Western Hemlock Zone plant associations in relation to temperature and moisture. See Table 10 for interpretation of species codes.

The driest sites in the Western Hemlock Zone on the Mt. Hood National Forest are occupied by the Western Hemlock-Douglas-fir/Oceanspray association. Drier sites than this either support Grand Fir Zone types (on the east side of the Cascade crest), or do not support forest cover (for example, grass balds on the west side). Slightly less dry (but still droughty) sites support the Western hemlock/Oceanspray and Western hemlock/Vine-maple/Vanilla-leaf associations.

At the wet end of the spectrum are associations dominated by moisture-loving plants, such as devil's club and/or skunk-cabbage. The Western hemlock/Devil's club, Western hemlock/Skunk-cabbage, Western hemlock/Alaska huckleberry-Devil's club and Western hemlock/Devil's club/Starry solomon's seal associations are examples. These associations tend to be extremely productive.

Associations rich in herbaceous species are found on productive soils in moist and mesic environments within the Western Hemlock Zone. These associations tend to support high growth rates for trees. Examples are the Western hemlock/Oregon oxalis, Western hemlock/Alaska huckleberry/Oregon oxalis, Western hemlock/Alaska huckleberry/dogwood bunchberry, and Western hemlock/Vanilla-leaf associations.

Associations dominated by rhododendron tend to occur in cooler, dry to mesic environments, and may represent soils deficient in nitrogen. Western hemlock/Rhododendron-Alaska huckleberry/Dogwood bunchberry is the most productive rhododendron-dominated association and tends to occur in moister sites than the others. On cold, dry sites we find the Western hemlock/Rhododendron/Beargrass association. In warmer areas, the Western hemlock/Rhododendron-Salal and Western hemlock/Rhododendron-Dwarf Oregon grape associations occur.

Areas that are warm and somewhat dry to mesic support the remainder of the Western Hemlock Zone plant associations. The Western hemlock/Swordfern, Western hemlock/Dwarf Oregon grape/Swordfern and Western hemlock/Dwarf Oregon grape associations all tend to be found on fairly rocky slopes, while the Western hemlock/Dwarf Oregon grape-Salal association occurs on deeper, finer-textured soils.

Table 4 shows the variation in selected site factors among Western Hemlock Zone plant associations.

Table 4. Summary of site factors for Mt. Hood NF Western Hemlock Zone plant associations.

	Geographic location	Elevation Mean	Elevation SD	Slope Mean	Slope SD	Most Common Aspect	Most Common Topo. Position
TSHE/ACTR	Throughout WHZ in moist sites	2494	681	33	19	all	Alluvial, colluvial areas
TSHE/ACCI/ACTR	Rocky slopes along Clackamas & Collowash Rivers & tributaries of Columbia	1642	756	59	16	all	A variety of slopes
TSHE/BENE	Mid-elevations throughout WHZ	2440	518	30	17	south, west	Midslopes
TSHE/BENE-GASH	Low to mid-elevations throughout WHZ	2180	406	48	24	south, west	Mid to upper slo.
TSHE/BENE/POMU	Low to mid-elevations throughout WHZ	1494	650	60	20	south,	A variety of slopes
TSHE-PSME/HODI	Basalt cliffs throughout WHZ	2020	705	60	21	south, west	A variety of slopes
TSHE/LYAM	Throughout WHZ in wet sites	2240	490	2	5	flat	Riparian areas
TSHE/OPHO/OXOR	Throughout WHZ in wet sites	1920	628	34	23	all	Riparian areas
TSHE/OPHO/SMST	Str. drainages E. of Cascade Crest	2387	251	19	9	all	Riparian areas
TSHE/POMU	Lower portions of Clackamas, Sandy & Columbia drainages	1854	651	54	20	all	A variety of slopes
TSHE/POMU-OXOR	Low to mid elevation WHZ in moist sites	1927	668	34	19	all	Alluvial areas, toe slopes
TSHE/RHMA/BENE	Mid to upper elevation WHZ, mainly in Clackamas drainage	2773	515	36	20	all	A variety of slopes
TSHE/RHMA-GASH	Throughout mid-elevation part of WHZ	2602	411	38	21	all	Lower to upper slo., steep
TSHE/RHMA-VAAL/COCA	Rare; throughout WHZ	2932	304	24	16	all	Toeslopes valley bottoms
TSHE/RHMA/XETE	Upper elevations of WHZ, especially near Cascade Crest	3115	277	32	21	all	Midslopes to upper slopes

Table 4. - Cont'd.

	Geographic location	Elevation Mean	SD	Slope Mean	SD	Most Common Aspect	Most Common Topo. Position
TSHE/VAAL/ COCA	Rare; on mid to upper elev WHZ sites	2748	340	17	16	all	Alluvial or colluvial areas, gentle slo.
TSHE/VAAL-GASH	Rare; mainly in mid to upper elev. WHZ in Bull Run watershed	2438	278	24	16	south	A variety of slopes
TSHE/VAAL-OPHO	Upper WHZ, mainly Bull Run Watershed	2349	291	28	19	north	Concavities, toe slopes (wet)
TSHE/VAAL/ OXOR	Mid-upper WHZ in Bull Run watershed	2365	412	26	18	all	A variety of slopes
TSHE/VAME/ XETE	Rare; low crest of Cascades, mainly Bear Sprs., Clackamas RD's	3291	214	26	20	all	A variety of slopes

SNAGS AND FALLEN TREES

Introduction

In recent decades, appreciation of snags and fallen trees as key structural and functional elements of forest ecosystems has evolved. In the past, this material often was viewed as either unwanted debris fostering hazardous fuel conditions and forest pests, or as a potentially salvable source of wood fiber. "Mortality" was something to be "harvested", or else it was wasted. But it is increasingly clear that Douglas fir forests have developed under a regime where standing and down dead wood is as important a component of ecosystem function as the live plants, soils or animals (Maser and Trappe 1984).

The value of snags, especially to cavity-nesting wildlife, has long been recognized. Since 1977 Mt. Hood National Forest policy has called for conservation of snags in harvested areas (Forest Service Manual 2405.14, Mt. Hood Supplement No. 72).

The value of fallen trees has not been as widely appreciated until recently. Current research indicates a need for management of down woody debris as well as snags (Maser and Trappe 1984). To manage this important resource, we first need to answer a critical question: How many and what type of snags and fallen trees are necessary in different sites to perpetuate their functional relationships? We have taken a step toward answering this question by characterizing the amount and kind of fallen trees and snags in unmanaged stands within the Western Hemlock Zone.

The distribution of snags and fallen trees is partly a function of elevation, aspect, slope and other site factors that contribute to overall site productivity. But the history of stand perturbation and intertree competition have perhaps even greater influence. Under natural conditions, disease, fire, pest infestation and the proximity of the trees to each other as the stand develops are factors that contribute to tree mortality, and make snags or fallen trees out of living trees.

Since plant associations reflect site conditions more than stand history, the amount of snags and fallen trees within a given plant association is highly variable. Plant associations by themselves are therefore not a very good index of the amount of snags and down wood.

The remainder of this discussion will emphasize the function of snags and fallen trees within the Western Hemlock Zone. For an excellent synthesis of available information on this subject, plus state-of-the-art management recommendations, see chapters by Neitro et al. and Bartels et al. in Brown 1985.

Snags

One of the major functions of snags in forest ecosystems relates to the diversity of wildlife habitat they provide. A large number of animals, especially birds, depend on snags for a variety of needs, including shelter from predators and temperature extremes, hunting perches, food (insects and fungi) and food storage. An estimated 70 species of birds on the Mt. Hood National Forest are in some way dependent on snags. Many of these are insectivorous birds that help control forest pests (USDA Forest Service 1982).

In addition, snags are a major source of fallen trees, which have their own set of important functional relationships, discussed below.

We tallied and measured snags on plots in approximately 200 unmanaged Western Hemlock Zone stands, ranging in age from approximately 50 to 600 years. Species, diameter at breast height (DBH), height class (10-30', 30-50' and >50') and condition class were recorded for each snag tallied. Condition class indicates the degree of decomposition of a snag, and is of interest because it determines how a snag will be used by wildlife. Our condition classes, modeled on Cline et al. (1980) are as follows:

Snag Condition Classes

Condition 1 - Fine branches and bark intact.
Condition 2 - A few larger limbs present, bark present.
Condition 3 - Limb stubs may be present, bark only partly intact.
Condition 4 - Bark nearly gone; solid buckskin.
Condition 5 - Rotten.

Western Hemlock Zone snag data is summarized in Tables 5 and 6. In general, mid-seral (100-200 years old) stands of small or large sawtimber have the greatest numbers of snags. Usually these snags have DBH less than 20 inches, and often contain numerous feeding holes, but lack true cavities. The majority of them are suppression mortality, trees that were severely weakened by intertree competition.

In old growth or late seral (>200 years old) stands, many of these smaller suppression snags have fallen over and mostly larger (both greater DBH and taller) snags remain. In these older stands, a higher proportion of the snags were created by disease, lightening or insects rather than by suppression. If sufficiently decomposed, they are rich in food for wildlife, and tend to be used by cavity dwellers more than the smaller snags. Many are tall, and provide good hunting perches for raptors.

Many of the younger Western Hemlock Zone stands have numerous large snags, remnants of previous stands that were destroyed by fire. Often these snags are highly decomposed and tend to be short. They are readily used by cavity dwellers, but don't make good hunting perches because of their short stature.

Current Mt. Hood National Forest policy requires retention of at least two snags greater than 20 inches DBH and 50 feet tall per acre. Tables 5 and 6 suggest that unmanaged stands, especially large sawtimber, have provided greater numbers than may occur under management; in the case of large sawtimber, about 61% more.

Table 5. Average Weight and Number of Snags[1] and Fallen Trees by Seral Stage, Western Hemlock Zone, Mt. Hood National Forest

	Total		Early Seral (30-100 yrs)		Mid-Seral (100-200 yrs)		Late Seral (> 200 yrs)	
	tons/ac	#/ac	tons/ac	#/ac	tons/ac	#/ac	tons/ac	#/ac
				SNAGS				
Condition 1[2]		6.94		7.15		8.78		5.47
2		16.39		19.02		15.20		13.86
3		15.70		5.36		33.33		17.10
4		6.84		6.28		5.93		8.13
5		12.16		17.97		10.02		6.26
Height 10-30'		26.28		26.85		43.00		14.59
30-50'		12.85		11.83		11.46		15.06
>50'		18.57		17.07		17.39		21.24
≥ 20" DBH & > 50' tall[3]		4.06		2.56		4.19		5.44
TOTAL SNAGS		57.43		55.82		70.61		50.79
				FALLEN TREES				
Condition 1[2]	2.20	13	1.60	11	2.33	10	2.96	17
2	14.15	151	10.52	122	11.98	164	20.00	178
3	16.08	166	22.85	196	10.48	162	11.41	132
Size 1[4]	2.04	198	2.17	211	2.00	198	1.90	182
6	3.95	73	3.49	69	4.43	94	4.21	67
12	7.86	40	6.40	28	7.00	34	10.19	60
20	18.62	18	22.92	21	11.35	11	18.06	18
TOTAL FALLEN TREES	32.47	330	34.99	329	24.78	337	34.37	328
No. of Plots	204		87		46		71	

1. Standing dead trees ≥10" DBH and ≥10' tall.
2. See text for description of condition classes for snags and fallen trees.
3. Size of snags targeted in snag management policies.
4. See text for description of size classes for fallen trees.

Table 6. Average Weight and Number of Snags[1] and Fallen Trees by Stand Structure Class, Western Hemlock Zone, Mt. Hood National Forest

	Stand Structure Class									
	Total		Poles 5-10.9" DBH		Small Sawtimber 11-20.9" DBH		Large Sawtimber ≥21" DBH		Old Growth	
	tons/ac	#/ac	tons/ac	#/ac	tons/ac	#/ac	tons/ac	#/ac	tons/ac	#/ac
SNAGS										
Condition[2] 1		6.94		-		6.15		8.72		3.81
2		16.39		-		18.49		17.48		5.69
3		15.70		1.00		7.85		25.23		8.72
4		6.84		-		7.54		6.43		8.44
5		12.16		20.29		15.57		9.05		8.25
Height 10-30'		26.28		18.29		24.39		30.20		17.06
30-50'		12.85		3.00		14.44		12.71		9.38
> 50'		18.57		-		16.76		23.33		8.63
≥ 20" DBH & > 50' tall[3]		4.06		-		2.01		6.35		4.81
TOTAL SNAGS		57.43		21.14		55.63		65.62		34.94
FALLEN TREES										
Condition 1[2]	2.20	13	-	-	1.95	13	2.35	13	4.25	22
2	14.15	151	5.43	50	10.31	144	14.73	175	35.94	98
3	16.08	166	11.14	100	20.41	190	12.52	159	16.06	108
Size 1[4]	2.04	198	0.86	68	2.34	230	1.86	192	1.75	120
6	3.95	73	1.86	39	3.70	67	4.58	88	2.43	40
12	7.86	40	5.57	25	7.07	32	9.27	50	5.44	40
20	18.62	18	8.28	18	19.56	18	13.89	16	46.62	28
TOTAL FALLEN TREES	32.47	330	16.57	150	32.68	347	29.60	347	56.25	229
No. of Plots	204		7		87		93		16	

1. Standing dead trees ≥10" DBH and ≥10' tall.
2. See text for description of condition classes for snags and fallen trees.
3. Size of snags targeted in snag management policies.
4. See text for description of size classes for fallen trees.

Fallen Trees

Fallen trees have a number of important functions in forest ecosystems, some of which are only partially understood. They provide habitat for a wide array of animals, some of which are instrumental in the inoculation of tree roots with mycorrhizal fungi (Maser and Trappe 1984). By accumulating or conserving certain nutrients (notably carbon, nitrogen and phosphorous) they play an important role in ecosystem nutrient retention and cycling (Graham 1982). By remaining on the forest floor through more than one stand rotation, they insure inheritance of these nutrients from one generation of the forest to the next. They are the site of considerable bacterial nitrogen-fixation (Graham 1982). They retain moisture, and thus are important in the continuation of biological activity during the dry summer months (Maser and Trappe 1984)). And when decomposed they provide rooting habitat for conifers, particularly western hemlock.

Larger fallen trees (greater than 12 inches in diameter) are particularly desirable ecosystem elements. Since they take longer to decompose, they retain their functional relationships longer. Different parts of the wood decay at different rates, so large pieces eventually become quite variable internally, providing many different types of habitat (Maser and Trappe 1984).

Tables 5, 6 and 7 summarize fallen tree data from our Western Hemlock Zone plots. Pieces of down wood were tallied according to size and condition classes. Diameter and length were also recorded. The size classes used in this study are:

Fallen Tree Size Classes

- Size 1 - Piece does not contain a segment which is at least 6" in diameter for a length of at least 5'.
- Size 6 - Piece contains a segment which is 6" in diameter or larger for a length of at least 5'.
- Size 12 - Piece contains a segment which is 12" in diameter or larger for a length of at least 5'.
- Size 20 - Piece contains a segment which is 20" in diameter or larger for a length of at least 5'.

Condition classes indicate relative states of decomposition, and are modified from Maser et al. 1979, as follows:

Fallen Tree Condition Classes

Condition 1 - Intact bark and wood. Fine branches present. (Maser et al. condition class 1)
Condition 2 - Bark loose, fine branches absent, wood intact or partly soft, slightly sagging. (Maser et al. condition class 2)
Condition 3 - Bark usually absent, no fine branches, wood soft to powdery, may be somewhat oval in cross-section, all of piece is on ground. (Maser et al. condition classes 3 and 4)

We did not tally highly decomposed pieces (Maser et al condition class 5) in this study; this should be kept in mind in comparing our data with that from other studies.

Table 7 shows that there are far more large pieces of down wood in condition classes 2 and 3 than in class 1. Part of the reason is that fallen trees pass relatively quickly out of class 1 due to decomposition. There also may have been some salvage of sound down material on our plots. About half of the weight of class 2 material is in large pieces (size class 20). A higher percentage of the class 3 material is in larger pieces, illustrating the fact that the larger the fallen tree, the longer it persists.

Table 7. Percent of Fallen Trees by Condition and Size Classes[1], Western Hemlock Zone, Mt. Hood National Forest

% of Total Weight (tons/ac)

		Size				
		1	6	12	20	Total
Condition	1	<1	1	2	4	7
	2	4	7	11	22	44
	3	2	4	12	31	49
Total		6	12	25	57	

% of Total No. Pieces/Ac.

		Size				
		1	6	12	20	Total
Condition	1	2	1	<1	<1	3
	2	29	11	4	1	45
	3	28	11	7	6	52
Total		59	23	11	7	

1. See text for description of condition and size classes of fallen trees.

Neither weight nor number of fallen trees seems to be significantly related to seral stage as we measured it (Table 5). However, a relationship with stand structure does appear to exist. Not surprisingly, old growth has the greatest amount of down woody material by weight, but the fewest number of pieces (Table 6), indicating the pieces are mostly large. This characteristic fosters greater nutrient retention in old growth forests compared to other structural types (Franklin et al. 1981). Sawtimber (large and small) stands have a lower amount by weight (about average for the Western Hemlock Zone) but many more pieces per acre. Pole stands have only half the average weight and less than half the average number of pieces for the Western Hemlock Zone. It is in these stands that the old, large fallen trees that carry over from the previous generation probably are especially critical for inoculation of mycorrhizal tree roots and provision of nutrients.

The plant associations with the highest amounts of large fallen trees are those with a warm, moist environment and relatively high productivity: Western hemlock/Alaska huckleberry-Devil's club, Western hemlock/Alaska huckleberry-Salal, Western hemlock/Devil's club/Oxalis and Western hemlock/Swordfern-Oxalis. The climate in these sites foster the development of large boles that become good sources of down wood.

The smallest amounts of down woody material occurred on the drier sites supporting Western hemlock/Oceanspray, Western hemlock/Rhododendron-Salal and Western hemlock/Rhododendron/Beargrass plant associations. Productivity on these sites tends to be low compared to the rest of the Western Hemlock zone, and trees are generally both shorter and smaller in diameter than average.

Management of fallen trees in timber harvest areas is problematic, since research has not yet established "how much is enough". Current Mt. Hood National Forest policy allows for leaving two fallen trees (each 40 cubic feet or greater in volume) per acre in harvested areas. Bartels et al. (1985) recommend that as a minimum, two class 1 or 2 logs at least 12-17 inches in diameter and at least 20 feet long per acre be left, plus all the more decomposed pieces. Both of these recommendations are far below the amount of material that exists in unmanaged stands in the Western Hemlock Zone.

Too much down woody material creates a fire hazard in some sites, may block travel of large mammals, provides a home for rodents that eat tree seedlings and may make tree planting difficult (Bartels et al 1985). On the other hand, fallen trees clearly are a key link in the development of mycorrhizal conifer roots (Maser & Trappe 1984), and their widespread removal could impair forest productivity. Until further research establishes the amount and type of fallen trees needed to preserve the function of this important resource, we recommend a conservative approach be taken in its management.

TIMBER PRODUCTIVITY

The Western Hemlock Zone supplies most of the timber produced on the Mt. Hood National Forest, despite the fact that it occupies less than half the land area. High production rates relative to other vegetation zones are achieved in the Western Hemlock Zone primarily because of the favorable climate.

Within the Western Hemlock Zone, however, there is great variability in timber productivity. Several factors contribute to this diversity, and generally they are the same factors that cause differences in plant communities. Therefore, plant associations tend to correlate well with timber productivity, and provide a useful tool for making inferences about growth and yield.

Productivity in the Western Hemlock Zone is mainly a function of four environmental factors: temperature, precipitation, topographic position and effective rooting depth.

Temperature depends mainly on elevation and aspect, and influences the length of the growing season, the likilhood of frost or heat damage to seedlings, evapotranspiration and the rate of decomposition and nutrient cycling. The greatest productivity in the Western Hemlock Zone is found in the warmest sites (providing moisture is adequate) since the season of photosynthesis and active shoot elongation is extended.

The amount of precipitation influences how much moisture is available for plant growth. Generally moisture is adequate throughout the Western Hemlock Zone, but sites with more growing season precipitation (generally the Bull Run drainage and the extreme western edge of the Forest) tend to be most productive.

Topographic position affects the translocation of downward-moving soil nutrients, fine soil particles and water, and erosion rates. It determines whether these elements accumulate, leave, or remain constant in a given site. In the Western Hemlock Zone, zones of accumulation (lower slopes and valley bottoms) tend to produce the greatest volume of timber.

Effective rooting depth is a function of both soil depth and texture, and determines available rooting space, moisture and nutrient retention, and plant anchoring ability. Deep, fine-textured soils provide the most favorable conditions for tree growth, as long as drainage is adequate.

Plant associations with the highest productivity are generally those in warm, moist environments with deep soils, on flatter slopes. They usually can be distinguished by the abundance of herb species in the understory. The Western hemlock/Devil's club/Oxalis, Western hemlock/Swordfern-Oxalis and Western hemlock/Alaska huckleberry/Oxalis plant associations fall into this category.

The least productive plant associations are those with an extremely hot or cold dry climate, shallow or coarse-textured soils, and steeper slopes. The Western hemlock/Rhododendron-Salal, Western hemlock/Rhododendron/Beargrass, Western hemlock/Big huckleberry/Beargrass and Western hemlock/Oceanspray plant associations are examples.

Table 8 summarizes characteristics of existing stands by plant association. Current volume increment was calculated according to methods developed by Hemstrom (1982), and is the average of the mean annual volume increment over the past 10 years. It is derived from a series of species-specific tree growth equations (available from the Area 7 Ecology Program on request). The values are estimates of net production, mortality not included, of natural, mixed-species stands (Brockway et al. 1983).

Table 9 presents several estimates of potential growth for Western Hemlock Zone plant associations: Stand density index (SDI), growth basal area (GBA), SDI-based volume index, GBA-based volume index, mean annual increment at culmination (CMAI) and Douglas-fir site index.

Table 8. Current Stand Characteristics of Western Hemlock Zone Plant Associations, Mt. Hood National Forest

Plant Association	Total Live Basal Area ft^2/ac		Total Stand Volume bd. ft/ac		Total Stand Volume ft^3/ac		Quadratic Mean Dia. In.		Trees/Ac.		Current Volume Increment ft^3/ac/yr		No. Plots
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
TSHE/ACCI/ACTR	285	105			15679	4186	24	9	162	122	76	28	7
TSHE/ACTR	305	73			12219	4290	18	6	229	146	116	59	114
TSHE/BENE	312	68			11549	3716	15	4	301	168	110	51	38
TSHE/BENE-GASH	285	83			9239	2857	15	4	252	131	122	54	25
TSHE/BENE/POMU	289	72			10983	4022	17	6	245	194	103	40	25
TSHE/HODI	274	72			10333	3282	17	4	188	104	113	78	10
TSHE/LYAM	200	-			6091	-	16	-	146	-	114	-	1
TSHE/OPHO/OXOR	355	123			14125	1063	27	10	97	71	98	74	2
TSHE/OPHO/SMST	424	168			n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5
TSHE/POMU	303	106			11645	3093	15	4	297	168	114	67	12
TSHE/POMU-OXOR	303	61			12489	3878	20	8	185	117	158	93	48
TSHE/RHMA-BENE	367	114			12939	3477	14	4	254	95	71	45	24
TSHE/RHMA-GASH	291	99			9859	5644	15	7	301	196	73	40	23
TSHE/RHMA-VAAL/COCA	380	100			11851	3873	18	8	358	345	95	68	5
TSHE/RHMA/XETE	323	99			8764	2954	15	8	368	234	47	19	5
TSHE/VAAL/COCA	283	79			11569	5031	19	6	205	217	66	41	18
TSHE/VAAL-GASH	258	61			11672	4534	21	6	132	72	67	55	10
TSHE/VAAL-OPHO	295	99			9251	2445	14	1	242	81	150	37	2
TSHE/VAAL/OXOR	283	58			9928	3512	17	7	252	146	140	61	15
TSHE/VAME/XETE	348	161			n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7

Table 9. Potential Timber Productivity of Western Hemlock Zone Plant Associations, Mt. Hood National Forest

Plant Association	Stand Density Index trees/ac		Growth Basal Area ft²/ac		SDI-based Volume Index[1]		GBA-based Volume Index[1]		Mean Annual Increment at Culmination[1] ft³/ac		Douglas-fir Site Index (age 100) ft.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TSHE/ACCI/ACTR	465	134	347	80	153	54	233	66	144	30	134	21
TSHE/ACTR	439	92	357	146	162	50	285	253	152	30	140	23
TSHE/BENE	483	93	298	133	152	48	190	97	131	30	126	20
TSHE/BENE-GASH	409	80	363	87	137	44	242	84	138	31	131	22
TSHE/BENE/POMU	426	101	317	105	162	45	226	85	155	25	142	18
TSHE/HODI	398	120	214	140	107	61	130	103	114	32	117	18
TSHE/LYAM	306	-	408	294	82	-	246	-	n.d.	n.d.	120	-
TSHE/OPHO/OXOR	379	95	538	381	129	19	370	282	114	13	161	22
TSHE/OPHO/SMST	n.d.	n.d.	212	66	n.d.	n.d.	155	-	162	-	146	9
TSHE/POMU	491	95	436	120	180	41	309	104	152	20	135	19
TSHE/POMU-OXOR	417	76	335	158	176	40	263	139	176	26	155	20
TSHE/RHMA-BENE	503	92	357	92	142	48	216	78	122	27	115	19
TSHE/RHMA-GASH	436	106	282	115	110	49	153	82	101	30	102	22
TSHE/RHMA-VAAL/COCA	544	123	269	14	145	29	154	9	117	4	121	15
TSHE/RHMA/XETE	465	64	260	16	99	15	132	12	97	7	94	23
TSHE/VAAL/COCA	399	116	277	119	130	34	189	99	146	31	132	28
TSHE/VAAL-GASH	351	72	270	139	113	39	164	103	129	33	119	17
TSHE/VAAL-OPHO	403	72	594	182	171	64	446	66	174	35	156	13
TSHE/VAAL/OXOR	428	88	297	143	147	30	208	99	147	18	141	18
TSHE/VAME/XETE	n.d.	n.d.	174	83	n.d.	n.d.	76	-	79	-	88	18

1. Not necessarily an accurate quantification of volume growth. To be used for comparisons between plant associations only.

SDI (Reineke 1933) and GBA (Hall 1980) are measures of stockability. SDI estimates the number of trees per acre a given site could support at a quadratic mean diameter of 10 inches. GBA estimates the amount of basal area per acre that would support a radial growth rate of 10/20ths per decade at age 100. Three indices of stand volume growth are also presented. SDI-based volume index is derived by using the ratio of SDI of a sampled stand to that of a normally-stocked stand to calculate cubic-foot volume productivity of the sampled stand from normal yield functions (Knapp 1981). GBA-based volume index is calculated using site index and GBA, and estimates cubic-foot volume growth for normally stocked, even-age stands at age 100. CMAI is based on a series of equations that compute CMAI from site index[1]. Douglas-fir site index is from McArdle (1961) and is indexed to age 100.

The purpose of presenting these indices is to allow comparison of productivity between plant associations. Because of the great amount of variability within our data, the nature of our sample and the limitations inherent in the calculation methods, the numbers should be used for comparative purposes only, and not as an inventory of timber being produced in the Western Hemlock Zone.

1. CMAI equations were supplied by John Teply, USDA Forest Service, Pacific Northwest Region, Division of Timber Management.

CHAPTER 4 KEYS TO FOREST ZONES AND PLANT ASSOCIATIONS

HOW TO USE THE KEYS

The keys below are for use in relatively undisturbed, mature forest stands. A fairly homogeneous area should be used to determine plant associations, and care should be taken to avoid locating the area too close to a road, stand edge or other artificial phenomenon that would influence the species present. A good plot configuration for this purpose would be a roughly circular area between 40 and 50 feet in radius.

After selecting the plot area, a list of all species present (including trees, shrubs and herbaceous plants) should be made, and their percent cover recorded. Percent cover is determined by projecting the total crown perimeter for a species to a plane surface, then estimating the percent of the plot area it constitutes. The diagrams in Appendix A are provided to assist in assessing percent cover.

After the plot area has been thoroughly examined, the results may be run through the keys that follow. In some stands, the canopy may be so dense that the understory may be severely limited. In such cases, relative dominance rather than actual percentages may be used to determine plant association.

```
*************************************************
*                                               *
*   NOTE:  THE KEY IS NOT THE CLASSIFICATION!!! *
*                                               *
*   Before accepting the results of keying out  *
*   an association, be sure the vegetation de-  *
*   scription found on pp 20 to 57 fits.  If in *
*   doubt, consult the species tables found in  *
*   Appendix B.                                 *
*                                               *
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KEY TO FOREST ZONES

1a. Mtn. hemlock ≥2% cover in understory or ≥10% cover in canopy . . . . Mountain Hemlock Zone

1b. Mt. hemlock <2% in understory and <10% in canopy . . 2

2a. Pacific silver fir ≥2% in understory or ≥10% in canopy . . . . Pacific Silver Fir Zone

2b. Pacific silver fir <2% in understory and <10% in canopy 3

3a. Grand fir ≥2% cover in understory or ≥10% in canopy, east of Cascade Crest (in Col. Gorge, east of Gorton Creek) . . . . Grand Fir Zone

3b. Grand fir <2% in understory and <10% in canopy, west of Cascade Crest 4

4a. Ponderosa pine present 5

5a. Douglas-fir present . . . . Grand Fir Zone

5b. Douglas-fir absent . . . . . Ponderosa Pine Zone

4b. Ponderosa pine absent, western hemlock present . . . . Western Hemlock Zone

FOREST ZONE DESCRIPTIONS

See Fig. 3, Chapter 3, for a diagram of forested zones on the Mt. Hood National Forest.

Mountain Hemlock Zone

The Mountain Hemlock Zone is the uppermost forested vegetation zone on the Mt. Hood National Forest. It occurs at high elevations on both sides of the Cascade Crest. Environmentally it is characterised by cold temperatures, deep snowpack and generally coarse-textured soils. The Zone is defined by the presence of at least 2% cover of mountain hemlock regenerating in the understory, or 10% in the overstory. A large number of conifers are also often associated: Douglas-fir, noble fir, Pacific silver fir, western hemlock, western white pine, western larch and lodgepole pine are common.

Productivity tends to be low compared to the forest as a whole, although there are some fairly productive stands within the Zone. Growing-season frost is common. Plant association classification for the Mountain Hemlock Zone is partially complete, with the two most extensive types described in Hemstrom et al. 1982. Classification for the balance of the Zone is in progress, and a complete guide will be published in 1987 or 1988.

Pacific Silver Fir Zone

The Pacific Silver Fir Zone generally occurs below the Mountain Hemlock Zone, in somewhat warmer environments. It too occurs on both sides of the Cascade Crest. Temperatures tend to be cool and summer frost in the upper elevations is common. The Zone is distinguished by the presence of at least 2% cover of regenerating Pacific silver fir, or 10% cover in the canopy. As in the Mountain Hemlock Zone, many conifer species are associated: Douglas fir, western hemlock, mountain hemlock, western white pine, western redcedar and noble fir are prevalent.

Productivity within the Pacific silver fir zone is variable, and tends to decrease with elevation. Growing-season frost is common at upper elevations, especially in flat terrain. Plant associations for the Pacific Silver Fir Zone are published in Hemstrom et al. 1982.

Grand Fir Zone

The Grand fir Zone occurs at moderate elevations east of the Cascade Crest. It is characterized by the presence of 2% or more cover of grand fir in the understory, or 10% in the canopy. Douglas-fir and Ponderosa pine are commonly associated. The environment of the Grand Fir Zone is warm and dry. Plant association classification for this Zone is in progress, with a guide to be published in 1987 or 1988.

Ponderosa Pine Zone

This is the warmest and dryest zone on the Mt. Hood National Forest, occurring at low elevations east of the Cascade Crest. Summer drought and frequent natural underburning are important factors in the environment of this Zone. Generally stands are nearly pure Ponderosa pine, although at the lowest elevations Oregon white oak is commonly associated. A guide to Ponderosa Pine plant associations will be published in 1987 or 1988.

Western Hemlock Zone

The Western Hemlock Zone occurs extensively at low to moderate elevations west of the Cascade Crest, and very sporadically at moderate elevations east of the Crest. It occupies a wide range of environments, but can be characterized as occurring in warm, moist sites relative to the rest of the Mt. Hood National Forest. Douglas-fir and western redcedar are commonly associated with western hemlock in this zone (in fact Douglas-fir is usually the stand dominant). Noble fir and grand fir are also found. Generally, Pacific silver and mountain hemlock are not present. Although variability exists, the Western Hemlock Zone is the most productive vegetation zone on the Mt. Hood National Forest.

KEY TO WESTERN HEMLOCK PLANT ASSOCIATIONS

See Table 10 for species names coded below.

1a. Devil's club >3% or Devil's club the major shrub . . 2
1b. Devil's club cover ≤3%, or a minor shrub 4

2a. Oregon oxalis present 3
2b. Oregon oxalis absend, understory dominated by moist herbs . . . . TSHE/OPHO/SMST

3a. Alaska huckleberry cover ≥3% . . . . . TSHE/VAAL-OPHO
3b. Alaska huckleberry cover <3% . . . . . TSHE/OPHO/OXOR

4a. Oregon oxalis ≥5% cover, or a major herb 5
4b. Oregon oxalis ≤5% cover, or a minor herb 6

5a. Alaska huckleberry >3% cover . . . . . . TSHE/VAAL/OXOR
5b. Alaska huckleberry ≤3% cover . . . . . . TSHE/POMU-OXOR

6a. Beargrass >5% cover or the major herb 7
6b. Beargrass <5% cover or minor 8

7a. Rhododendron >5% cover or a major shrub TSHE/RHMA/XETE
7b. Rhododendron <5% cover or minor, big huckleberry present . . . . TSHE/VAME/XETE

8a. Rhododendron ≥10% cover or a major shrub 9
8b. Rhododendron minor or absent 11

9a. Alaska huckleberry >3% or a codominant, >3 moist herbs present . . . . TSHE/RHMA-VAAL/COCA
9b. Alaska huckleberry minor or absent 10

10a. Salal >5% cover or codominant . . . . . TSHE/RHMA-GASH
10b. Salal minor or absent . . . . TSHE/RHMA-BENE

11a. Alaska huckleberry >5% cover or a major shrub . . . 12
11b. Alaska huckleberry minor or absent 13

12a. Salal a major shrub . . . . TSHE/VAAL-GASH
12b. Salal minor or absent, moist herbs present . . . . TSHE/VAAL/COCA

13a. Salal ≥10% cover . . . . TSHE/BENE-GASH
13b. Salal minor or absent 14

14a. Shrub layer consists mostly of Dwarf oregongrape, herb layer mainly twinflower or sparse . . . TSHE/BENE
14b. Not as above 15

15a. Herbaceous layer mainly wet-site herbs (skunk-cabbage, lady fern, great betony, piggyback plant, deer fern) . . . . .TSHE/LYAM
15b. Not as above 16

16a. Herbaceous layer mainly swordfern; dry site shrubs (Rocky moountain maple, service berry, oceanspray) absent or minor 17
16b. Swordfern minor, and/or dry-site shrubs present . . 18

17a. Dwarf oregongrape ≥10% cover . . . . . .TSHE/BENE/POMU
17b. Dwarf oregongrape <10% cover . . . . TSHE/POMU

18a. Herb layer mainly moist-site herbs (starry solomonseal, coolwort foamflower, dogwood bunchberry, queencup beadlily) or vanillaleaf, dry-site shrubs and herbs minor or absent . . . . TSHE/ACTR
18b. Moist-site herbs minor or absent, and/or dry-site shrubs present. Vanillaleaf may be present 19

19a. Vanilla-leaf dominant, dry-site herbs (bearded fescue, white hawkweed, bigleaf sandwort, alumroot, star flower, leafy peavine, dogbane, rough-leaved aster) present . . . . .TSHE/ACCI/ACTR
19b. Vanillaleaf minor or absent, dry-site shrubs present . . . . TSHE-PSME/HODI

If the plot does not key out, or if the description does not seem to fit, go back to the beginning of the key and use relative percent cover.

Table 10. List of species codes, scientific and common names and indicator value for key Western Hemlock Zone species. See Topik 1982 and Halverson et al. 1986 for descriptions and illustrations of these plants.

Species Code	Scientific Name	Common Name	Indicator Value
TREES			
ABAM	Abies amabilis	Pacific silver fir	cool
ABGR	Abies grandis	Grand fir	
ABPR	Abies procera	Noble fir	cool
ACMA	Acer macrophyllum	Bigleaf maple	warm
ALRU	Alnus rubra	Red alder	warm
PIMO	Pinus monticola	Western white pine	cool
POTR2	Populus trichocarpa	Black cottonwood	wet
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	cold
SHRUBS			
ACCI	Acer circinatum	Vine maple	
ACGLD	Acer glabrum var. douglassii	Rocky mountain maple	warm
AMAL	Amelanchier alnifolia	Serviceberry	warm/dry
BEAQ	Berberis aquifolium	Tall oregongrape	warm/dry
BENE	Berberis nervosa	Dwarf oregongrape	
CACH	Castanopsis chrysophylla	Golden chinkapin	
CHUM	Chimaphila umbellata	Prince's pine	
COCO2	Corylus cornuta var. californica	California hazel	warm/dry
CONU	Cornus nuttallii	Pacific dogwood	
GASH	Gaultheria shallon	Salal	
HODI	Holodiscus discolor	Oceanspray	warm/dry
OPHO	Oplopanax horridum	Devil's club	wet
RHDI	Rhus diversiloba	Poison oak	warm/dry
RHMA	Rhododendron macrophyllum	Rhododendron	N-poor ?
RISA	Ribes sanguineum	Red-flowered currant	warm
RIVI	Ribes viscocissimum	Sticky currant	
RUNI	Rubus nivalis	Snow dewberry	
RUPA	Rubus parvifolius	Thimbleberry	
RUPE	Rubus pedatus	5-leaved bramble	cool
RUSP	Rubus spectabilis	Salmonberry	moist
SYAL	Symphoricarpos albus	Snowberry	
SYMO	Symphoricarpos mollis	Creeping snowberry	
VAAL	Vaccinium alaskaense	Alaska huckleberry	cool/moist
VAME	Vaccinium membranaceum	Big huckleberrv	cool
VAPA	Vaccinium parvifolium	Red huckleberry	

Table 10. - Cont'd.

Species Code	Scientific Name	Common Name	Indicator Value
HERBS			
ACTR	Achlys triphylla	Vanilla leaf	
ADBI	Adenocaulon bicolor	Pathfinder	
ANDE	Anemone deltoidea	Three-leaved anemone	
APAN	Apocynum androsaemifolium	Dogbane	warm/dry
ARLA	Arnica latifolia	Mountain arnica	
ARMA3	Arenaria macrophylla	Bigleaf sandwort	dry
ASCA3	Asarum caudatum	Wild ginger	moist
ASRA	Aster radulinus	Rough-leaved aster	
ATFI	Athyrium filix-femina	Ladyfern	moist
BLSP	Blechnum spicant	Deerfern	moist
CAPE	Carex pennsylvanica	Long-stolon sedge	cool/dry
CAREX	Carex spp.	Sedges (various species)	wet
CLUN	Clintonia uniflora	Queencup beadlily	cool
COCA	Cornus canadensis	Dogwood bunchberry	cool/moist
DIFO	Dicentra formosa	Bleeding heart	moist
DIHO	Disporum hookeri	Fairy bells	
DRAU2	Dryopteris austriaca	Mountain woodfern	moist
FESU	Festuca subulata	Bearded fescue	warm/dry
GAOR	Galium oreganum	Oregon bedstraw	
GATR	Galium triflorum	Sweetscented bedstraw	
GOOB	Goodyera oblongifolia	Rattlesnake plantain	
HEMI	Heuchera micrantha	Small-flowered alumroot	warm
HIAL	Hieracium albiflorum	White hawkweed	warm/dry
JUNCUS	Juncus spp.	Rushes (various species)	wet
LAPO	Lathyrus polyphyllus	Leafy peavine	warm/dry
LIBO2	Linnaea borealis	Twinflower	
LYAM	Lysichitum americanum	Skunk-cabbage	wet
MADI2	Mianthemum dilatatum	False lily-of-the-valley	
MOSI	Montia sibirica	Siberian montia	
OSCH	Osmorhiza chilensis	Mountain sweet-cicely	
OSPU	Osmorhiza purpurea	Purple sweet-cicely	
OXOR	Oxalis oregana	Oregon oxalis	moist
POMU	Polystichum munitum	Swordfern	
PTAQ	Pteridium aquilinum	Bracken fern	
PYSE	Pyrola secunda	Sidebells pyrola	
SMRA	Smilacina racemosa	False solomonseal	
SMST	Smilacina stellata	Starry solomonseal	moist
STCO4	Stachys cooleyi	Betony	wet
SYRE	Synthyris reniformis	Snow queen	
TITR	Tiarella trifoliata	Coolwort foamflower	moist
TOME	Tolmeia menziesii	Piggy-back plant	warm/moist
TRLA2	Trientalis latifolia	Star-flower	
VAHE	Vancouveria hexandra	Inside-out flower	moist
VISE	Viola sempervirens	Redwoods violet	
XETE	Xerophyllum tenax	Beargrass	cool/dry

CHAPTER 5 PLANT ASSOCIATION DESCRIPTIONS

SEE APPENDIX B FOR COMPLETE LISTS OF SPECIES AND % COVER VALUES FOR WESTERN HEMLOCK PLANT ASSOCIATIONS

WESTERN HEMLOCK/VINE MAPLE/VANILLALEAF
Tsuga heterophylla/Acer circinatum/Achlys triphylla

Structure and Composition

The TSHE/ACCI/ACTR association is characterized by the presence of both mesic and dry-site species. The shrub layer is often dense, and consists mainly of vine maple and dwarf Oregongrape. California hazel is also often present. The herbaceous layer is usually dominated by vanillaleaf and swordfern, with traces (usually no more than 2% cover) of dry-site species such as bigleaf sandwort, bearded fescue, white hawkweed, starflower and/or pathfinder. Even though these dry-site plants may seem to be an insignificant part of the vegetation of these sites, their presence is indicative of drier conditions compared to other areas in the Western Hemlock Zone. It should be noted that vanillaleaf has a "bimodal" distribution in the Western Hemlock Zone. In other words, it is a dominant in both moist and dry sites, but less so in mesic sites. It cannot therefore be used by itself as an indicator of environmental conditions; the species with which it occurs must be taken into consideration also.

The overstory in the TSHE/ACCI/ACTR association is primarily Douglas-fir, often associated with bigleaf maple and western hemlock. In general, the canopy is fairly open.

Environment and Distribution

The TSHE/ACCI/ACTR association is found primarily on steep rocky sites along the lower slopes of the Columbia, Clackamas and Collawash drainages. It occurs at fairly low elevations, indicating a long growing season compared to the rest of the Western Hemlock Zone. Soils in these sites are generally shallow, stony and dry. Aspects are mainly south- or west-facing, indicating high insolation. This association probably represents the hot-dry edge of the Western Hemlock Zone.

Productivity and Management

The TSHE/ACCI/ACTR association appears to be moderately productive for Douglas-fir. Current stand volume is high compared to the rest of the Wetern Hemlock Zone, but growth rates are avegate. Table 11 gives timber productivity data for this association.

These sites can be challenging to manage. Due to the large amount of rock in the soil, as well as its shallow depth, tree planting may be difficult. In clearcuts the soils may dry out quite early in the growing season, making early planting a necessity. Since these slopes tend to be very

Table 11. Timber Productivity Statistics - TSHE/ACCI/ACTR

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	134	21	9.5	4.9	238	112	144	30	33	24
Western hemlock	138	-	15.0	-	472	-	204	-	59	-
Western redcedar	119	-	11.0	-	462	-	n.d.	n.d.	11	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

hot and dry in summer, use of artificial shade for tree seedlings should be considered. It may also be desirable to consider shelterwood harvest rather than clearcutting where feasible. Since the forest floor in these sites tends to be thin, an effort should be made to minimize its destruction by heavy equipment use and fire.

In clearcuts, brush invasion may reduce seedling growth and/or survival if trees are not established the first or second season following harvest. Growth of vine maple, red-flowered currant and sticky currant into disturbed areas may be rapid and present significant competition to tree seedlings for soil moisture.

Similar Associations

The TSHE-PSME/HODI (Western hemlock-Douglas-fir/Oceanspray) association is somewhat similar floristically, but has more dry-site shrub species, and a much less significant herbaceous layer. It is less productive, and is found at higher elevations.

The TSHE/BENE (Western hemlock/Dwarf Oregongrape) association is less likely to have vanillaleaf, and lacks the dry-site herbs that characterize the TSHE/ACCI/ACTR association. It is more restricted to the south half of the Mt. Hood National Forest, and represents a cooler, moister environment.

In the TSHE/POMU (Western hemlock/Swordfern) and TSHE/BENE/POMU (Western hemlock/Dwarf Oregongrape/Swordfern) associations, swordfern is dominant and dry-site species are absent. These two associations are also more widely distributed than the TSHE/ACCI/ACTR association.

In the TSHE/ACTR (Western hemlock/Vanilla leaf) association, vanilla leaf is dominant, but occurs with moist-site species, such as starry-solomonseal and coolwort foamflower, rather than dry-site species. The TSHE/ACTR association occurs at higher elevations and in less rocky sites than TSHE/ACCI/ACTR.

TSHE/ACTR
CHF2-21

WESTERN HEMLOCK/VANILLALEAF
Tsuga heterophylla/Achlys triphylla

Structure and Composition

This is an herb-rich association that is dominated by vanillaleaf and a number of moist-site herbs. Tree cover is predominantly Douglas-fir with western hemlock having greater importance in old stands. Western redcedar is occasionally abundant. Both grand fir and Pacfic yew also were found on some of our plots. Swordfern is usually present but always in small amounts. A diverse assemblage of herbs constitute a substantial portion of the understory vegetation. These range from moderately-moist site affiliates (such as inside-out flower and starry solomonseal) to moderately-dry site indicating species: bigleaf sandwort, white hawkweed and grass species. Vanillaleaf is virtually always present; it is often accompanied by pathfinder, three-leaved anemone, starflower, trillium and twinflower. Shrub cover can be quite high, but if so, it is in conjunction with high cover of the herb species mentioned above. Vinemaple and dwarf Oregongrape are prevalent. Baldhip rose, creeping snowberry, red huckleberry and California hazel are also frequently present but with less cover. Salal occurs in small amounts. In general, sites in this association having greater than 10% cover of dwarf Oregongrape exhibit lower timber productivity and have floristics indicative of slightly drier environments than sites where dwarf Oregongrape is not abundant. The diagnostic feature of the TSHE/ACTR association is the plethora of mesic-site herb species and the lack of shrubs common to either very moist or very dry environments.

Environment and Distribution

This association indicates well-drained, fairly warm upland forest sites. Generally it represents moderate environmental conditions. Water-logged soils and cold temperatures should almost never interfere with logging or reforestation operations. This association is located mostly on slopes, most frequently with grades greater than 30%. Soils are generally fairly deep and not very rocky.

Productivity and Management

Stands of this association attain highly productive levels without substantial management problems. Stocking and productivity indices are usually quite high, though variation occurs (Table 12).

Intensive forestry practices yield high benefits and the potential for site degradation following careful management activities is relatively low. Major potential management concerns result from occasional steep slopes and relatively dry conditions. Some sites within this association share, to a lesser degree, the drought conditions of dry-site Western Hemlock Zone associations. Managers need to be alert to such dry conditions on very steep or south-facing slopes, where shade cards and harvest unit design maximizing shade are appropriate. Shrub competition may also cause reforestation problems.

Table 12. Timber Productivity Statistics - TSHE/ACTR

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	140	23	11.0	8.0	306	143	152	30	64	52
Western hemlock	120	19	12.0	5.0	416	156	169	38	35	20
Western redcedar	116	27	13.0	4.0	505	221	143	53	35	37
Noble fir	160	-	29.0	-	891	-	206	-	30	-
Grand fir	122	34	13.0	10.0	431	208	127	48	45	42

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981; Noble fir, Herman et al. 1978; Grand fir, Cochran 1979.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

This can result from rapid reinvasion by established brush following logging or from invasion, particularly by snowbrush ceanothus, after slash burning.

Similar Associations

The relative absence of the more severe-site indicating species is what helps distinguish this association. Dwarf Oregongrape may be abundant, but if so, it is in combination with several herb species and so is distinguished from the TSHE/BENE association. There is always less salal than in the TSHE/BENE-GASH association.

TSHE/BENE
CHS1-25

WESTERN HEMLOCK/DWARF OREGONGRAPE

Tsuga heterophylla/Berberis nervosa

Structure and Composition

The TSHE/BENE association is a very herb-poor type. The shrub layer consists of a moderate cover of dwarf Oregongrape and vine maple, sometimes with traces of other species (including red huckleberry, salal and Prince's pine). The herbaceous layer may have a fair amount of twinflower, but only traces of other herbs, such as rattlesnake plantain, redwoods violet and vanillaleaf. The overstory is a mix of Douglas-fir and western hemlock, often with western redcedar in addition.

Environment and Distribution

The TSHE/BENE association appears to represent sites that are somewhat drier than average with a moderate temperature regime. We found it mainly at middle elevations in the Western Hemlock Zone on areas with south to west aspects and often rocky or gravelly soils. It occurs mainly on midslopes above tributaries and the main stem of the Clackamas River, and is rare on the north half of the Mt. Hood National Forest. TSHE/BENE is also found on the Gifford Pinchot National Forest (Topik et al. 1986).

Productivity and Management

Productivity is moderate in the TSHE/BENE association. Table 13 gives productivity statistics from our data set.

Because it generally occurs on soils with high rock content, plantability may be restricted in some sites with the TSHE/BENE association.

Table 13. Timber Productivity Statistics - TSHE/BENE

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	125	21	10.0	6.0	380	116	131	30	44	46
Western hemlock	118	18	12.0	3.0	258	156	166	36	44	24
Western redcedar	124	15	9.0	3.0	455	43	154	25	36	10

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

A major challenge to reforestation efforts in this type is presented on slopes with droughty soils, particularly on south-facing aspects. In such sites, consideration of artificial shade in clearcuts is recommended. The forest floor tends to be thin in the TSHE/BENE association, and efforts to avoud its destruction will help maintain site productivity.

Another potential outcome of clearcutting in this association is competition from shrub species. If the ground is extensively disturbed through burning or scarification, snowbrush may invade.

Similar Associations

In the TSHE/BENE-GASH (Western hemlock/Dwarf Oregongrape-Salal) association, salal and swordfern are present. It generally occurs in less rocky sites than the TSHE/BENE association, and is more common in the Sandy River drainage and on the lower reaches of the Clackamas River.

A TSHE/BENE plant association has been described by Hemstrom and Logan (1986) for the Oregon Coast Range. It differs from ours in having a well-developed herb layer of swordfern, and is more productive.

The TSHE/RHMA-BENE (Western hemlock/Rhododendron-Dwarf Oregongrape) association occurs at higher elevations, and is distinguished by the presence of rhododendron. It is less productive than TSHE/BENE.

The TSHE-PSME/HODI (Western hemlock-Douglas-fir/Oceanspray) association is somewhat similar floristically but can be separated from TSHE/BENE by the presence of dry-site species such as oceanspray, serviceberry, tall Oregongrape, bigleaf sandwort and/or white hawkweed.

The TSHE/ACTR (Western hemlock/Vanilla leaf) association is richer in moist-site herbs, such as starry solomonseal, vanillaleaf and coolwort foamflower. It is also more productive and occurs in sites with finer-textured soils.

Both the TSHE/POMU (Western hemlock/Swordfern) and TSHE/BENE/POMU (Western hemlock/Dwarf Oregongrape/Swordfern) associations are distinguished by the presence of swordfern and occur at lower elevations.

The TSHE/ACCI/ACTR (Western hemlock/vine maple/Vanilla leaf) association is more restricted to basalt cliffs, and has dry-site herbaceous species (bigleaf sandwort, bearded fescue, white hawkweed and pathfinder) in the understory.

TSHE/BENE-GASH
CHS1-24

WESTERN HEMLOCK/DWARF OREGONGRAPE-SALAL

Tsuga heterophylla/Berberis nervosa-Gaultheria shallon

Structure and Composition

This is a shrubby plant association, dominated by dwarf Oregongrape and salal. Vine maple and swordfern are also common. The canopy is often quite open, and usually consists of a mix of Douglas-fir and western hemlock, often with western redcedar. Where the canopy is open, a dense shrub cover can develop.

Environment and Distribution

TSHE/BENE-GASH is thought to represent moderately warm/dry environmental conditions within the Western Hemlock Zone. It is generally found in the lower half of the Zone on middle and upper slope positions with south to west aspects. Soils where this association occurs appear to be relatively deep and fine-textured. Its presence may, in some cases, be related to ground disturbance.

Productivity and Management

The TSHE/BENE-GASH association generally occurs in moderately productive sites (see Table 14).

Table 14. Timber Productivity Statistics - TSHE/BENE-GASH

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	131	22	13.0	5.3	266	126	138	31	49	26
Western hemlock	133	23	16.0	5.9	440	96	195	45	69	34
Western redcedar	90	-	7.0	-	205	-	n.d.	n.d.	14	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Where this association occurs on south-facing slopes, hot, dry conditions during the summer can be anticipated. Use of artificial shade for planted seedlings in clearcuts should be considered in such areas. Douglas-fir is a good choice for reforesting harvested areas in the TSHE/BENE-GASH association.

The forest floor tends to be thin in TSHE/BENE-GASH sites, and efforts should be made to prevent it's destruction by heavy equipment and fire.

A potential outcome of clearcutting in this association is competition from shrub species. If the ground is significantly disturbed through slash treatment (burning or scarification), snowbrush may invade and cause severe competition unless tree seedlings are established quickly.

Similar Associations

A TSHE/BENE-GASH association that differs floristically from that on the Mt. Hood National Forest occurs elsewhere west of the Cascades (for example, see Topik et al. 1986). The major difference is the widespread occurrence of swordfern in the Mt. Hood version. Productivity and management implications are similar.

Both the TSHE/RHMA-BENE (Western hemlock/Rhododendron-Dwarf Oregongrape) and the TSHE/RHMA-GASH (Western hemlock/Rhododendron-Salal) associations are distinguished by the presence of rhododendron, and generally lack swordfern and western redcedar. Both associations are less productive than TSHE/BENE-GASH, and occur in rockier sites at higher elevations.

In the TSHE/VAAL-GASH (Western hemlock/Alaska huckleberry-Salal) association, Alaska huckleberry is present. It is generally less productive than the TSHE/BENE-GASH association, occurs at higher elevations and is more restricted to the north half of the Mt. Hood National Forest.

The TSHE/BENE (Western hemlock/Dwarf Oregongrape) association is generally found in rockier sites, and is distinguished by its lack of salal and swordfern. It is also more restricted to the south half of the Mt. Hood National Forest.

TSHE/BENE/POMU
CHS1-26

WESTERN HEMLOCK/DWARF OREGONGRAPE/SWORDFERN
Tsuga heterophylla/Berberis nervosa/Polystichum munitum

Structure and Composition

This association has an herb layer dominated by swordfern and a fairly dense shrub layer of vine maple and dwarf Oregongrape. Some drier site shrubs (salal, baldhip rose and creeping snowberry) are common. The canopy is dominated by Douglas-fir, with substantial amounts of western hemlock, bigleaf maple and western redcedar. The herb layer frequently includes pathfinder, starflower, trillium, and vanillaleaf.

Environment and Distribution

This association is found on moderately moist and warm sites which are very well drained. Lower elevations (< 2000 feet) with middle or lower slope positions predominate. Three-fourths of our plots in this association occurred on slopes greater than 30% grade. This association is widespread, but is especially abundant in the central portions (in an east-west direction) of the Western Hemlock Zone on the Gifford Pinchot and Mt. Hood National Forests.

Productivity and Management

This association is quite productive for timber. Table 15 summarizes productivity statistics for the TSHE/BENE/POMU association. Stocking and volume growth indices are moderate for the Western Hemlock Zone as a whole.

Table 15. Timber Productivity Statistics - TSHE/BENE/POMU

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	142	18	12.0	5.0	401	120	155	25	49	44
Western hemlock	128	15	12.0	5.0	380	152	184	29	40	15
Western redcedar	98	17	10.0	5.0	381	75	105	38	36	32

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

In general, this association includes sites which should respond favorably to careful timber management practices. Potential problems may result from the steep and somewhat unstable slopes which frequently occur. Full-suspension logging systems and extra-careful road placement are warrented. Excessive soil moisture will limit logging operations only during brief periods of the year. Reforestation practices aimed at reducing the evaporative demand of seedlings, such as early spring planting and shade cards, may be required where this association occurs on steep, south-facing slopes. Bigleaf maple is common, so this association provides good opportunities for its management and conservation.

Similar Associations

The TSHE/BENE/POMU association is very similar to the TSHE/POMU association (Mt. Hood version). They are distinguished mainly by the presence of Dwarf Oregongrape and occasional moist-site herbs in the TSHE/BENE/POMU association.

The TSHE/ACCI/POMU type on the Siuslaw N.F. is somewhat similar but lacks dwarf Oregongrape and occurs on moister sites (Hemstrom and Logan 1986).

TSHE-PSME/HODI
CHC2-12

WESTERN HEMLOCK-DOUGLAS FIR/OCEANSPRAY

Tsuga heterophylla-Pseudotsuga menziesii/Holodiscus discolor

Structure and Composition

This association is considered transitional to the Douglas-fir Zone where Douglas-fir is the dominant climax tree species. (Forest zones are defined Chapter 3.) Both western hemlock and Douglas-fir occur in the regeneration layer and can be expected to co-exist in a long term stable condition.

This is a very shrubby association characterized by the presence of dry-site species. These include an abundance of oceanspray, snowberry, baldhip rose and California hazel and lesser amounts of serviceberry and tall Oregongrape. The other abundant shrubs are dwarf Oregongrape and vine maple. Herbs present are typical of forested Western Cascades dry sites, including various grasses, bigleaf sandwort, starflower, pathfinder and white hawkweed. Swordfern is common but only in small amounts. Less abundant, but more diagnostic of dry sites, are leafy peavine and vetch.

Environment and Distribution

Some of the hottest and driest sites in the forested Western Cascades support this association. On the Mt. Hood National Forest it is found mainly on basalt cliffs above the Clackamas, Salmon and Collawash Rivers and tributaries of the Columbia River. It is also found on the Gifford Pinchot National Forest. Sites are always upper slopes and fairly steep, where drainage and solar input are excessive. Bare ground and surface rock and gravel are also typical of these dry sites. Soils are shallow and stony, with thin forest floor layers being the rule.

Productivity and Management

Timber productivity of this association is low to moderate (Table 16).

TSHE-PSME/HODI offers considerable management problems and can not be dealt with in the same manner as most areas in the western Cascades. Timber planners need to be especially mindful of the

Table 16. Timber Productivity Statistics - TSHE-PSME/HODI

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	113	22	12.0	9.9	372	158	114	3.2	65	60

1. McArdle et al. 1961. Indexed to age 100.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

silvicultural problems which may result from large openings lacking shade. The shelterwood system should be considered whenever possible. If clearcuts are used, shade should be maximized, by both natural and artificial means if necessary. Broadcast burning may lead to considerable snowbrush ceanothus competition with young conifers. Growth of vine maple, red-flowered currant and sticky currant into disturbed areas may be rapid and present significant competition to tree seedlings for soil moisture. Grasses may also invade disturbed sites in this association so it is wise to avoid any grass seeding projects if conifer establishment is a goal for the site. Douglas-fir is the preferred species for reforestation and every effort should be made to match seed source to site. Plantability will be poor in some cases, so high stocking levels should not be demanded or expected. Soils may dry out quite early in the growing season, making early planting a necessity.

The same hot and dry environmental conditions which make this association challenging to timber management lead to long, snow-free periods. The abundance of suitable shrub species for browse also indicates the high winter range value of this association.

Similar Associations

The TSHE/ACCI/ACTR (Western hemlock/Vine maple/Vanillaleaf association has vanillaleaf as an understory dominant, and generally lacks the significant cover of dry-site shrubs. It is slightly more productive, and may occupy a slightly more moist environment. Both the TSHE/BENE/POMU (Western hemlock/Dwarf Oregongrape/Swordfern) and TSHE/POMU (Western hemlock/Swordfern) associations lack the dominance by dry-site species, and have more swordfern.

TSHE/LYAM
CHM1-21

WESTERN HEMLOCK/SKUNKCABBAGE
Tsuga heterophylla/Lysichitum americanum

Structure and Composition

This association is found in very wet sites, and is rich in moisture-loving herbaceous species. The dominants are lady-fern, skunk cabbage, betony, a variety of sedges and rushes, wild ginger and piggy-back plant. The major shrub is vine maple. The canopy is generally a mix of Douglas-fir, red alder, western hemlock and western redcedar. Species composition in all layers (overstory, shrubs and herbs) varies considerably from site to site, as this group is somewhat of a "catch-all" for swampy Western Hemlock Zone sites. A notable feature of this association is the open, broken canopy, caused by a combination of disease-related top damage, windthrow and treeless patches of standing water.

Often the TSHE/LYAM association is either transitional to non-forest wetland, or represents small "pockets" of swampy conditions within a larger, more mesic area.

Environment and Distribution

The TSHE/LYAM association occurs in the wettest parts of the Western Hemlock Zone throughout the Mt. Hood National Forest. It also occurs on the Gifford Pinchot National Forest (Topik et al. 1986). Our plots tended to be at moderate elevations in riparian areas, such as alluvial bottoms or other wet, poorly-drained sites. Often there is standing water, and soils tend to have a very high organic matter content.

Productivity and Management

The TSHE/LYAM association represents moderate to low productivity. Stocking, standing volume and volume growth are generally lower than average (Table 17).

Table 17. Timber Productivity Statistics - TSHE/LYAM

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	120	-	23.5	21.9	408	294	124	-	n.d.	n.d.
Western redcedar	102	-	27.0	-	812	-	113	-	75.0	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Because these sites are excessively moist, decreased productivity due to soil erosion and/or compaction can result from ground disturbance. In addition, poorly aerated soils with high organic material content may be difficult to reforest following logging. Such soils are not only physically hard to work in, but may have chemical conditions unfavorable to the growth of Douglas-fir. In addition, shallow rooting may contribute to a greater potential for windthrow in certain sites. Use of western redcedar, red alder or black cottonwood may be considered for reforestation where "swampy" conditions prevail.

Similar Associations

The TSHE/LYAM association is easily distinguished from other riparian types by the absence of devil's club. It is not likely to be confused with any other associations.

TSHE/OPHO/OXOR CHS5-22

WESTERN HEMLOCK/DEVIL'S CLUB/OXALIS

Tsuga heterophylla/Oplopanax horridum/Oxalis oregana

Structure and Composition

The vegetation of this rich and productive association is characterized by a carpet of Oregon oxalis and swordfern under a layer of devil's club. Traces of other moist-site herbs, such as starry solomonseal, lady fern, and fairy-bells are fairly common, and vine maple and red huckleberry may also be present in the shrub layer. As in the TSHE/LYAM association, the canopy is often quite open, and may contain a relatively large number of defective tops. Dominant overstory species are Douglas-fir, western hemlock and western redcedar.

Environment and Distribution

The TSHE/OPHO/OXOR association occupies warm, wet sites in the lower and middle portions of the Western Hemlock Zone (ranging from about 1300 to 2600 feet in elevation). Our plots occured mainly in riparian areas, often on colluvial toe slopes where water seeps and accumulates. This association probably indicates a year-round saturated soil condition.

Productivity and Management

The TSHE/OPHO/OXOR association represents, on the average, the most productive sites in the Western Hemlock Zone. Even though stocking is somewhat low, per acre volume productivity remains high (Table 18) due to the very large size of trees. This reflects the abundant moisture, deep, fine-textured soil and high level of soil organic matter characteristic of sites where the association is found.

Because these sites may be excessively moist, decreased productivity due to soil erosion and/or compaction may result from ground disturbance. In addition, poorly aerated soils with high organic material content may be difficult to reforest following logging. Such soils are not only physically hard to work in, but may have chemical conditions unfavorable to the growth of Douglas-fir. Also, shallow rooting may contribute to increased likelihood of windthrow in certain sites. Use of western redcedar, red alder or black cottonwood may be considered for reforestation where "swampy" conditions are found.

Table 18. Timber Productivity Statistics - TSHE/OPHO/OXOR

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	161	22	12.0	11.0	335	212	144	13	25	18
Western hemlock	133	21	21.0	14.0	288	108	193	40	30	4

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Similar Associations

The TSHE/VAAL-OPHO (Western hemlock/Alaska huckleberry-Devil's club) association is floristically similar, but always has Alaska huckleberry. It usually lacks lady-fern and swordfern, but has deerfern. It occurs at higher elevations than the TSHE/OPHO/OXOR association and is less productive.

The TSHE/POMU-OXOR (Western hemlock/Swordfern-Oregon oxalis) association lacks devil's club, and occurs on better-drained sites.

TSHE/OPHO/SMST
CHS5-23

WESTERN HEMLOCK/DEVIL'S CLUB/STARRY SOLOMONSEAL
Tsuga heterophylla/Oplopanax horridum/Smilacina stellata

Structure and Composition

At first glance, a stand with this association appears floristically similar to TSHE/OPHO/OXOR (Western hemlock/Devil's club/Oregon oxalis), but further observation will show the lush understory to consist of a number of moist-site herbs (starry solomonseal, dogwood bunchberry, vanillaleaf, inside-out flower, queencup beadlily, and coolwort foamflower). Oregon oxalis is completely absent. Devil's club is the dominant shrub, with lesser amounts of vine maple and red huckleberry. The overstory is a mix of western hemlock and Douglas-fir, and as other wet-site associations is afflicted with a relatively large amount of breakage and mortality due to disease and windthrow.

Environment and Distribution

The TSHE/OPHO/SMST association is found east of the Cascade crest, along major creeks at the upper end of the Western Hemlock Zone. It is likely that this association extends lower in elevation, but since the lower reaches of these drainages have been logged, they were not sampled in this project.

TSHE/OPHO/SMST is found in sites where soils are saturated virtually year-round.

Productivity and Management

The TSHE/OPHO/SMST association is found in the most productive Western Hemlock Zone sites east of the Cascade crest. Stocking is somewhat lower than average, but per acre volume growth and site index are high (Table 19). As in the TSHE/OPHO/OXOR association, this appears to be a function of an accumulation of water and nutrients, as well as deeper soil on toe slope positions.

Because these sites may be excessively moist, decreased productivity due to soil erosion and/or compaction may result from ground disturbance. In addition, poorly aerated soils with high organic material content may be difficult to reforest following logging. Such soils are not only physically hard to work in, but may have chemical conditions unfavorable to the growth of Douglas-fir. Also, shallow rooting may contribute to an increased potential for windthrow. Use of western redcedar, red alder or black cottonwood should be considered for reforestation in sites where "swampy" conditions prevail.

Table 19. Timber Productivity Statistics - TSHE/OPHO/SMST

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	146	9	6.8	4.1	212	66	162	-	n.d.	n.d.
Noble fir	120	-	6.0	-	126	-	142	-	n.d.	n.d.

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Noble fir, Herman et al. 1978.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Similar Associations

The TSHE/OPHO/SMST association could possibly be confused with only two other associations, both of which are found west of the Cascade crest. They are TSHE/VAAL-OPHO (Western hemlock/Alaska huckleberry-Devil's club) and TSHE/OPHO/OXOR (Western hemlock/Devil's club/Oregon oxalis). Both have Oregon oxalis, which does not occur in the TSHE/OPHO/SMST association.

TSHE/POMU
CHF1-23

WESTERN HEMLOCK/SWORDFERN

Tsuga heterophylla/Polystichum munitum

Structure and Composition

The shrub layer in the TSHE/POMU association is predominantly vine maple, often with traces of dwarf Oregongrape and salal. The herb layer consists mainly of swordfern, with a moderate amount of bracken fern on some sites. Traces of dry-site herbs, such as white hawkweed, starflower and bigleaf sandwort, are common. The overstory is a mix of western hemlock and Douglas-fir, often in association with western redcedar and/or bigleaf maple.

Environment and Distribution

On the Mt. Hood National Forest, the TSHE/POMU association occurs on steep, rocky slopes with a variety of aspects. Soils tend to have a high rock content, and the forest floor in generally thick. It was found in the low to middle elevation range of the Western Hemlock Zone, and is most common in the lower portions of the Clackamas and Sandy River drainages and along the tributaries of the Columbia River. Our interpretation is that this association represents a warm, somewhat dry environment. Traces of moist-site species that occur here are thought to be a result of seeping water that occurs locally.

Productivity and Management

Sites with the TSHE/POMU plant association tend to be moderately productive (Table 20).

Table 20. Timber Productivity Statistics - TSHE/POMU

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	135	19	14.0	6.6	267	153	152	20	60	39
Western hemlock	136	11	20.0	5.7	466	76	200	22	74	42

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

The physical environment in which this association occurs presents at least two challenges with respect to reforesting clearcut sites. First, slopes tend to be very steep, rocky and somewhat unstable. These factors make tree planting difficult. In addition, where this association occurs on south-facing slopes, high evaporative demand may reduce seedling growth and survival. At lower elevations, soils in bare areas will tend to dry out early in the season, and tree planting should occur as soon after snowmelt as possible. Consideration of artificial shade for tree seedlings on south slopes is recommended.

Similar Associations

A TSHE/POMU association that differs from that on the Mt. Hood National Forest occurs elsewhere west of the Cascade crest (for example, see Topik et al., 1986). The Mt. Hood version is less productive, and more likely to have traces of dry-site species present.

The TSHE/BENE (Western hemlock/Dwarf Oregongrape) association lacks swordfern, and occurs at higher elevations.

The TSHE-PSME/HODI (Western hemlock-Douglas-fir/Oceanspray) association in general has less swordfern and more dry-site species, especially shrubs such as oceanspray, serviceberry and tall Oregongrape. It is also less productive.

In the TSHE/ACTR (Western hemlock/Vanilla leaf) association, moist-site herbs, such as starry solomonseal, coolwort foamflower and vanilla leaf are dominant, and swordfern is of minor importance. It generally occurs in sites with gentler slopes and finer-textured soil.

The TSHE/BENE/POMU (Western hemlock/Dwarf Oregongrape/Swordfern) association is closely related and floristically similar. However, cover of dwarf Oregongrape is greater, and moist-site herbs are more common. TSHE/BENE/POMU appears to occur in slightly moister conditions.

TSHE/POMU-OXOR
CHF1-24

WESTERN HEMLOCK/SWORDFERN-OXALIS

Tsuga heterophylla/Polystichum munitum-Oxalis oregana

Structure and Composition

The TSHE/POMU-OXOR association is probably the most visually appealing association of the Western Hemlock Zone. Many stands with this association are old growth, with huge, widely-spaced Douglas-firs, western hemlocks and western redcedars towering over a lush carpet of Oregon oxalis interspersed with swordfern. The shrub layer is usually sparse, consisting of an occasional vine maple, dwarf Oregongrape or red huckleberry. In the herb layer, other moist-site species may occur in addition to Oregon oxalis: mountain woodfern, deerfern, ladyfern, starry solomonseal, coolwort foamflower, inside-out flower and fairybells.

Environment and Distribution

The TSHE/POMU-OXOR association is found at low to mid-elevations in the Western Hemlock zone on sites with abundant moisture and productive soils. Many of our plots with this association were in alluvial areas or moist toe slopes where fine soil particles and nutrients collect. Effective rooting depth and forest floor thickness both tend to greater than average. In general, this association occurs on flatter slopes, although exceptions are found.

This association occurs mainly in the lower reaches of the Bull Run, Sandy and Clackamas River drainages and on the western edge of the Gifford Pinchot National Forest (Topik et al. 1986).

Productivity and Management

The TSHE/POMU-OXOR association generally indicates productive, easy-to-manage sites. After the TSHE/OPHO/OXOR (Western hemlock/Devil's club/Oregon oxalis) association, this is the most productive of the lower-elevation Western Hemlock Zone associations. Productivity statistics for this association are found in Table 21.

The presence of this association generally indicates conditions favorable for most management activities. Moisture is usually abundant, and soils tend to be deep, adequately drained, and fertile. An abundance of deerfern in stands of this association may indicate local areas of high water table, where the risk of soil erosion and compaction is greater than usual.

Table 21. Timber Productivity Statistics - TSHE/POMU-OXOR

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	157	18	14.0	5.0	463	127	176	26	64	43
Western hemlock	145	18	18.0	6.0	527	199	218	35	90	48
Western redcedar	141	7	28.0	10.0	706	119	170	10	63	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Similar Associations

The TSHE/VAAL/OXOR (Western hemlock/Alaska huckleberry/Oregon oxalis) association has significantly more Alaska huckleberry than the TSHE/POMU-OXOR association, as well as more moist-site herbs besides Oregon oxalis. It is less productive , occurs at higher elevations and is more restricted to the Bull Run River drainage and portions of the Gifford Pinchot National Forest.

In the TSHE/OPHO/OXOR (Western hemlock/Devil's club/Oregon oxalis) association, devil's club is present. It occurs on poorly-drained sites and usually indicates greater productivity.

The TSHE/BENE/POMU (Western hemlock/Dwarf Oregongrape/Swordfern) and TSHE/POMU (Western hemlock/Swordfern) associations lack Oregon oxalis, are less productive than TSHE/POMU-OXOR and occur on steeper, rockier sites.

TSHE/RHMA-BENE
CHS3-28

WESTERN HEMLOCK/RHODODENDRON-DWARF OREGONGRAPE

Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa

Structure and Composition

The TSHE/RHMA-BENE association is a rather depauperate, herb-poor type dominated by evergreen species. The shrub layer consists of a moderately dense cover of rhododendron and dwarf Oregongrape. The herb layer is extremely sparse, consisting of a few scattered individuals of twinflower, redwoods violet and rattlesnake plantain. The overstory is a mix of Douglas-fir and western hemlock, with western redcedar on about half our plots.

Environment and Distribution

The TSHE/RHMA-BENE association is quite common and occurs on a variety of slope aspects and positions at mid-to upper elevations in the Clackamas River drainage portion of the Western Hemlock Zone. As with other associations with rhododendron as a dominant species, it probably indicates soils with low nitrogen content.

Productivity and Management

Productivity of the TSHE/RHMA-BENE association is low to moderate compared to the rest of the Western Hemlock Zone, although standing volume is quite high (Table 22).

Because of the inference that these sites are somewhat nutrient-poor, the forest floor should be protected from damage by heavy equipment or fire.

Table 22. Timber Productivity Statistics - TSHE/RHMA-BENE

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	115	19	7.3	3.2	103	53	122	27	40	39
Western hemlock	118	12	11.0	5.5	388	179	164	23	33	30
Western redcedar	71	-	9.0	-	259	-	n.d.	n.d.	16	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Where this association occurs on soils with high rock content, plantability may be restricted. In areas with a dense rhododendron shrub layer, the presence of residual roots following logging may further reduce plantability.

A major challenge to reforestation efforts in this type is presented on steep slopes with droughty soils, particularly on south-facing aspects. In such sites, consideration of artificial shade is recommended for clearcuts.

Another potential outcome of clearcutting in this association is competition from shrub species. Sites that have a dense shrub cover prior to logging may develop a heavy rhododendron component unless some kind of control is undertaken. If the ground is excessively disturbed through slash treatment (burning or scarification), snowbrush may invade and cause severe competition unless tree seedlings are established quickly.

Similar Associations

A TSHE/RHMA-BENE association has been described for the Oregon Coast Range by Hemstrom and Logan (1986). It differs from our TSHE/RHMA-BENE in the presence of swordfern, and is more productive.

The TSHE/RHMA-VAAL/COCA (Western hemlock/Rhododendron-Alaska huckleberry/Dogwood bunchberry) association has Alaska huckleberry in combination with rhododendron, and is distinguished by the presence of moist-site herbs such as dogwood bunchberry, starry solomonseal, coolwort foamflower and inside-out flower. It occurs on moister sites with finer-textured, deeper soils.

The TSHE/RHMA/XETE (Western hemlock/Rhododendron/Beargrass) association has beargrass as a codominant with rhododendron and generally has lower cover of dwarf Oregongrape. It is much less productive and occurs at higher elevations.

The TSHE/RHMA-GASH (Western hemlock/Rhododendron-Salal) association may be floristically similar, but generally can be distinguished by the greater abundance of salal. It is significantly less productive, and occurs more often on the north half of the Mt. Hood National Forest than does the TSHE/RHMA-BENE association.

The TSHE/BENE (Western hemlock/Dwarf Oregongrape) association lacks rhododendron, and is more productive.

In the TSHE/BENE-GASH (Western hemlock/Dwarf Oregongrape-Salal) association, swordfern is present. It is a more productive association than TSHE/RHMA-BENE, and occurs at lower elevations in less rocky sites.

TSHE/RHMA-GASH
CHS3-27

WESTERN HEMLOCK/RHODODENDRON-SALAL

Tsuga heterophylla/Rhododendron macrophyllum-Gaultheria shallon

Structure and Composition

This is an herb-poor association dominated almost totally by evergreen shrub species. The vegetation is characterized by a relatively dense shrub layer of rhododendron and salal, with a small amount of twinflower. The overstory is a mix of Douglas-fir and western hemlock.

At upper elevations, this association becomes transitional with the ABAM-TSHE/RHMA-GASH (Pacific silver fir-Western hemlock/Rhododendron-Salal) association described by Hemstrom et al. (1982). Where cover of Pacific silver fir exceeds 2% in the understory or 10% in the canopy, the stand is considered to be part of the Pacific Silver Fir Zone, and the Plant Association and Management Guide for that zone should be consulted for management implications.

Environment and Distribution

Sites with the TSHE/RHMA-GASH association are scattered throughout the mid-elevation portion of the Western hemlock zone, often on rocky slopes with shallow or coarse textured soils. As with other associations where the understory vegetation is dominated by rhododendron, its presence may be related to low soil nitrogen content.

Productivity and Management

Although the stands tend to be well-stocked, productivity of the TSHE/RHMA-GASH association is low to moderate compared to the rest of the Western Hemlock Zone (Table 23).

Because of the inference that these sites are somewhat nutrient-poor, the forest floor should be protected from damage by heavy equipment or fire.

Because of the high rock content of the soil in many sites where this association occurs, plantability may be restricted. In many areas, however, the rock is primarily at the surface and there is finer-textured soil below 8 to 10 inches. In areas with a dense rhododendron shrub layer, the presence of residual roots following logging may further reduce plantability.

A major challenge to reforestation efforts in this type is offered by steep slopes with droughty soils, particularly on south-facing aspects. In such sites, consideration of artificial shade is recommended for clearcuts.

Another potential outcome of clearcutting in this association is competition from shrub species. Sites that have a dense shrub cover prior to logging may develop a heavy rhododendron component unless some kind of control is undertaken. If the ground is severely disturbed through slash treatment (burning or scarification), snowbrush may invade and cause severe competition unless tree seedlings are established quickly.

Table 23. Timber Productivity Statistics - TSHE/RHMA-GASH

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	102	21	8.8	3.0	189	101	42	28	101	30
Western hemlock	112	27	9.4	6.3	299	114	153	53	26	24
Western redcedar	84	11	13.0	4.9	308	20	n.d.	n.d.	15	9

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Similar Associations

A TSHE/RHMA-GASH association has been described for the Oregon Coast Range by Hemstrom and Logan (1986). It differs from our TSHE/RHMA-GASH in the presence of evergreen huckleberry and swordfern, and is more productive.

In the TSHE/RHMA/XETE (Western hemlock/Rhododendron/Beargrass) association, beargrass is a dominant species and salal is absent. It generally occurs at higher elevations, in cooler environments than the TSHE/RHMA-GASH association.

The TSHE/RHMA-VAAL/COCA (Western hemlock/Rhododendron-Alaska huckleberry/Dogwood bunchberry) association has an herb layer of moist-site species (dogwood bunchberry, starry-solomonseal, inside-out flower and coolwort foamflower) and is more productive. It is found in sites with finer-textured soils and more abundant moisture.

In the TSHE/RHMA-BENE (Western hemlock/Rhododendron-Dwarf Oregongrape) association, dwarf Oregongrape rather than salal is codominant with rhododendron. It is also a somewhat more productive association.

The TSHE/VAAL-GASH (Western hemlock/Alaska huckleberry-Salal) association occurs on moister sites and is more productive than TSHE/RHMA-GASH. It has Alaska huckleberry rather than rhododendron as a dominant with salal in the shrub layer.

Rhododendron is absent in the TSHE/BENE-GASH (Western hemlock/Dwarf Oregongrape-Salal) association, and swordfern is present. It is a more productive association and occurs at lower elevations, on sites with less rock.

TSHE/RHMA-VAAL/COCA

CHS3-26

WESTERN HEMLOCK/RHODODENDRON-ALASKA HUCKLEBERRY/DOGWOOD BUNCHBERRY

Tsuga heterophylla/Rhododendron macrophyllum-Vaccinium alaskaense/Cornus canadensis

Structure and Composition

Although the herbaceous layer in the TSHE/RHMA-VAAL/COCA association is rather sparse, this is the most herb-rich of any of the rhododendron-dominated associations. The shrub layer is composed of rhododendron and Alaska huckleberry, commonly with a small amount of dwarf Oregongrape. In the herb layer, dogwood bunchberry and twinflower are the most common species, with traces of other moist-site species (starry solomonseal, inside-out flower and coolwort foamflower). Many plots also have a small amount of beargrass. The overstory is a mix of Douglas-fir, western hemlock and western redcedar.

Environment and Distribution

The TSHE/RHMA-VAAL/COCA association occupies sites within the Western hemlock zone that are cool, well-watered and possibly deficient in nitrogen. Our plots often fell on toe slopes, valley bottoms or other areas with abundant moisture at upper elevations. As compared with other associations where rhododendron is dominant, the TSHE/RHMA-VAAL/COCA association occurs on deeper, finer-textured soils on gentler slopes. The forest floor in our sample tended to be thinner than average for the Western Hemlock Zone.

We found this association scattered across the Western hemlock zone on the Mt. Hood National Forest, but it is not common.

Productivity and Management

The TSHE/RHMA-VAAL/COCA association appears to indicate sites with moderate productivity. This is the most productive of the associations that have rhododendron as a dominant (Table 24).

Because of the inference that these sites are somewhat nutrient-poor, the forest floor should be protected from damage by heavy equipment or fire.

Table 24. Timber Productivity Statistics - TSHE/RHMA-VAAL/COCA

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	121	15	7.0	3.0	229	69	117	4	36	23
Western hemlock	119	1	16.0	8.0	517	208	116	1	64	19
Western redcedar	101	-	25.0	-	857	-	n.d.	n.d.	69	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

This is a relatively easy-to-manage plant association. The main threat to reforestation efforts is probably a possible increase in rhododendron cover following removal of the canopy. This would most likely to be of concern where the cover was already high prior to logging. Where this association is found in flat sites, a potential for frost during the growing season may exist, and frost-tolerant species such as Noble fir or Western white pine should be considered along with Douglas-fir in the mix of species to be planted.

Similar Associations

The TSHE/VAAL/COCA (Western hemlock/Alaska huckleberry/Dogwood bunchberry) association lacks rhododendron, and has greater cover of moist-site herbs (dogwood bunchberry, starry solomonseal, coolwort foamflower and/or inside-out flower) than the TSHE/RHMA-VAAL/COCA association.

The TSHE/RHMA/XETE (Western hemlock/Rhododendron/Beargrass) association has beargrass as a codominant with rhododendron, rather than Alaska huckleberry and moist-site herbs. It is less productive and tends to be found on steeper, rockier sites.

In the TSHE/RHMA-GASH (Western hemlock/Rhododendron-Salal) association, salal is present and moist-site herbs are not as abundant. It is also less productive and occurs on rockier sites.

The TSHE/RHMA-BENE (Western hemlock/Rhododendron-Dwarf Oregongrape) association is virtually devoid of herbaceous species except for twinflower, and also lacks Alaska huckleberry. As with the other rhododendron-dominated associations, it is found on rockier, drier sites than the TSHE/RHMA-VAAL COCA association.

TSHE/RHMA/XETE
CHS3-25

WESTERN HEMLOCK/RHODODENDRON/BEARGRASS

Tsuga heterophylla/Rhododendron macrophyllum/Xerophyllum tenax

Structure and Composition

The TSHE/RHMA/XETE association has a relatively dense shrub cover dominated by rhododendron, often with a scattering of dwarf Oregongrape. Many of our plots in this association also had some Alaska huckleberry. The major herbaceous species is beargrass, commonly occuring with a minor amount of twinflower. The overstory is a mix of Douglas-fir and western hemlock. As with the TSHE/VAME/XETE (Western hemlock/Big huckleberry/Beargrass) association, TSHE/RHMA/XETE is frequently transitional between the Western Hemlock and Pacific Silver Fir Zones. The presence of more than 2% cover of Pacific silver fir in the understory or more than 10% in the canopy indicates a Pacific Silver Fir Zone stand, and the Plant Association and Management Guide for that zone (Hemstrom et al, 1982) should be consulted.

Environment and Distribution

This association is quite common in the upper elevations of the Western Hemlock zone, especially near the crest of the Cascade mountains. It generally occurs on steep, rocky slopes with low effective rooting depth, and may represent soils that are deficient in nitrogen. We interpret the sites where the TSHE/RHMA/XETE association is found as cool, dry and unproductive.

Productivity and Management

Standing volume and productivity in the TSHE/RHMA/XETE association are low (Table 25).

As a rule, the dominance of beargrass in an association indicates potential reforestation problems following clearcutting. The TSHE/RHMA/XETE association is no exception. On south slopes, both drought and high temperatures may make shade protection desirable. In flatter areas, frost during the growing season is possible,

Table 25. Timber Productivity Statistics - TSHE/RHMA/XETE

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	94	23	8.3	4.7	165	51	143	118	14	6
Western hemlock	83	-	7.0	-	278	-	97	-	44	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

so frost-tolerant species such as Noble fir or western white pine should be included in the mix of planted species. In areas that appear frost-prone, it may be desirable to consider shelterwood harvest rather than clearcutting where feasible.

Because of the inference that these sites are somewhat nutrient-poor, the forest floor should be protected from damage by heavy equipment use and fire.

If the ground is extensively disturbed following logging, either by fire or logging equipment, invasion of bare areas by beargrass and long-stolon sedge is possible. Where there is a dense cover of rhododendron in the understory prior to logging, removal of the canopy may stimulate its growth unless attempts are made to reduce it. Both of these conditions result in competition by tree seedlings, shrubs and ground cover species for moisture, nutrients and growing space. Finally, the high rock content of soils in many locations where this association occurs presents physical barriers to tree planting.

Similar Associations

The TSHE/RHMA-GASH (Western hemlock/Rhododendron-Salal) association differs from TSHE/RHMA/XETE in the presence of salal and the absence of beargrass. It generally occurs at lower elevations.

The TSHE/RHMA-VAAL/COCA (Western hemlock/Rhododendron-Alaska huckleberry/Dogwood bunchberry) association is more herb-rich, with greater occurrence of moist-site species, such as dogwood bunchberry, inside-out flower, starry solomonseal and coolwort foamflower. It is also more productive and generally occurs on finer-textured soils.

The TSHE/RHMA-BENE (Western hemlock/Rhododendron-Dwarf Oregongrape) association is less likely to have beargrass, and has more dwarf Oregongrape and western redcedar. It is more productive and is found at lower elevations than TSHE/RHMA/XETE.

In the TSHE/VAME/XETE (Western hemlock/Big huckleberry/Beargrass) association, rhododendron is absent and big huckleberry is present. It occurs at slightly higher elevations, in general.

TSHE/VAAL/COCA
CHS6-15

WESTERN HEMLOCK/ALASKA HUCKLEBERRY/DOGWOOD BUNCHBERRY

Tsuga heterophylla/Vaccinium alaskaense/Cornus canadensis

Structure and Composition

This association has an abundance of huckleberry species, including Alaska, oval-leaf, red, and big huckleberry. Dogwood bunchberry and twinflower were present in nearly all of our plots. The canopy is dominated by Douglas-fir in younger stands and western hemlock in stands over 100 years old. Western redcedar is very common and Pacific silver fir may be found. In addition to the abundant huckleberry cover, the shrub layer is dominated by vine-maple and lesser amounts of dwarf Oregongrape and baldhip rose. Salal is common but occurs only in small amounts. Herb cover is fairly high, including dogwood bunchberry, twinflower, queencup beadlily, coolwort foamflower and vanillaleaf. Fern species other than swordfern are almost entirely absent. Moss cover is quite substantial.

Environment and Distribution

This association is in the cooler portion of the Western Hemlock Zone and may intergrade with the Pacific Silver Fir Zone. Moisture conditions are moderately high. It occurs on both the Gifford Pinchot and Mt. Hood National Forests, mainly above 2500 feet in elevation. This association has a limited distribution, but usually is found on flat benches or lower slopes. It also may be found on alluvial plains or colluvial toe slopes. Cold air accumulates on these sites and may account for the presence of this association at lower elevations within the Western Hemlock Zone. The forest floor usually has intermediate surface organic matter accumulations typical of cooler environments. The cool, moist environment may also be responsible for the preponderance of old-growth stand conditions found in this association, demonstrating a low occurrence of wildfire.

Productivity and Management

Relative to the rest of the Western Hemlock Zone, this association has intermediate potential productivity. Stocking and productivity indices were in the lower midrange for the Western Hemlock Zone (Table 26).

Table 26. Timber Productivity Statistics - TSHE/VAAL/COCA

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	135	22	8.0	9.0	349	113	146	31	18	18
Western hemlock	125	24	9.0	4.0	375	153	178	47	34	28
Noble fir	131	-	5.0	-	347	-	160	-	n.d.	n.d.

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Noble fir, Herman et al. 1978.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

The likelihood of cool temperatures should be taken into account when managing sites with this association. Frost could cause reforestation problems when clear cut unit design results in impeded cold air drainage. Silviculturists should consider using planting stock from the next highest elevation seed zone, particularly when this association is encountered at low elevations (< 2000 feet). Otherwise, these sites should be able to respond favorably to most normal management regimes.

Similar Associations

This association is somewhat similar to the other Alaska huckleberry dominated Western Hemlock Zone plant associations. The TSHE/RHMA-VAAL/COCA (Western hemlock/Rhododendron-Alaska huckleberry/Dogwood bunchberry) association has rhododendron as a dominant, and is less herb-rich than TSHE/VAAL/COCA. In TSHE/VAAL/OXOR (Western hemlock/Alaska huckleberry/Oxalis, the herb layer is dominated by Oxalis rather than dogwood bunchberry. It is more productive and occurs at lower elevations than TSHE/VAAL/COCA. The TSHE/VAAL-OPHO association (Western hemlock/Alaska huckleberry-Devil's club) has devil's club and oxalis, is far more productive and occupies wetter sites. Finally, the TSHE/VAAL-GASH (Western hemlock/Alaska huckleberry-Salal) association has more salal and is less herb-rich. It indicates sites of lower productivity, and generally occurs on steeper slopes.

TSHE/VAAL-GASH
CHS6-14

WESTERN HEMLOCK/ALASKA HUCKLEBERRY-SALAL
Tsuga heterophylla/Vaccinium alaskaense-Gaultheria shallon

Structure and Composition

This association has an abundance of huckleberry species, especially Alaska huckleberry and red huckleberry. Oval-leaf and big-leaf huckleberry also are common. The substantial cover of salal is diagnostic. Dwarf Oregongrape, vine maple, baldhip rose, and prince's pine are the other common shrubs. The canopy is dominated by Douglas-fir and western hemlock, but species typical of higher elevations also occur, including Pacific silver fir, noble fir and western white pine. The herb layer is usually sparse. The most common species are twinflower, dogwood bunchberry, beargrass, and bracken fern. Swordfern is in two thirds of the plots, but in only trace amounts. Moist site ferns (deerfern and lady fern) are nearly absent.

Environment and Distribution

This association includes sites with moderate moisture conditions which are fairly cool for the Western Hemlock Zone. It is most common on gentle slopes and ridges which have undulating or concave microtopography. Drainage of both cold air and water are adequate. The presence of some of the lowest elevation Pacfic silver fir suggests that this association can have colder climates than elevation alone would indicate. It is not a very common association, and mainly occurs on the western portion of the Wind River Ranger District of the Gifford Pinchot National Forest and within the Bull Run River drainage on the Mt. Hood National Forest.

Productivity and Management

Compared to most of the rest of the Western Hemlock Zone, this association has relatively low forest productivity (see Table 27). On the one plot where we encountered noble fir we found it to have excellent growth. This association is a good place to plant noble fir occasionally and western hemlock frequently, as well as Douglas-fir.

Opportunities for benefits from intensive forestry practices, such as tree improvement, pre-commercial and commercial thinning, are good. Management concerns include the possibility of frost and reduced growth due to cool temperatures, even at lower elevations. High stocking levels should not be demanded as these sites likely can not support them. More stems will result in less volume per bole at harvest than in other, more productive, Western Hemlock Zone associations. Pre-commercial thinning should not discriminate against western hemlock. This association may respond to slash burning with considerable shrub re-growth, so reforestation needs to proceed rapidly. The gentle slopes where this association is usually found are suitable for tractor logging, but considerable care needs to be exercised so as not to compact soils and further reduce the productive capacity of these sites.

Table 27. Timber Productivity Statistics - TSHE/VAAL-GASH

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] ($ft^3/ac/yr$)		Current Overstory Vol. Inc.[4] ($ft^3/ac/yr$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	126	23	8.0	5.0	396	116	129	33	36	46
Western hemlock	117	19	7.0	2.0	295	120	164	37	31	21
Noble fir	159	-	20.0	-	395	-	204	-	60	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Noble fir, Herman et al. 1978.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Similar Associations

This association is an herb-poor relative of the TSHE/VAAL/COCA type, the main difference being the substantial cover of salal in TSHE/VAAL-GASH. The abundance of Alaska huckleberry distinguishes it from the other associations having considerable salal: TSHE/BENE-GASH and TSHE/GASH.

TSHE/VAAL-OPHO
CHS6-11

WESTERN HEMLOCK/ALASKA HUCKLEBERRY-DEVIL'S CLUB

Tsuga heterophylla/Vaccinium alaskaense-Oplopanax horridum

Structure and Composition

The vegetation of the TSHE/VAAL-OPHO association is lush, with a rich component of moist-site herbs. The shrub layer is composed of Alaska huckleberry and devil's club. The herb layer is a carpet of Oregon oxalis, often with small amounts of deerfern, queencup beadlily, starry solomonseal and coolwort foamflower. The overstory generally is a mix of Douglas-fir, western hemlock and western redcedar.

Environment and Distribution

This association occupies the cooler sites at the wet end of the moisture gradient in the Western Hemlock Zone. Most of our plots occurred on concavities or toe slopes where water either collects or seeps to the surface, and northerly aspects were most common. Where this association occurs, soils are probably saturated year-round. Development of a very thick forest floor is common. Virtually all of our plots in TSHE/VAAL-OPHO were in the Bull Run River drainage.

Productivity and Management

The TSHE/VAAL-OPHO association is highly productive (Table 28). Even though stocking may be low, per acre volume productivity is high due to the large size of trees. As with the other associations dominated by devil's club, high productivity seems to reflect the typical site where the association occurs: very moist with abundant nutrients and deep soils.

Table 28. Timber Productivity Statistics - TSHE/VAAL-OPHO

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	156	13	25.0	2.1	278	217	174	35	68	18
Western hemlock	164	-	18.0	-	634	-	254	-	77	-

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Because these sites may be excessively moist, decreased productivity due to soil erosion and/or compaction may result from ground disturbance. In addition, poorly aerated soils with high organic material content may be difficult to reforest following logging. Such soils are not only physically hard to work in, but may have chemical conditions unfavorable to the growth of Douglas-fir. Also, shallow rooting may contribute to increased likelihood of windthrow. Use of western redcedar, red alder or black cottonwood should be considered for reforestation in swampy sites.

Similar Associations

The association most likely to be confused with TSHE/VAAL-OPHO is TSHE/VAAL/OXOR (Western hemlock/Alaska huckleberry/Oregon oxalis), which lacks devil's club and occurs on slightly drier, less productive sites. Other similar types are TSHE/OPHO/SMST (Western hemlock/Devil's club/Starry solomonseal), which occurs only east of the Cascade crest and lacks Oregon oxalis, and TSHE/VAAL/COCA (Western hemlock/Alaska huckleberry/Dogwood bunchberry), which lacks devil's club and Oregon oxalis, and occurs on drier, less productive sites.

TSHE/VAAL/OXOR
CHS6-13

WESTERN HEMLOCK/ALASKA HUCKLEBERRY/OXALIS
Tsuga heterophylla/Vaccinium alaskaense/Oxalis oregana

Structure and Composition

The vegetation of the TSHE/VAAL/OXOR association consists of a fairly dense shrub layer of Alaska huckleberry over a carpet of Oregon oxalis. Dwarf Oregongrape, vine maple, salal and red huckleberry also occur frequently. In the herb layer small amounts of deerfern, dogwood bunchberry, coolwort foamflower and swordfern are common. The overstory is a mix of western hemlock and Douglas-fir.

Environment and Distribution

This association is found in moist, cool sites with productive soils in the mid- to upper portions of the Western Hemlock Zone. Almost all of our plots with this association were located in the Bull Run River drainage. It also occurs on the Gifford Pinchot National Forest (Topik et al. 1986).

Productivity and Management

Productivity in this association is moderate to high, although standing volume is low compared to other Western Hemlock Zone associations (Table 29).

The presence of this association generally indicates conditions favorable for most management activities. Moisture is abundant, and soils tend to be deep, adequately drained, and fertile. An abundance of deerfern in stands with this association may indicate local areas of high water table, where the risk of soil erosion and compaction is greater than usual.

Table 29. Timber Productivity Statistics - TSHE/VAAL/OXOR

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	136	13	15.0	6.0	437	114	147	18	53	43
Western hemlock	121	17	14.0	5.0	444	104	170	32	67	53
Western redcedar	95	5	15.0	0.7	404	84	n.d.	n.d.	32	18
Noble fir	134	34	22.0	17.0	564	263	164	54	21	26

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962; Western redcedar, Hegyi et al. 1981; Noble fir, Herman et al. 1978.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

Similar Associations

The TSHE/POMU-OXOR (Western hemlock/Swordfern-Oregon oxalis) association is floristically similar to the TSHE/VAAL/OXOR association and to some extent their geographic distribution overlaps. But the TSHE/POMU-OXOR association lacks Alaska huckleberry and is less likely to have other moist-site herbs besides Oregon oxalis. It is also more productive and extends to lower elevations. The TSHE/VAAL/OXOR association probably indicates a cooler environment.

The TSHE/VAAL-OPHO (Western hemlock/Alaska huckleberry-devil's club) association is also similar, but has Devil's club, is more productive and occupies wetter sites. The TSHE/VAAL/COCA (Western hemlock/Alaska huckleberry/Dogwood bunchberry) association lacks Oregon oxalis, is less productive and occurs more widely south of the Bull Run River drainage.

TSHE/VAME/XETE
CHS6-12

WESTERN HEMLOCK/BIG HUCKLEBERRY/BEARGRASS

Tsuga heterophylla/Vaccinium membranaceum/Xerophyllum tenax

Structure and Composition

The TSHE/VAME/XETE association is similar in both appearance and management implications to the ABAM/VAME/XETE (Pacific silver fir/Big huckleberry/Beargrass) association that occurs at higher elevations. The shrub layer is dominated by big huckleberry (or occasionally, Alaska huckleberry), with dwarf Oregongrape, prince's pine and/or golden chinkapin often associated with it. The herbaceous layer consists of beargrass and little else. The overstory is usually dominated by Douglas-fir and western hemlock, with Noble fir occurring in addition in many sites. Often Pacific silver fir is found reproducing in stands with this association, indicating a transition between the Pacific Silver Fir and Western Hemlock Zones. Where percent cover of Pacific silver fir exceeds 2% in the understory or 10% in the canopy, the stand is considered to be part of the Pacific Silver Fir Zone, and the Plant Association and Management Guide (Hemstrom et al, 1982) for that zone should be consulted for management recommendations.

Environment and Distribution

This association occurs in the coldest, driest portions of the Western Hemlock Zone. It was found only at the upper elevations in the Zone (generally above 2800 feet), often in steep, rocky sites. It is mainly scattered along the low crest of the Cascades between Mt. Hood and Mt. Jefferson, and is not common.

Productivity and Management

The TSHE/VAME/XETE association represents the least productive sites within the Western Hemlock Zone (Table 30). Noble fir may be a more productive species than Douglas-fir in this plant association.

Table 30. Timber Productivity Statistics - TSHE/VAME/XETE

Species	Site Index[1] (feet)		Current 10-yr. Radial Increment (20ths)		Growth Basal Area[2] (ft^2/ac)		Mean Annual Inc. at Culmination[3] (ft^3/ac/yr)		Current Overstory Vol. Inc.[4] (ft^3/ac/yr)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Douglas-fir	88	18	6.8	2.0	175	83	79	-	n.d.	n.d.
Western hemlock	50	-	6.0	-	126	-	33	-	n.d.	n.d.

1. Indexed to age 100. References: Douglas-fir, McArdle et al. 1961; Western hemlock, Barnes 1962.
2. Hall 1980.
3. See discussion of Timber Productivity in Chapter 3 for references.
4. Methods after Hemstrom 1982.

The TSHE/VAME/XETE association presents several challanges for reforestation. On south slopes, both drought and high daytime temperatures during the summer may make shade protection desirable. In flatter areas, frost during the growing season is likely, so frost-tolerant species such as Noble fir or western white pine should be included in the mix of planted species. Such a severe environment in openings argues for consideration of shelterwood harvest rather than clearcutting where feasible.

If the ground is extensively disturbed following logging, either by fire or logging equipment, invasion of bare areas by beargrass and long-stolon sedge is likely. Not only does this condition result in competition between tree seedlings and ground cover species for moisture, nutrients and growing space, but it may also present habitat favorable for pocket gophers. Finally, the high rock content of soils in many locations where this association occurs presents physical barriers to tree planting.

Similar Associations

The only association that is likely to be confused with TSHE/VAME/XETE is the TSHE/RHMA/XETE (Western hemlock/Rhododendron/Beargrass) association. It is distinguished by the presence of rhododendron and the absence of big huckleberry. It is a little more productive and extends lower in elevation.

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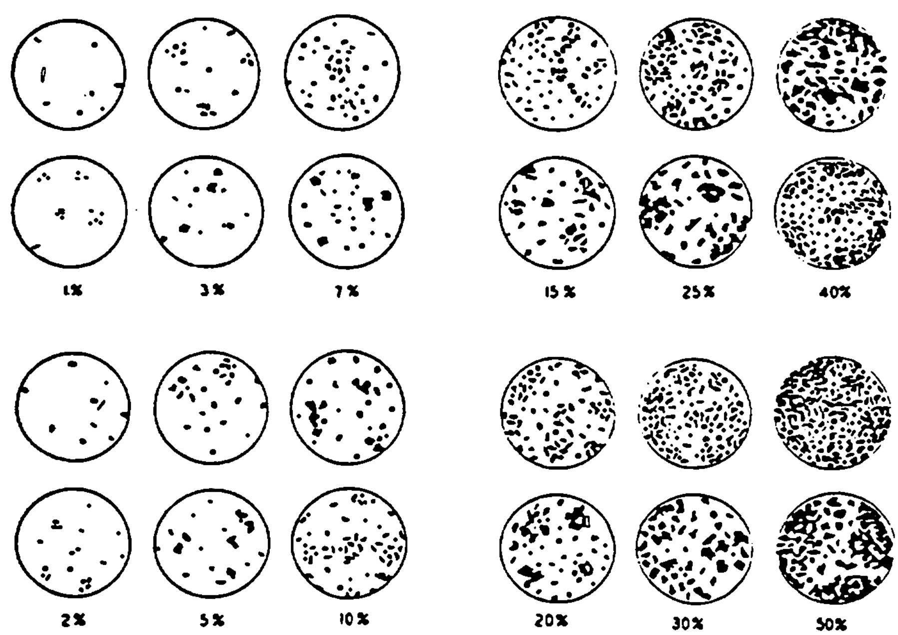
APPENDIX A

Comparison Charts for Visual Estimation of Foliar Cover

Use these charts to estimate percent cover of both understory and overstory species.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

COMPARISON CHARTS FOR VISUAL ESTIMATION OF FOLIAGE COVER 1/



1. Developed by Richard D. Terry and George V. Chilingar. Published by the Society of Economic Paleontologist and Minerologist in its Journal of Sedimentary Petrology 25 (3): 229-234, September, 1955.

APPENDIX B

Mean Relative Cover and Constancy of Plant Species in Western Hemlock Plant Associations

NOTES

Data from the Mt. Hood and Gifford Pinchot National Forests were combined for the following plant associations:

TSHE/ACTR
TSHE/BENE
TSHE/BENE/POMU
TSHE-PSME/HODI
TSHE/LYAM
TSHE/POMU-OXOR
TSHE/VAAL/COCA
TSHE/VAAL-GASH
TSHE/VAAL/OXOR

MRC = Mean Relative Cover = The average percent cover of a species for those plots on which it occurs.

CONS = Constancy = The percent of the total plots in an association on which a species occurs.

See Table 10, Chapter 4, for interpretation of species codes.

	TSHE/ACCI/ACTR		TSHE/ACTR		TSHE/BENE		TSHE/BENE-GASH	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
MATURE TREES:								
ABAM			3	5	3	9		
ABGR	15	8	15	9	17	3	9	8
ABPR			7	3	1	5		
PSME	63	100	49	100	37	97	59	100
THPL	8	8	14	36	9	58	14	43
TSHE	21	58	25	66	40	88	33	86
ACMA	31	67	5	22	2	9	11	27
ALRU			6	9	2	2	8	5
REPROD. TREES:								
ABAM			1	12	1	16	1	5
TABR			2	11	2	5	2	16
THPL			3	23	3	36	4	24
TSHE	2	42	6	87	3	97	7	78
ACMA	3	33			3	2	4	8
ALRU			1	4	1	2	1	3
SHRUBS:								
ACCI	37	92	17	90	10	84	17	95
AMAL	2	25	2	8	1	3	2	14
BEAQ	1	17			2	3		
BENE	25	100	16	97	14	94	29	100
CACH	1	8	8	4	2	11	3	27
CHUM	1	25	3	33	2	44	2	32
COCO2	10	75	2	30	2	9	3	27
CONU	13	50	2	26	2	5	8	25
GASH	2	8	5	42	2	44	31	100
HODI	2	33	2	7			1	14
OPHO			1	8			2	3
RHDI	10	17					3	5
RHMA	1	17	2	8	2	14	2	30
RUNI	1	8	2	11	1	11		
RUPA	2	25	2	19	1	2	2	11
RUPE								
RUSP			1	8	1	3	1	5
SYAL	3	17	1	4			3	3
SYMO	3	33	2	42	1	23	2	27

	TSHE/ACCI/ACTR		TSHE/ACTR		TSHE/BENE		TSHE/BENE-GASH	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
VAAL			2	10	1	3	2	11
VAME			1	16	1	13		
VAPA	1	25	2	61	1	64	3	92
HERBS:								
ACTR	22	100	7	92	1	42	3	46
ADBI	2	83	2	46	1	14	1	27
ANDE	2	67	2	70	1	14	1	57
ARLA	2	25	1	4				
ARMA3	1	92	1	16	1	3	1	16
ASCA3	3	25	2	16			1	3
ATFI			2	7	1	3	1	3
BLSP			1	6	1	5		
CAREX							1	3
CLUN			2	41	1	17	2	19
COCA			3	34	1	17	1	8
DIFO			2	2				
DIHO	2	42	1	38	1	3	1	27
DRAU2			2	2			2	3
FESU	2	67	2	4	1	2	1	8
GAOR								
GATR	1	83	1	38	1	11	1	32
GOOB	1	33	1	38	1	39	1	27
HIAL	1	75	1	30	1	9	1	19
LAPO	1	33	2	4	1	2	1	5
LIBO2	2	50	5	54	5	47	3	62
LYAM			1	1				
MADI2			1	6			1	5
MOSI	2	8	1	6	1	2	1	3
OSCH	1	25	2	15				
OSPU	1	33	1	3	1	2	1	3
OXOR			1	3			3	14
POMU	9	100	3	67	2	41	11	89
PTAQ	1	33	5	51	2	19	4	49
PYSE			1	9	1	9		
SMRA	1	42	1	21	1	6	1	30
SMST	2	33	4	53	1	17	2	49
STCO4							1	3
SYRE	1	33	1	1			1	3
TITR	1	8	2	43	1	28	1	8
TOME			1	3				
TRLA2	2	92	2	47	1	17	2	46
VAHE	3	67	3	55	1	13	1	30
VISE	2	83	2	45	2	52	2	81
XETE			3	4	1	8	3	5

	TSHE/BENE/POMU		TSHE-PSME/HODI		TSHE/LYAM		TSHE/OPHO/OXOR	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
MATURE TREES:								
ABAM	5	6	1	6				
ABGR					30	20		
ABPR								
PSME	46	100	66	100	22	60	34	100
THPL	14	48	8	11	32	80	14	82
TSHE	27	76	18	28	30	40	46	100
ACMA	9	58	15	44	30	20	9	36
ALRU	2	3			32	80	3	27
REPROD. TREES								
ABAM	1	6						
TABR	3	24	1	4				
THPL	2	27	2	14	1	80	2	36
TSHE	3	82	2	46	1	20	7	100
ACMA	2	18	1	6				
ALRU					2	20		
SHRUBS:								
ACCI	24	94	22	86	31	100	13	64
AMAL	2	6	2	53				
BEAQ	1	3	2	31				
BENE	22	100	22	86	2	20	2	18
CACH			2	17				
CHUM	1	18	2	14				
COCO2	6	36	4	72	1	20	4	18
CONU	3	24	2	14				
GASH	4	61	3	19			2	27
HODI	2	12	8	83				
OPHO	1	15	1	3	5	20	17	100
RHDI			2	8				
RHMA	1	3	4	8			2	9
RUNI	1	12					1	9
RUPA	2	40	4	22	2	40	2	18
RUPE								
RUSP	1	3	1	3	2	40	1	18
SYAL	1	12	7	17				
SYMO	2	18	5	67				

	TSHE/BENE/POMU		TSHE-PSME/HODI		TSHE/LYAM		TSHE/OPHO/OXOR	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
VAAL	1	12	2	3	2	20	3	27
VAME			2	6				
VAPA	3	70	2	28	1	40	6	91
HERBS:								
ACTR	3	67	3	42			4	27
ADBI	2	39	3	50	1	40	2	9
ANDE	2	52	2	47				
ARLA			3	4				
ARMA3	2	15	2	69				
ASCA3	2	9	2	6	2	80	2	45
ATFI	1	15	2	6	15	100	7	73
BLSP	3	6					4	45
CAREX			1	4				
CLUN	2	21	1	3	1	40	1	18
COCA	1	6			2	20	1	18
DIFO			1	8	1	40	2	27
DIHO	1	21	2	28			1	73
DRAU2	1	3			2	60	2	55
FESU	2	6	2	14				
GAOR								
GATR	2	42	2	33	1	40	1	36
GOOB	1	42	1	17	1	60	1	9
HIAL	1	18	1	61				
LAPO	1	3	11	22				
LIBO2	2	36	2	28			1	27
LYAM					2	40	1	9
MADI2	2	6			27	100	6	55
MOSI	1	12			1	60		
OSCH	6	9	1	17	3	60		
OSPU			1	14				
OXOR	5	3			1	20	72	91
POMU	25	100	6	75	3	60	14	100
PTAQ	2	36	14	28	7	80	2	36
PYSE			1	3				
SMRA	1	27	1	50				
SMST	1	36	2	25			5	64
STCO4					3	20	1	9
SYRE	2	6	1	18	2	75		
TITR	2	36					2	73
TOME	1	3			16	60		
TRLA2	2	52	2	86	14	60		
VAHE	2	52	3	33			3	45
VISE	3	21	2	25	2	20		
XETE			2	3				

	TSHE/OPHO/SMST		TSHE/POMU		TSHE/POMU-OXOR		TSHE/RHMA-BENE	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
MATURE TREES:								
ABAM	3	20	3	5	5	1	4	5
ABGR					15	2	2	10
ABPR	5	20			5	1	5	8
PSME	38	100	52	100	48	100	54	100
THPL	6	40	12	50	18	55	14	50
TSHE	39	100	47	90	37	95	52	98
ACMA	2	20	5	40	8	23	1	3
ALRU			5	15	9	6		
REPROD. TREES								
ABAM					1	1	1	10
TABR	5	20			2	4	12	15
THPL			3	25	2	30	2	18
TSHE	5	80	4	60	6	88	5	85
ACMA			1	20	1	13		
ALRU					1	9		
SHRUBS:								
ACCI	12	60	26	75	15	73	12	80
AMAL			2	5	1	1		
BEAQ								
BENE	6	40	3	85	11	82	15	100
CACH			1	5			1	15
CHUM	2	20	1	5			4	60
COCO2			3	30	2	7	3	5
CONU					2	1		
GASH			3	10	7	54	2	40
HODI			2	5	2	5	2	3
OPHO	39	100	1	5	2	21		
RHDI								
RHMA	2	40	2	20	6	18	28	100
RUNI			2	5	1	10	2	8
RUPA	1	20	1	15	2	5	1	3
RUPE	3	40						
RUSP					1	4	1	3
SYAL			3	10	1	2		
SYMO			1	10	1	6	1	33

	TSHE/OPHO/SMST		TSHE/POMU		TSHE/POMU-OXOR		TSHE/RHMA-BENE	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
VAAL	3	40			2	18	2	8
VAME	1	20	2	10	7	4	1	23
VAPA	2	60	2	40	4	88	3	68
HERBS:								
ACTR	10	100	1	30	3	24	3	48
ADBI	1	40	1	20	2	15	1	5
ANDE	1	80	1	35	1	22	1	35
ARLA			1	5				
ARMA3			2	15			1	5
ASCA3	3	80	3	10	1	12		
ATFI	3	60	1	5	2	32		
BLSP					2	39		
CAREX			1	5	2	1		
CLUN	2	60	1	5	1	16	1	15
COCA	12	100			2	12	2	18
DIFO	1	20	4	5	2	17		
DIHO	3	80	1	20	1	41	1	5
DRAU2	2	20	2	10	2	29		
FESU			1	5	1	5	1	5
GAOR								
GATR	1	40	1	20	2	5	1	8
GOOB	1	60	1	20	2	5	1	60
HIAL			1	30	1	5	1	25
LAPO							1	8
LIBO2	5	60	1	20	3	20	7	75
LYAM					2	2		
MADI2					2	26		
MOSI	1	20	1	15	1	12	1	3
OSCH			1	5	1	2		
OSPU	1	20	2	5	1	1		
OXOR			3	10	45	100	3	8
POMU	2	80	36	100	19	100	4	45
PTAQ			2	35	3	40	4	15
PYSE	1	60					1	3
SMRA			1	20	1	15	3	3
SMST	22	100	2	10	3	33	1	10
STCO4					2	1		
SYRE							1	3
TITR	3	80	1	15	2	38	2	20
TOME			3	5	2	1		
TRLA2			1	45	1	13	1	25
VAHE	17	100	1	30	2	37	1	13
VISE	1	40	1	70	1	33	2	68
XETE					1	4	2	18

	TSHE/RHMA-GASH		TSHE/RHMA-VAAL/COCA		TSHE/RHMA/XETE		TSHE/VAAL/COCA	
	MRC %	CONS %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
MATURE TREES:								
ABAM	2	7	4	23	2	21	3	33
ABGR	3	4	1	8				
ABPR	3	7	26	31	12	15	3	7
PSME	45	100	41	100	38	100	28	96
THPL	15	58	21	92	12	47	18	70
TSHE	46	89	43	100	55	97	46	96
ACMA	2	2			4	3		
ALRU	3	4	1	15			10	4
REPROD. TREES								
ABAM	2	9	2	69	1	44	2	41
TABR	1	31	25	8	3	15	2	43
THPL	2	35	3	54	2	21	3	48
TSHE	4	85	4	77	3	88	8	88
ACMA	1	2						
ALRU	1	2	2	8				
SHRUBS:								
ACCI	10	62	6	46	5	38	12	63
AMAL	1	11			1	12	1	7
BEAQ								
BENE	12	91	6	92	6	91	9	89
CACH	2	36	2	8	1	32	1	11
CHUM	2	55	2	38	2	41	3	56
COCO2	3	2			1	3	1	7
CONU	3	6						
GASH	39	100	13	38	6	41	3	48
HODI	3	9			2	3		
OPHO			1	8			1	11
RHDI								
RHMA	43	100	28	100	43	100	5	33
RUNI	2	7					1	15
RUPA	1	4						
RUPE			1	8				
RUSP							1	4
SYAL			1	8				
SYMO	1	13	1	15	1	3	1	15

	TSHE/RHMA-GASH		TSHE/RHMA-VAAL COCA		TSHE/RHMA/XETE		TSHE/VAAL/COCA	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
VAAL	7	18	17	100	13	35	17	96
VAME	2	15	3	38	3	65	4	52
VAPA	2	84	4	69	3	85	5	78
HERBS:								
ACTR	2	18	3	23	2	6	3	44
ADBI	1	4					1	4
ANDE	1	22	2	23	3	9	1	19
ARLA			1	8				
ARMA3	1	4						
ASCA3	1	2	1	8			4	7
ATFI							2	4
BLSP			1	23	2	3	1	15
CAREX								
CLUN	1	4	2	54	1	18	2	59
COCA	3	16	8	77	3	29	8	100
DIFO								
DIHO	1	2	3	15			1	15
DRAU2								
FESU	1	2						
GAOR								
GATR	1	4					1	7
GOOB	1	31	1	35	1	35	1	41
HIAL	1	11					1	4
LAPO								
LIBO2	4	71	8	92	3	62	8	93
LYAM								
MADI2	2	2	1	15			3	15
MOSI							1	4
OSCH	1	2						
OSPU							1	4
OXOR			3	15	1	3	5	4
POMU	2	36	2	54	1	21	2	41
PTAQ	5	31	1	54	2	12	5	26
PYSE	1	2	2	15	1	6	1	15
SMRA	1	5	1	8	1	3	1	11
SMST	2	16	4	38	1	12	4	37
STCO4								
SYRE	1	4					1	14
TITR	1	5	3	31	1	6	3	56
TOME							1	4
TRLA2	1	15					1	4
VAHE	1	4	5	31	3	3	3	41
VISE	2	40	3	17	1	29	1	30
XETE	3	33	2	54	13	100	9	33

	TSHE/VAAL-GASH		TSHE/VAAL-OPHO		TSHE/VAAL/OXOR		TSHE/VAME/XETE	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
MATURE TREES:								
ABAM	2	29	2	38	4	13	2	14
ABGR								
ABPR	5	12			15	4	9	29
PSME	29	88	36	88	36	100	40	86
THPL	7	65	14	75	16	46	2	14
TSHE	39	100	55	100	43	100	46	86
ACMA					1	4		
ALRU					15	4		
REPROD. TREES:								
ABAM	4	35	1	25	3	38	1	43
TABR	1	11			1	9	1	14
THPL	2	41	1	38	4	33		
TSHE	3	100	12	100	20	91	7	86
ACMA								
ALRU								
SHRUBS:								
ACCI	21	59	13	75	13	54	7	57
AMAL								
BEAQ								
BENE	5	76	2	50	4	67	10	100
CACH	2	6					2	71
CHUM	3	41			1	4	2	86
COCO2					4	4	1	29
CONU	2	6			5	4		
GASH	14	100	1	13	12	46		
HODI								
OPHO			20	100	1	33		
RHDI								
RHMA	2	24			1	13	2	43
RUNI					2	13		
RUPA	2	6			1	4		
RUPE	2	22	1	38	2	27		
RUSP	2	6	3	13	1	13		
SYAL								
SYMO	10	6			1	4	1	14

	TSHE/VAAL-GASH		TSHE/VAAL-OPHO		TSHE/VAAL/OXOR		TSHE/VAME/XETE	
	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %	MRC %	CONS. %
VAAL	13	94	18	100	23	100	2	14
VAME	5	18			2	8	6	100
VAPA	6	88	4	50	8	79	2	57
HERBS:								
ACTR	2	18	2	38	4	29	1	43
ADBI								
ANDE	1	12	1	13	1	21	2	29
ARLA								
ARMA3								
ASCA3			2	13	3	8		
ATFI			3	25	2	21		
BLSP	1	24	2	100	3	75		
CAREX								
CLUN	3	18	2	88	2	50	1	43
COCA	3	35	2	75	5	79	3	29
DIFO					2	8		
DIHO			1	25	2	29		
DRAU2			3	50	2	25		
FESU								
GAOR								
GATR	1	12	1	13	1	8		
GOOB	1	12	1	13	1	8	1	43
HIAL							1	29
LAPO								
LIBO2	6	71	2	88	3	63	6	71
LYAM			25	13				
MADI2	2	18	2	50	3	33		
MOSI					1	4		
OSCH	1	6						
OSPU								
OXOR	2	6	56	100	27	100		
POMU	1	65	3	75	3	92		
PTAQ	2	41	2	13	2	13		
PYSE							1	29
SMRA			1	25				
SMST	1	18	2	88	7	50		
STCO4			1	13				
SYRE								
TITR	1	35	2	88	2	75		
TOME								
TRLA2					1	8	2	14
VAHE	2	29	3	63	6	25	1	29
VISE	1	12			1	25	2	29
XETE	3	35			1	4	17	100