United States
Department of
Agriculture

Forest Service

Pacific
Northwest
Region

R6-ECOL-TP 001-88
1989

Forested Plant Associations of the Olympic National Forest

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Forest Service
Pacific Northwest Region

R6 ECOL TECHNICAL PAPER 001-88

June 1989

ABSTRACT

A potential vegetation classification system is presented for the Olympic National Forest. It is based on a sample of 1046 Reconnaissance and 408 Intensive plots. The hierarchical classification includes six vegetation series and 64 plant associations. Diagnostic keys are presented to aid in the identification of series and associations. Descriptions are presented for each series and association which are oriented toward the application of this classification for land management objectives. Association descriptions include information about plant species occurrences, including mosses and lichens, mammals, birds, insect pests and diseases. Most descriptions include information on timber productivity and soils. Background information is also presented on the ecology, geology, soils and history of the Olympic Mountains.

Key words: vegetation classification, climax vegetation, climax plant communities, plant association, vegetation series, plant community ecology, forest ecology, mosses, lichens, birds, mammals, forest diseases, timber productivity, soil, Olympic Mountains.

ACKNOWLEDGEMENTS

Many people contributed to this publication, too many in fact, to fully acknowledge here. Since the beginning of this project in 1979, several Regional Foresters, Forest Supervisors and Forest Staff have supported and encouraged this project. At the present time they are J. Torrence, D. MacWilliams, T. Stubblefield, D. Yates and R. Dearsley. Especially significant for their technical support and encouragement are Regional Ecologists, F. Hall and L. Volland, who not only initiated the project but who have made significant technical and professional contributions. Many people assisted the authors on field crews during the project. They are L. Ecklund, J. Evans, A. Freed, M. Freiberg, J. Koontz, L. O'Callahan, A. Pemberton, L. Potash, D. Rial, B. Schrader, R. Tokach and S. Wagstaff. In addition to these crew members, many others assisted on an occasional or short-term basis. They include W. Brown, R. Crawford, D. Daoust, T. Endo, R. Gold, S. Greene, F. Hall, B. Henderson, P. Morgan, F. Rhoades, R. Schuller, M. Sheehan, G. Van der Rey, L. Volland, M. Webster and J. Wirsing. Primary responsibility for study design and interpretation of results belongs to the senior author. D. Peter did most of the soil profile analysis and interpretation; M. Webster did some soil profile descriptions. R. Lesher had primary responsibility for moss and lichen taxonomy and analysis, with consultation from F. Rhoades and J. Ammirati. D. Shaw was responsible for much of the disease and insect information. R. Lesher, D. Shaw and B. Schrader were responsible for much of the field identification of birds. R. Lesher analyzed the bird and mammal data, and C. Chappell prepared the table of common breeding forest birds. N. Buckingham was consulted on some taxonomic aspects and verified some vascular plant specimens. Many of the computer programs used in the project were developed or modified by M. Connelly, L. Volland or D. Wheeler. D. Hood and J. Vosburgh helped in many ways with computer applications. Special thanks is extended to the following people for their review comments: J. Franklin, R. Tabor, J. Hadfield, K. Russell, B. Leonard, K. McAllister, L. Volland, F. Hall, S. Simon, T. Stubblefield, K. Coon, C. Williams, J. Nelson, M. Madrid and W. Jennings. G. Saunders assisted in design and publication details. Finally, the senior author wishes to acknowledge the indirect contribution of four people--W. Chilcote, R. Daubenmire, J. Franklin and R. Pfister, whose ideas and philosophies greatly influenced the ecological approaches used here.

Cover photo by Asahel Curtis, Courtesy the Washington State Historical Society.

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INTRODUCTION

Gifford Pinchot said the Forest Service has only two resources--its people and its land. People manage the land and the land yields outputs of timber, water, wildlife, forage, and recreation. The key element of what we mean by "land" however, is the ecosystem. The job of the Forest Service is to manage the ecosystem *for outputs* of timber, water, wildlife, forage, or recreational experiences. Maintaining a high level of these outputs is dependent on maintaining the health and vitality of both resources--the people and the ecosystem. Prudent and effective management of the land requires a high level of knowledge and understanding about the ecosystem and its components. The foundation for this level of management is an inventory and classification of ecosystems. The purpose of this book is to describe the kinds of ecosystems on the Olympic National Forest in terms of their potential (climax) plant communities and to describe their composition, distribution, environment, and opportunities for management.

Origin of the Plant Association Concept

The use of plants as indicator species and the recognition that different sites support different plant communities with different resource values dates back to the 19th century. These ideas were formalized in the early 20th century by Europeans such as Cajander (1926) and Sukachev (1928). Cajander described "site types" in Finland based on ground cover composition including lichens, and Sukachev described boreal spruce "associations" in Russia based on herbs, mosses, and lichens. Not only was there the recognition that forests were more than just trees, but that an understanding of these other components could aid in the management of forests. The concepts of "site types" and "associations" allowed us to think more in terms of whole ecosystems rather than individual species or commodities.

In the United States these concepts were applied by Daubenmire (1952, 1968) in the northern Rocky Mountains. He merged these ideas and described the climax ecosystem in terms of the association. He also described the land area where an association occurs as the "habitat type". Thus, the potential of the land for supporting a particular kind of vegetation was recognized. About the same time the Soil Conservation Service promoted an idea that was very similar, but with the addition of the elements soil and climate. Their units were called "range sites" and implied a potential for vegetation development.

In the West, early application of the association concept were by Franklin (1966), Dyrness *et al.* (1976), Pfister (1972), Pfister *et al.* (1977) and Hall (1973). Today classifications of plant associations (and habitat-types using Daubenmire's [1968] concept) are available for parts of all Forest Service Regions in the West. Information is used in forest planning, silvicultural applications, environmental analysis, and many other aspects of forest and range ecosystem management.

Region 6 Ecology Program

The roots of the Forest Service Region 6 Ecology Program can be traced back to the pioneering work of Fred Hall in the 1950's and 1960's in eastern Oregon (Hall 1973). Later, with the National Environmental Policy Act (NEPA) of 1969, federal agencies were directed to "utilize ecological information in the planning and development of resource-oriented projects." In 1976, the National Forest Management Act (NFMA) identified a number of new areas of emphasis in Forest land and resource management planning, including requirements for integration of inventories, monitoring and prediction of environmental changes following management actions. All of these requirements indicated the need for identification, classification and systematic inventory of ecosystems.

The Regional Ecology Program began about 1973 with the publication of Plant Communities of the Blue Mountains (Hall 1973). By 1979, the program was formally organized and all Forests in Oregon and Washington were served by an Area Ecologist. A memo from Regional Forester R.E. Worthington dated February 28, 1980 (ref 1920) helped define the objectives of the Ecology Program. "The program is designed to provide ecological input...to the land manager for project level work and for program planning." The objectives are to produce a "site potential classification generally known as Habitat-types (Associations) which are interpreted for management opportunities and limitations, productivity, regeneration characteristics, range condition and wildlife habitat. When existing vegetation is known and site potential is identified by these ecological types, improved management decisions can be made." Plant associations are identified with Region 6 ECOCLASS codes (Hall 1984) and used in the Forest Service's basic resource data storage and retrieval system known as Total Resource Inventory (TRI). In a letter (2060) dated May 2, 1983, Regional Forester Jeff Sirmon recognized that the Pacific Northwest Region "leads the nation in plant community classification" and noted that, "These Plant Associations are particularly helpful in land management because they are designed for cross-function application." As of Winter 1989, there are 20 ecologists in the Region and ten Plant Association guides have been published with several more near completion or in revision.

Objectives

The objectives of the current project are to develop and implement a classification of the Forested Plant Associations of the Olympic National Forest. The classification phase of the project was initially projected to take 10-16 years for the Olympic and Mt. Baker-Snoqualmie National Forests. Development of the potentials and constraints for each association and application of this information into project and Forest management was projected to take an additional 5-8 years.

A classification of non-forested associations is planned for the future. A sample of 155 non-forest plots is already in hand. Further development of the potentials, constraints and successional relationships for each association is also planned. A detailed computer-based map of groups of associations is in progress.

Figure 1. Photo of southeastern Olympic Mountains, Le Bar Creek and Mt. Tebo.

AREA

The area covered by this classification includes all lands under the administration of the Olympic National Forest (Figure 2). This amounts to about 643,419 acres and includes land from sea level (Seal Rock) to 7134 feet elevation (Mt. Fricaba). This area includes five Wilderness Areas with a combined area of 88,265 acres and one Research Natural Area (Quinault RNA) with 1468 acres (USDA Forest Service 1987).

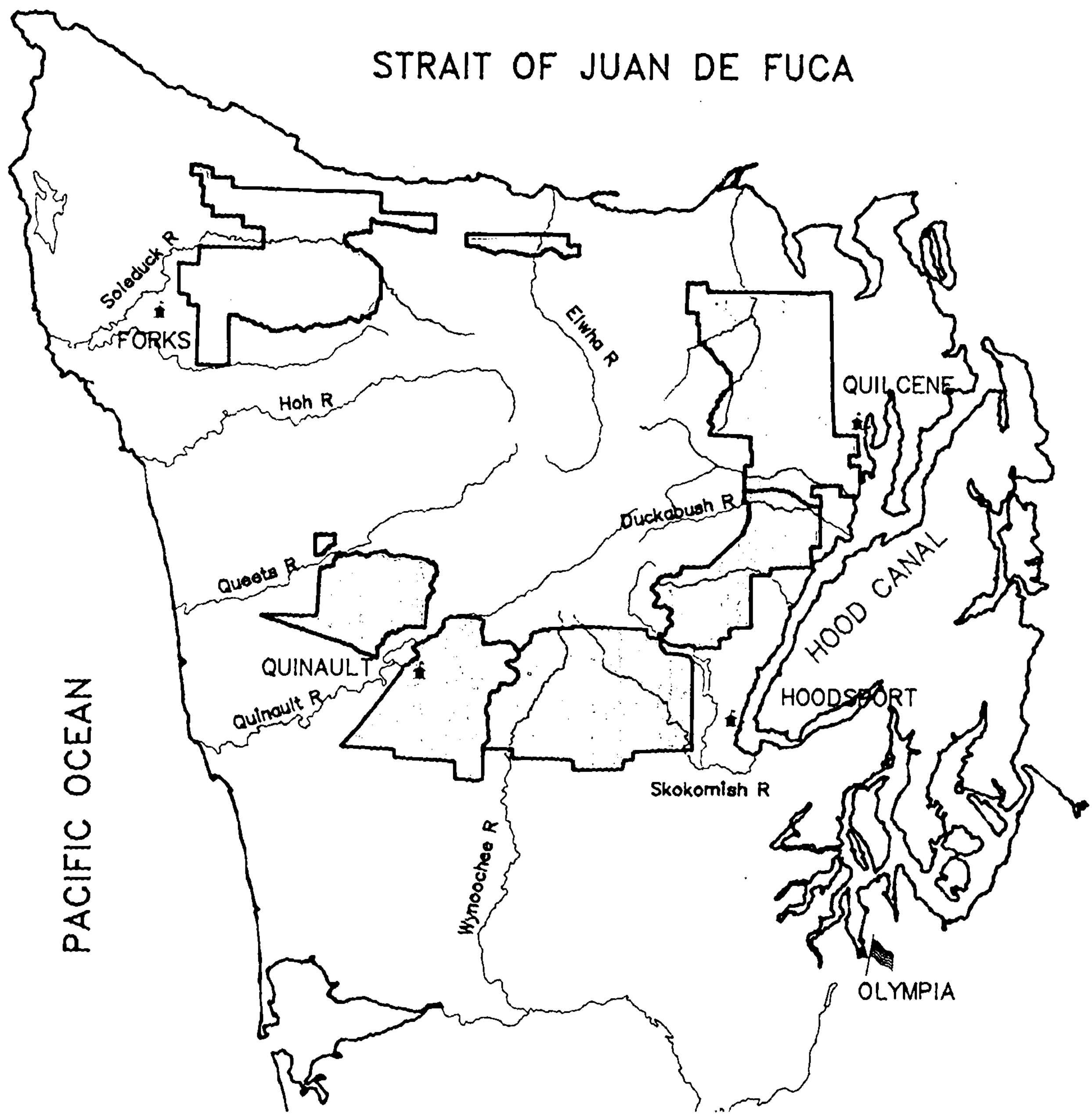


Figure 2. Map of Olympic Peninsula showing the Olympic National Forest.

HISTORY

History of Indian Cultures

The earliest known people on the Olympic Peninsula were hunters and gatherers (Bergland 1983) who migrated into the area from the south following the ice retreat about 13,000 years ago (Vashon Stade of the Fraser Glaciation [Thorson 1980] [see Glacial History p. 27]). Little documentation of these people exists. They were nomadic tribes with simple tools who left few signs and made a minimum impact on the land. Some remains have been found at the Manis Mastodon site near Sequim (Gustafson *et al.* 1979) which date these people in the area about 12,000 years ago. Some stone tools, worked bone and tusk, and a bone projectile point embedded in a mastodon rib, among other artifacts, are currently all that is known from this early period. Climate at the time was cold and dry and the vegetation was arctic in appearance (Kirk and Daugherty 1978, Heusser 1972, 1973a) (see Paleobotanical History p. 54). Caribou, bison, mastodon and mammoth were probably the main source of food and material for tools and clothing. These animals migrated out of the area or became extinct shortly after the close of the Ice Age. The fate of these aboriginal people is unknown. They may have moved on, following the bison and caribou to other areas,or may have become extinct along with the mastodons and mammoths, or they may have become the ancestors of modern Indian peoples (Table 1).

The next inhabitants of the area (6,000-9,000 years ago) were also hunters and gatherers, but by this time the climate and vegetation had changed (see Climatic History p. 32, Paleobotanical History p. 54). This was a warm, dry period when the dominant vegetation of the lowlands was probably an open woodland dominated by lodgepole pine and Douglas-fir, and may have been similar to some open forests today of the Rocky Mountains or areas of southern Oregon (Deevey and Flint 1957, Heusser 1973a, Porter and Denton 1967). Madrone, Oregon oak and tanoak were probably much more widespread. The food source had also changed from large cold-climate herbivores (mastodon, caribou, mammoth) to warmer climate species such as

Table 1. History of Indian cultures of the Olympic Peninsula.

PERIOD	YEARS BEFORE PRESENT	CULTURAL ATTRIBUTES
Early Prehistoric	12,000 - 9,000 b.p.	Nomadic, hunter-gatherers relied on mastodon, bison, caribou and mammoth.
Early Prehistoric	9,000 - 6,000 b.p.	Nomadic, hunter-gatherers relied on deer and elk.
Middle Prehistoric	6,000 - 3,000 b.p.	Transition from hunting land mammals to fishing and sea mammals and shellfish.
Early Maritime	3,000 - 1,000 b.p.	Settlements along coast, often on the beach itself. Reliance on sealife. Use of cedar becoming important.
Modern Prehistoric	1,000 - 200 b.p.	Continued use of sealife (salmon, whales, shellfish, sea otters, etc.), extensive use of camas, fern roots and berries.
Historic	< 200 b.p.	Hunting of fur-bearing sea mammals for trade. Considerable European influence. Abrupt decline due to introduced diseases and cultural impacts.

deer and elk, plus seeds and roots. Some archaeologists (Bergland 1983, Righter 1978) tend to combine the earliest mastodon-caribou hunters (9,000-12,000 years ago) with the more recent (6,000-9,000 years ago) deer and elk hunters as "early prehistoric" cultures (Table 1). There was such a large change in climate, flora and fauna during this time, it is likely that cultures and habits during these two periods were quite different. Evidence for this latter culture is represented at the Olcott, Van Os and Quilcene archaeological sites (Bergland 1983).

Modern Indian cultures (as well as modern climatic and biotic patterns) became established about 4,000-6,000 years ago, although little is known of these cultures. Pollen records (Heusser 1972, 1973a) show that the "modern" forest flora dominated by western redcedar, western hemlock and Douglas-fir was established by this time. The stabilization of sea level and climate at the end of the Hypsithermal marked the beginning of Indian cultures which relied on salmon (Fladmark 1975 in Bergland 1983), shell-fish and redcedar. An "Early Maritime" culture was established on the Olympic Peninsula about 3,000 years ago (Bergland 1983). Artifacts at Tongue Point, Sand Point and the Hoko River are from this period. Animal remains, plus stone and wood artifacts, indicate that reliance had shifted from land mammals to shell-fish and sea mammals (Bergland 1983). This relationship with maritime resources is no doubt related to the stabilization of sea level and increased precipitation, which allowed the establishment of reliable salmon runs and an extensive intertidal shell-fish ecosystem. Establishment of this culture was also facilitated by the increased abundance of redcedar about this time, without which these cultures would have probably been much different. During this period woodworking was highly developed; the use of cedar plank houses had begun but the use of flaked projectile points had declined.

Pre-18th century contact with Orientals may have significantly altered the course of Northwest Coast Indian cultures. Prior to 1875 no less than 75 oriental craft had been found adrift or ashore along the west coast (Gibbs, cited in Campbell 1979). The first known contact of Northwest Coast Indians with oriental cultures was by Chinese explorer Hwui Shan, about the fifth century a.d. (Campbell 1979). This may have been an important event in affecting the course of Northwest Coast culture since this apparently marks the beginning of Indian access to metal tools (Drucker 1955, Ellis n.d., Bergland 1983).

The prehistoric Northwest Coast culture from ca. 200-1000 years ago is noted for its lack of chipped stone tools, elaboration of a cultural pattern founded on an abundance of food, the beginning of stylized art forms, and the development of social status differentiation and individual economic specializations. This period is represented by the recently studied Ozette site near Lake Ozette. Cedar plank houses, canoes, and many fishing tools including nets, hooks and primitive rope, indicate the importance of native plant materials (such as western redcedar) to this culture.

The Historic Period of Indian culture started with the first contact with Spanish explorers in 1775 (Pethick 1979, Bergland 1983). At that time (*ca.* 1780) there were about nine recognized tribes on the Peninsula (Bergland 1983, Campbell 1979). These included the Chimacums (400 but now extinct or absorbed into other tribes), Klallam (2,000), Makah and Ozettes (2,000), Quillieute (500), Hoh (100), Queets (250), Quinault (several hundred), and Skokomish (several hundred), the Twana to the east and Copalis to the south may also have been included with this group. The last 200 years have witnessed the decline and sometimes the extinction (*e.g.* the Chimacum Indians) of Northwest Indian tribes and the dismantling of their cultures. Early cultural history of these people was recorded by Swan (1857, 1869) who lived among the Makah-Klallams at Neah Bay in the middle 19th century, Eells (1886, 1887, 1903), a missionary, who lived on Hood's Canal (as it was called then) during the late 19th century, and the anthropologist, Franz Boas, who lived on the Olympic Peninsula in the 1890's (Campbell 1979).

The Indians made extensive use of native plant materials (Gunther 1945, Norton 1979). Western redcedar (*Thuja plicata*) (as previously noted) was the most important native plant species to Pacific Northwest cultures. However camas (*Camassia quamash*), bracken fern (*Pteridium aquilinum*), salmonberry (*Rubus spectabilis*), salal (*Gaultheria shallon*), and huckleberries (*Vaccinium* spp.) were also very important food.

Western redcedar was one of the most important commodities in Indian culture prior to the beginning of white settlement and for some time thereafter. This species, along with the establishment of reliable and abundant salmon runs about 5,000 years ago, contributed without equal to the development of prehistoric Indian cultures. Its wood was widely used for canoes, including large oceangoing craft which could carry up to 3 tons (Reagan 1934). Redcedar was also the major house building material, owing to its ability to be split into planks and its resistance to decay. Other items made of redcedar included boxes, cradles, arrowshafts, spindles for spinning and paddles (Gunther 1945). The bark was as important as the wood. It was shredded or separated and used to make mats, hats, rain garments, clothes, baskets, eating utensils and numerous other objects. Shredded inner bark was used as padding (as in infants cradles), and as fire starter. The limbs were woven to make a strong rope. The roots were widely used in basketry and in making ropes and nets (Gunther 1945).

Camas is not known today from sites on the Olympic National Forest. It occurs in several prairies in the lowlands around the Peninsula, mainly near the coast. Jones (1936) reported it from "Quillayute" Prairie, Aloha, Elma and Scott's Prairies. Gunther (1945) and Reagan (1934) also noted the Indians got camas from Forks, Baker, Cook, O'toole and other prairies on the west side of the Olympic Peninsula. These prairies were regularly burned (according to early accounts [Lang 1961, Norton 1979]) as a means of cultivating and maintaining the camas and other food plants. The Indians knew how to vegetatively propagate camas by separating the bulbs and leaving immature ones or transplanting them to new sites. They also actively traded camas among the tribes (Gunther 1945). The camas bulbs were cooked in a pit in the ground then dried or pressed into cakes for storage (Gunther 1945).

Bracken fern (*Pteridium aquilinum*) occurs in open areas throughout the lowlands of the Olympic Peninsula and was a major source of starch in the Indian diet. The Indians roasted the rhizomes in hot ashes (Gunther 1945) or extracted the starch and made a bread of the fern paste (Reagan 1934). The emerging fiddleheads were also eaten raw.

Salmonberry is a common shrub of wetter areas on the Olympic Peninsula. The fruits were commonly eaten fresh but were too soft to preserve by drying. The sprouts were cooked in the warm ashes in a fire pit and were often eaten with dried salmon (Gunther 1945).

Salal is one of the most common shrubs on the Olympic Peninsula, preferring mesic lowland sites, but also occurring in high precipitation areas along the coast. The berries are collected in the summer, dried in cakes and preserved for the winter. Such loaves often weighed as much as 10 to 15 pounds (Gunther 1945). The Indians also used the roots, bark, and leaves for medical purposes. The leaves were smoked with kinnikinnick; according to Gunther (1945), the medicinal benefits of the juice of ericaceous leaves are due to the presence of tannic and gallic acid.

Huckleberries (mostly *Vaccinium alaskaense*, *V. membranaceum*, *V. ovalifolium*, *V. ovatum* and *V. parvifolium*) are common and widespread throughout the Peninsula. *Vaccinium ovatum* and *V. parvifolium* are particularly common at low elevations, *V. membranaceum* and to some extent *V. ovalifolium* and *V. alaskaense* are more common at higher elevations. All were treated similarly. They were eaten fresh or dried in the sun or smoked, and sometimes pressed into cakes and wrapped in leaves for storage. One type, identified by Swan (1869) as "shot-berries" was stored fresh and eaten the following spring before other berries had ripened (Gunther 1945).

Other species of importance among the Indians, but not necessarily for food, were nettle (*Urtica dioica*), used for medicine and rope; cattail (*Typha latifolia*), the leaves were used in basketry, the roots and lower stalks were used for food; kinnikinnick (*Arctostaphylos uva-ursi*), used as tobacco; cascara (*Rhamnus purshiana*), commonly used as a laxative but also in the treatment of sores and dysentery; thimbleberry (*Rubus parviflorus*), berries and shoots used as food; blackberry (*R. ursinus*), berries as food, leaves as tea; beargrass (*Xerophyllum tenax*) was very widely used in basketry; Pacific yew (*Taxus brevifolia*) wood was used for weapons and implements; oceanspray (*Holodiscus discolor*), called "ironwood" by the English, was used as a medicine, as well as roasting tongs, digging sticks, arrow and spear shafts, and prongs of spears; Sitka spruce (*Picea sitchensis*) roots were widely used among coastal Indians for cordage and nets, and other minor uses were made of the pitch, limbs, bark and wood.

History of European Exploration and Discovery

It is uncertain when the first European visited the Olympic Peninsula. As early as 1521 Magellan sailed across the Pacific from Tierra del Fuego to the Indian Ocean. In 1577 Sir Francis Drake followed Magellan's route around the world and sailed up the western coast of North America at least as far as San Francisco and perhaps, as he himself claimed, nearly to the latitude of the Strait of Juan de Fuca. He referred to the entire Northwest Coast as "New Albion" and claimed it for England (McDonald 1958).

In 1592, a Greek named Apostolos Valerianus, who sailed out of Mexico under the name "Juan de Fuca" claimed to have sailed north to 47 degrees N. latitude and to have discovered the entrance to the fabled Northwest Passage. He described native Indians, including their clothing and a stone pillar at the mouth of the strait which now bears his name (McDonald 1958). Despite this, many historians disclaimed Valerianus' story (Lavender 1958) and didn't recognize his discovery of the Strait of Juan de Fuca or that he may have been the first European explorer to the Olympic Peninsula. Whether his claim is true or false, he was immortalized by the European cartographer J. N. Bellin when he placed the "Entrance of Juan de Fuca" on a map of North America in 1755 (Pethick 1979). Later sea captains such as Meares and Vancouver perpetuated the name.

Vitus Bering sailed into the North Pacific from Russia in 1728, and later sailed across the Pacific in 1741 to southeast Alaska (Lavender 1958). Bering was accompanied by George Steller, a German botanist and physician, who made the earliest natural history observations in this part of the world. Steller Sea Lion (Northern Sea Lion) and Steller's Jay were among his discoveries (Pethick 1979).

In 1774 Juan Perez sailed north from Mexico to southeast Alaska and back, but failed to discover either the Columbia River or the Strait of Juan de Fuca (Lavender 1958). On his trip back he anchored in Nootka Sound and established Spanish claim to Vancouver Island, and thereby initiated the Spanish fur trade that was to flourish there for many years. On his way back (August 9, 1774), passing the Washington Coast, Perez sighted a "snow-white cliff on the eastern horizon, flanked by foothills." He named the peak Santa Rosalia. In 1788 it was renamed Mt. Olympus by Captain John Meares. Interestingly, Perez also noted that "smoke of forest fires shrouded the Washington coast" (McDonald 1958). The next year, in 1775, Perez again sailed north accompanied by Bruno Heceta and Juan Francisco de Bodega y Quadra. On July 14, 1775 they anchored off the coast of Washington within sight of the Olympic Mountains. Quadra and Heceta each led a small party ashore in the vicinity of the Quinault River, Quadra to obtain water for the expedition and Heceta to claim the land for Spain. Heceta carried out his chore while seven of Quadra's party were massacred by the natives. This is the first documented landing by Europeans on the Olympic Peninsula. It also established Spain's claim to Washington State. Spain had already claimed Vancouver Island by landing at Nootka Sound the previous year (McDonald 1958). On the return trip (August 17, 1775) they also discovered the mouth of the Columbia River, although they did not enter it.

Captain James Cook left England in 1776 and sailed eastward across the Pacific in 1778 to California and thence northward, naming, among other things, Cape Perpetua and Cape Flattery. Although Cook discovered and named Cape Flattery, he missed the entrance to the Strait of Juan de Fuca, writing in his log: "In this very latitude geographers have placed the pretended Strait of Juan de Fuca. But nothing of that kind presented itself to our view, nor is it probable that any such thing ever existed." Interestingly Midshipman George Vancouver accompanied Cook on these early voyages and returned later to explore this same "pretended" strait and the rest of Puget Sound. Cook sailed north to Nootka Sound where he named "Friendly Cove" and engaged in fur trade (McDonald 1958).

In 1786 Captain Barkley discovered Barkley Sound on Vancouver Island and the Strait of Juan de Fuca. On the way south, he sent a party up either the Hoh or Quillayute River for water. This party was also killed by Indians. Destruction Island, nearby, was named for this massacre. Barkley's bride, Frances Trevor (who accompanied him on the voyage), became the first European woman to visit the Northwest Coast (McDonald 1958).

The person who actually discovered the Strait of Juan de Fuca for the first time is not known for sure. Apostolus Valerianus is the first to have claimed it.

Later Barkley claimed to have found it. Cook sailed by the mouth without discovering it. Captain Robert Duncan also claimed to be the first. In 1788, after wintering in Hawaii (Sandwich Islands), Duncan visited Tatoosh Island and also anchored near an Indian fishing camp west of Neah Bay. Later in the same year, Captain John Meares also discovered the Strait, and thought he was the first. Meares is often given credit for discovering the fabled passage. He did discover Willapa Harbor later in that voyage (McDonald 1958). It is a commentary on the history of the Northwest Coast as we know it that almost every different book on the subject credits a different person with the discovery of the Strait of Juan de Fuca. Although Barkley's journal was lost, he appears to have been the first after Juan de Fuca to have "discovered" the Strait.

Captain Robert Gray's first voyage to the Northwest Coast was in 1787 aboard the Lady Washington, accompanying Captain John Kendrick aboard the Columbia Redeviva. They were the first Americans to enter the Pacific fur trade. Gray reported seeing the Strait of Juan de Fuca. Later Kendrick and Gray switched vessels, and sailed to China. Gray, as captain of the Columbia, completed the expedition in 1790 and became the first American to circumnavigate the globe. Gray's second voyage to the Northwest Coast followed in 1791. After business on Vancouver Island (it was not yet called Vancouver Island, nor was it even known to be an island), he returned south, revisiting the Strait of Juan de Fuca, met Captain George Vancouver on his historic exploration and discovered Grays Harbor, which he originally named Bulfinch's Harbor. Gray was the first to cross the bar of the Columbia River and sail up river. This was May 10, 1792, which established American claim to the Oregon Territory including that part north of the Columbia River. He stayed 8 days on the Columbia River and explored only about 35 miles upriver. His goal was mostly trade, not exploration, and since trade was not good, he left. Before departing, he named the river after his ship, the Columbia. This was the same river called "San Rogue" by Heceta in 1775 (Lavender 1958) and the "Oregon" by Jonathan Carver in 1766 (Lavender 1958).

Captain George Vancouver with his two ships, the Discovery and the Chatham, entered the Strait of Juan de Fuca on May 5, 1792, three weeks before the Spaniard Fidalgo and two months before Galiano and Valdez. By the 18th of May he had explored "Hood's Canal" which he named. Notable members of Vancouver's party were the botanist and physician Dr. Archibald Menzies and Lieutenant Peter Puget, who lead much of the explorations and for whom "Puget's Sound" was named. Menzies was the first botanist in Puget Sound and reported many new species. Menzies made more than one trip to the Northwest Coast and also botanized on Vancouver Island (McDonald 1958, Vancouver 1801, Meany 1942).

The Spaniards were heavily involved with the early fur trade and explorations, although this has often been discredited by some historians of the Northwest Coast. They completed the first circumnavigation of Vancouver Island (originally called "Quadra and Vancouver's Island"). By the time of Gray and Vancouver in 1792, the Spanish settlement at Nootka Sound (Friendly Cove) consisted of 16 buildings. The settlement was presided over by Juan Francisco de Bodega y Quadra, the same Quadra who with Heceta first claimed the coast of Washington for Spain and named the Columbia River "San Rogue" in 1775. He entertained Gray and his crew at a feast served on no less than 270 solid silver plates (McDonald 1958).

About the same time as Vancouver and Gray, Salvador Fidalgo left San Blas, Mexico to establish a colony in Washington. He landed near Neah Bay, May 29, 1792, at Village Creek where Quimper had put ashore two years earlier and placed the cross of possession. He was accompanied by 89 men and erected a settlement of crude wooden buildings and a brick oven for baking bread. Their first visitors (July 16) were Galiano and Valdez on their way to do the Spanish version of Vancouver's survey of the Strait of Juan de Fuca. Interestingly they carried an instrument called an "eudiometer", for measuring the quality of the atmosphere (McDonald 1958). From Bellingham Bay in June 1792, Galiano and Valdez noted a mysterious illumination on "Mount Carmel" (Mt. Baker) plus "rumblings like those of a volcano, flashes and clouds of ... steam" (McDonald 1958).

The dispute between England and Spain over rights to the Northwest Coast, especially Nootka Sound, was partially resolved by the Nootka Convention of 1790, which relieved Spain of much of its claim to the area. Later events in Europe, especially the French Revolution, would cause Spain to lose interest in such a far away place and eventually to give up claim to any part of it, leaving behind much history and many place names. Disputes between the United States and England were settled in 1846, when a treaty established the northern boundary of the Oregon Territory as the 49th parallel, however, that portion of Vancouver Island south of there was excluded, and the entire island was given to the British (McDonald 1958).

Following Vancouver, the next major exploration of Puget Sound was by Captain Charles Wilkes in 1841 (Wilkes 1874). Wilkes made detailed maps and charts, and members of his expedition compiled the first comprehensive Flora of the area.

Settlement History

By the mid-19th century the settlement period had begun. Hudson's Bay and Northwest Fur Companies had been trading furs for decades. The Oregon Trail had been opened and settlement had begun east of the Cascades. Fort Nisqually was established in 1833. Settlement of most of the major towns of the Olympic Peninsula and western Washington occurred in the mid- to late 1800s. The "settlement period", as we refer to it, began *ca.* 1845. The first of these settlements was New Market on the Deschutes River, later to be called Tumwater. It was founded by Colonel Michael T. Simmons in 1845. Olympia (originally called Smithfield), was founded in 1846 by Edmund Sylvester and Levi Smith (Newell 1950). Smith staked his claim near present downtown Olympia. At the dedication of Smith's claim as a town in 1850, the name was changed to Olympia in reference to the view of the Olympic Mountains from Budd Inlet, although the exact intention or the person who suggested the name is now obscure. Colonel I.N. Ebey is credited by Newell (1950) as suggesting the name. There are also suggestions that the name carried at least a double reference to the Greek Gods as well as to an obscure Italian poet (Newell 1950). Port Townsend was settled in 1850 by Charles Bachelor and George Emery, Sequim in 1854, and Dungeness in 1855. Port Angeles was settled in 1857 by Angus Johnson. However, A. Sampson, R. Holmes and W. Winson had settled nearby at Ediz Hook the year before (Campbell 1979).

The first timber company, Pope and Talbot Company, was formed in 1833. The first sawmill was built at Port Discovery in 1858, and another at the mouth of Chimacum Creek in 1859. The beginnings of the timber industry were in the northwest part of the Olympic Peninsula and in the Grays Harbor country (Campbell 1979).

Sometime about 1890 Theodore Moritz learned of Sol Duc Hot Springs from the Indians and filed a claim on it. After Moritz's death, Michael Earley bought the hot springs. He built a hotel at the site which opened May 15, 1912. On May 26, 1916, it burned to the ground. Later, the National Park Service acquired the site for $880,000 (Campbell 1979).

The first white family came to the town site of Forks in 1878. Originally it was called "Indian Prairie". The windstorm of 1921 destroyed many buildings in the young town, hitting Forks between 5 and 8 PM on January 29, 1921 (see p. 20). The first railroad to Forks was built during World War I by the United States Spruce Division, and was completed in 1919 at the end of the war (Campbell 1979). This railroad ultimately belonged to the Port Angeles and Western Railroad, who were suspected of starting the great Forks Fire in 1951 (see p. 18). John Huelsdonk homesteaded in the Hoh Valley in 1892 (Fletcher 1979).

Grays Harbor was explored by land by David Douglas in 1825. Settlement in the Grays Harbor country began in 1852 when B. Armstrong and two men named Strahill and Cox cut a trail from near Grand Mound to Cedar Creek on the Chehalis River. There they built a sawmill intending to cut 3 x 12 planks and ship them to San Francisco via Grays Harbor. By this time the early settler and missionary, James G. Swan, had established himself among the Indians on Shoalwater Harbor (Willapa Bay) (McDonald 1972, Van Syckle 1980).

Early logging (Figure 3) in the southern Olympics began in the 1870's and involved the Polson Brothers, Alex and Robert (1882), the Shafer Brothers, John and Anton (1871), and Sol Simpson beginning in 1887 (James 1986), among many others. The Polsons logged mainly around Hoquiam. They formed the Polson Brothers Logging Company in 1891. Originally they used bull teams, but switched to donkey engines *ca.* 1892. By 1894 they were planning a railroad. At the height of their operations, the Polsons owned two sawmills, a shingle mill, 100 miles of railroad, operated 12 logging camps and cut about 300 million board feet per year.

The Shafer Brothers logging centered near Satsop. The Shafer Brothers Logging Company was incorporated in 1914, a year after they began railroad logging. Over time they acquired many of the smaller operations in the area. This included the Chehalis Logging and Timber Company, Grays Harbor Commercial Company, Wynoochee Timber Company, and National Lumber Manufacturing Company, among others (Van Syckle 1980). In 1955, the Shafers sold out to Simpson Logging Company.

Much of the early timber from the Grays Harbor area was exported to San Francisco via steamship. Also, there was an emerging ship building industry in Grays Harbor from 1887 to the 1920's. While most of the area's timber left in ships, a considerable quantity left as ships (Van Syckle 1980), as shipbuilding was a major industry at the time.

Sol Simpson arrived in the area in 1887 and formed the S.G. Simpson and Company in 1890, which became the Simpson Logging Company in 1895, and the Simpson Timber Company in 1960. Simpson logged much of the southeast part of the Olympic Peninsula, including much of the Shelton Ranger District under an agreement authorized by the Cooperative Sustained Yield Act of 1946 (Van Syckle 1980).

In 1885 a military expedition led by Lieutenant J.P. O'Neil made a short exploration of the northeastern Olympic Mountains. They explored part of the Dungeness River, Hurricane Ridge and the Elwha River. They reported shooting a large wolf. They also shot elk, and noted deer and bear near the head of Chambers Creek. They reported evidence of hunters already having been in the area (Wood 1976).

The first exploration of the interior of the Olympics began in December 1889, only a month after Washington became a State. The famous Press Expedition, lead by James H. Christie, traveled up the Elwha River and down the Quinault River, arriving at Lake Quinault in May 1890, naming many landmarks and enduring an Olympic winter (Seattle Press, July 16, 1890 [now the Seattle Times], Wood 1967).

Lieutenant O'Neil lead a second expedition in 1890 which explored both the South Fork and North Fork of the Skokomish River up to O'Neil Pass, where they started a forest fire while trying to burn out a yellow jacket's nest. From there they traveled down the Quinault River to Lake Quinault. Professor Louis Henderson accompanied O'Neil on part of this exploration and made the first botanical observations of the area (Wood 1976).

History of Olympic National Forest

The Olympic National Forest began in 1897 as the Olympic Forest Reserve. It was established by proclamation of President Grover Cleveland under the authority of the Forest Reserve Act of 1891 and included some 2,188,800 acres (USDA Forest Service 1973, Dodwell and Rixon 1902, Brier 1958). Alienated land in Clallam County, mostly around the town site of Forks, was removed from the reserve in 1900 reducing the acreage to 1,939,200 (Dodwell and Rixon 1902). Land additions and deletions continued in 1901. President McKinley, yielding from pressure from settlers and loggers, reduced the reserve by 750,000 acres, leaving it at 1,466,880 acres.

In 1905 the Forest Reserve was transferred from the U.S. Department of Interior to the Department of Agriculture. By Congressional action in 1907, all Forest Reserves became National Forests. Only two days before that Act, President Roosevelt restored 127,000 acres to the Olympic Forest Reserve (soon to be the Olympic National Forest), putting total acres at about 1,594,560 acres.

In 1909, President Roosevelt under pressure from Congressman W.E. Humphrey, established the 610,560 acre Mount Olympus National Monument in the center of Olympic National Forest. His reason was to protect the native elk which were being hunted heavily (poached) by settlers. This action left the dwindling Olympic National Forest at 984,000 acres. In 1915, President Wilson reduced the size of the Monument and returned 305,280 acres to the Forest, bringing it back up to about 1,289,280 acres. A small amount of land was lost in 1925 (USDA Forest Service 1973). Around 1935, about 50,000 acres in the Clearwater drainage was transferred to Washington State as trust land.

In 1938 Olympic National Park was created out of Mount Olympus National Monument and parts of the Olympic National Forest. The park was established at 680,000 acres, 69,440 acres larger than the original National Monument. Two years later an additional 187,411 acres was transferred from Olympic National Forest to the Park. This included land in the Elwha, Calawah, Hoh, Queets, Quinault, North Fork Skokomish, Dosewallips and Duckabush drainages, and brought the Park to 867,411 acres and the Forest to about 670,000 acres. In 1943 an additional 20,600 acres in Ennis and Morse Creek drainages were added to the Park for watershed protection. By 1953 the Queets Corridor and the Coast strip were added to the Park bringing it to approximately its modern size at 936,011 acres.

As of September 1987, the Olympic National Forest land is 643,419 acres (USDA Forest Service 1987) with an additional 65,776 acres of other ownership as inholdings within the Forest administrative boundary.

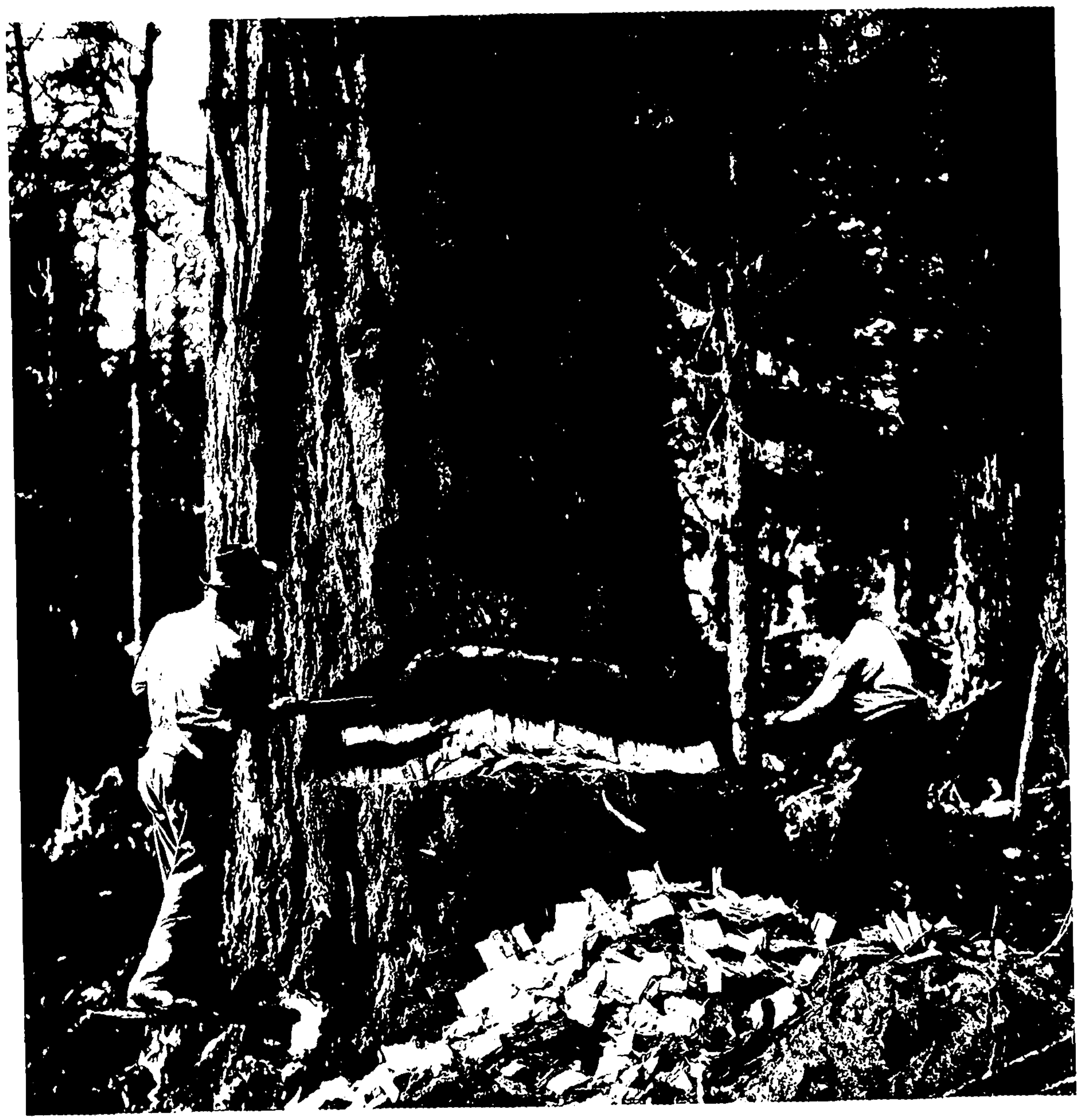


Figure 3. Felling a large old Douglas-fir on the Olympic Peninsula. Photo by Asahel Curtis, ca. 1920. (Courtesy of the Washington State Historical Society, Tacoma, Washington).

FIRE HISTORY

The occurrence of wildfires on the Olympic Peninsula is closely tied to climate and climatic history (see p. 32). It appears that the pattern of fires has been as variable as the pattern of past climates. Some periods have had many stand destroying fires, others have had almost none. Still other periods may have had a pattern of high fire frequency but low fire intensity. Because of this variability and the many factors involved, one aspect of the fire history of the Olympics seems certain--one cannot characterize the fire patterns of one period by knowing what it is in another.

Our earliest evidence of fire in the Olympics comes from a bog in the Hoh River drainage. In a core from this bog, Heusser (1974) noted two layers of charcoal at 3.1 and 3.4 m depth, just below a layer of 6800 year old Mazama ash. These layers are remnants of two fires which appeared to have burned in the lower Hoh River drainage between 7200 and 8700 years ago. They appear to have been large fires since they left behind enough charcoal to still be recognized today. These fires occurred in the early Hypsithermal period when the climate was drier, probably warmer, and less maritime than today. The vegetation of the Olympics at that time was dominated by Douglas-fir, western hemlock, spruce, alder and lodgepole pine (Heusser 1974). The species composition resembles that of northern Idaho today, suggesting that the climate of the Hypsithermal may have been similar to that of the northern Rocky Mountains. The abundance of Douglas-fir also suggests a forest in which fires were common. The vegetation of the Puget Trough was characterized by Douglas-fir, alder and oak (Barnosky *et al.* 1987), suggesting a climate similar to the present day Willamette Valley.

The Hypsithermal was followed by the Neoglacial Period (see p. 30), beginning about 4000 years ago. The fire history of the Olympic Peninsula appears to have been quite different during the Neoglacial Period than it was in the Hypsithermal. The climate became slightly cooler, but significantly wetter and more maritime. The vegetation of this period (see p. 55) appears to reflect this change in climate and fire history. The fire history of the Neoglacial Period is not uniform and can be characterized by periods of large intense fires and periods of few small fires.

Our knowledge of the fire history increases greatly about 1000 years ago. Prior to that time we can only speculate about fires, based on evidence such as charcoal preserved in bogs and our knowledge of different tree species. For the period of the past 1000 years we can study living trees (Douglas-fir and western redcedar both live to over 1000 years) and refer to historical records to construct a much more detailed picture of the fire history.

The Medieval Optimum (see Climatic History p. 32) was warmer and drier than today (Lamb 1965). This period lasted from about 1000 a.d. to about 1300 a.d. We assume that fires burned frequently throughout Northwest forests during this time. Pollen studies are not detailed enough to support this, however, and there are too few living trees from early in that period to help construct a detailed picture. The fact that there are very few trees surviving from this period suggests that fires may have been either frequent or large, at least near the end of the Medieval Optimum. Very old Douglas-firs are mostly found outside of their present natural range. That is, they have survived on a site where they can no longer regenerate. These sites are mostly at high elevations in the upper Silver Fir Zone or Mountain Hemlock Zone.

Three great burning periods occurred from 1300 to 1750 during the Little Ice Age. The first occurred at the end of the Medieval Optimum and the beginning of the Little Ice Age. This was a very large fire or series of fires which swept western Washington and burned at least half of the Olympic Peninsula. It occurred in about the year 1308. Douglas-fir trees from this time are mostly 640 to 680 years old. They occur sporadically throughout much of the Silver Fir Zone, especially on cool or moist sites.

The second great burning episode occurred between the years 1448 and 1538, or 450 to 540 years ago. Several fires burned during this time, the biggest one about the year 1508 or about 480 years ago (Figure 4). Remnants of this series of fires occur at mid-elevations or stream bottoms in the Silver Fir

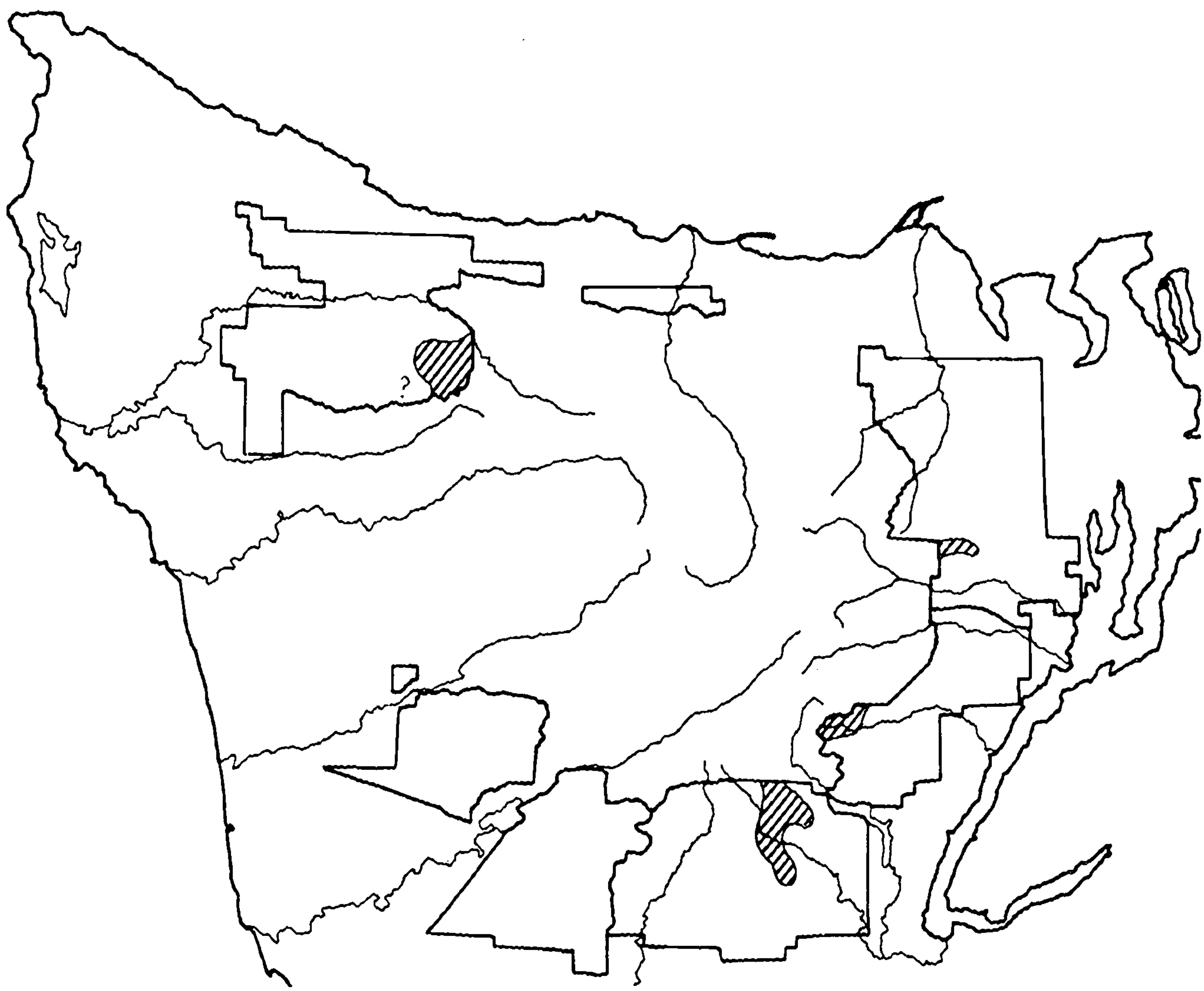


Figure 4. Map of Olympic Peninsula showing the remnant stands from the fire about 1508.

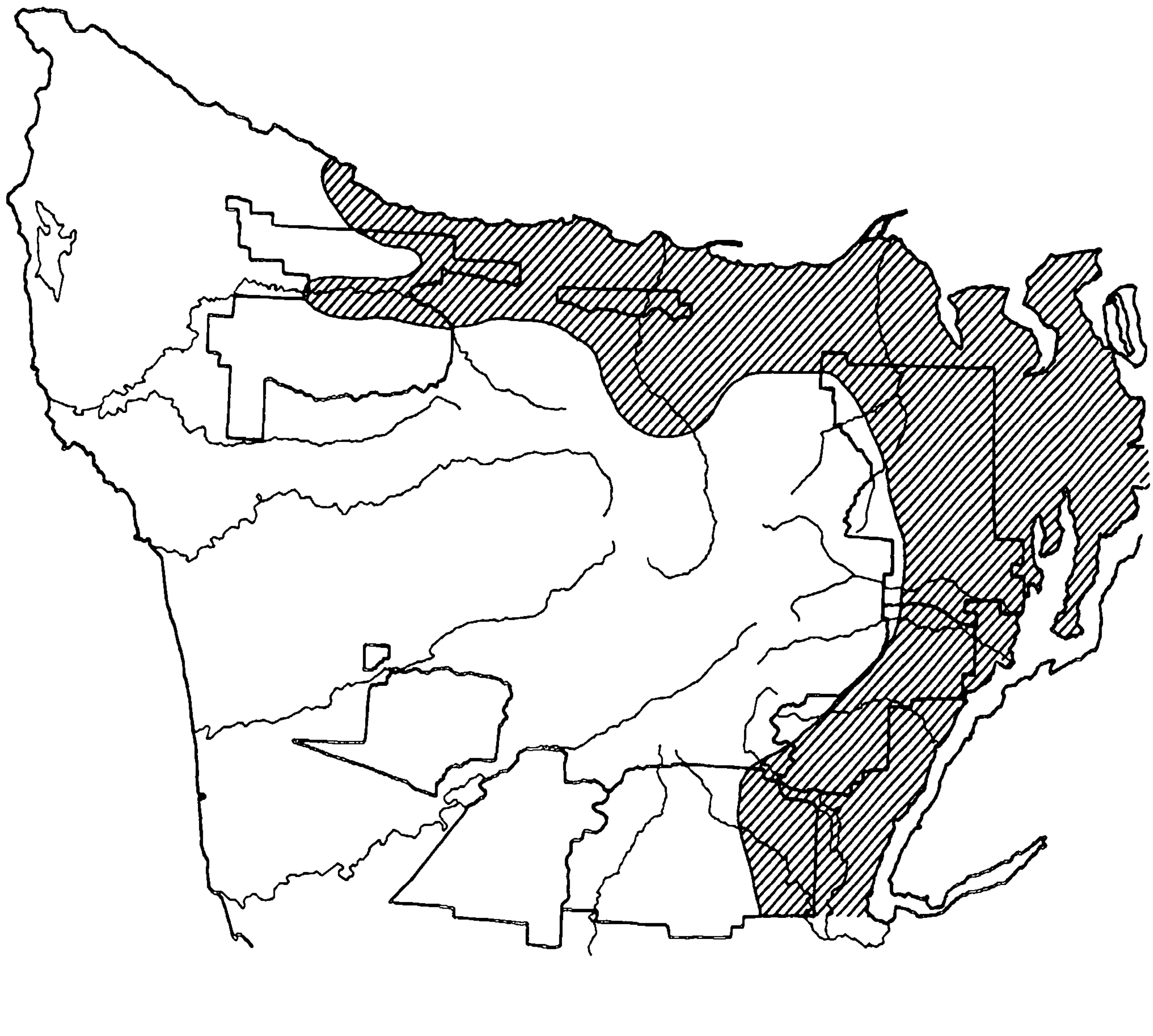


Figure 5. Map of Olympic Peninsula showing the remnant stands from the fire about 1701.

or Western Hemlock Zones. Many of the areas that burned during this time are believed to have also burned earlier in about 1308. Also, it is believed that the area covered by these fires was much more extensive than indicated by the present distribution of trees or stands 450 to 540 years old; for much of the area burned during that time also burned during the episode from 280 to 320 years ago. These later fires, therefore destroyed many of the trees which originated from fires 450 to 540 years ago. This age class is also common in the Cascades of Washington and Oregon.

The last of the three great burning episodes during the Little Ice Age occurred between 287 and 320 years ago. During that time there were two fairly well documented fires or burning episodes, one in about 1668 and the other about 1701. Since the fire about 1701 (287 years ago) was the last of the big fires, we have the best records of its distribution. Areas where stands from this fire occur are shown in Figure 5. This fire or series of fires apparently burned more than one million acres on the Olympic Peninsula, and 3 to 10 million acres in western Washington. Much of the valuable Douglas-fir old-growth, that has formed the basis for the local timber industry, is the result of this great fire.

An interesting aspect to these three great burning episodes is their correlation with the long-term sunspot cycle (Figure 6). Since the Medieval Optimum, there have been three extended periods when there were virtually no sunspots on the sun. These periods were the Wolf Sunspot Minimum from 1282 to 1342 (Stuiver and Quay 1980), the Sporer Minimum from 1416 to 1534 (Eddy 1977, Stuiver and Quay 1980) and the Maunder Minimum from 1645 to 1715 (Eddy 1976). The three burning periods and the five biggest fires (*i.e.* about 1308, 1448, 1508, 1668, and 1701) all occurred during these three periods of very low sunspots.

The correlation between low sunspot numbers and increased fires in western Washington is speculative. There is a great deal that we do not know about the physics of the sun or the causes of climatic patterns on earth. However, during these periods of absence of sunspots, the energy of the sun's output (and the solar wind) is lower, perhaps by about 1% (Eddy 1977). The temperate global climate is cooler and mid-latitude glaciers advance during these sunspot minima. At this point the linkage between cooler climate and forest fires is still unclear. It is believed that the global climatic pattern is affected by these changes, that the position of the jet stream and summer high pressure cells shift (Schneider and Londer 1984), and that at least for western Washington the summer climate becomes drier. It is possible that if these climatic shifts do occur, the likelihood of high east winds may also increase and create the opportunity for very large fires.

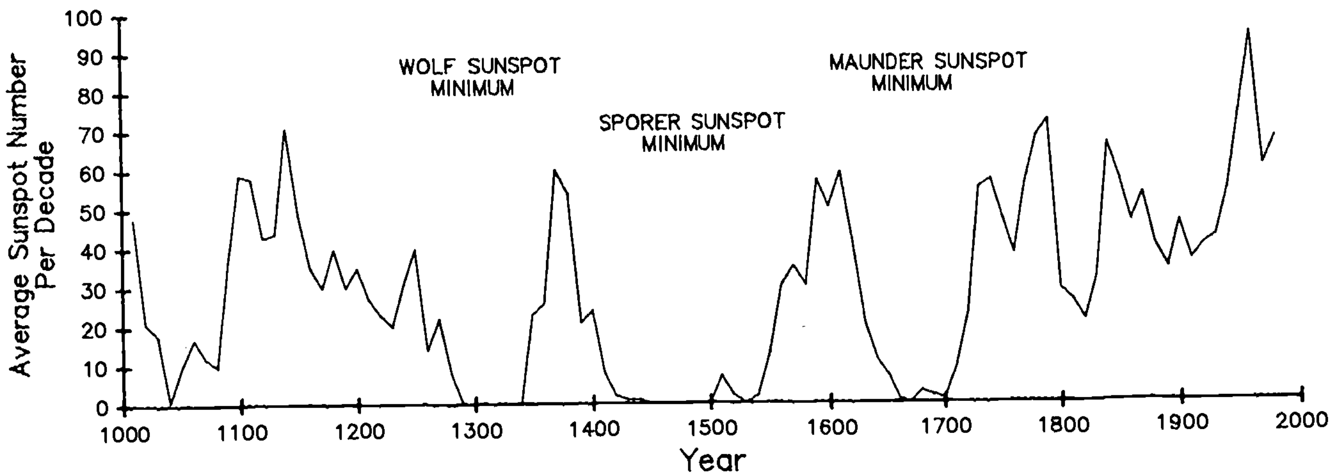


Figure 6. The longterm sunspot cycle (adapted from Stuiver and Quay 1980).

At the end of the Little Ice Age, there was a period from 1720 to 1850 when there were virtually no large fires on the Olympic Peninsula. The climate was still cool during this time, but it had apparently become wetter. Known fires were small (only a few thousand acres) and were restricted to southerly aspects in drier environmental zones. One such fire in the South Fork of the Skokomish River occurred about 1833 and covered about 3000 acres.

Beginning in the late 19th century until about 1934 there was a period of high fire frequency in the Olympics. However, these fires were all small compared to fires that burned during the Little Ice Age. These fires were caused by both lightning and humans. They were almost restricted to the Western Hemlock and Subalpine Fir Zones, and burned on southerly aspects unless there was a high east wind. The following is a recapitulation of some of the bigger or more significant fires during this period. This information is excerpted mostly from Morris (1934) and Miller (1943). Acreage burned for each year from 1905 to 1985 is shown in Figure 7.

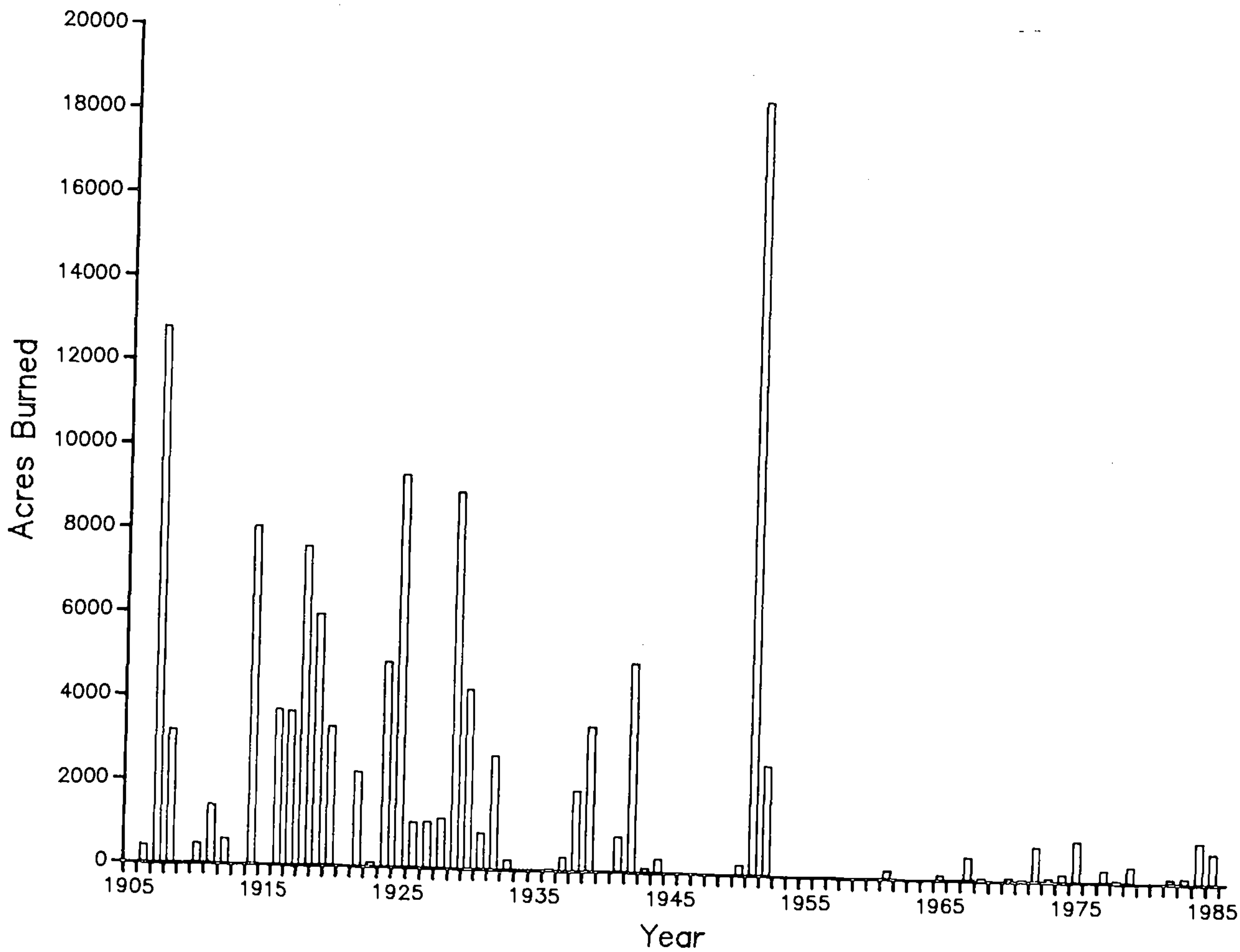


Figure 7. Acres burned on the Olympic National Forest, 1905 to 1985.

SUMMARY OF RECENT FIRES:

1849--Great fires burned in the Coast Range of Oregon, but apparently none occurred in the Olympics.

1864 to 1868--Many large fires burned in Oregon and Washington in 1864, 1867 and 1868. The Ludlow-Quilcene Fire started in slash near Port Ludlow in September 1864 and burned several thousand acres under a high east wind. The fire burned on Mt. Walker, Mt. Turner, and the Quilcene Ridge. Most of the area burned in one or two days. Other fires occurred in the area, including Vancouver Island. In 1868, again many fires occurred in western Washington and Oregon. Much of the area was covered by smoke for extended periods. Apparently little of the Olympic National Forest burned in this year, but there were fires all around. There was at least one large fire between Olympia and Seabeck (August 13) and others in the San Juans, near Montesano, on both sides of Hood Canal, Discovery Bay, near Bellingham, Snoqualmie, and on Vancouver Island. These fires burned into September, flaring up under east wind conditions. The drought was so severe that summer that heavy thunder showers on September 2 apparently did little to quell the fires. Records taken at the mouth of the Columbia River showed that this was the driest June, July, August and September for the 58-year record up to that time. This appears to have been the worst fire season since the early 1700's. Most of these fires started from land clearing or careless tending of cooking fires.

1885--The Neilton Burn near Lake Quinault started from right-of-way clearing on "the old Quinault trail". It burned about 2000 acres.

1890 and 1891--Several fires apparently burned in the Soleduck Valley in the early 1890's. One in Kugel Creek burned about 2000 acres. Others occurred in the Bear Creek, Pysht River and Twin Creeks area. In 1890 land clearing fires burned out of control in the foothills near Sequim. Rainfall that next winter was light and at least one of these fires survived the winter by smoldering in rotted logs or stumps. It flared up the next spring and burned toward the south, eventually covering about 30,000 acres on the Quilcene District, mostly in the Dungeness drainage.

1902--This was another fire year like 1868. Many fires burned throughout western Washington and Oregon. Much property and at least 16 lives were lost. The biggest of the fires during this summer was the famous Yacolt Burn in the Lewis Valley. It burned about 250,000 acres. The biggest fire on the Olympic Peninsula, the Elma-Humptulips Fire, burned from near Elma to the Humptulips River mostly on September 11. Both the Yacolt and the Elma-Humptulips fires burned under high east wind conditions. A small fire appears to have burned near the Tubal Cain Mine. There were perhaps hundreds of fires burning in western Washington and in western Oregon in September 1902. It was perhaps the worst fire year of the last 275 years, being more severe, even, than the fire season of 1868.

1907--The Great Soleduck Fire burned about 12,800 acres in the Soleduck Valley between Lake Crescent and Bear Creek along the south side of Snider Ridge in the summer of 1907. It started in April when a settler named Cap Mueller was burning ferns in a field (a common practice at the time). The fire was not put out, as was also common, and it spread to nearby forest. By July it was burning out of control and threatening other settlers in the Lake Crescent-Soleduck Valley area. Most of the area burned during one afternoon when a strong east wind came up (Morgenroth 1935). Another fire in the same area burned about 3000 acres in 1908.

1910--Many fires burned in western Washington and Oregon, but none of any consequence and apparently no fires occurred on the Olympic National Forest. The big fires in this summer occurred in Idaho and Montana.

1916 to 1920--Many small to moderate fires burned on the Forest during these dry years. Most were logging related fires, although some were caused by lightning. Most of these fires occurred in the rainshadow of the Olympics, especially in Environmental Zones 9, 10, and 11. The biggest of these fires were :

Duckabush Fire - 4810 acres (1918)
Littleton Fire - 3200 acres (1920)
Slab Camp Fire - 3000 acres (1917)
Dosewallips Fire - 2665 acres (1918)
Canyon Hill Fire - 2170 acres (1918)
Mt. Zion Fire - 2000 acres (1916)

1922--Duckabush Fire. Another 2000 acres burned in the Duckabush drainage in 1922.

1924 and 1925--This was another dry period with many fires in the Olympics, mostly in the rainshadow area. The biggest of these fires were:

Green Mt. Fire - 9615 acres (1925)
Twin Creek Fire - 9250 acres (1924)
Discovery Bay Fire - 5000 acres (1924)
Snow Creek Fire - 3825 acres (1925)
Snow Creek Fire - 3100 acres (1924)
Phoenix Camp Fire - 3080 acres (1924)
Penney Creek Fire - 1774 acres (1924)

1928--The Hobi Fire burned 3507 acres near Quinault. In 1927, 35,000 acres of the Yacolt burn in the Lewis River reburned.

1929--Many lightning fires were started this year. The Forest recorded 85 lightning caused fires. The biggest was the Interrorem Fire which burned 8602 acres in the lower Duckabush and Fulton Creek drainages. Also, 1495 acres burned in the Hamma Hamma drainage.

1930--This was another year with many lightning fires, 120 on the Forest, but none larger than 1000 acres.

1932–The Hamma Hamma fire started from logging and burned 2165 acres.

1933–A few small fires burned on the Forest. The Tillamook fire in Oregon covered about 250,000 acres.

1939–The Deep Creek Fire burned 13,000 acres of which 3460 acres were on the Olympic National Forest.

1942–Two fires burned in the Bear Creek-Calawah River area and covered 5844 acres.

1951–The Great Forks Fire, also called the Port Angeles-Western (PAW) Fire covered about 33,000 acres (18,500 acres of National Forest land) (Figure 8). In August, a fire started along the Port Angeles-Western right-of-way. The fire was contained, but by September 19th it flared up again. By the morning of September 20th it was raging out of control, carried by a strong east wind. At 2:30 pm everyone in the town of Forks was ordered to evacuate. The town was thought to be doomed. By evening the wind shifted, and an oncoming low pressure system helped stop the fire at the outskirts of town. Over 30 buildings were burned, including one mill, a motel, and 28 houses (Smith 1976, Campbell 1979).

1952–At least two fires burned in the Bear Creek-Deadman Creek area, and covered about 16,000 acres. This was the last big fire to occur on the Forest.

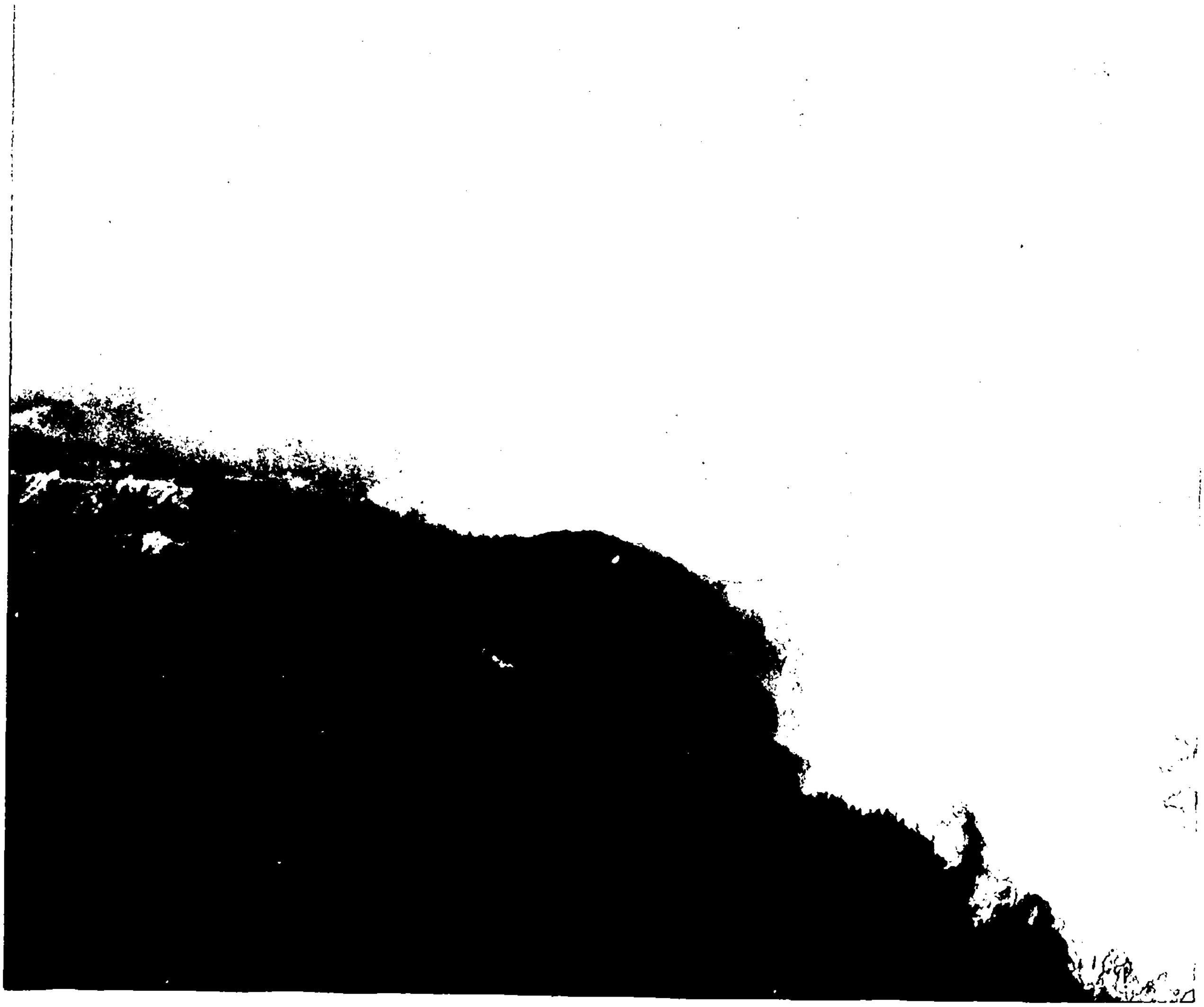


Figure 8. The Forks Fire of 1951. Aerial view of the fire on September 20.

Since 1952 the Olympic National Forest has averaged less than 300 acres of fire per year. The worst years were 1975 and 1984 when 1003 and 1016 acres burned. Although fire fighting techniques have certainly improved since the early years, the two main reasons for these decades of low fire occurrence are: 1) greatly improved prevention, as most of the severe historical fires were man-caused and therefore preventable and 2) a change in the summer precipitation pattern (Figure 21 p. 37). During the decades of the 1910's and 1920's,for example, summers with less than 2 inches of precipitation were common. During the period from 1953 to 1983, there were only two years with summer (June, July, and August) precipitation less than 2 inches at the Olympia weather station. Of course much of the Forest gets more rainfall than Olympia. In this context, this figure is used as an index to show the marked difference between the summer precipitation pattern during the period when there were extensive fires on the Forest and the summer precipitation pattern during more recent times when relatively few acres burned.

The patterns of past fires also correlate with plant associations and vegetation series. In the cooler, moister associations, fires appear to have been much less frequent than on drier or warmer types. An analysis of the reconstructed fire patterns showed that the Sitka Spruce, Silver Fir and Mountain Hemlock Zones had much less acres burned than the Western Hemlock, Subalpine Fir or Douglas-fir Zones. During the last 340 years, only 30 percent of the area of the Silver Fir or Mountain Hemlock Zones had burned, while 128 percent of the Western Hemlock Zone burned. The fire return period for the Sitka Spruce, Mountain Hemlock and Silver Fir Zones for the last 800 years were 900, 844 and 629 years, respectively; for the Western Hemlock, Subalpine Fir and Douglas-fir Zones they were 234, 208 and 138 years respectively (Table 2). These relationships reflect the environmental differences between different groups of associations even at the series level. They also suggest that the occurrence of wildfires in the future will vary by plant association or vegetation series.

Table 2. Summary of fire history statistics by vegetation zone.

	Western Hemlock Zone	Silver Fir Zone	Sitka Spruce Zone	Subalpine Fir Zone	Moutain Hemlock Zone	Douglas-fir Zone
Acres	430,500	163,600	19,000	14,300	17,300	2,200
Percent of Forest	64	24	3	2	3	<1
Average Fire Return Period for the last 800 years	234	629	900	208	844	138
Acres burned since 1645 (340 years)	550,500	49,200	7,000	19,000	5,100	3,700
Percent of acres burned in the last 340 years	128	30	37	133	30	168

WIND DISTURBANCE HISTORY

Wind is an important element in the ecosystems of the Olympic Peninsula. In the last century, hurricane force winds have hit the coast of Washington on the average about every 20 years. Our earliest record of a stand destroying windstorm comes from the log of the English sea captain John Meares, who in 1788 noted extensive areas of blowdown along the Washington coast, with "trees all lying in a southwest to northeast direction" (Ficken 1987).

Stand ages and historical records show that a significant storm occurred in 1780-88, 1880, 1895, 1921 (January 29), 1923, 1955, 1961 (December 16), 1962 (October 12), 1979 (November 27, 28), and 1981 (November 13, 14). The most violent storms were the "21 Blow", in 1921 and the "Columbus Day Storm" in 1962. These storms originated in the tropics as typhoons. The Columbus Day Storm of 1962 began as typhoon Freda (Lilly 1983, Lynott and Cramer 1966). Occasionally these "super storms" stray into the North Pacific and when they contact the jet stream the low pressure is intensified. As the jet stream carries the storm onto the coast it results in a brief but violent windstorm (Lilly 1983). The highest wind from one of these storms was on October 12, 1962, when wind gusts at the Cape Blanco Loran Station were estimated at 170 mph. At that point the anemometers had already been broken (Lynott and Cramer 1966). During the 21 Blow the anemometers at the North Head weather station at the mouth of the Columbia River had been disabled at 132 mph and estimates put the wind at about 150 mph (Campbell 1979).

The 21 Blow of January 29, 1921 (Figure 9), was called the "Big Blowdown" by early residents of the Peninsula (Campbell 1979). It affected an area about 30 miles wide, extending from the mouth of the Columbia River to Vancouver Island, and blew down an estimated 6.7 to 8.0 billion board feet of timber (Pugh 1963, Campbell 1979). Much of the timber was salvaged, but much of it rotted where it fell. A survey in the Olympic National Forest (Boyce 1929) found that western hemlock and silver fir accounted for almost 40% of the volume, while Sitka spruce, Douglas-fir and western redcedar amounted to only about 25%. Boyce (1929) also noted that not only was there more western hemlock and silver fir in the affected area, but that these species appeared to be more susceptible to windthrow than Douglas-fir and western redcedar. Western hemlock and silver fir deteriorated very rapidly, followed by Sitka spruce, while Douglas-fir and western redcedar were more resistant to decay. Causes of deterioration of windthrown trees in the first couple of years included ambrosia beetles and blue stain fungi. After about three years wood rots become common; *Fomitopsis pinicola* (brown crumbly rot, p. 69) and *Ganoderma applanatum* (=*Fomes applanatus*), (white mottled rot) caused the greatest loss from decay (Boyce 1929).

The Columbus Day Storm of October 12, 1962, blew down an estimated 11 billion board feet of timber in Washington and Oregon (Pugh 1963). It affected a much wider area than the 21 Blow, including considerable area in the Coast Range of Oregon. It caused more damage than any other recorded storm in Northwest history. Damage was estimate at 260 million dollars and 31 people died. The amount of timber leveled by the storm approximated the amount of timber cut from Oregon and Washington in one year (Lynott and Cramer 1966).

The historical record shows that ten known storms of hurricane force winds have hit the coast in the past 200 years, with two of these having winds in excess of 150 mph. On this basis, there seems little doubt that such storms will continue to periodically batter the west side of the Olympic Peninsula, and that forest management strategies will have to deal with this natural phenomenon.

Figure 9. Photo of windthrown timber from the "21 Blow" Storm of 1921.
(Photo courtesy the Bert Kellogg Collection and Jack Zaccardo).

Geologic History of the Olympics

The story of the Olympic Mountains is a chapter in the building of the Cordillera, which began sometime prior to the Jurassic Period (Mintz 1972) (Figure 10). At that time, according to the theory of plate tectonics, the North American continent split from Europe and began moving west, setting into motion the events which eventually built all the mountains of the West. The western edge of the continent collided with an oceanic plate which was moving east. At the point of contact the oceanic plate was pulled downward (subduction), and was overridden by the continental plate. During this collision, the continental plate scraped off sediments and volcanic material being carried by the oceanic plate. This material buckled upward. Later, when the subduction zone shifted further west, this whole mass bobbed upward as it was released from the downward pull of subduction.

For the story of the Olympic Mountains, we only need to look back as far as the Eocene (58 million years ago). During this time, the coastline was roughly along the front of the present Cascade Mountains. However, the Cascades had not yet been built. There was only a rolling lowland extending far inland. The climate was much warmer than today, and without a mountain range to interrupt the flow of moist air, the rain penetrated the mainland a considerable distance (Chaney and Axelrod 1959, Wolfe 1969). Apparently, much of the present Pacific Northwest was a large subsiding terrestrial basin, where sediments and volcanics were accumulating (McKee 1972).

During the Oligocene (30 million years ago) the Olympic bedrocks began to take shape (Figure 11). At this time the subduction zone (the contact between two tectonic plates) was where the Puget-Willamette Trough is now (Warren 1982). A tremendous thickness of marine sediments, plus a chain of basalt seamounts, had accumulated on the eastward moving Juan de Fuca (oceanic) plate. As this plate was forced to bend down and under the continental margin, sediments were scraped off and added to the continental margin. At least one large seamount was also scraped off and became part of the Crescent Formation (peripheral rocks). The upper part of this formation is mostly columnar basalts presumed to have come from seamount islands (Tabor 1975). The lower part consists of pillow basalts deposited under water in the seamount(s). At some point, perhaps as late as the Miocene, a piece of sea floor basalt (a piece of the Juan de Fuca plate itself?) may also have broken off and became wedged under the seamount basalt (Glassley 1973). This massive underthrusting caused an extensive series of folded thrust faults, the largest of which are called the Calawah, Hurricane Ridge and the Southern Fault zones (Tabor and Cady 1978). These major faults which date to the mid-Miocene (17 million years ago), mark the time that the Olympic Mountains first began to build (Glassley 1973)..As more sediments accumulated from the west, they were thrust under the rocks of the Crescent Formation and associated peripheral rocks, undergoing much folding and faulting in the process. These marine sediments became what is known as the core rocks, and consist mostly of sandstones, siltstones, shales and conglomerates. The core rocks are most deformed deeper and towards the center, and along the contact zone with the Crescent Formation. The intense pressure generated by the underthrusting may have actually squeezed the seamount basalts into a notch in the continental margin resulting in the present day horseshoe shape of the Crescent Formation (Tabor 1975, Beck and Engebretson 1982). Fossils show the sedimentary core rocks to be younger than the Crescent Formation, but because they lie under the Crescent Formation there was originally much confusion about this aspect of Olympic geology. Development of the Theory of Plate Tectonics provided the key to unlocking this underthrusting mystery.

The subduction currents under the Olympics stopped about 12 million years ago (Pliocene). At this time the subduction zone may have shifted to the west. Released from the downward pull of subduction, the materials which had been added to the margin of the continent, began to rise since they were less dense than the mantle into which they were being pulled (Warren 1982). The Olympic Mountain mass is probably still rising, although perhaps not as fast as it is being eroded (Tabor 1975).

ERA	PERIOD	EPOCH	EVENTS	TIME
				present
CENOZOIC	QUATERNARY	PLEISTOCENE	Human cultures evolve. Olympic Mountains continue to rise as glaciers and water wear them down. Forests dominated by conifers.	
				2 my ago
CENOZOIC	TERTIARY	PLIOCENE	Olympic Mountains begin to rise. Subduction zone shifts to the west. Forests dominated by angiosperms, with some conifers.	
				13 my ago
CENOZOIC	TERTIARY	MIOCENE	More sediments scraped off ocean floor and added to the continental margin. Much folding, faulting and thrusting of the Olympic rock formations.	
				25 my ago
CENOZOIC	TERTIARY	OLIGOCENE	Seamounts scraped off oceanic plate and added to the continental margin at the subduction zone.	
				36 my ago
CENOZOIC	TERTIARY	EOCENE	Volcanic island arc forms in ocean. Columbia Embayment accumulates thick beds of sediments.	
				58 my ago
CENOZOIC	TERTIARY	PALEOCENE	Coastline is approximately along the front of the present day Cascade Mountains.	
				63 my ago
MESOZOIC	CRETACEOUS			
				135 my ago
MESOZOIC	JURASSIC		North American Plate moves west.	
				190 my ago
MESOZOIC	TRIASSIC		North American Plate splits from Europe and starts moving west.	
				225 my ago

Figure 10. Geologic Time Line showing the major events in the building of the Olympic Mountains.

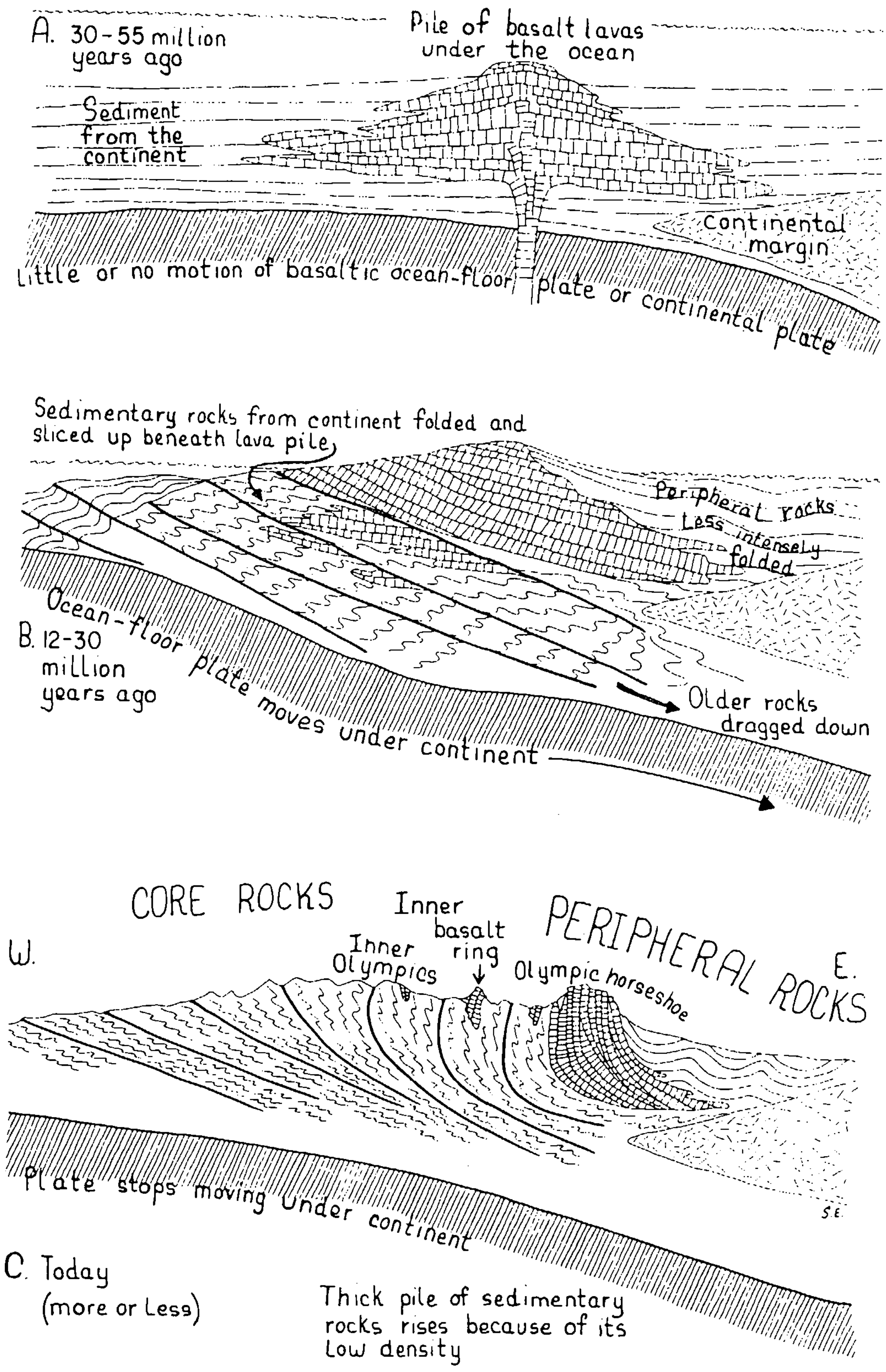


Figure 11. The origin of the Olympic Mountains (adapted from Tabor 1975).

As the Olympic Mountains rose, they began to intercept moist air flowing in from the Pacific, stimulating greater precipitation. The rising mountain range formed into a circular mass and precipitation ran off carving a radial pattern of stream valleys. This erosional process was greatly accelerated by the carving of glacial ice in the Pleistocene and continues to the present day, with streams now eroding into the glacially widened valleys.

Bedrock Geology

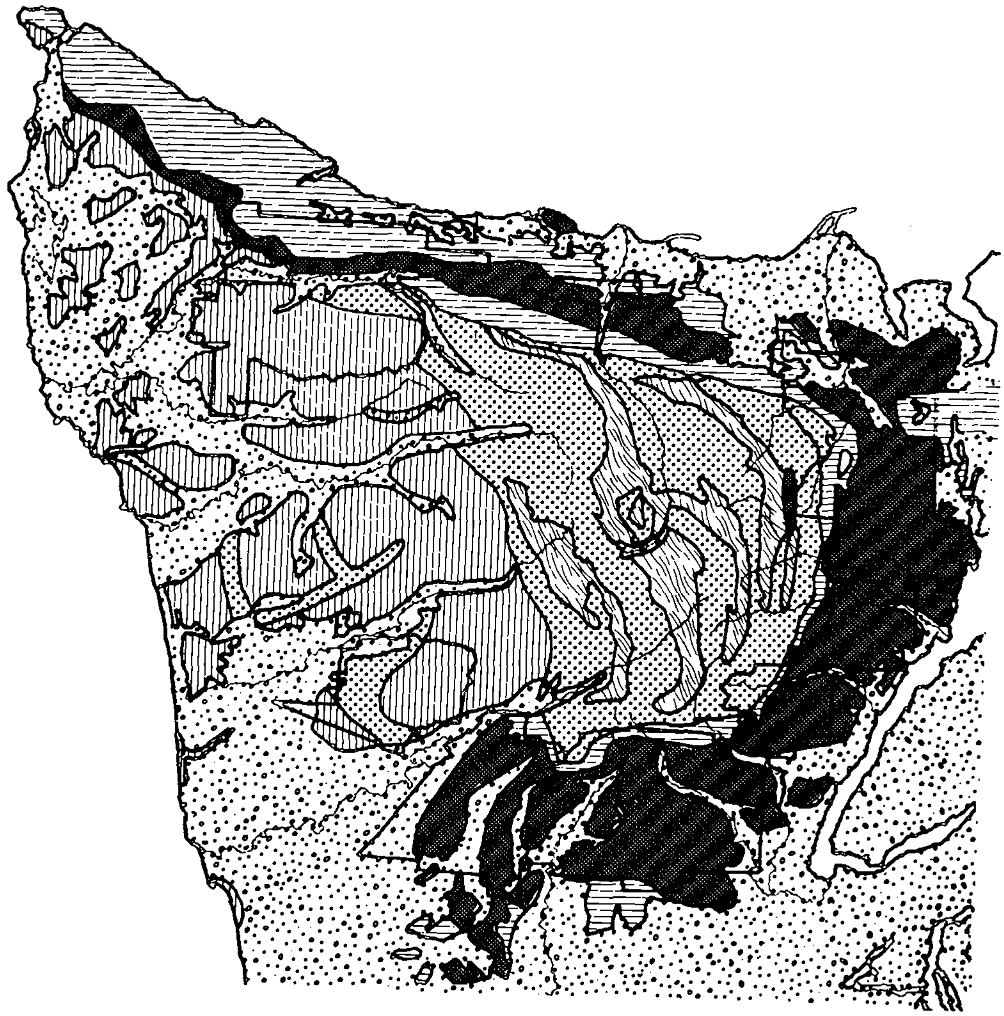
The two basic rock types in the Olympics are sedimentary and volcanic (Figure 12). The sedimentary rocks comprise most of the center and western part of the Peninsula and are often referred to as the "core rocks". The volcanic rocks which comprise most of the Crescent Formation occur around the northern, eastern and southern fringe and are often referred to as the "peripheral rocks" (Tabor and Cady 1978). All of the volcanic and many of the sedimentary rocks are of Eocene age. Most of the remainder of the sedimentary rocks are Oligocene (36-25 million years ago) and Miocene age (25-13 million years ago) (Tabor and Cady 1978).

The volcanic Crescent Formation appears to overlie the sedimentary core rocks, and it was once thought that the core rocks were older (McKee 1972). However, fossil evidence shows the opposite to be true. Interbedded in the Crescent Formation are early to mid-Eocene pelagic red limestones, Eocene coccoliths (planktonic algal remains), Eocene gastropods (snails), and mid- to late Eocene foraminiferans (oceanic unicellular organisms) (Tabor and Cady 1978). Fossils in the sedimentary core rocks, on the other hand, span the time from Eocene to mid-Miocene, and are therefore partly younger. The sedimentary core rocks have been thrust under the older volcanics of the Crescent Formation along a series of thrust faults which now separate the two rock groups (Tabor and Cady 1978) (Figure 11).

The Crescent Formation can be divided into upper and lower members. The lower Crescent is mostly pillow basalt (Figure 13) with a few sedimentary interbeds. It is prominent in some of the higher peaks of the southern, eastern and northern Olympics. The upper member is prominent along Hood Canal and is characterized by volcanic breccia, some sedimentary interbeds and columnar jointing although pillow basalts are also present. Interbedded with the lower member are red limestones which sometimes contain copper and manganese ores. These ores have been mined or prospected in the vicinity of Lake Crescent, Mt. Constance, Buckhorn Mtn. and Mt. Cruiser, but none have become major sources (Tabor 1975).

Basalt of the Crescent Formation is a dense, hard volcanic rock rich in iron and magnesium minerals. It is more resistant to erosion than the sedimentary rocks associated with it. Most of the Olympic basalts are massive (without bubbles) but some vescicular basalt formed when gas bubbles were present as it cooled. Basalt extruded into the sea cooled quickly on the surface forming pillow and tube shaped structures. Nearly all of the lower Crescent basalts are of this kind. Basalt extruded on land cools more slowly and often develops large hexagonal shrinkage joints. This columnar basalt is found in the upper Crescent Formation which demonstrates that islands did form on top of the seamounts. Violent eruptions of lava often release much pulverized and broken rubble which may solidify into rock. This is called volcanic breccia if the pieces are large, or tuff if they are smaller. Deposits of breccia and tuff are found in the Crescent Formation in the Klahhane Ridge, Mt. Angeles, Silver Creek, Silver Lake, upper West Fork Satsop River and Stovepipe Mt. areas (Tabor 1975, Tabor and Cady 1978). Dikes and sills of more coarsely crystalline diabase and gabbro are common in the basalts and sedimentary beds of the Crescent Formation. These formed when basaltic lava was injected into cracks in the rock formations but never reached the surface (Tabor 1975).

The core rocks are mostly composed of different marine sedimentary rocks including sandstone (Figure 14), shale, and conglomerate. Olympic sandstones occur both as interbeds in the Crescent volcanics and as a major component of the core rocks. Sandstone is softer than basalt, but more resistant to erosion than shale or slate (Tabor 1975) and tends to form ridges and peaks in areas of other sedimentary rocks. Mt. Olympus is primarily sandstone. Olympic sandstones are mostly graywackes (poorly sorted sandstones containing rock fragments as well as quartz). They often contain much



Unconsolidated Sediments

Glacial outwash, glacial till, alluvium, etc.

Peripheral Rocks--primarily Crescent Formation

Predominantly extrusive volcanics (mostly basalt and metabasalt)

Sedimentary rocks--sandstone, shale, and conglomerate

Core Rocks--primarily marine sediments

Highly folded, little disrupted sandstone, shale and other sedimentary rocks

Highly folded, highly disrupted sandstone, shale and other sedimentary rocks

Highly folded, highly disrupted slate

Figure 12. Map of the bedrock geology of the Olympic Mountains (modified from Tabor 1975).

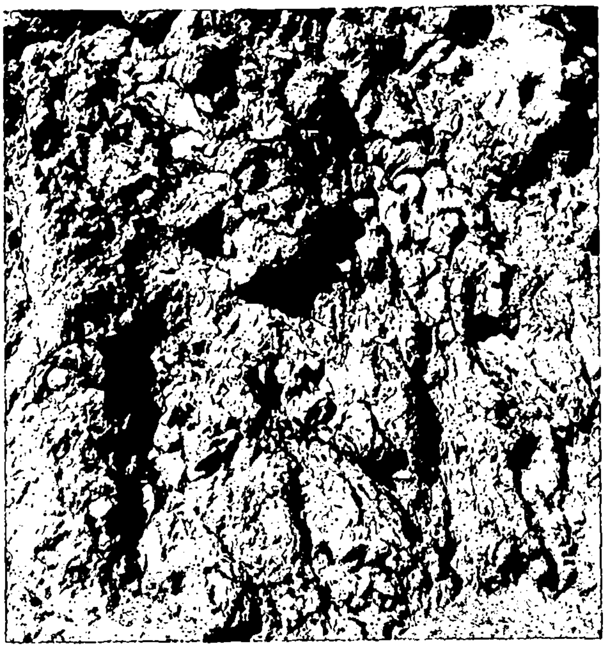


Figure 13. Pillow basalt from the Crescent Formation, upper Dungeness River valley.

Figure 14. Sandstone outcrop representing the sedimentary core rocks from Three Peaks in the southern Olympics.

feldspar and mica and may also contain tuff or volcanic grains. The cementing agent of marine sandstones is often calcareous, which is quite susceptible to chemical weathering. The forces of underthrusting have metamorphosed some of the sandstone into semischist (Tabor 1975).

Shale is fine-grained sedimentary rock formed from mud. Olympic shales are of marine origin and are composed of clay minerals, quartz, feldspar, and micas (Tabor 1975). Shales are quite prominent in the core rocks and occur in the Crescent Formation as interbeds. Some shales in the core rocks were metamorphosed into slate and phyllite by the forces of underthrusting. Slope failures are a common problem on steep slopes underlain by shale bedrock tilted with the bedding planes parallel to the slope.

Olympic conglomerates are also of marine origin. and formed from gravels or larger fragments. If the gravels are angular, the term breccia is used. Conglomerates are often quite hard and may form ridges (Tabor and Cady 1978), such as Mt. Zion.

Glacial History

The glacial history of the Olympic Peninsula is not well known. In general, we recognize two geologic epochs: the Pleistocene which includes the glaciations of the last million years or so, and the Holocene which begins about 10,000 years ago and includes the present. The Wisconsin Ice Age includes several glaciations between 10,000 and about 100,000 years ago. The Holocene is divided into the Hypsithermal (Deevey and Flint 1957) from about 10,000 to about 4000 (Porter and Denton 1967), the Neoglacial period from about 4000 years ago to about 138 years ago, and the Modern Period since about 1850 (Figure 15).

During the period from about 30,000 to about 1 million years ago there were several glacial-interglacial periods. Little is known about these episodes in terms of their extent or the climate-vegetation relations. Even the absolute ages are uncertain. The Salmon Springs Glaciation was ap-

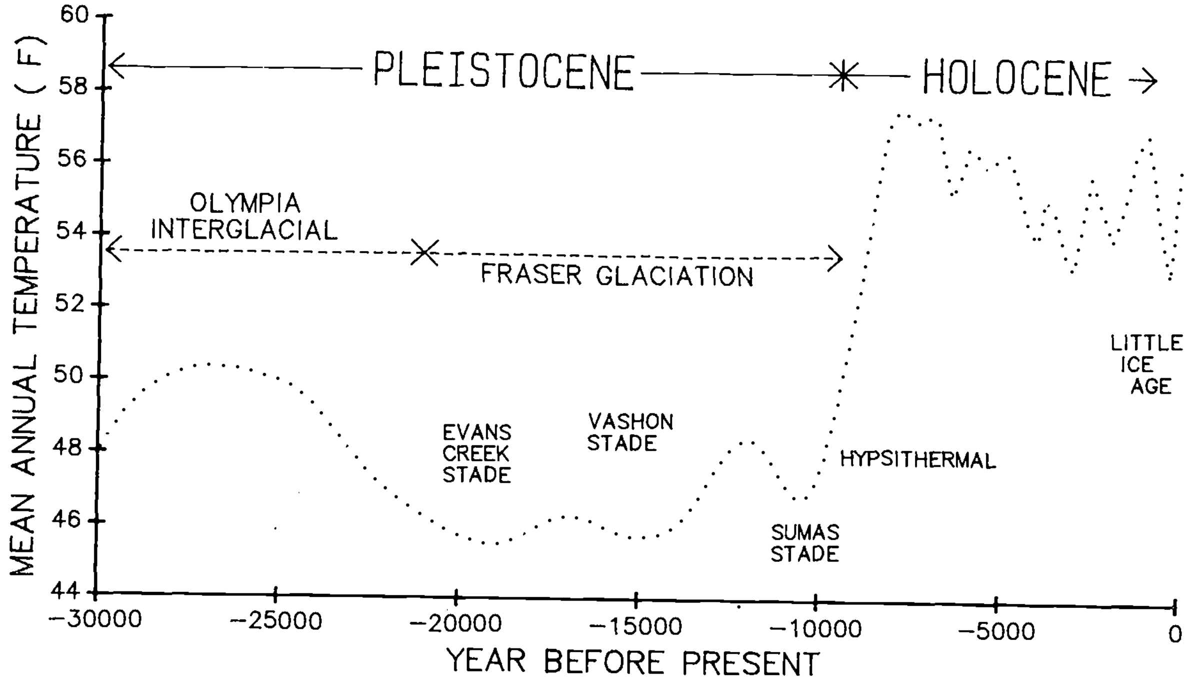


Figure 15. The climate of the past 25,000 years as depicted by mean annual temperature.

parently the most recent of these periods. In extent and climate it was probably similar to the Vashon episode described below.

Prior to the Salmon Springs glaciation in order of increasing age were the Puyallup Interglaciation, Stuck Glaciation, Alderton Interglaciation and Orting Glaciation (*ca.* 80,000 years ago) (Crandell *et al.* 1958, Armstrong *et al.* 1965). During the Stuck and Salmon Springs Glaciations, the Hoh Glacier apparently extended to the sea. During the Stuck Glaciation (about 50,000 years ago), the terminus of the Hoh Glacier was about 1000 feet thick. During the Salmon Springs all major valleys in the Olympics contained glaciers.

Glaciers in the Queets, Quinault and Humptulips valleys all fed piedmont lobes which were responsible for the flat to rolling, gravelly and cobbly outwash deposits of the Wedge Point and Cook Creek areas of the Quinault District. In the Wynoochee drainage, glaciation caused a major change in the drainage pattern. Prior to glaciation, the West Fork of the Satsop River drained into the Wynoochee River near the Satsop Work Center (Long n.d.). As the glacier slid past the old mouth of the West Fork of the Satsop River, it formed a dam and created a large lake. The lake surface probably lay at about 1100 feet when it found a new outlet east of Weatherwax Ridge and began to rapidly cut a new channel. Before the glacier retreated, the rock gorge of the West Fork of the Satsop River had been cut deeper than the original outlet, thus permanently changing the drainage pattern (Long n.d.).

Following the Salmon Springs Glaciation there was a cool, dry period called the Olympia Interglacial (Figure 15). The vegetation at that time was quite different from today, being characterized by species of spruce and pine (lodgepole) (Armstrong *et al.* 1965). Many early authors presumed that the spruce pollen from this period was Sitka spruce, thereby inferring a cool moist climate during the Olympia Interglacial. However, Barnosky (1981) identified two macrofossils of Engelmann spruce from Davis Lake. The implication, therefore is that the Olympia Interglacial was a cool, dry period just prior to the Fraser Glaciation.

The most recent of the Wisconsin Ice Age events was the Fraser Glaciation. It lasted about 10,000 years and consisted of three cold stages (called stades) and two warmer stages (or interstades) (Figure 15). The earliest of these was an advance of alpine glaciers about 18,000-21,000 years ago called the Evans Creek Stade (Figure 15). Alpine glaciers in the Olympics (and throughout much of North America) accumulated mass and moved down the major valleys. The valleys on the west side of the Olympics contained large glaciers that extended nearly to the ocean. The glaciers of the drier northeastern valleys were much smaller, often being restricted to the headwalls or upper parts of the side valleys. Many previously forested cirques filled with glaciers or permanent ice, and timberline was considerably lower than today (see Paleobotanical History pp. 54-55, Climatic History pp. 32-33). Alpine timberline at this time was probably about 3000 feet elevation as the temperatures were believed to be 10-12 degrees F colder (Heusser 1973b).

This alpine glaciation was followed by a contential glaciation called the Vashon Stade (Figure 15). It was perhaps not the largest of the Pleistocene continental glaciations, but was the most recent, and shaped the landscape of Puget Sound that we see today. Massive ice sheets began moving south out of the Coast Range of British Columbia sometime after 25,000 years ago. By 15,000-18,000 years ago, the glaciers had reached the northern part of Puget Sound (Armstrong *et al.* 1965). Estimates from the area south of Seattle indicate that the ice front was moving south about 400 feet per year (Crandell 1965). At its maximum, about 13,000 years ago, the glacier was about 3,000 feet thick in the vicinity of Seattle (Armstrong *et al.* 1965) and about 6,000 feet thick near Bellingham (Easterbrook 1969).

The glaciers followed river valleys and low channels and carved them deeper as they advanced. They scoured over much of the North Cascades, and gouged their way down the Puget Trough south past Olympia. They split when they reached the Olympic mountains, however, with part moving down the east side of the Olympics and the Puget Trough, and part following the Strait of Juan de Fuca along the northern portion of the Olympics. This lobe of the continental ice sheet gouged its way around the west side of the Peninsula and south to about the Bogachiel River (Figure 16).

The extent of the Vashon Stade (continental) ice sheet on the Olympic Peninsula is shown in Figure 16 (Armstrong *et al.* 1965). The area affected on the Olympic National Forest includes the northern part of the Soleduck District, including Snider Ridge and Ellis mountain, and the northeast corner of the Quilcene District to about Ned Hill and Bon Jon Pass. On Mt. Zion the ice extended to at least 3550 feet above sea level (Long n.d.). The ice extended up the Dungeness Valley about 11 miles to about 2500 feet elevation and up the Gray Wolf to an elevation of about 1600 feet. In the Elwha it pushed up the valley to about Olympic Hot Springs at 2350 feet elevation (Long n.d.). Along Hood Canal, the Puget glacial lobe rode up over Mt. Walker, but only skimmed along the eastern part of the Olympic National Forest down to Lake Cushman. (Old Lake Cushman formed behind a glacial moraine of this time period.) The Dennie Ahl area and the South Fork of the Skokomish Valley were covered with ice at this time, as was the site of Olympia, all of Hood Canal, part of the Black Hills, and the Puget Trough east to the Cascades.

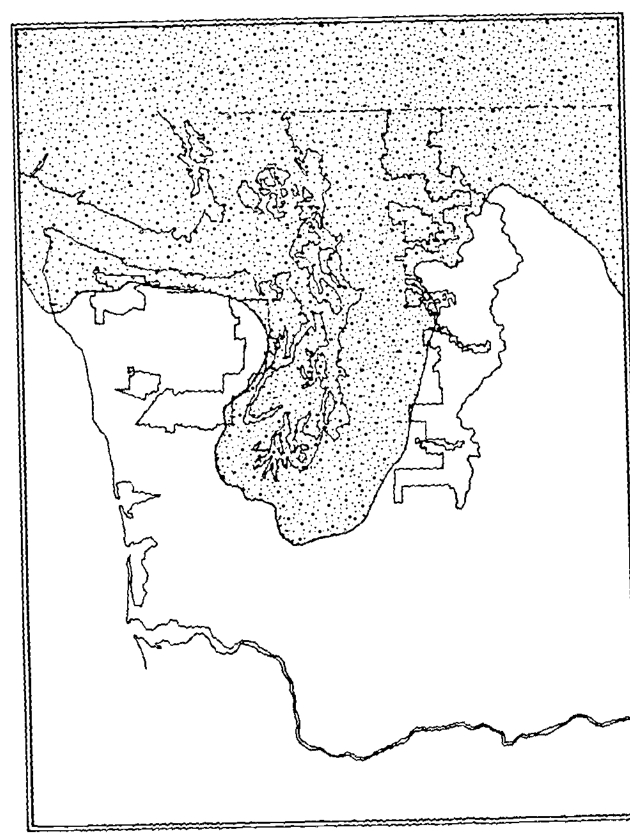


Figure 16. Map of the extent of glaciation during the Vashon Stade (adapted from Armstrong *et al.* 1965).

Many large lakes formed behind ice dams of the continental ice sheet (Warren 1982). Thick beds of fine sediments accumulated in these lakes, especially in the Gold Creek, Dungeness and Gray Wolf drainages. In some cases these buried silt or clay layers are overlain by coarse gravelly material which has been interpreted as outwash that followed recession of the continental ice sheet. However, some of this "outwash" may be contemporary with fossil bearing glacio-marine sediments of the Everson Interstade when sea level rose several hundred feet. Following the Vashon Stade, there was a warm interglacial period (from about 11,000-14,000 years ago) (Figure 15). This was called the Everson Interstade. Glaciers receded and sea level rose briefly to several hundred feet above the current level (Easterbrook 1969).

The last episode of the Fraser Glaciation is known as the Sumas Stade (about 10,000 years ago) (Figure 15), named after till left in the lower Fraser Valley near the town of Sumas, Washington. Its effect was minor compared to the earlier ice advances. During this time, alpine glaciers expanded and some major valleys filled with ice. It was short-lived and marked the end of the Wisconsin Ice Age and the transition to the Holocene Epoch (Figure 15).

A major climatic change apparently took place about 10,000 years ago. The cold, dry Ice Age climates gave way to a warmer, but still dry, postglacial climate called the Hypsithermal (Hammond 1976) (Figure 15). The Hypsithermal was followed by the slightly cooler and much wetter Neoglacial period in western Washington. It corresponds to the period when the modern vegetation (as we know it) became established (see Paleobotanical History pp. 54-55). Early in the Neoglacial period there were glacial advances comparable to the Little Ice Age (Figure 15). On Mt. Rainier moraines of the Burroughs Mountain Stade were built between about 3500 and 2000 years ago (Porter and Denton 1967). This glacial advance is not often mentioned in accounts of the Neoglacial period. This may be because most of the morainal evidence for this period has been overrun or obliterated by more recent glaciations.

The Little Ice Age is the last of the glacial-geologic units of the Neoglacial period. It began about 680 years ago (*ca.* 1300 a.d.) and ended about 138 years ago (*ca.* 1850) (Figure 15). Most moraines from this period date from about the years 1400-1550 or from 1700 to 1850 (Porter and Denton 1967, Crandell 1965, Crandell and Miller 1964). The Little Ice Age may have consisted of two or three glacial advances (and recessions) which were apparently not synchronous from mountain to mountain or glacier to glacier. This is apparently due to the relative effect of precipitation and temperature on different glaciers.

We see evidence of the Little Ice Age throughout the higher mountains (Figure 17). Many of the major glaciers in the Cascades and Olympics have receded from their Neoglacial positions (Crandell 1969; Heusser 1957, 1974). This has left small moraines which mark the position of the terminus of the glaciers at that time, and extensive areas between the current position of the glacier and the moraines which are unvegetated, raw glacial rubble. There are also extensive areas which were covered by year-round or long-persistent snowfields only a couple hundred years ago, which are now open rock, scree or talus (Figure 17). The abrupt transition from unweathered rock debris to vegetated areas often marks the extent of these Neoglacial ice fields.

Changes in Sea Level

The relative position of sea level has changed several times during the last 20,000 years. Study of these changes is complicated; not only does the absolute level of the ocean rise and fall as more or less water is tied up in glaciers on the land, but the land mass itself rises and falls under the weight of the glaciers during ice ages. During the last continental ice advance (about 16,000 years ago), sea level in western Washington was 300-400 feet lower than today and the coastline was 5 or 6 miles farther west (Kirk and Daugherty 1978). Almost immediately after glacial retreat, sea level rose to several hundred feet above its current level relative to the land. Easterbrook (1963) put it at 400 feet higher than today, while Armstrong *et al.* (1965) put sea level about 600 feet higher than today, and Crandell (1965) put it about 250 feet higher. This rapid rise in sea level was followed by a rise in the land mass (Crandell 1965). The effect of this rebound was for sea level to recede rapidly to a level contemporary with ice age sea level or about 400 feet below its present level. This occurred about 11,000 years ago (Grebmeier 1983, Crandell 1965, Easterbrook 1963). Then, as if the land mass were vibrating up and down, this scenario apparently occurred again about 10,000 years ago. Shortly after this second inundation, sea level became relatively stable about 33 feet lower than today, and then began rising slowly to the present (Grebmeier 1983).

Figure 17. Photo from the Olympic Mountains showing the Little Ice Age effect. Much of the area of bare rock and talus behind the riders was covered by permanent snowfields during the Little Ice Age. Photo by Asahel Curtis, ca. 1920. (Courtesy Washington State Historical Society.)

CLIMATE

Climatic History

A reconstruction of the long-term climatic history of an area is speculative at best. Even with our extensive network of climatic stations, modern technology and satellites, we still don't understand the current climate very well. We start with an unclear understanding of modern weather patterns and have to deal with an increasing degree of uncertainty as we go back farther in time. However, most paleontologists and geologists seem to agree on some basic aspects of the climatic history of this area. Figure 15 (p. 28) shows a reconstruction of the mean annual temperature for western Washington for the past 25,000 years. It is based on dozens of different pieces of data and references too numerous to conveniently cite here. It serves as the basis for much of the climatic interpretations which follow. This is a rough curve, subject to revision. Also, it implies nothing about the winter to summer variations which might have occurred or the accompanying precipitation patterns.

The climate of today on the Olympic Peninsula is relatively warm and wet compared to what we know of the climate of the past 50,000 years. This modern climate (see p. 34), however, on a global scale, is best described as cool, temperate and maritime. It supports a lush flora and is favorable for the growth of trees. The current climatic period began by the mid-19th century and corresponds to the period of the Industrial Revolution. Even within this short 100-200 year time span there have been important temperature and drought cycles.

Prior to about 1850 and back to about the 14th century, was a period called the Little Ice Age (Mathes 1939, Porter and Denton 1967). It was a period of about 600 years with cold winters, and generally unfavorable climate in the northern latitudes. Its beginning corresponds to the beginning of the Renaissance in Europe, the decline of Viking settlements in the North Atlantic, and the end of Pueblo (Anasazi) cultures along the Mogollon Rim in Arizona (Schneider and Londer 1984). The climate in Europe was cold by modern standards. Icebergs in the North Atlantic were major navigation hazards (Bryson and Murray 1977). The shipping canals in Holland repeatedly froze over, and by 1492, "because of excessive freezing of the waters," no ship had put ashore on Greenland for 80 years. Alpine glaciers expanded in the mountains of Scandanavia, France and throughout Europe and North America, and arctic timberline was many kilometers south of its present limit. In the middle of this period the villages of LaRoziere and Argentier in France were overrun by glaciers, vineyards which thrived in England during the 11th century declined, and the Santa Fe River in New Mexico froze over (Bryson and Murray 1977, Schneider and Londer 1984). While conditions in the northern latitudes may have been more severe, life around the Mediterranean may have been favorable. However, it is important to note that this was not a long period of a homogeneous or stable climate. There was considerable variability, probably in both temperature and precipitation. The coldest periods were probably from 1400-1510 and 1645-1715 (the Sporer and Wolf sunspot minimums) (Eddy 1976, Stuiver and Quay 1980, Schneider and Londer 1984). Towards the end of the Little Ice Age the climate in the Pacific Northwest was apparently cool and wet as interpreted from tree rings and glacial records. This period, from about 1750 to about 1830, was apparently a period of poor growth for most tree species. However, these conditions were apparently favorable to silver fir, which expanded its range at that time.

Evidence for Little Ice Age glacial activity is common throughout the Olympic and Cascade Mountains. There are numerous small moraines which mark the maximum extent of glaciers during this time. There are also extensive areas of bare rock, talus and scree that represent areas covered by year-round snow and ice 200 years ago that now melt off during the summer (Figure 17).

Prior to the Little Ice Age there was a period which lasted from about 1000 to 1300 a.d. which we call the Medieval Optimum (Lamb 1965). Historians also call it the Age of the Vikings. The Medieval Optimum was the period when Vikings plundered much of Europe. The North Atlantic was relatively free of ice during this time and the climate in Newfoundland and Greenland was favorable to Viking settlement. Solar activity was very high during this period (Eddy 1977b, Stuiver and Quay 1980), and the climate was believed to be correspondingly warm (Schneider and Londer 1984).

We characterize the Medieval Optimum as a warm-dry period in the Pacific Northwest. Indirect temperature records (oxygen isotope levels, apparent glacial recessions, and an apparent increase in forest fire frequency) all indicate a warmer climate then. Alpine glaciers probably receded from their current positions. The vegetation of the Olympics probably included greater proportions of Douglas-fir (especially in younger age classes due to the frequency of fires), subalpine fir, lodgepole pine and western white pine, and less Sitka spruce, silver fir and mountain hemlock. Some of the area which is now the Sitka Spruce, Silver Fir and Mountain Hemlock Zones was probably Western Hemlock Zone.

Discovery of plant roots buried deep in the Greenland permafrost suggests that Northern Hemisphere temperatures may have been 2-4 degrees C (3.6 to 7.2 degrees F) higher than today (Lamb 1965). We believe the temperature in the Pacific Northwest was about 1-2 degrees C higher during the Medieval Optimum. It also may have been another 1-2 degrees C colder during the Little Ice Age (Figure 15). Using a temperature lapse rate of 5 degrees C per 1000 m (2.7 degrees F/1000 ft.) potential timberline may have been 650-1300 ft. (200-400 m) higher in medieval times and perhaps lower by the same amount during the Little Ice Age.

Prior to the Medieval Optimum our knowledge about climate in this area declines substantially. There were two or three "Little Ice Age" type glaciations from 1000-4000 years ago, including the Burroughs Mountain Stade (Crandell 1969, Porter and Denton 1967). Climate at those times was probably comparable to the Little Ice Age.

The Hypsithermal Period was about 4,000 to 10,000 years ago (Deevey and Flint 1957). This was a warm-dry period with apparently a more continental climate than today. Palynology studies (Heusser 1964, 1969, 1973a) point to an abundance of alder, lodgepole pine and Douglas-fir, and also the scarcity of many of the tree species we associate with the Puget Sound area today, such as silver fir, western redcedar and mountain hemlock (Dunwiddie 1986).

After the continental glaciers retreated, by about 12,000 years ago, the newly deglaciated surfaces were raw till and outwash with little soil development. Early successional species such as alder and lodgepole pine were well adapted to these conditions. Bracken fern was apparently common in the understory of these forests. The warm, dry summers probably favored frequent forest fires. The pine forests may have burned every 50-100 years as is typical of modern lodgepole pine forests. As pine was replaced by Douglas-fir later in succession and later in the Hypsithermal, the fire pattern may have shifted to a longer period between stand-destroying fires and a shorter interval between ground fires.

Although the Hypsithermal and the Little Ice Age appear to be very different by modern standards, compared to the climate of the previous 100,000 years (during the Wisconsin age glaciations), they are relatively similar and can be considered part of the Holocene climate. Prior to the Hypsithermal there was a series of glaciations which scoured and molded the landscape of the northern latitudes several times. These glaciations are collectively referred to as the Wisconsin Ice Age and include the Fraser Glaciation (Figure 15). This period is generally colder than the modern period, but includes some warmer interstades in which the climate may have been comparable to today. Little is known about the climate of this period with any degree of certainty. The coldest periods of the Wisconsin Ice Age are generally acknowledged to be 10-12 degress F (5-7 degrees C) colder than today (Heusser 1973b). During the periods between glaciations the climate was presumably warmer but specific details of the climate during these periods is very general (Heusser 1973b, Heusser *et al.* 1980).

The climate of the Pacific Northwest cannot be reliably reconstructed for periods earlier than about 25,000 years ago. However, we do know that at a very broad scale, by Pliocene or Miocene time (13-25 million years ago) (see Geologic History p. 22), the climate and vegetation was quite different. This is a time scale that spans millions of years and is significant in the evolution of species and the migrations and evolutions of entire floras. The Cascade Mountains rose from the sea during the Pliocene or Miocene and the Olympics during Pliocene time (see Geologic History p. 22). The absence of major mountain ranges prior to the Pliocene significantly affected the climate and vegetation. The climate during the Miocene was warm, wet and temperate. Many species of hardwoods such as oak, elm and maples dominated. Metasequoia and gingko (now found in China) plus some true fir species are common in the fossil records for that era (Wolfe 1969). The modern flora in the Pacific Northwest developed sometime after the rise of the Cascade and Olympic Mountains.

Current Climate

The climate of the Olympic Peninsula varies from very wet, humid and maritime along the far west coast, to relatively dry and almost continental in the rainshadow of the northeastern corner. Within a distance of only 25 air miles the rainfall varies from over 200 inches to about 20 inches. These values represent both the highest and lowest for western Washington and western Oregon. Weather patterns are strongly influenced by the flow of winter storms and the counter-clockwise air circulation pattern around these storms. The prevailing wind at the front of such storms is from the southwest. The movement of such storms follows the jet stream and varies from northwest to southwest. Winter storms with winds in excess of 50 mph and 24-hour rainfall in excess of 3 inches are common. This pattern is responsible for the very wet climate on the windward (southwest) part of the Olympic mountains and the dry climate on the leeward (northeast) part of the mountains. Table 3 gives summer and annual precipitation, plus mean July and mean annual temperature values for selected weather stations on the Peninsula. The precipitation map shown in Figure 18 gives the average annual precipitation as estimated by the Soil Conservation Service (1965).

The precipitation pattern on the Olympic Peninsula can be partially described by the two lines in Figure 19. The upper line is taken from the precipitation map (Figure 18) and shows the average precipitation for each environmental zone (Figure 24 p. 40). The lower curve shows the average annual precipitation for weather stations near sea level around the peninsula. These stations have an average elevation of 328 feet. A derivative of the two curves shown in Figure 20, represents the effect of elevation on precipitation, given as the change in precipitation (in inches) per 1000 feet elevation gain. In all environmental zones, precipitation increases with a rise in elevation. In Environmental Zone 2, for example, precipitation increases 24.6 inches per 1000 feet, while in Environmental Zone 8 it increases only 8.7 inches per 1000 feet elevation. Thus, the wetter maritime zones show a much greater orographic effect than the drier, more continental zones.

Table 3. Temperature and precipitation data for weather stations on the Olympic Peninsula.

Station	Elevation (ft.)	Mean Annual Temperature[1]	Mean July Temperature[1]	June, July, Aug. Precipitation[2]	Annual Precipitation[2]
Aberdeen	436	50.5	60.5	5.89	82.34
Cushman	760	50.8	64.7	5.10	100.25
Forks	350	49.4	60.2	8.12	119.06
Port Angeles	200	49.4	59.8	2.20	25.38
Quilcene	123	50.1	63.5	4.79	50.98
Quinault	220	51.1	63.3	9.70	134.43
Olympia	206	49.6	63.0	3.54	50.96
average	328	50.1	62.1	5.62	80.48

[1] temperature in degrees Fahrenheit
[2] precipitation in inches

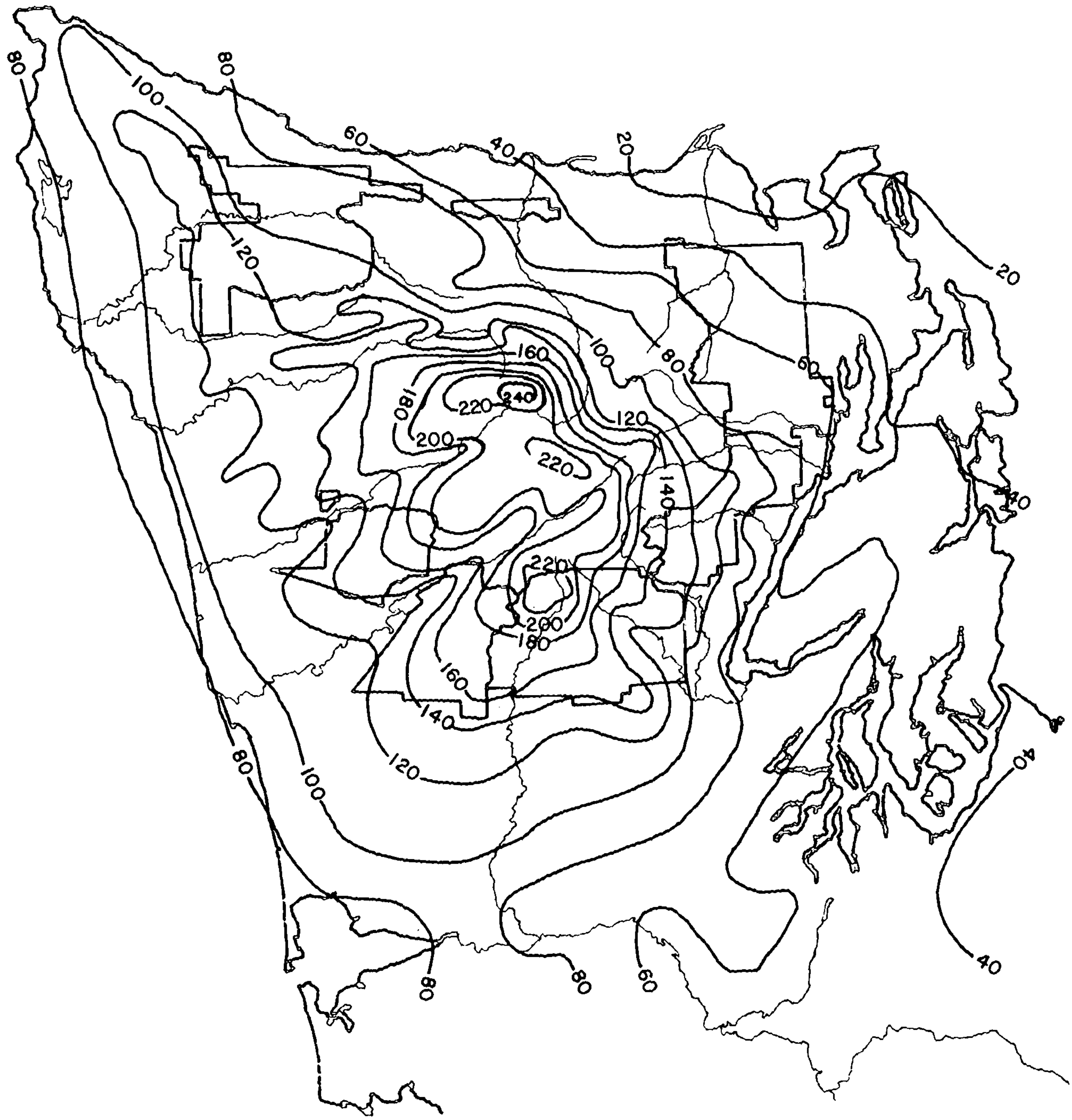


Figure 18. Map of mean annual precipitation (in inches) for the Olympic Peninsula (adapted from Soil Conservation Service 1965).

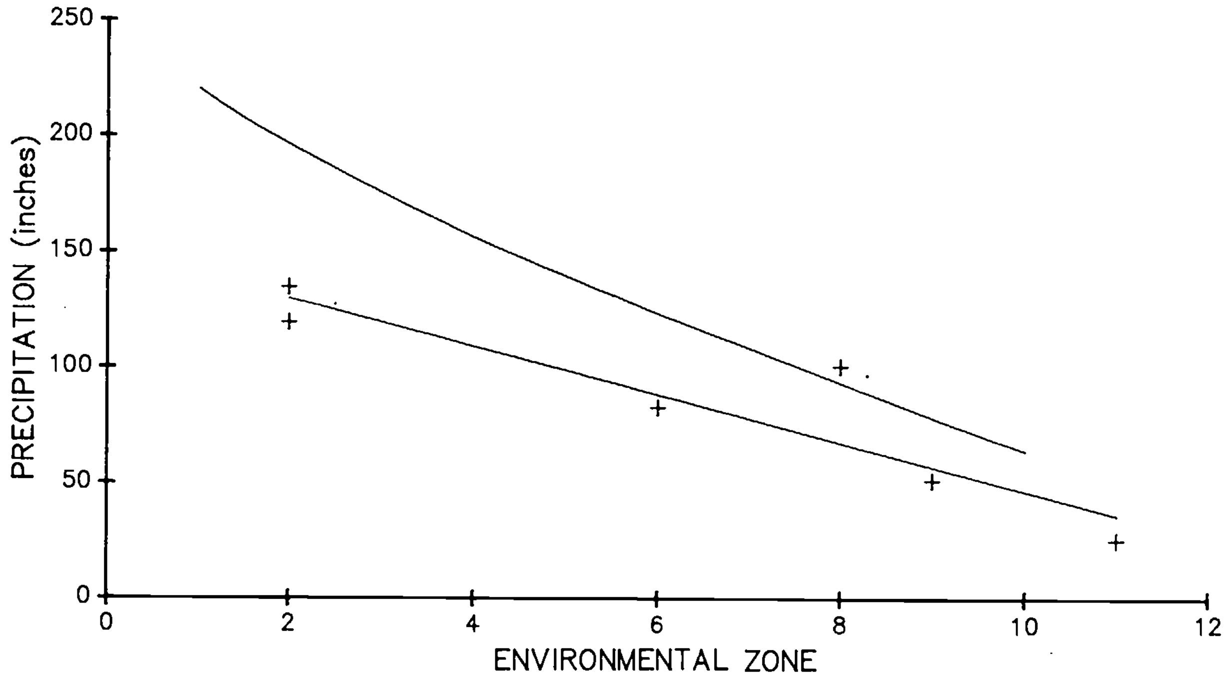


Figure 19. Precipitation by environmental zone. Upper curve is the average precipitation for the zone, the lower curve is sea level precipitation for the zone.

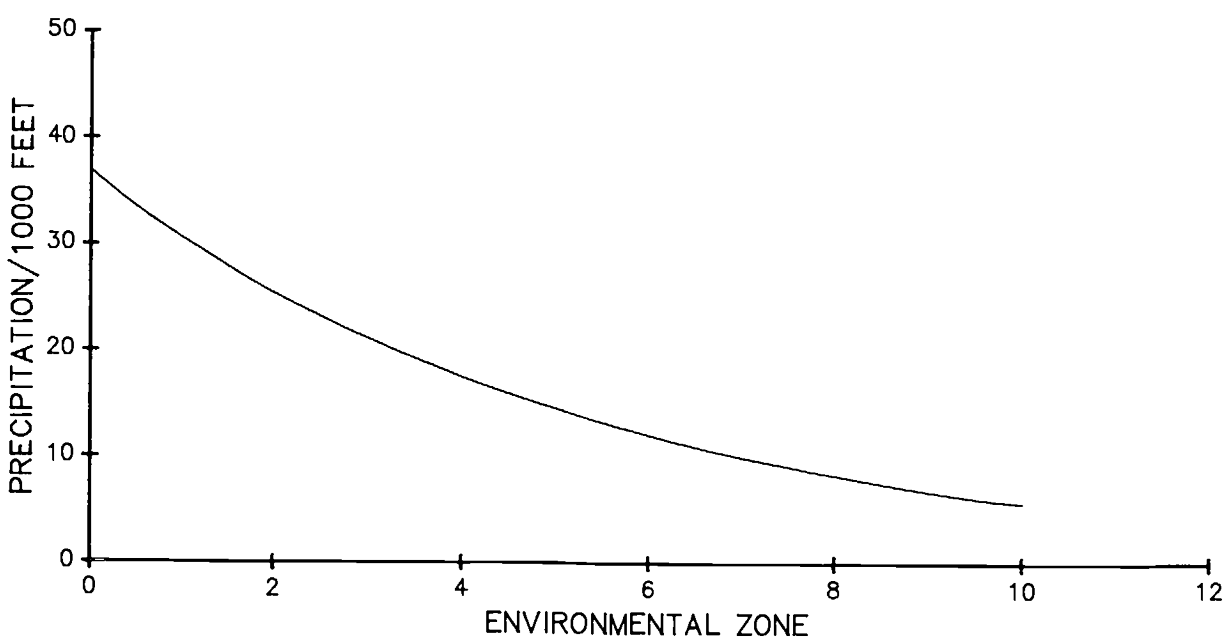


Figure 20. Rate of increase of precipitation by environmental zone. This figure is derived from the two lines in Figure 19.

The climate can also be characterized by having a summer drought. About 7 percent of the total annual precipitation comes in the summer months of June, July and August. Analysis of the summer precipitation records since the early 1900's show considerably less summer precipitation compared to recent decades (Figure 21). This relates to the high frequency of fires during the same period (Figure 7).

Snow accumulations vary from light and intermittent in the Western Hemlock Zone, from 3 to 10 feet in the Silver Fir Zone, 4-6 feet in the Subalpine Fir Zone, and over 10 feet in the Mountain Hemlock Zone. Areas in the Subalpine Meadow Zone may accumulate 20 feet or more of snowpack in a typical winter. Figure 22 shows snow accumulations for the years 1949 to 1983 at Hurricane Ridge in Olympic National Park. This station is in Environmental Zone 10 at 4300 feet elevation.

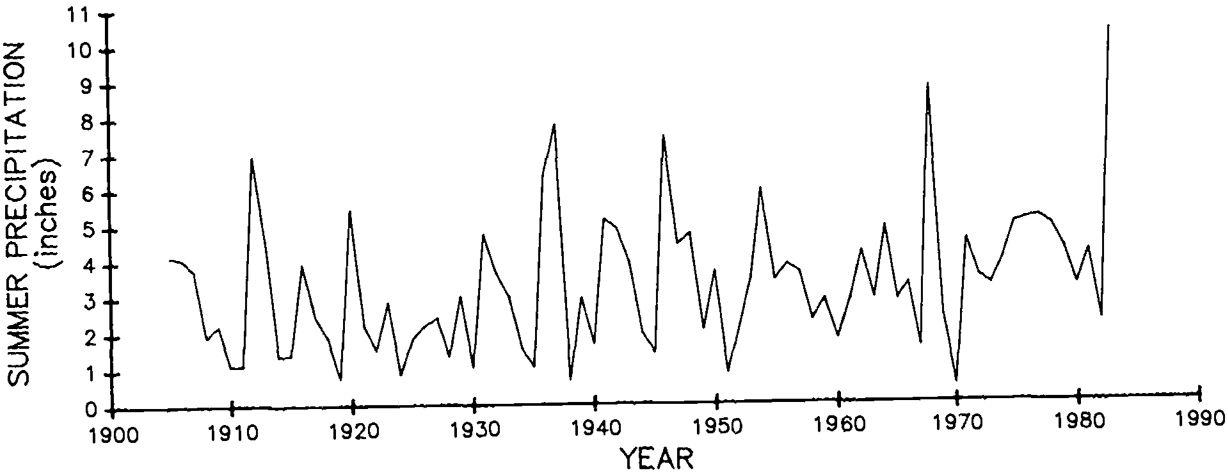


Figure 21. Summer precipitation (June, July, August) for Olympia weather station, 1920-1983. (U.S. Dept. of Commerce)

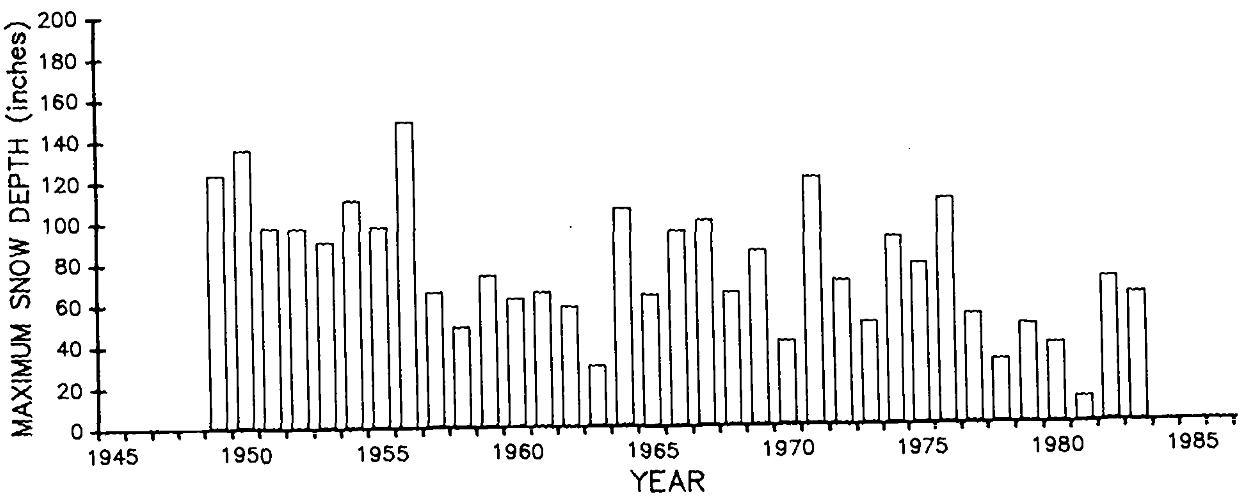


Figure 22. Winter snowpack at Hurricane Ridge.

ENVIRONMENTAL ZONES

Environmental zones are geographical areas of roughly similar environments. They are delimited on the basis of abundance and distribution of plant indicator species. In this way, a certain combination of key species is used to indicate a certain combination of environmental factors. These zones are not based on elevation directly but are related to orographically induced climatic patterns, so that wetter (lower numbered) zones occur along windward slopes of mountains and drier (higher numbered) zones occur in the rainshadow. Within any zone there is an elevational effect as precipitation increases and temperature decreases with elevation (Figure 20 p. 36, Figure 38 p. 84).

Environmental zones were derived originally as a mapping tool and were based on the elevational distribution of silver fir. It was observed that the elevational limits of silver fir varied geographically around the Olympic Peninsula. In places silver fir occurs near sea level, elsewhere it is not encountered until almost 3,000 feet, and in some areas it appears to be virtually absent. Some environmental causes for this distribution pattern were suggested from analysis of the data. However, the approach used was strictly empirical. The objective was to develop a model which could describe the distribution pattern of silver fir in a predictable and mappable way.

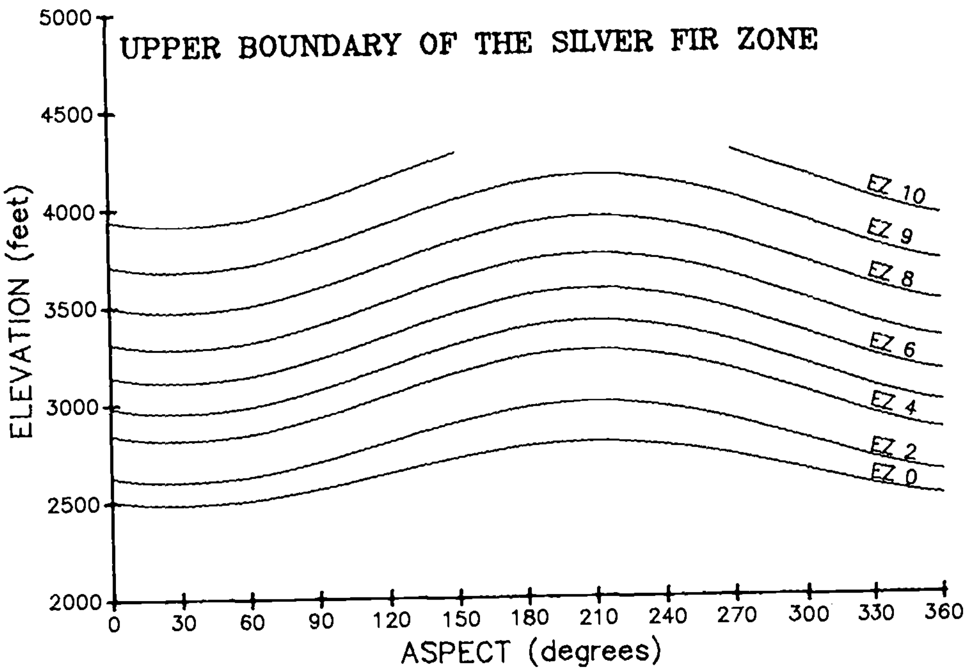
The process of delimiting environmental zones began with three observations. The pattern of silver fir varied 1) with elevation, 2) with aspect, and 3) geographically. The effect of elevation and aspect were apparent from the beginning. Silver fir occurred at lower elevations on northerly aspects than on southerly aspects. However, the magnitude of this relationship varied from the wet zones to the dry zones. It was observed that silver fir occurred at lower elevations in the wetter, western parts of the Olympic Peninsula and at progressively higher elevations around the mountain range to the rainshadow. It was apparent that there was an obvious relationship with moisture. The more water (precipitation, fog drip, etc.), the lower silver fir was able to grow. It was also evident that in drier zones, at least on southerly aspects, silver fir was not able to tolerate the drought.

After the general pattern was established using silver fir as the key indicator, the approach was expanded to delineate the Silver Fir and Mountain Hemlock Zones. This placed limits of abundance (10 percent cover in old-growth stand condition) on the key species - silver fir and mountain hemlock. The distribution of the Subalpine Fir and Douglas-fir Zones was added to give resolution in areas where silver fir and mountain hemlock were poorly represented.

The results were a series of aspect-elevation curves (Figure 23) which help delineate the Silver Fir and Mountain Hemlock Zones, and a map (Figure 24) of the 13 environmental zones defined for the Olympic Peninsula. From these two figures we were then able to draw a map (Figure 25) which shows the distribution of the vegetation zones which are based on these relationships. In developing this map Zone 12 was delineated to encompass most of the Subalpine Fir and Douglas-fir Series. Also, in field checking the maps we discovered some minor local anomalies which appeared to be related to cold air drainage patterns or steepness of slope. These factors were not built into the model directly, but were used to interpret and redefine the boundaries of the Silver Fir and Mountain Hemlock Zones on the map. The map shown in Figure 25, correctly depicts virtually all 1609 plots taken during this project and thus has less than a 1% error at this scale.

Once the environmental zone relationship was defined and the maps drawn (Figure 24), many other vegetation-environmental relationships became apparent. Many of these are discussed or mentioned throughout this guide. Some of the applications include relating the fire history pattern to the environment, analyzing and describing species distribution patterns along geographical-environmental gradients, and understanding the patterns of soils around the Forest.

1-Fire History--the pattern of historic and prehistoric fires varies tremendously from the wet zones to the dry ones. In zones 0-3 there were very few fires of appreciable size in the last 700 years. Those that have been recognized occur along southerly aspects mostly at mid-elevations (the thermal belt) and rarely exceed 1000 acres in size.



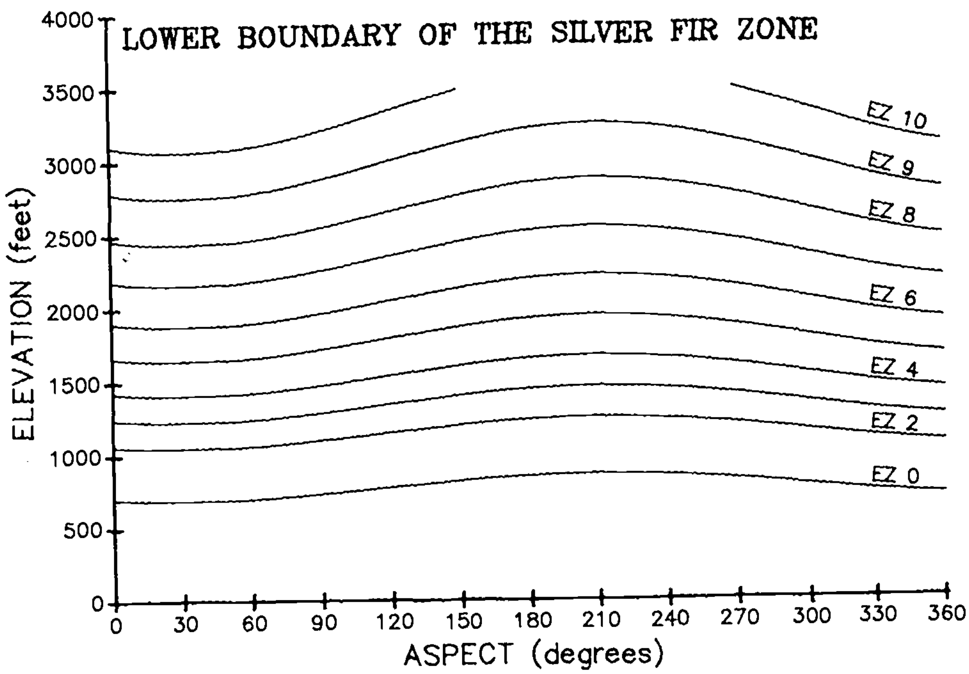


Figure 23. Aspect-elevation curves for the Silver Fir Zone.

The upper set of curves represents the upper limit of the Silver Fir Zone for each different environmental zone (EZ). The upper boundary of the Silver Fir Zone is usually the same as the lower boundary of the Mountain Hemlock Zone. Note that the Silver Fir Zone extends higher on both southerly aspects and in drier environmental zones (e.g. EZ 10). The break in the curves for Environmental Zone 10 indicates that for that EZ and on southerly aspects, the Silver Fir Zone is absent. The lower set of curves represents the elevation and aspect where one should expect to find the lower limit of the Silver Fir Zone (upper limit of the Western Hemlock Zone). Both of these relationships represent topographically modal conditions. The actual boundary of the Silver Fir Zone can shift upward on dry or steep slopes, and shift lower on moist toe-slopes or stream bottoms.

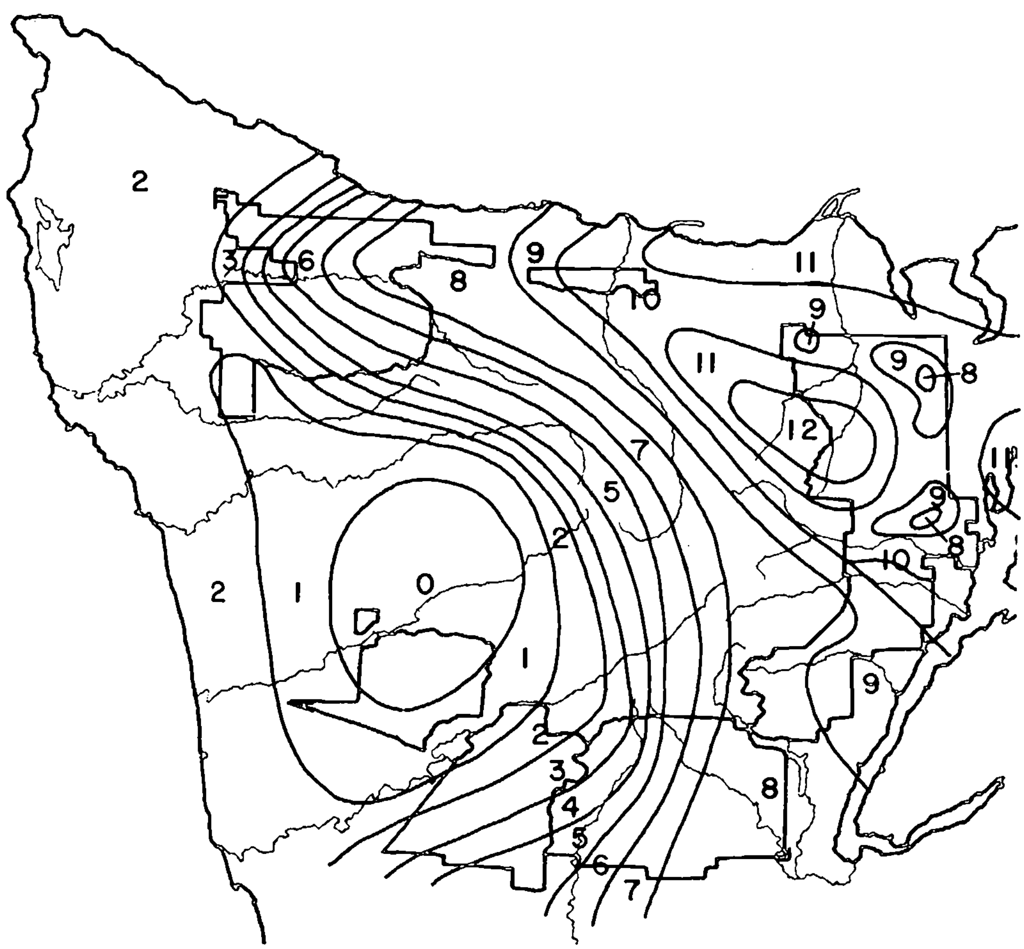


Figure 24. Map of environmental zones.

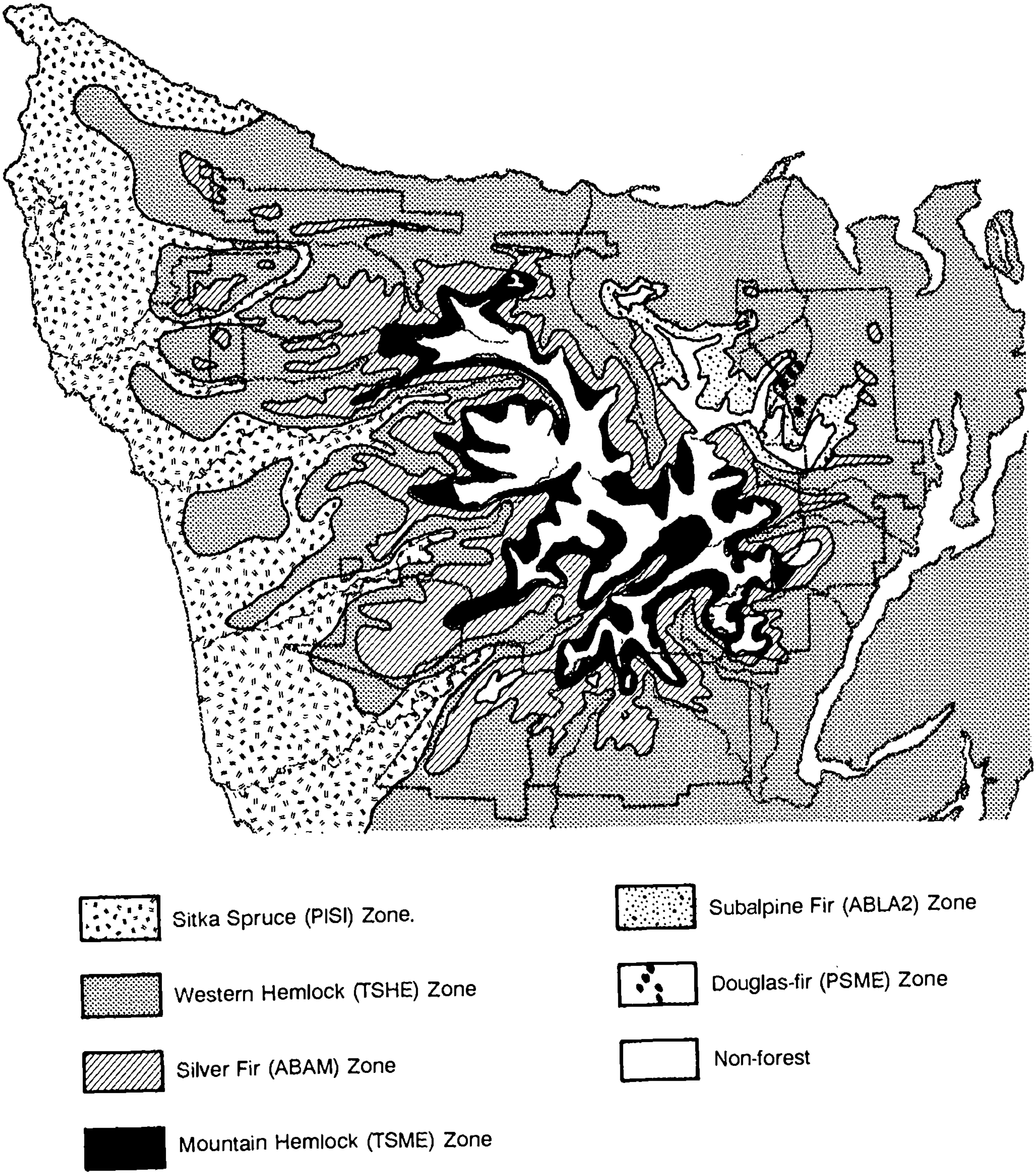


Figure 25. Map of vegetation zones based on aspect-elevation curves and environmental zones.

In contrast, wind has played a much more significant role as a disturbing force in these zones than fire. In zones 4-7 there have been a few fires, but not much more than in zones 0-3. Some evidence can be found of large fires that burned 480, 680 and 750 years ago. Wind is less of a disturbance factor than in zones 0-3. Fire has played a major role in zones 8-12, and much of this area has burned several times in the last 700 years. Fire is a major element in these ecosystems (Figure 26). Wind has played a minor role compared to the wetter zones 0-3.

2-Species distribution patterns--not only does the distribution of silver fir and mountain hemlock vary by environmental zones, but most other species on the Olympic Peninsula show similar distribution patterns. Douglas-fir is uncommon in zones 0-3, more common in 4-6 and very common in zones 7-12. In contrast silver fir is very common in zones 0-6, less so in zones 7-9 and almost absent in zones 10-12. Western hemlock is common throughout but more abundant in zones 0-3 (Figure 27).

3-Soil relationships--Most of the well developed spodosols are found in zones 0-8. Soils derived from sandstone in the wettest zones seem especially likely to become spodosols. Among the inceptisols the umbrepts are restricted to zones 0-8. Orthents were found throughout the Forest but were more common in zones 7-12 where soil formation is probably slower.

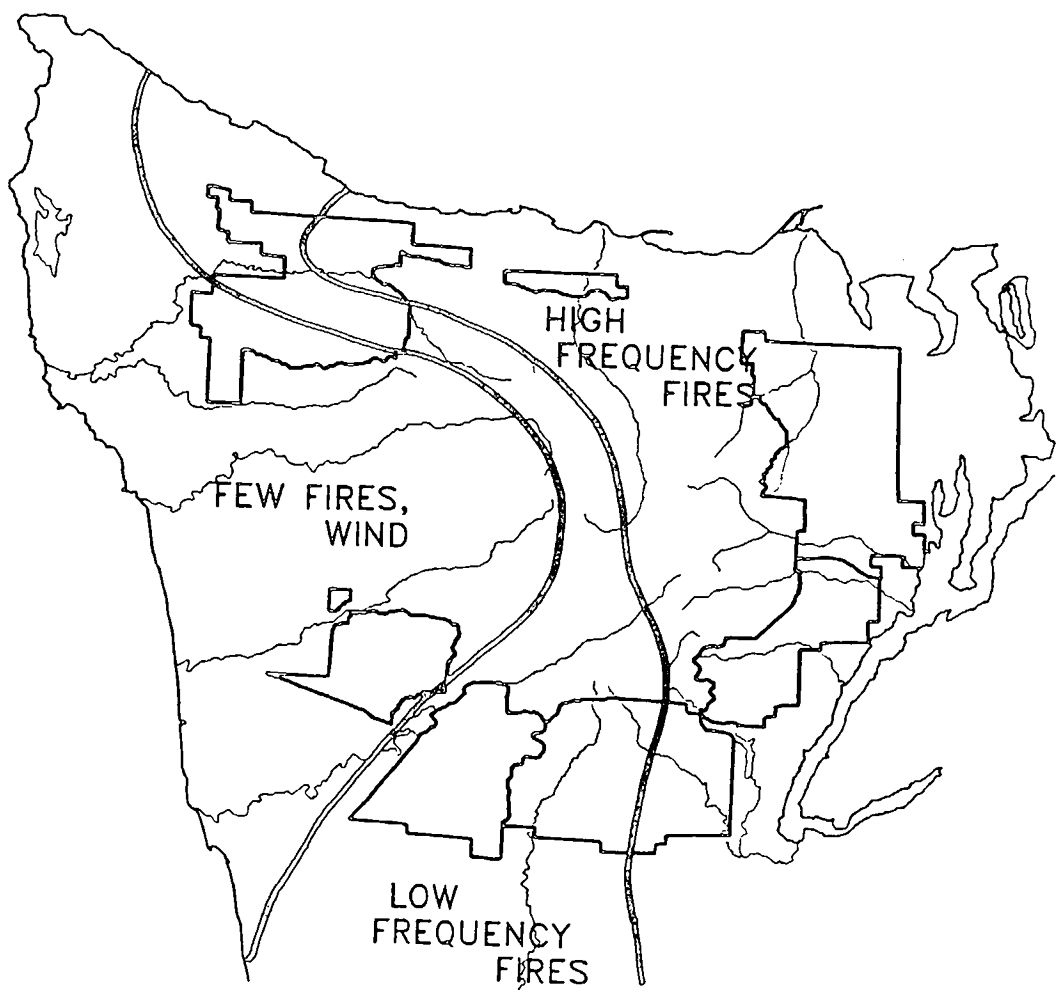


Figure 26. Map of Olympic Peninsula showing the relationship between groups of environmental zones and forest fire frequency.

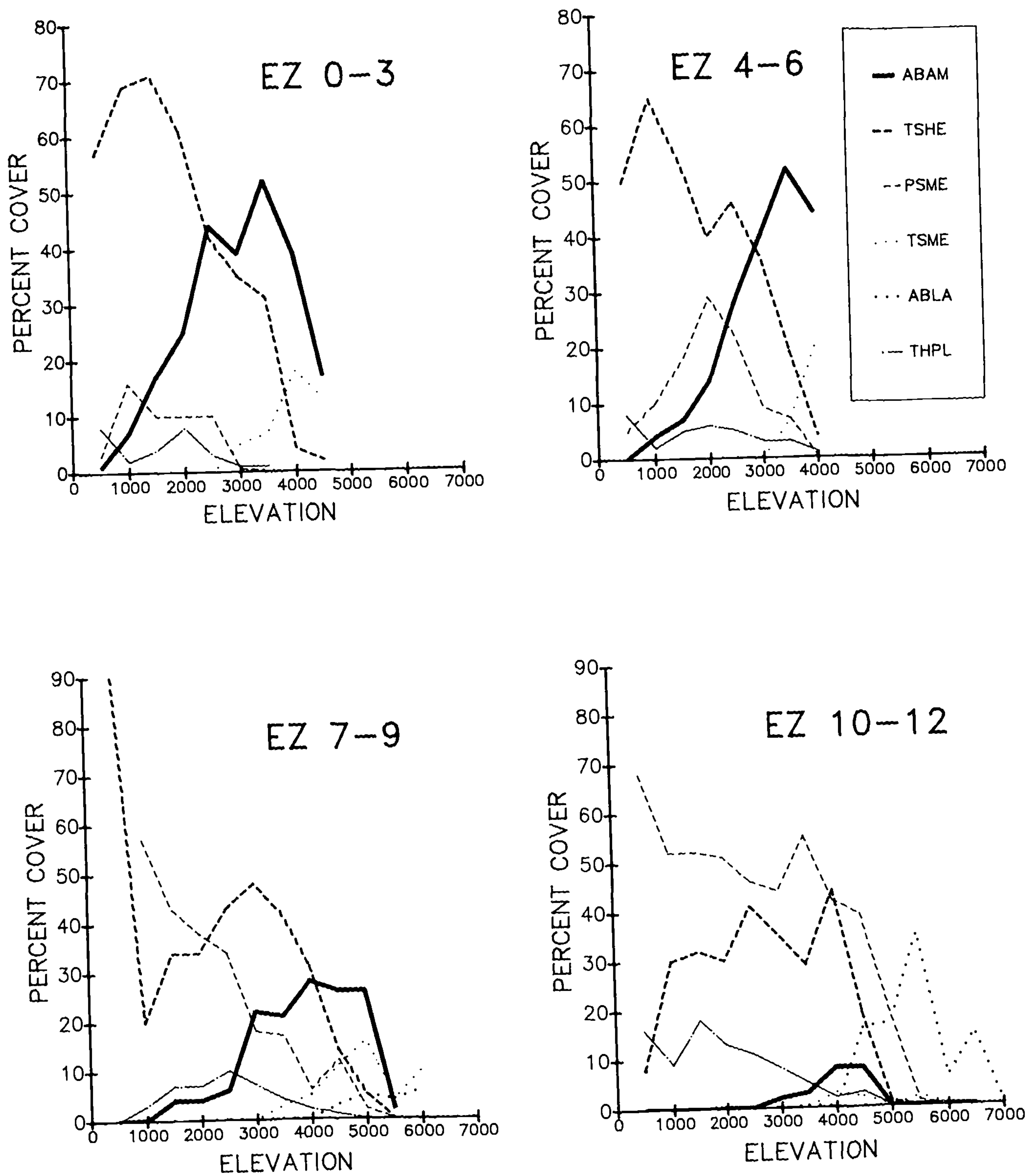


Figure 27. Distribution of tree species by elevation and environmental zone.

SOILS

The soils of the Olympic Peninsula reflect a varied environment and complex history, but are generally quite young. The complex geologic history of the Olympics has left a diversity of parent materials for soils to form from. Bedrock on the Peninsula includes a variety of sedimentary rocks and marine basalts. Much of the lowland and valley bottoms are covered with glacial sediments which may or may not have been derived locally. Although no granitic bedrock exists on the Peninsula, deep deposits of granitic glacial sediments from the mountains of Canada were deposited by the continental ice sheet on the eastern and northern sides of the Peninsula. Since the retreat of the glaciers, deep piles of colluvium have accumulated in the valleys and on the slopes of the mountains. Rivers have reworked whatever sediments were left in the valley bottoms and spread sheets of alluvium along their courses. From time to time, eruptions of Cascade volcanos have dusted the Olympics with volcanic ash, as happened in 1980 from Mt. St. Helens. Mazama ash deposits from about 6800 years ago occur in the Hoh River Drainage (Heusser 1974). Compounding all of this is a ten-fold range of precipitation, a 7000 foot range in elevation, and topography from flat to vertical. In addition, for all but the very youngest soils, the climate that the soils are currently developing under is different from when they began their genesis.

Environmental Factors

The amount of moisture in the soil is the driving force in soil development. Acting over a long period of time, it influences most of the chemical and physical features of the soil. Rates of mineral weathering are largely determined by the presence of water to dissolve and carry away soluble compounds, and to freeze and expand thereby cracking rocks to expose more surface area. Sufficient water is present over most of the Peninsula to cause both rapid weathering and leaching of nutrients out of the profile. Thus our soils tend to be relatively infertile. It is not by chance that plants and plant communities that tolerate infertile soils predominate here. Many plants tolerate infertile soils by an association with mycorrhizal fungi. This seems to be especially important with regards to phosphorus uptake (Trappe and Bollen 1979, Heilman 1979).

The soil moisture regimes present on the Forest are aquic, perudic, udic and xeric. Aquic conditions occur where water collects causing wet anaerobic conditions. It is not required that the soil is always saturated, but it must be saturated and anaerobic at some time. Thus wet soils that are supplied with oxygen by moving ground water are excluded (Soil Survey Staff 1975). These soils fall into the perudic regime. In this regime, water moves through the soil in all months that it is not frozen (Soil Survey Staff 1975). Wet areas occur in all parts of the Forest but the greatest opportunity for these conditions is in the wetter environmental zones, especially in the flats of the Quinault District. The most common soil moisture regime is udic. It includes all moist soils but can be dry up to 90 total days during the year or 45 consecutive days in the summer in 6 out of 10 years (Soil Survey Staff 1975). Udic soils occur throughout most of the Peninsula, but are rarely found in the rainshadow area (Environmental Zones 11 and 12). It is in this area that xeric soils are common although they can be found on dry microsites elsewhere. Xeric soils are dry for at least 45 consecutive days in most years (Soil Survey Staff 1975). It is these soils where the lack of moisture becomes a critical limiting factor for plants.

Topography and slope steepness have a profound effect on soil development by influencing soil stability and redistribution of soil water. In general, lower slopes have deep colluvial regolith which has accummulated from mass-wasting of the upper slope. Deeper regoliths allow deeper soils to develop which makes a greater area available to roots for water and nutrient uptake. Abrupt soil textural changes many cause perching of the water table resulting in subirrigation of the site. Many of the better growing sites especially in the lower environmental zones are on well-watered toe slopes which are subirrigated in this manner.

The soil temperature regimes present on the Forest are mesic, frigid and cryic (Figure 28). (See Soil Methods pp. 82-84, Figure 37 p. 83 and Figure 38 p. 84). Most of the Forest has a frigid regime which corresponds with the mid-montane region. It is the

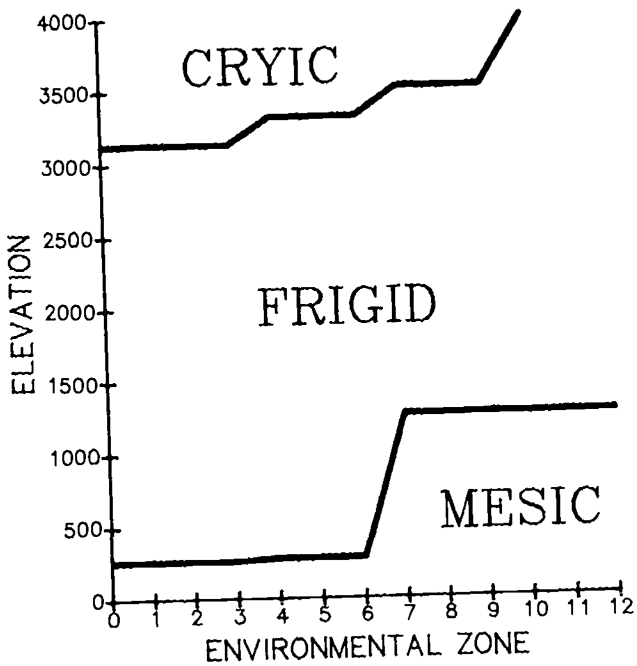


Figure 28. Soil temperature regimes.

area where the annual soil temperature is less than 8 degrees C at 50 cm, but has greater than 5 degrees C fluctuation between summer and winter (Soil Survey Staff 1975). These conditions exist over much of the Peninsula below the Mountain Hemlock Zone, in virtually all of the Silver Fir Zone, the upper Western Hemlock Zone, and the Douglas-fir and the Subalpine Fir Zones. The mesic temperature regime is that area where the mean annual temperature is greater than 8 degrees C but less than 15 degrees C at 50 cm, and there is a summer--winter fluctuation greater than 5 degrees C (Soil Survey Staff 1975). This regime is very common in the lowlands and foothills of the Olympics up to about 1300 feet elevation on the eastern slope, but probably only a few hundred feet on the western slope of the mountains. It probably includes the Sitka Spruce Zone and much of the Western Hemlock Zone. The coldest temperature regime is cryic. It has a mean annual temperature less than 8 degrees C at 50 cm, and fluctuates less than 5 degrees C between summer and winter at 50 cm depth (Soil Survey Staff 1975). On the Olympic Peninsula it occurs primarily in the Mountain Hemlock Zone. The Subalpine Fir Zone has a cold average annual temperature that fluctuates more than 5 degrees C, so it is placed in the frigid regime. Figure 29 shows the reconstructed annual temperature pattern for different environmental zones. (See Soil Methods p. 83, Figures 37, 38 pp. 83-84).

Soil nutrients are strongly influenced by bedrock, regolith, climate, and the biotic community. The source of most nutrients other than nitrogen is the weathering of parent material. The availability of nutrients to plants is determined by the efficiency of nutrient cycling, the intensity of the leaching and weathering environment, and chemical factors such as soil pH, and anion and cation exchange capacities. Nitrogen is supplied by microbial fixation of atmospheric nitrogen and atmospheric inputs. Nitrogen input from rainwater or atmospheric compounds such as ammonia, are often derived from volatilized soil nitrogen (Stevenson 1986). Sulfur can be supplied from common minerals such as gypsum or pyrite, or from atmospheric gases (Stevenson 1986). Sulfur and nitrogen are principally bound in the organic fraction of the soil and are dependent on microorganisms for their various transformations (Brady 1974). Regardless of the source of the nutrient, the carbon cycle is important to maintaining levels of available nutrients.

Our data indicate relationships of soil nutrients to pH, moisture, regolith and vegetation. The availability of soil nutrients is strongly related to pH. Phosphorus is most available at pH 6 and 7. As the pH decreases, phosphorus is bound up as insoluble aluminum and iron phosphates (Bohn *et al.* 1979). Since nearly all of our soils have a pH lower than 6.0 we can expect to have relatively low levels of available phosphorus. Although there was much variability in our data, they indicate an average of about 2.5 ppm at pH 4.2 and about 10 ppm at pH 6.0. Nitrogen paralleled organic matter very closely; the largest quantities of both nitrogen and organic matter occurred about pH 4.8. Potassium generally increased with pH but the effect of pH on potassium can vary widely depending on the soil (Bohn *et al.* 1979). Calcium, magnesium, manganese and copper were all highest in the pH range of 5.7 to 6.2. There were also some parallels between nutrient levels and the moisture variables of environmental zone and topographic moisture. Potassium was highest in drier areas with respect to both of these variables. Phosphorus and manganese were highest in the drier environmental zones. Nitrogen and boron were highest in wetter areas with respect to

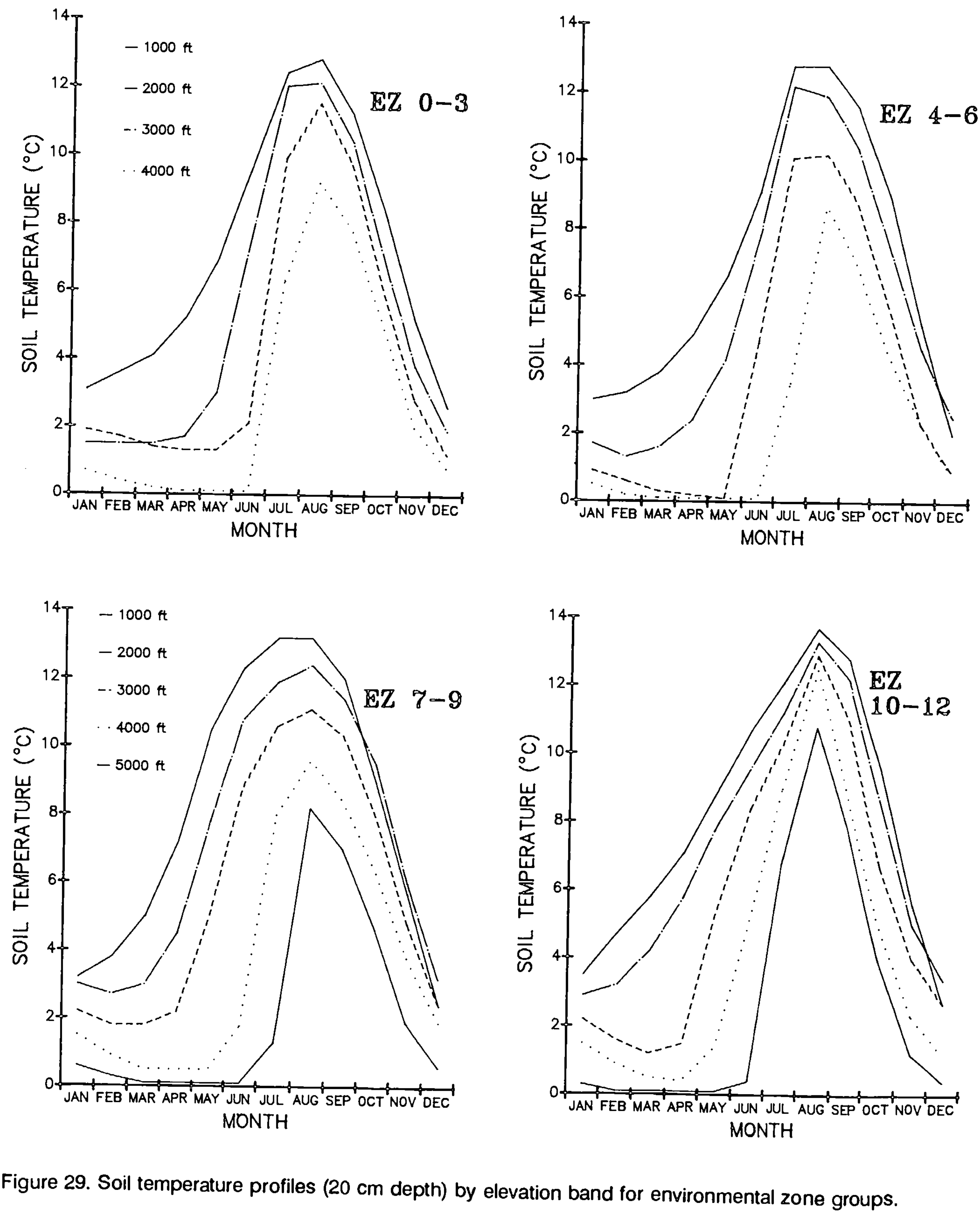


Figure 29. Soil temperature profiles (20 cm depth) by elevation band for environmental zone groups.

both variables, and calcium and copper were highest in topographically wetter areas. With respect to regolith, potassium and phosphorus were highest on soils formed from marine shales and sandstones. Phosphorus was lowest on basaltic soils. Sulfate was highest on continental tills and lowest on the marine sandstones and shales. Copper and manganese were highest on soils derived from basalt and continental till. Some patterns were also discernable with respect to the vegetation series. The highest levels of potassium, calcium, phosphorus and manganese were in the Douglas-fir Series (Tables 153 and 154, pp. 434-435). Sulfate was highest in the Western Hemlock Series. Boron, zinc and copper were highest in the wetter types of the Western Hemlock Series. Nitrogen was lowest in the Douglas-fir Series and increased in wetter and cooler series.

Effects of Different Types of Rock

Different types of rock weather at different rates, producing different soil materials and nutrient compositions (Table 4). Highly fractured bedrock weathers into soil much more rapidly because of its greater surface area. Basalts, shales and softer sandstones weather to clay (Tabor 1975), although not at the same rate. Granitics are very slow to weather because they are high in quartz and potassium feldspars, and because of their coarse texture which offers little surface area. Eventually, however, the feldspars weather leaving quartz sand (Hausenbuiller 1972). Granitics tend to be relatively high in silicon and potassium, and low in magnesium, iron, sulfur and phosphorus (Bohn *et al.* 1979). Although no granitic bedrock exists in the Olympics, much granitic till and outwash was deposited by the continental glaciers.

Basalt bedrock is widespread in the Olympics. It is frequently referred to as "metabasalt" because it is somewhat metamorphosed, but for purposes here it is assumed to weather the same as non-metamorphosed basalt. Because basalt is high in calcium feldspars and ferro-magnesium minerals, it weathers rapidly for an igneous rock. It usually weathers to sesquioxide clays (Hausenbuiller 1972) and releases more calcium, iron, manganese and phosphorus than most other rocks. Basalt is more easily weathered than most igneous rocks, yet it is much more resistant to weathering than many sedimentary rocks.

Shales are prominent in the core rocks, and are composed principally of clay and weather back to clay. In general shale weathers rapidly. The rate that shale weathers to soil has much to do with the degree of consolidation and whether the exposed eroding surface is parallel or perpendicular to the bedding plane. Layered sedimentary rocks, such as shale, weather very rapidly if the layered edges are exposed when tilted, but weather fairly slowly when just the original bedding plane is exposed. Minerals released during weathering of shales are intermediate to basalt and granite (Bohn *et al.* 1979).

Sandstone weathering is strongly dependent on the cementing agent. Lime cement weathers rapidly and silica cement weathers very slowly. Sandstone generally produces weathering products very high in silicon and low in iron and manganese, such as quartz sands, or clays (in the case of very soft sandstone) (Tabor 1975). Most Olympic sandstones are cemented with lime and are fairly soft.

Table 4. Weathering characteristics of Olympic rocks.

Rock Type	Location	Weathering Rate	End Product
granitics	continental till	slow	sand
basalt	igneous Crescent Form.	moderate	clay
shale	sedimentary Core rocks	rapid	clay
sandstone[1]	sedimentary Core rocks	rapid	sand

[1] Lime-cemented sandstone, i.e. most of the Olympic sandstones.

The effect of bedrock on the soil is expressed mainly in the way it influences the water table. Perennial subirrigation may produce seeps and springs such as are often found in Devil's club communities. In slightly drier or better drained areas, more productive swordfern communities may develop. In the absence of subirrigation, extremely dry communities such as Douglas-fir climax, madrone, oak and some non-forest associations develop. The ability to perch water is also affected by the jointing and fracturing of the bedrock; highly fractured bedrock may allow fairly rapid drainage. On steep tilted bedding planes, water collects and lubricates the smooth plane surface, causing slope failures. In this situation or with any other shallow bedrock with few fractures, windthrow can also be a serious problem.

Types of Regolith

Regolith is unconsolidated surficial material which overlies bedrock. It can form in place by weathering of the bedrock below, or it can be transported by water, wind or glaciers from someplace else. It is possible for several different layers of regolith to exist in one place. For example, a layer of volcanic ash may occur on top of an older layer of glacial till which may overlie older colluvium. Parent material is a term for the upper part of the regolith in which the soil is forming. Common types of regolith on the Olympic National Forest include colluvium, glacial till, glacial outwash, alluvium and residuum. Talus is a peculiar type of colluvium.

Colluvium is the most common regolith. These are materials that have been eroded or mass-wasted from positions higher on the slope. Colluvium is primarily angular, unsorted rock fragments. Hardpans are almost nonexistent, and abrupt textural changes that could cause perching of the water table are less common than in glacial soils. Subirrigation is more likely to result from contacts with shallow bedrock.

Glacial sediments are one of the most important regoliths on the Peninsula. They range from stratified outwash to glacial till . They may be derived from native rocks brought downslope by alpine glaciers, or from non-native rocks transported from Canada by the continental glaciers. Several different ages of depositions are represented, some are older than 70,000 years, but most are less than 20,000 years (Crandell 1964). Glacial regolith forms an apron completely surrounding the Olympic Mountains and extending up the valleys of the major rivers. Pockets can be found in the higher mountains where new regolith is still being created by active glaciers.

Along the eastern and northern parts of the Peninsula, most of the glacial sediments are derived from the most recent continental glaciation and contain much granitic material. These glacial sediments are of a uniformly young age. According to Crandell (1964), the Vashon glacial materials are 13,000 to 20,000 years old and exhibit no weathering rinds nor any formation of red clays. The depth of oxidation is typically only two feet (Crandell 1964), thus soils formed in this material are rather poorly developed. There is also some pre-Vashon continental drift exposed around the fringes of the Vashon drift (Crandell 1964). This material is oxidized six to twelve feet deep but has still not formed red clay. Weathering rinds are typically a couple of millimeters thick (Crandell 1964). Long (n. d.) found well-weathered rocks in this pre-Vashon till, which he believes is from the Salmon Springs Glaciation.

On the south and southwest sides of the Peninsula where the continental glaciers did not reach, exposures of several older alpine tills can be found. Soils derived from this material are more mature. Located mostly off the Forest to the southeast, the oldest glacial outwash (70,000 to 150,000 years ago) is oxidized to a depth greater than 25 feet (Crandell 1964). These are some of the most mature soils on the Olympic Peninsula, with almost complete degradation of rocks and an abundance of red clay (Crandell 1964). In the Humptulips drainage, but mostly off Forest, soils are forming in early Wisconsin drift which is younger than 70,000 years. This drift is oxidized to about 12 feet, and has weathering rinds three to six millimeters thick but no red clay (Crandell 1964). More common on the Forest in the Humptulips drainage are deposits of alpine glacial outwash and till of intermediate and younger Wisconsin ages. The younger Wisconsin till is far more extensive both on and off the Forest. It is contemporary with the Vashon continental glaciation and is less than 20,000 years old (Crandell 1964). Huge piedmont glaciers deposited vast aprons of drift eroded from native rocks on the plains near the mountains (Tabor 1975). Like the Vashon drift it is only oxidized to about two feet, has no weathering rinds and no red clay (Crandell 1964). The intermediate Wisconsin drift is oxidized to about seven feet, has one to two millimeter weathering rinds and no red clay (Crandell 1964). Thus it has taken more than 70,000 years to convert glacial gravel to a predominantly clay soil.

Most of our glacial soils are less than 20,000 years old and show very little weathering. Soil compaction in glacial soils is very common. We find strongly compacted and cemented hardpans often less than a meter deep in Vashon and alpine drift on the east side of the Forest. According to Brackett (1966), the hardpans are mostly compacted continental basal till, although in some cases they are old lake sediments. The parent material for the soil on top of these hardpans appears to be a looser ablation till left on top of the basal till as the glaciers receded. These hardpans decrease total available soil volume, restrict roots and perch the water table. Glacial outwash can also be somewhat stratified. Major textural boundaries can cause perching of the water table. It is not unusual to find poorly-drained soils even in fairly coarse-textured glacial outwash. Coarse fragments are usually quite high in these soils, although layers of fine material are not uncommon.

Alluvium is a relatively minor kind of regolith composed of sediments deposited by moving water. Most Olympic rivers and streams are young and swift. Their active downcutting results in steep narrow canyons with little room for accumulation of alluvium. The rivers flowing west have cut through softer sedimentary rocks and are fed by much higher precipitation than the eastern rivers. Thus these rivers have cut larger, deeper valleys than the eastern rivers (Tabor 1975), which flow almost entirely through harder basalt. Broader floodplains covered with alluvium are more common along the westside, and on the gentle lower reaches of rivers usually outside the Forest boundary. Alluvial soils are not unimportant, however, since these subirrigated soils tend to be highly productive, but may also be frequently flooded. Alluvial soils within the Forest boundary tend to be coarse, with much sand, gravel and cobbles, but pockets of finer silts and sands may accumulate along slower parts of rivers and streams, especially along the lower reaches.

Residuum is regolith which has formed in place from underlying bedrock. Most of the Olympic Peninsula is either too steep to allow accumulation of residuum or the residuum is buried under colluvium or glacial materials. Residuum can be expected only on relatively gentle slopes in areas which were either not glaciated or were scoured by glaciers. Because of the geologic history of the Olympics, residual soils are rare, and when they occur, are shallow and rocky.

Volcanic ash is uncommon in Olympic soils. The thick layers of ash which are common in the Cascades are not found here. Occasional light dustings of ash from Cascade volcanoes have probably added significant amounts of fine soil materials. Tests show that amounts of amorphous clays are high. These clays are often the breakdown products of volcanic ash.

Organic Matter

The amount and kind of organic matter in the soil is very important to soil structure and fertility. Structurally, humus improves stability and aeration by binding soil particles into aggregates. Organic matter contains many organically bound nutrients (*e.g.* nitrogen, phosphorus and sulfur) which are released slowly in the rooting zone where they are most available (Hausenbuiller 1972). Humus has a high cation exchange capacity (CEC), thus helping to prevent leaching of soluble nutrients (Hausenbuiller 1972). Soil organic matter is also the food base for many animals which are important in soil mixing and aeration, and soil microbes which help release nutrients for plant use.

In cool moist forest soils, such as are present on the Olympic Peninsula, the tendency is for organic material to accumulate on the soil surface in O layers. The amount of organic material at the surface and the proportions of O1 to O2 give some indication about the kind of environment present at a site. The O1 layer is undecomposed litter and the O2 layer is well decomposed, but not necessarily unrecognizable material. A mor is composed of thick-matted, partially decomposed organic material and litter lying on top of the mineral soil. A mull is characterized by a thin litter layer lying on a mineral horizon with much organic material mixed in. A third classification, the duff mull, is an intermediate type. Most of our forest floors are duff mulls or mors. We occasionally find mull under hardwood stands and climax Douglas-fir stands. In hardwood stands this probably relates to the readily decomposable nature of the litter. Mulls in Douglas-fir stands indicate a low level of litter production and warmer temperatures. In general there is a gradient from mull at low elevations to mor at high elevations (Topik 1982). This relates both to the effect of temperature on rates of decomposition and decomposability of the litter itself (Topik 1982). Generally we have found mors in the Mountain Hemlock and Silver Fir Zones and duff mulls in the Western Hemlock and Sitka Spruce Zones, although mors occasionally occur in the lower zones, especially on wetter sites. Silver fir and mountain hemlock litter decomposes much slower than western hemlock or Douglas-fir litter

(Topik 1982). In general mull has more invertebrates which break down and mix organic material into the mineral soil (Topik 1982). Earthworms which are common in mull are nearly absent in mors. In our work we have only rarely observed earthworms. Mor is often completely permeated with fungal mycelia and fine roots (Topik 1982). Ericaceous shrubs are common on mor soils (Topik 1982).

Much of the nutrient capital of the soil is tied up in the organic layer. The importance of this is emphasized in the Olympics by the preponderance of mor and duff mull soils. Topik (1982) found 43% of the soil nitrogen and 57% of the soil organic matter occurred in the forest floor at higher elevations in the Oregon Cascades.

Common Soil Orders

Spodosols (Table 5) are forming in most soils on the Forest. The development of a classic spodic profile has not yet occurred because most soils are very young. The process of podsolization begins as organic matter decomposes and begins to move down into the soil profile. This organic matter, known as humus, generally accumulates in the top mineral horizon. This can be seen in the profile as a darkening caused by humus coatings on the mineral grains and such a horizon is called an A (also A1 or Ah in older classifications). Where precipitation is high enough, some or all of the humus may move beyond the A horizon and be deposited in the B horizon producing a Bh. This process is known as podsolization and is common on the Olympic Peninsula. Given sufficient time a leaching environment such as this drives most soils in the direction of being spodosols. In a well developed spodosol, upper soil horizons may become leached (elluviated) of all soluble minerals, clays, organic materials, iron, and aluminum oxides, leaving only light-colored quartz sand behind (albic horizon). The organic matter and oxides may be redeposited in the B horizon (illuviation) imparting red or black color (Bir or Bh).

The kind of climatic conditions that result in accumulation of acidic organic layers on the surface produce spodosols. These are generally cool, moist climates with coniferous forests (Mitchel 1979). Acidic leachate from the organic layer and chelating organic compounds cause most of the bases, plus iron and aluminum to be leached from the surface horizon. Slight changes in the ionic content of the B horizon cause precipitation of the humus, iron, and aluminum (Birkeland 1974), but the bases are generally lost from the profile altogether. This results in an infertile, acidic soil. Conditions favorable to the development of spodosols exist over much of the Olympic Peninsula except for parts of the dry northeast, and are especially favorable on the wetter west side and at cooler high elevations. Albic horizons were observed several times in the Mountain Hemlock Zone and wetter silver fir types. Silver fir types which occur on soils derived from sandstone in the Matheny area seem especially likely to produce albic horizons.

According to Birkeland (1974) it may take 1000 years for a spodosol to come into equilibrium although it should be identifiable well before that. If aluminum oxide is the primary translocated compound there will be very little color change. In this case chemical tests may be the only way to determine whether or not a spodosol is present. Spodosols can be rapidly destroyed, however. Churning of the soil by mass-wasting, plowing, windthrow, burrowing animals, or even logging operations (Mitchel 1979) is often sufficient. Nearly all the spodosols in our sample were in Environmental Zones 0-8. This is probably due to more intense leaching and fewer fires resulting in greater stability of the soil.

Inceptisols (Table 5) are soils which show a moderate degree of profile development but not enough to be considered at equilibrium with the environment (Hausenbuiller 1972). They do not have any horizons showing marked leaching (elluviation) or accumulation (illuviation), although they have lost some bases, iron and aluminum oxides, and retain some weatherable minerals (Soil Survey Staff 1975). They are young soils and are the most common soil order on the Olympic Peninsula. Because they are not at equilibrum with the soil forming environment they are constantly evolving toward other soil orders. Most inceptisols on the Olympic Peninsula are probably moving in the direction of spodosols. Because spodosols are frequently difficult to identify in the field it is possible that a number of the soils here identified as inceptisols may in fact be very young spodosols. In our sample two suborders of inceptisols were identified--ochrepts and umbrepts. Ochrepts are light-colored brownish, freely drained inceptisols which usually form under forest vegetation (Soil Survey Staff 1975). Umbrepts are acid, dark, organic rich and freely drained. They form under coniferous forests in areas of high precipitation but with a distinct summer dry season (Soil Survey Staff 1975). In our sample, ochrepts were distributed across the entire Forest. Umbrepts were restricted to Environmental Zones 0-8, with most occurring in zones 0-5.

Entisols represent the youngest and least developed of the soil orders (Table 5). These are soils with little or no evidence of pedogenic horizons (Soil Survey Staff 1975). In other words, horizons caused by soil forming processes are absent, but horizons caused by deposition of different layers of regolith are often quite prominent. Entisols are usually in areas of very recent deposits such as flood plains or in areas where erosion has been severe enough to remove the A and B horizons. In our sample we found two suborders of entisols - orthents and fluvents. Orthents are entisols on recently eroded surfaces, such as eroding slopes or landslide debris, and were more common on colluvium in Environmental Zones 7-12. Fluvents are common along floodplains. Erosion and mass-wasting occur in both wet and dry areas, but entisols do not persist. They develop into other soils over time and the time required is probably much less in the wetter environmental zones. In addition the more intense fire history of the dry, eastern Olympics has probably resulted in accelerated erosion and mass-wasting. All the orthents in our sample were in colluvial regolith although there are probably orthents in rapidly eroding glacial drift as well.

Histosols are organic soils, commonly called bogs, moors, peats or mucks (Table 5). They are usually saturated with water most of the year but this is not a requirement (Soil Survey Staff 1975). The only two histosols in our sample occurred in Environmental Zones 1 and 2. No doubt they form elsewhere too, but the wet anaerobic conditions conducive to their formation are more likely to occur on the rolling outwash plains in the wetter environmental zones.

The proposed Andisol Soil Order (Leamy 1987) includes primarily soils developed in volcanic ejecta (Table 5). However, since the definition of andisols is based on chemical properties, many non-volcanic soils in humid climates may also meet the criteria. To be an andisol, the colloidal fraction of the soil must be dominated by minerals such as allophane, imogilite and ferrihydrite or aluminum-organic complexes. Normally these minerals are unstable, but in andisols they persist. Another important concept of andisols is that little translocation of iron or aluminum occurs. This means they will never have an albic horizon in association with a spodic horizon (Leamy 1987). Field identification of andisols will be difficult. Non-ash soils in areas of high precipitation with much organic matter are prime candidates. The clay fraction should feel more smeary than sticky, and the soil will have a low bulk density (0.9 gm/cu cm or less). Meurisse (in press) described two andisol "ecosystems" west of the Cascade crest in Oregon and Washington. These are the coastal western hemlock/Sitka spruce, medial, iso-mesic and mesic ecosystem, and the Cascade, western hemlock/Pacific silver fir, ashy, cindery and medial, frigid and cryic ecosystem.

Table 5. Summary of major Soil Orders of the Olympic National Forest.

Spodosols	Highly developed soil: leached (podsolized) A horizon, iron, aluminum and organic matter deposited in B horizon, acidic pH; main suborders are Orthods and Humods.
Inceptisols	Immature soil: no evident leaching or deposition, horizons recognized by color or structure; main suborders are Ochrepts and Umbrepts.
Entisols	No significant soil development: flood plains, landslides, eroded areas; main suborders are Orthents and Fluvents.
Histosols	Organic soil: bogs, moors, peats, mucks, often saturated; main suborders are Fibrists, Hemists and Saprists.
Andisols	Proposed new soil order: Primarily volcanic ash soils but may form nonvolcanic materials in some cases, translocation of weathered products is minimal, aluminum-humus complexes and amorphous clays accumulate, many soils of the wetter environmental zones in the Olympics will probably be reclassified as Andisols.

VEGETATION

Overview

The vegetation of the Olympic Peninsula is strongly influenced by a maritime climate, as it is surrounded by saltwater on three sides. Temperatures are mild and drought is usually not severe. The resulting forests and meadows are often dense and lush. Timber productivity is among the highest in the world. The dominant climax tree species are western hemlock and silver fir. The dominant seral tree species and the most important commercial species at lower elevations is Douglas-fir. The upper elevational limit of forests (timberline) occurs at about 5300 feet in the wetter environmental zones to over 6200 feet in the rainshadow.

Using the vegetation series described in this guide, we can generalize a broad vegetation pattern (Figure 25). When mapped, these series are called zones and consist of the Western Hemlock, Sitka Spruce, Douglas-fir, Silver Fir, Mountain Hemlock and Subalpine Fir Zones. The Western Hemlock and Sitka Spruce Zones occur at the lower elevations. Figure 30 shows the generalized distribution pattern of the major vegetation zones on the Olympic National Forest.

The Sitka Spruce Zone is limited to the area of strong maritime influence along the western side of the Peninsula. It generally occurs where precipitation exceeds 100 inches (Figure 18) and there is a summer fog effect. It also appears to be limited above 600 feet elevation. Most of the Sitka Spruce Zone occurs in Environmental Zones 0, 1, and 2 (see Figures 24 and 25). It is characterized by such species as Sitka spruce, western hemlock, western redcedar, salmonberry, salal, vine maple, red huckleberry and Alaska huckleberry. Herbs include oxalis, swordfern, ladyfern, deerfern and foamflower. Timber productivity is very high.

The Western Hemlock Zone occurs around the Peninsula from very wet to moderately dry habitats. It usually extends up in elevation to where the Silver Fir Zone begins, unless the precipitation is very low as in Environmental Zones 10-12, where it is often replaced by the Subalpine Fir Zone. In the wetter parts of the Peninsula, it may extend up to only about 2000 feet, but in drier areas it may go to about 4000 feet. Forest fires have been common in the Western Hemlock Zone, with large fires occurring at intervals of 50-250 years for most places. Stands throughout most of the Western Hemlock Zone are dominated by Douglas-fir. In the wetter parts of the zone western hemlock may be dominant, even in young stands. In very old stands the composition shifts to dominance by western hemlock and western redcedar. Common shrubs include salal, vine maple, Oregongrape, red huckleberry, Alaska huckleberry, salmonberry and rhododendron. Herbs include swordfern, deerfern, oxalis, beargrass, twinflower, prince's pine, evergreen violet, vanillaleaf, trillium and foamflower.

The Silver Fir Zone is also very common on the Peninsula, occurring in all but the driest environmental zones. It is generally the mid- to upper slope forest, occurring above the Western Hemlock Zone and below the Mountain Hemlock Zone. The dominant trees are silver fir and western hemlock. Douglas-fir can occur as old relicts from earlier periods on many sites in this zone, or it may occur as a component of young-growth stands in drier sites or at lower elevations in the Silver Fir Zone. Western redcedar, Alaska yellowcedar, mountain hemlock and Pacific yew can also occur. Common shrubs include Alaska huckleberry, red huckleberry, salmonberry, fool's huckleberry, salal and Oregongrape. Herbs include queen's cup, bunchberry, rosy twisted-stalk, vanillaleaf, false lily-of-the-valley, deerfern, swordfern, five-leaved bramble, foamflower and trillium.

The Mountain Hemlock Zone occurs at upper elevations in all but the driest parts of the Olympic Peninsula, where it is replaced by the Subalpine Fir Zone. It occurs above the Silver Fir Zone and grades into subalpine parkland at upper elevations. It is a cold, snowy zone where winter snowpacks usually exceed 10 feet. It is dominated by silver fir and mountain hemlock, and sometimes Alaska yellowcedar. Common shrubs include Alaska huckleberry, oval-leaf huckleberry, big huckleberry, white rhododendron, mountain-ash, fool's huckleberry and red heather. Herbs include five-leaved bramble, trailing bramble, avalanche lily, deerfern, queen's cup, beargrass and sidebells pyrola.

The Subalpine Fir Zone occurs in the drier parts of the Olympic Peninsula (Environmental Zones 10-12), at elevations generally above 4000 feet. Snow accumulations are less than 10 feet. Dominant trees are subalpine fir and/or lodgepole pine. Shrubs include big huckleberry, white rhododendron, common juniper and pachistima. Herbs include subalpine lupine, Sitka valerian, sidebells pyrola, trailing bramble, Martindale's lomatium and white hawkweed.

The Douglas-fir Zone occurs sporadically on dry microsites, usually in Environmental Zones 10-12. It is most common in the Dungeness River drainage. Douglas-fir is the dominant tree, while grand fir, lodgepole pine, Rocky Mountain juniper, madrone and western hemlock can occur in small amounts. Common shrubs include kinnikinnick, Oregongrape, serviceberry, oceanspray, baldhip rose, creeping snowberry and salal. Herbs can include western fescue, vanillaleaf, white hawkweed, prince's pine, Scouler's harebell, bigleaf sandwort and starflower.

Subalpine and Alpine Zones occur in a mosaic with the Mountain Hemlock and Subalpine Fir Zones and at higher elevations. Trees occur as sporadic individuals or clumps, or at the transition from subalpine to alpine, as nearly prostrate shrubs (krummholz). The communities in these non-forest zones are dominated by shrubs (red heather, white heather, phlox) or herbs (lupine, bistort, valerian, sedges and grasses).

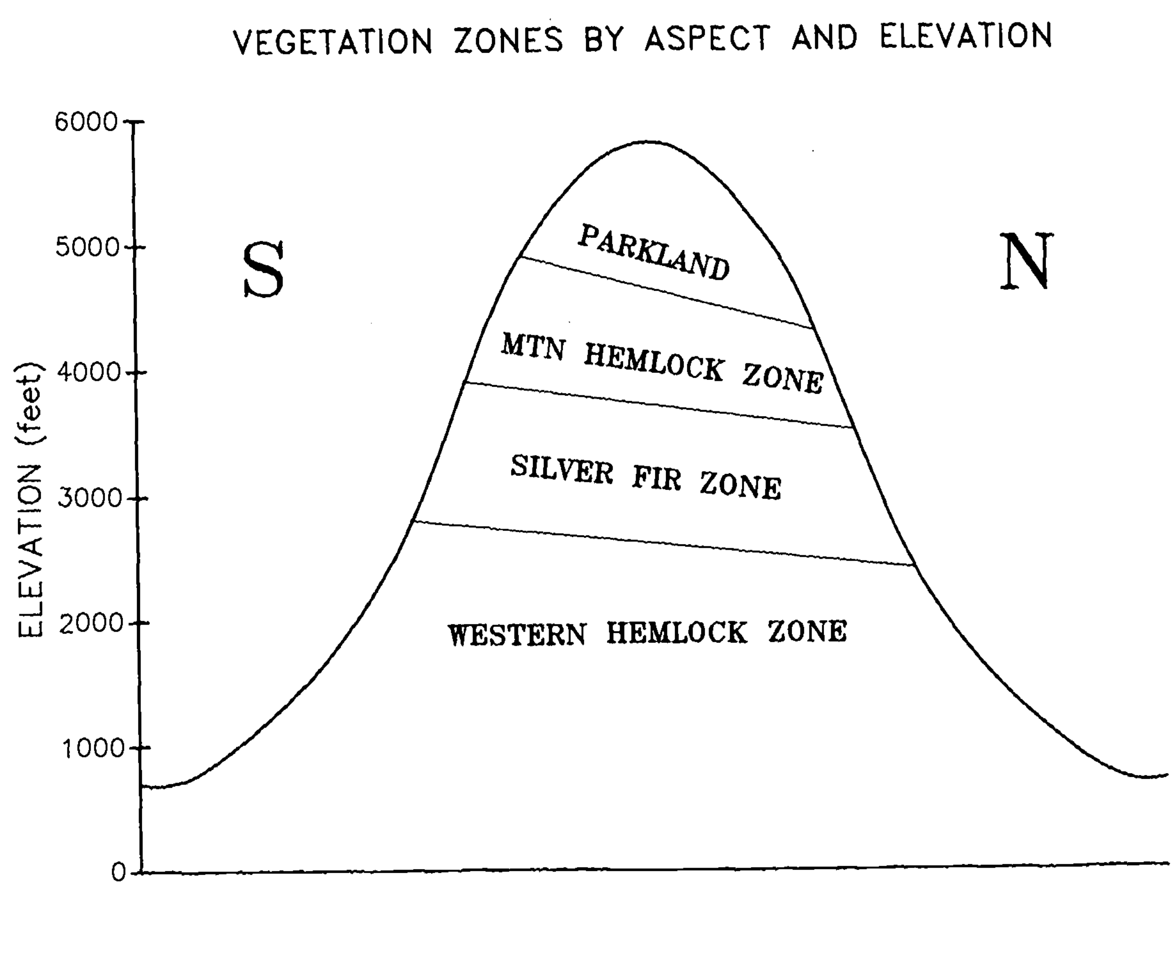


Figure 30. Diagram showing the relative distribution of the major vegetation zones for the Olympic National Forest.

Paleobotanical History

The ancient history of the flora and vegetation of the Olympic Peninsula dates back to only about 12 million years ago when the primordial Olympic Mountains rose from the sea. By that time the Cascades had developed considerable altitude, and this had begun to affect the regional climate. The angiosperm dominated forests (mixed mesophytic forest) of earlier periods in the Pacific Northwest had declined, and the early conifer dominated forests began to develop. The lowland tree flora in the Cascades during late Miocene (Wolfe 1969) includes members of the following conifer genera, *Pinus*, *Picea*, *Abies*, *Tsuga*, *Pseudotsuga* plus several broad-leaved genera. Although the early Olympic Mountains were nothing more than low hills or plains, the early forests of the Olympic Mountains were probably similar in composition to the flora of the Cascades.

During the Pliocene, 2 to 10 million years ago, the paleobotanical record is very weak. However, during this time we know that the flora underwent slow changes. Most conifer genera persisted in the area while many broad-leaved taxa became extinct. These changes in taxa suggest an increasing summer drought during this period.

Many of the modern taxa of the Olympic Peninsula were represented in the Northwest flora during late Miocene, when the Olympics began to rise out of the ocean. They include black cottonwood, Oregon oak, red alder, chinkapin, Oregongrape, oceanspray, bigleaf maple and madrone. These species have persisted in the area through mountain building, climatic shifts and ice ages. Taxa which entered the area about 10 million years ago (as the regional biome shifted from a mixed mesophytic to a more temperate conifer forest), include Scouler willow, Sitka alder, vine maple, salal and Alaska huckleberry. Also members of the genera *Pinus*, *Picea*, *Tsuga* and *Abies* were present in the uplands during the time of the mixed mesophytic flora, and expanded their range during the Pliocene. Douglas-fir was poorly represented during late Miocene and Pliocene periods, and apparently did not become dominant in the area until the Pleistocene Ice Age began about 2 million years ago (Wolfe 1969).

The vegetation history during the early Pleistocene (30,000 to about 2 million years ago) is not well known. We can speculate that the vegetation during that time was dominated by temperate or boreal conifers. At times during the period from 20,000 to 80,000 years ago, the lowland forests of the Olympics included western hemlock, mountain hemlock, *Pinus* spp. (mostly lodgepole and white pine), *Picea* spp. (Sitka and/or Engelmann spruce), *Abies* spp. (grand fir or subalpine fir), alders and numerous members of the grass, sedge, and composite families (Stuiver et *al*. 1978, Heusser 1964, Florer 1972, Petersen *et al*. 1983). Douglas-fir is conspicuously absent from early pollen profiles in the Olympics representing the period from 10,000 to 40,000 years ago. It is known from the Willamette Valley and as far north as Fargher Lake in Washington during the Fraser Glaciation. By about 11,250 years ago it had migrated as far north as Davis Lake near Mineral (Tsukada 1982).

During the Evans Creek ("Alpine") glacial period about 18,000-20,000 years ago, the lowland forests of the Olympics were characterized by mountain hemlock with some spruce (probably *P. engelmannii*) lodgepole pine, subalpine fir, and western hemlock (Heusser 1964, 1972). This was a cold period when timberline was probably only about 3,000 feet in western Washington. During the Vashon ("Continental") glacial period about 13,000 to 17,000 years ago, the composition of the forests changed to a predominance of lodgepole pine. Mountain hemlock declined and subalpine fir and spruce (both Engelmann and Sitka) persisted (Heusser 1964, 1972, Peterson et *al*. 1983, Barnosky et *al*. 1987). The climate had become drier and apparently more continental (see p. 32), and sea level was several hundred feet lower than today (see p. 31). This is a time period relatively well studied in the Olympics; however, many of the earlier bog profile descriptions lacked reliable radiocarbon ages (Hansen 1941, Hansen and Mackin 1949).

Following the continental deglaciation 12,000 to 13,500 years ago, many studies show that the lowland forests of the Olympics were still characterized by lodgepole pine with species of true fir and spruce. About 10,000 years ago an abrupt change occurred with pine declining and western hemlock, Douglas-fir, true fir species (probably grand fir), and red alder entering the forests. This represents the approximate beginning of the Hypsithermal period (see p. 33) and the last time sea level was higher than the present. The forests along the west side of the Peninsula were mainly lodgepole pine, western hemlock, red alder, spruce and Douglas-fir (Heusser 1964, 1965, 1973a). These forests resembled forests farther inland today. The presence of Douglas-fir and red alder pollen, plus charcoal from this period, suggest that even along the west coast forest fires were common (see p. 12).

About 4,000 years ago another change in forest composition occurred. Douglas-fir virtually disappeared from the Hoh-Bogachiel area, red alder declined significantly, and spruce, hemlock and western redcedar assumed dominance. This is approximately the composition of the forests of that area today (Barnosky 1981, Tsukada 1982).

We know little of the drier parts of the Olympic Peninsula from this period. We can assume that it might be comparable to climatic-vegetational reconstructions from near Battleground or Davis Lake. In these studies (Barnosky 1981, 1985), lodgepole pine, subalpine fir and spruce forests were replaced about 10,000 years ago by Douglas-fir, grand fir, western hemlock, western redcedar and red alder forests. The noticeable change in species composition about 4,000 years ago are not clearly represented in Barnosky's data. However, there appears to be a shift in proportions of the species about that time. At Battleground, Douglas-fir and western hemlock remain about the same but western redcedar increases (Barnosky 1985). At Davis Lake, Douglas-fir and red alder decline as western redcedar increases (Barnosky 1981).

Little is known of high elevation forests during any of these periods. The only published pollen or macrofossil record for a montane or subalpine bog in western Washington was by Dunwiddie (1986) from Mt. Rainier. His study site is comparable to much of the wetter parts of the Olympics today. It occurs near the lower boundary of the Mountain Hemlock Zone. He shows that about the time of Mt. Mazama ash, those forests were dominated by subalpine fir and silver fir. About 3,000 years ago the composition changed to approximate the current species composition of silver fir and mountain hemlock. Based on this, we can speculate that during the Hypsithermal period, subalpine fir was much more common throughout the Olympics and there was much less mountain hemlock than today.

The paleobotanical record of the past shows that the floristic composition and presumably the structure of Olympic forests have changed many times and are probably still undergoing changes associated with changes in climate. Even during the last 1000 years we have detected significant shifts in the ranges of important tree species associated with changes in climate (see p. 32). Silver fir has apparently expanded its range considerably during this time and the range of Douglas-fir has decreased.

Botanical History

The earliest botanist to explore this part of the world was Dr. George Steller, who was botanist and physician to Vitus Bering on his historic voyage from Russia across the north Pacific in 1741 (Lavender 1958). Bering and Steller did not get as far south as the Strait of Juan de Fuca, however. He is best remembered in our area by the Steller's jay.

The first botanist to explore the Olympic Peninsula (and western Washington also) was Dr. Archibald Menzies in 1792. He was botanist and physician to Capt. George Vancouver on his historic exploration and discovery of the area we now refer to as Puget Sound. Vancouver actually called this area "New Georgia" and the body of water as a whole the "Gulph of Georgia". "Puget's Sound" as he first used the term applied only to the body of water south of the Tacoma Narrows. Menzies described many new species on this trip and returned to England with numerous specimens of seeds and plants for the famous Kew Gardens. Menzies, Mr. Whidbey and Lieutenant Peter Puget were the first to explore Hood Canal (named Hood's Canal by Vancouver for his friend the "Honorable Lord Hood" who apparently never visited the area). Menzies is remembered by the trees *Pseudotsuga menziesii*, *Arbutus menziesii*, and the herb *Chimaphila menziesii* among others (Vancouver 1801).

David Douglas made several early explorations of the far west. He spent some time at Fort Nisqually *ca.* 1833 and apparently traveled as far as Hood Canal, but most of his botanizing was done elsewhere. While exploring the lower Columbia River between Fort Vancouver and The Dalles he climbed a high mountain and discovered Pacific silver fir and noble fir (Piper 1906). He is perhaps best remembered by "Douglas-fir". Dr. John Scouler was a companion of Douglas in the 1820's and collected some plant specimens from the "Straits of Juan de Fuca".

During the famous Wilkes expedition of 1841 there were two botanists, Dr. Charles Pickering and Mr. W.D. Brackenridge. They spent some time collecting on the northeast part of the Olympic Peninsula during May 1841 (Piper 1906). Their collections formed the basis of the first formal taxonomic treatment for the area (Wilkes 1874).

Mr. J.M. Grant collected a few specimens of plants "from the Olympic Mountains" in 1889 which he sent to the Gray Herbarium (Piper 1906).

The first botanist to explore the interior of the Olympic Mountains was Prof. Louis F. Henderson who accompanied the O'Neil expedition in 1890 (Henderson 1891, Wood 1976). He is remembered by the shrub *Petrophytum hendersonii* and the sedge *Carex hendersonii*. Henderson was followed by J.B. Flett in 1895 who not only botanized the Olympic Mountains but explored parts of Mt. Rainier and Mt. Adams. He is remembered by *Viola flettii* and *Senecio flettii*. Mr. L.H. Lamb was perhaps the pioneer botanist in the southwest part of the Olympic Peninsula, collecting plants northward from Grays Harbor in 1897 (Piper 1906). The second comprehensive flora for the area was by C.V. Piper in 1906. The "Flora of Washington" (Piper 1906) was a landmark publication. It included a compilation of the early botanists' works as well as Piper's own extensive collections. He botanized in the Olympic Mountains himself in 1890 and 1895. He is remembered by the herb *Campanula piperi* among others.

The next major work was by George Neville Jones (1936). He based his book on the work of earlier botanists plus his own extensive explorations from 1923 to 1935. He described 1015 species including 16 species and 4 varieties he considered to be endemics. He noted that on a species per area basis, the Olympic Peninsula represents one of the greatest concentrations of endemics in the world. He also noted that the species list included 40 non-native species by the turn on the century and 143 non-natives in 1935. He described broad communities of plants, including a description of the area in terms of Merriams Life Zones.

Two modern works have had significant input to the current study. "The Vascular Plants of the Pacific Northwest" published in five volumes (Hitchcock *et al.* 1955-1969), is a landmark work and was the major taxonomic reference throughout this project. It is the taxonomic authority for all vascular plants that we identified. In practice, the condensed and slightly modified version, "Flora of the Pacific Northwest" (Hitchcock and Cronquist 1973), was used in the field. Another work by Nelsa Buckingham and Ed Tisch (1979) provided an up-to-date checklist of vascular plants of the Olympic Peninsula. It was heavily used during the field stages of this project and was an invaluable reference. It is the most current taxonomic treatment for this area.

Previous Ecological Studies

Jones' (1936) description of Merriams Life Zones for the Olympics constitutes the first ecological description of the vegetation of the Olympics. His Hudsonian Zone corresponds closely with our Mountain Hemlock Zone plus the Subalpine Fir Zone; his Canadian Zone corresponds closely with our Silver Fir Zone, and his Humid Transition Zone corresponds with our Western Hemlock and Sitka Spruce Zones. His map of these Zones bears a great resemblance to our map of Vegetation Zones (page 43). Other descriptions from the early 1900's were oriented toward a timber or cover type objective *e.g.* Dodwell and Rixon (1902), National Park Service (1940).

Following Jones there was a period where mosses and lichens were emphasized, as the rich epiphytic flora of the "rain forests" attracted much attention. Although much of this work was floristic-based, some of the studies (*e.g.* Sharpe 1956) tried to relate mosses and lichens to communities and habitats. Coleman *et al.* (1956) inventoried the epiphytes of the Olympic Peninsula, in a comparative study with the flora of New York State. They found 195 epiphyte species and related them to elevation, moisture and host species. Harthill (1964) did a more complete inventory of mosses. Following along the lines of Coleman *et al.* (1956), Hoffman (1971) and Hoffman and Kazmierski (1969) studied the epiphytes on Douglas-fir. More recently Nadkarni (1984) studied the biomass and nutrient capital in "rain forest" epiphytes. Kunze (1980) studied the distributional patterns of alpine lichens at Deer Park.

Early vegetation classification efforts followed European traditions. Spilsbury and Smith (1947) and Becking (1954) described site types for western Washington using a system which resembled that of Cajander (1926). Spilsbury and Smith (1947) described 5 site types for Douglas-fir dominated communities. They were: (1) Swordfern, (2) Swordfern-salal, (3) Salal, (4) Salal-Parmelia and (5) Salal-Usnea site types. The first three bear close resemblance to three of our major Western Hemlock Zone Associations.

The earliest vegetation classifications using a plant community or association approach were those of Fonda and Bliss (1969) for the forests of the Olympics, and Kuramoto and Bliss (1970) for the subalpine meadows. Fonda and Bliss (1969) recognized seven "community types" based on their sample of 39 plots. Their level of resolution is very similar to our series level classification. Their *Pseudotsuga menziesii* type represents our Douglas-fir Series; their *Abies amabilis-Tsuga mertensiana* type represents our Mountain Hemlock Series; their *Abies lasiocarpa* type represents our Subalpine Fir Series. Their *Tsuga heterophylla-Pseudotsuga menziesii* type and *Pseudotsuga menziesii-Tsuga heterophylla* type represents a wetter and a drier segment of our Western Hemlock Series. Lastly their *Abies amabilis-Tsuga heterophylla/Oxalis* type and the *Abies amabilis-Tsuga heterophylla* types represent a wet and a dry segment of our Silver Fir Series. Kuramoto and Bliss (1970) described eight non-forest subalpine meadow types based on 38 plots.

Franklin and Dyrness (1973) reviewed and described the vegetation of Oregon and Washington, including the Olympic Peninsula. Their work was a landmark synthesis at the time. Their general treatment of the vegetation of the Olympics emphasized the very limited nature of ecological work up to that time.

Working in the Sitka Spruce Zone, Kratz (1975) described eight community types based on his sample of 37 plots. Taking a different approach Ossinger (1983) made a more thorough analysis of one community, the *Pseudotsuga-Tsuga/Rhododendron* type. Later, in a study in the Hoh and Dosewallips drainages in Olympic National Park, Smith and Henderson (1986), recognized 49 forested, and 47 non-forested associations based on 313 and 236 plots respectively.

In the current study, preliminary plant association classifications were reported for the Shelton District, the Quinault District, the Soleduck District, and the Hoodsport and Quilcene Districts (Henderson and Peter 1981a, b, 1982a, 1983a).

During the late 1970's and 1980's most of the ecological interest has focused on studies of ecological processes, and the interactions between ecosystems and the environment. Studies relating to fire and fire effects include Pickford *et al.* (1977), Fonda (1976), Agee and Huff (1980), Agee and Smith (1984). Successional studies include Fonda (1974), who described successional relationships on the river terraces in the Hoh Valley, Henderson (1982), who described general successional relationships for the Western Hemlock/Salal and Silver Fir/Alaska Huckleberry Associations, and Dale *et al.* (1986), who applied a stand development model to the tree components in a Douglas-fir, western hemlock, silver fir ecosystem.

Since about 1975, del Moral and his students and associates have been studying the dynamics of subalpine ecosystems in the northeastern Olympics (del Moral [1982], Belsky and del Moral [1982], del Moral [1984b] and Loneragan and del Moral [1984]). He also applied this research to more fundamental or theoretical aspects of ecology (del Moral [1983, 1984a], del Moral *et al.* [1985]). Other studies from that area include Milliren (1983) who looked at snowpack - meadow interactions, Stevenson (1983) who studied the response of subalpine fir to summer drought at timberline, and Pfitsch (1981) and Stevens (1982), who looked at mountain goat-plant community interactions.

Lastly, an integrated study of ecosystem structure and process has been carried on in the S. Fork of the Hoh drainage since 1978. This project has been led by J. Franklin. Early papers from this study include Franklin (1982), Franklin *et al.* 1982, Graham (1982), McKee *et al.* (1982) and Swanson and Lienkaemper (1982).

Taxonomic Considerations

During all phases of this work, an attempt was made to identify all vascular plants to species. Variety was sometimes determined, but this was not an objective of sampling. Later in the project, cryptogams, mammals, birds and amphibians were also identified. Mosses, liverworts and lichens were identified to genus in most cases and to species whenever possible. There is considerable difficulty with the taxonomy of some genera, especially some lichens and mosses, such that field identification beyond genus was impossible.

The authorities for each of the following taxa are Hitchcock *et al.* (1955-1969) for vascular plants; Lawton (1971) for mosses; Hale 1979, Brodo and Hawksworth (1977), Thomson (1967) for lichens, and Conard (1956) for liverworts. Nomenclatural changes occur rapidly for fungi, so we have used Hadfield *et al.* (1986) as the taxonomic standard for names for the pathogenic fungi. Nomenclature for birds follows the current American Ornithologists' Union Checklist (1983).

A number of taxa among all of these groups have undergone recent revision. Notably among the vascular plants, there are newer names for some species than used by Hitchcock *et al.* (1955-1969). However, we have chosen to not adopt these recent changes, and to continue to use the older names. For example, they recognized the species *Tiarella unifoliata* and *T. trifoliata*. Subsequently, these two species have been assigned variety status in the single species *T. unifoliata*. Also *Cornus canadensis* has been renamed *C. unalaskensis*. We feel that using one regional authority enhances communication and reduces ambiguity.

Field identification of some taxa proved to be difficult or inconsistent. Although crew members were experienced in plant taxonomy and considerable time was spent keying unknown plants in the field and in collecting and verifying them later, some misidentifications probably still exist in the database. In other cases plots were taken when some species were in a phenological stage which did not allow proper or positive identification. Some sedges or grasses were identified only to genus if mature flowers were not available. Early in the project *Symphoricarpos albus* and *S. mollis* were not consistently distinguished; *Festuca occidentalis* was confused with *F. idahoensis*; *Festuca subuliflora* was not consistently distinguished from *F. subulata*, and *Stachys mexicana* and *S. cooleyae* were not consistently distinguished. The species *Galium triflorum* and *G. trifidum* were not consistently distinguished. When there was uncertainty the specimen was identified as *G. triflorum*, although some of these plants were probably *G. trifidum*. The high elevation species of *Ribes* were usually called *R. howellii*. However, some of these specimens were apparently misidentified *R. triste*.

Indicator Species

The following table (Table 6) gives all of the vascular plant species used to indicate or identify the forested plant associations of the Olympic National Forest. To use this guide one should be competent at identifying these species. They are described in Lesher and Henderson (1986), "Indicator Species for the Olympic and Mt. Baker-Snoqualmie National Forests."

Table 6. Indicator species of the Olympic National Forest.

SPECIES	COMMON NAME	CODE
Abies amabilis	Silver Fir	ABAM
Abies lasiocarpa	Subalpine Fir	ABLA2
Acer circinatum	Vine Maple	ACCI
Acer macrophyllum	Bigleaf Maple	ACMA
Achlys triphylla	Vanillaleaf	ACTR
Alnus rubra	Red Alder	ALRU
Arctostaphylos uva-ursi	Kinnikinnick	ARUV
Berberis nervosa	Oregongrape	BENE
Blechnum spicant	Deerfern	BLSP
Clintonia uniflora	Queen's Cup	CLUN
Cornus canadensis	Bunchberry	COCA
Erythronium montanum	Avalanche Lily	ERMO
Festuca occidentalis	Western Fescue	FEOC
Galium triflorum	Fragrant Bedstraw	GATR
Gaultheria shallon	Salal	GASH
Holodiscus discolor	Oceanspray	HODI
Juniperus communis	Common Juniper	JUCO4
Linnaea borealis	Twinflower	LIBO2
Lupinus latifolius	Subalpine Lupine	LULA
Lysichitum americanum	Skunkcabbage	LYAM
Oplopanax horridum	Devil's Club	OPHO
Oxalis oregana	Oxalis	OXOR
Phyllodoce empetriformis	Red Heather	PHEM
Picea sitchensis	Sitka Spruce	PISI
Polystichum munitum	Swordfern	POMU
Pseudotsuga menziesii	Douglas-fir	PSME
Rhododendron albiflorum	White Rhododendron	RHAL
Rhododendron macrophyllum	Rhododendron	RHMA
Rosa gymnocarpa	Baldhip Rose	ROGY
Rubus pedatus	Five-leaved Bramble	RUPE
Rubus spectabilis	Salmonberry	RUSP
Smilacina stellata	Star-flowered Solomon's seal	SMST
Streptopus roseus	Rosy Twisted-stalk	STRO
Thuja plicata	Western Redcedar	THPL
Tiarella trifoliata	Three-leaved Foamflower	TITR
Tiarella unifoliata	Single-leaved Foamflower	TIUN
Tsuga heterophylla	Western Hemlock	TSHE
Tsuga mertensiana	Mountain Hemlock	TSME
Vaccinium alaskaense	Alaska Huckleberry	VAAL
Vaccinium deliciosum	Blueleaf Huckleberry	VADE
Vaccinium membranaceum	Big Huckleberry	VAME
Vaccinium ovalifolium	Oval-leaf Huckleberry	VAOV
Vaccinium ovatum	Evergreen Huckleberry	VAOV2
Vaccinium parvifolium	Red Huckleberry	VAPA
Xerophyllum tenax	Beargrass	XETE

Endangered, Threatened and Sensitive Species

There are 40 listed sensitive vascular plant species, two threatened, and no endangered species known or suspected to occur on the Olympic National Forest. Also, there are an additional 22 taxa on the Monitor List whose current status is in doubt but warrants further study and continued concern. These are listed in Table 7. It represents the status of the Endangered, Threatened, Sensitive and Monitor species as of Spring 1988. This list is subject to constant revision. For the current status of any species on this list, consult the current Region 6 Sensitive Plant List (USDA 1988) or Washington Natural Heritage Program List (1987).

Table 7. Endangered, threatened, sensitive and monitor plants known or suspected to occur on Olympic National Forest. Based on February 1988 Region 6 Sensitive Plant List and 1987 Washington Natural Heritage Program List of Endangered, Threatened and Sensitive Vascular Plants of Washington.

ENDANGERED--none

THREATENED (2 species)

Astragalus cottonii	Olympic Nat. Park, Gray Wolf, Morse Cr. drainages
Ophioglossum vulgatum	Mason County, boggy areas with spiraea?

SENSITIVE (40 species)

Arenaria paludicola	possibly extirpated
Aster sibiricus var. *meritus*	rocky, high elevation, N (Buckhorn)
Astragalus microcystis	alpine, NE (Buckhorn, Tyler Peak)
Botrychium boreale (B. pinnatum)	moist, (Silver Cr.)
Botrychium lanceolatum	moist, (Higley Peak)
Carex anthoxanthea	moist meadows, SE
Carex circinata	moist, (Colonel Bob)
Carex interrupta	moist, (Three Peaks)
Carex obtusata	subalpine, alpine, snowmelt, NE (Buckhorn)
Carex pluriflora	wet, low elevation
Carex saxatilis	wet areas, mid-elevation, N
Carex stylosa	moist
Chrysolepis chrysophylla	dry, low to mid-elevation, SE (Washington Cr.)
Cimicifuga elata	moist woods, low elevation
Claytonia lanceolata var. *pacifica*	-
Coptis asplenifolia	moist woods, bogs, SW
Draba lanceolata	subalpine, alpine, rocky, NE (Tyler Peak)
Epipactis gigantea	wet areas, N
Erigeron aliceae	subalpine, moist to dry
Erigeron peregrinus ssp. *peregrinus* var. *thompsonii*	low elevation bogs, SW
Erythronium revolutum	moist woods, low to mid-elevation, SW (Higley Pk)
Galium kamtschaticum	boreal species, SW (Moonlight Dome)
Gentiana douglasiana	wet, low elevation, W (Lake Ozette)
Lobelia dortmanna	shallow water, low elevation, N
Microseris borealis	
Montia diffusa	moist woods
Orobanche pinorum	moist woods
Oxytropis viscida	subalpine, alpine, rocky, N
Parnassia palustris var. *neogaea*	wet, mid-elevation, SW
Plantago macrocarpa	cool, wet, low elevations
Pleuricospora limbriolata	moist to dry forest
Poa grayana	subalpine, alpine, meadow and scree, NE
Poa laxiflora	moist to dry, low elevation
Polemonium carneum	thickets and openings, low to mid elevation
Ranunculus cooleyae	damp rock crevices, SW (Colonel Bob)
Sanguisorba menziesii	coastal bogs, W (Wedgepoint)
Saxifraga debilis	damp rock crevices, alpine
Synthyris pinnatifida var. *lanuginosa*	alpine, talus, scree, NE
Utricularia intermedia	aquatic, NW
Woodwardia fimbriata	streambanks, seeps, SE. Hamma Hamma

MONITOR (22 species)

Anemone oregana var. *felix*	moist areas, SW
Asplenium viride	high cliffs, NE
Aster paucicapitatus	subalpine
Botrychium lunaria	moist woods, N
Botrychium virginianum	lowland, often with hardwoods, E
Campanula piperi	rocky, subalpine, N and E (Mt. Townsend)
Eburophyton austiniae	lowland-montane, woods, E (Satsop)
Erigeron flettii	subalpine, rocky, throughout O.P. (Mt. Townsend)
Erythronium oregonum	lowland-montane, woods, E (Duckabush R.)
Geum triflorum var. *campanulatum*	subalpine, N, E
Hemitomes congestum	dry, lowland woods, often with salal,
Lloydia serotina	rocky, subalpine, N, E (Mt. Baldy)
Nephrophyllidium crista-galli	wet, lowland, SW
Orthocarpus imbricatus	subalpine, NE
Pedicularis bracteosa var. *atrosanguinea*	subalpine, NE
Petrophytum hendersonii	cliffs at higher elevations, throughout O.P.
Phlox hendersonii	alpine, rocky, NE
Poa marcida	montane, moist woods, NW (Snider)
Selaginella douglasii	lowland to montane, N, E (?)
Senecio neowebsteri	subalpine scree, NE (Tyler Peak)
Synthyris schizantha	montane, S
Viola flettii	rocky, subalpine, alpine N, E (Mt. Townsend)

Cryptogams

Cryptogams are non-vascular plants which include mosses, lichens and liverworts. Their primary source of water and nutrients comes from the atmosphere through precipitation, humidity and throughfall, and is absorbed directly into their tissues. They also have the ability to tolerate prolonged periods of drought, when they become dormant until water is available again for growth. These aspects of their physiology enable them to be successful pioneering species, colonizing sites which may be inhospitable to higher plants, such as barren rock, soil and wood. Cryptogams colonize down wood and standing trees, creating microsites favorable for other species of plants, insects and microbes. Cryptogams aid in the cycling of nutrients. Members of the lichen genera *Lobaria* and *Peltigera* are able to convert atmospheric nitrogen into a form available for uptake by higher plants. Lichens also provide important winter forage for deer (Stevenson and Rochelle 1984), especially the genera *Alectoria* and *Bryoria* and to a lesser degree *Platismatia* and *Lobaria*. Cryptogams also provide food for small mammals (Ure and Maser 1982, Gunther *et al*. 1983, Maser *et al*. 1978).

Cryptogams are important components of forest ecosystems. They may be dominant on the forest floor or abundant as epiphytes on tree boles or in canopies. In our sampling of cryptogams, we dealt mainly with those species which were common, abundant or conspicuous. Tables 8 and 9 show the relative distribution by vegetation series of the major

Table 8. Common mosses, lichens and liverworts of forest floor, down wood and lower tree boles. Percent frequency by vegetation series is based on forest plots where cryptogams were sampled.

	SERIES					
	PISI	TSHE	ABAM	TSME	PSME	ABLA2
Number of sample plots	22	294	156	35	29	16
Average moss cover (%)	47	38	29	24	31	7
Cladonia spp.		12	6	11	34	50
Dicranum spp.	14	17	22	43	38	50
Eurhynchium oreganum	54	34	22		17	
Eurhynchium praelongum	13	3	3		3	
Homalothecium megaptilum		3			24	
Hylocomium splendens	40	39	18	2	58	12
Hypnum circinale		11	19	28	10	25
Isothecium stoloniferum		4	4		6	
Leucolepis menziesii	13	1	1			
Lobaria linita			1	11	3	
Lobaria pulmonaria					14	
Peltigera aphthosa		5	2	2	48	6
Peltigera spp.	9	6	10	10	34	75
Plagiomnium insigne	13	1	2			
Plagiothecium undulatum	9	16	20	8	6	
Polytrichum spp.		6	10		24	12
Rhacomitrium spp.		7	2		27	31
Rhizomnium glabrescens	18	6	10	8		
Rhytidiadelphus loreus	36	14	15	20		
Rhytidiadelphus triquetrus	4	3	1		34	6
Rhytidiopsis robusta		11	24	45	17	50
Scapania bolanderi	4	9	15	11		
Sphagnum spp.	4	3	1	8		

taxa which were recorded on our forest plots. Some species within a genus are discussed at the genericlevel, as it was difficult to identify them in the field. In addition, some taxonomic problems exist in certain genera. Vouchers have been collected to verify at a later date. This list is a first approximation of the relative frequency of common cryptogams.

Some interesting patterns of distribution for ground cryptogams are shown in Table 8. The mosses *Eurhynchium oreganum* and *Hylocomium splendens* are primarily low to mid-elevation species. *Rhytidiopsis robusta* becomes a dominant moss in the mid- to high elevations. *Rhytidiadelphus loreus* was not recorded in the Douglas-fir or Subalpine Fir Series, where *Peltigera* spp. were most abundant.

Table 9 shows the distribution of common epiphytes. *Lobaria oregana* is commonly found in stands over 200 years old, in the wetter environmental zones, and in the mesic to wetter types, often below 3000 feet elevation. *Alectoria sarmentosa* and *Bryoria* spp. are common lichens at the mid- to high elevations, especially in the colder or drier climatic areas of the Forest. Species of *Hypogymnia* and *Platismatia* are common and fairly ubiquitous, yet it is interesting that they are relatively rare in the the Sitka Spruce Series. Generally, lichens are the dominant epiphytes, but in the Sitka Spruce Zone the moss *Isothecium stoloniferum* becomes dominant, and it seems to favor the wetter climatic areas of the Sitka Spruce, Western Hemlock and Silver Fir Zones.

Table 9. Common epiphytic lichens, mosses and liverworts recorded on forest plots. Percent frequency by vegetation series is based on plots where epiphytes were sampled.

	SERIES					
	PISI	TSHE	ABAM	TSME	PSME	ABLA2
Number of sample plots	8	104	58	18	20	14
Alectoria sarmentosa		44	47	100	95	79
Bryoria spp.		22	15	44	85	100
Cetraria spp.		1	1	11	30	36
Cladonia spp.		11	10		25	
Dicranum spp.		9	1	5	5	
Frullania spp.	12	7	1		10	
Hypnum circinale		13	21	28	25	
Hypogymnia enteromorpha		34	26	17	50	21
Hypogymnia imshaugii		4	5	5	15	14
Hypogymnia inactiva		7	3		10	
Hypogymnia physodes	9	1			30	7
Hypogymnia spp.		22	16	44	30	57
Isothecium stoloniferum	62	21	22			
Letharia spp.					15	21
Lobaria oregana	12	13	24	28		
Lobaria spp.		1	14	11		
Neckera douglasii	25	5				
Parmelia sulcata		3			10	
Parmeliopsis hyperopta		7	31	33	25	
Platismatia glauca		29	47	55	75	43
Platismatia herrei		3	3	5	25	21
Porella spp.	37	11				
Scapania bolanderi	12	5	3	5		
Sphaerophorus globosus		19	38	50	20	
Usnea spp.		10	9		5	

Diseases and Insects

Fungi and insects are important components of forest ecosystems. Many cause disease and damage while others play a more beneficial role. All are important in the functioning of ecosystems. This section will deal only with those fungi and insects that cause important diseases, major damage, or are important wood rotters. The parasite, dwarf mistletoe, is included in this discussion, even though it is a vascular plant. Table 10 lists the major diseases, rots and insect pests on the Olympic National Forest. Table 11 lists field observations of major diseases for plant associations on the Forest. These are further discussed in this section as well as under individual plant association descriptions.

Table 10. Common diseases and insect pests on the Olympic National Forest.

ROOT DISEASES	
Armillaria root disease	*Armillaria obscura*
Laminated root rot	*Phellinus weirii*
Annosus root disease	*Heterobasidion annosum*
Black stain root disease	*Verticicladiella wageneri* (imperfect stage) (also *Ceratocystis wageneri* (perfect stage)
HEART AND BUTT ROTS	
Brown cubical butt rot	*Phaeolus schweinitzii*
Annosus root rot	*Heterobasidion annosum*
Red ring rot	*Phellinus pini*
Brown trunk rot	*Fomitopsis officionalis*
Rusty-red stringy rot	*Echinodontium tinctorum*
Armillaria root rot	*Armillaria obscura*
Crumbly brown rot	*Fomitopsis pinicola*
Long pocket rot	*Hericium abietis*
DWARF MISTLETOE	
Hemlock dwarf mistletoe	*Arceuthobium campylopodum* f. *tsugensis*
POTENTIAL INSECT PESTS	
Douglas-fir beetle	*Dendroctonus pseudotsugae*
Silver fir beetle	*Pseudohylesinus sericeus*
Western blackheaded budworm	*Acleris gloverana*
Hemlock looper	*Lambdina fiscella lugubrosa*
Balsam woolly aphid	*Adelges piceae*
Spruce weevil	*Pissodes sitchensis*

1- syn. *Fomes annosus*
2- syn. *Leptographium wageneri* (imperfect stage) (Harrington and Cobb 1988)
3- syn. *Ophiostoma wageneri* (perfect stage) (Harrington and Cobb 1988)
4- syn. *Arceuthobium tsugense* (Hawksworth and Weins 1972)

Table 11. Field observations of major diseases on Olympic National Forest by plant association for the Silver Fir, Sitka Spruce and Western Hemlock Series.

Plant Association	Diseases [1]							
	AROB	HEAN	PHWI	VEWA	PHSC	PHPI	FOOF	ARCA6
Silver Fir/Alaska Huckleberry	o					o		o
Silver Fir/Alaska Huckleberry/Avalanche Lily							o	
Silver Fir/Alaska Huckleberry/Beargrass							o	
Silver Fir/Alaska Huckleberry-Oregongrape								o
Silver Fir/Alaska Huckleberry/Oxalis								+
Silver Fir/Alaska Huckleberry/Queen's Cup								o
Silver Fir/Alaska Huckleberry/Twinflower	o							
Silver Fir/Beargrass					o			
Silver Fir/Devil's Club		o						
Silver Fir/Oxalis	o							+
Silver Fir/Rhododendron	o				o	o	o	o
Silver Fir/Rhododendron-Alaska Huckleberry					o			
Silver Fir/Salal/Deerfern								o
Silver Fir/Salal/Oxalis	o							+
Silver Fir/Skunkcabbage			?					
Silver Fir/Swordfern		o						+
Silver Fir/Swordfern-Oxalis	+	o	?			o		+
Silver Fir/Vanillaleaf-Foamflower								o
Sitka Spruce/Swordfern-Oxalis								+
Western Hemlock/Alaska Huckleberry	o	?						o
Western Hemlock/Alaska Huckleberry/Beargrass								o
Western Hemlock/Alaska Huckleberry/Oxalis								+
Western Hemlock/Alaska Huckleberry-Salal	o							+
Western Hemlock/Oregongrape/Swordfern	o		?					
Western Hemlock/Oxalis	o							+
Western Hemlock/Rhododendron	+	?			o	+	o	
Western Hemlock/Rhododendron-Salal	+	?		o	o	+	o	o
Western Hemlock/Rhododendron/Swordfern								o
Western Hemlock/Salal	o	?	o		o		o	
Western Hemlock/Salal/Beargrass	o		o				o	
Western Hemlock/Salal-Oceanspray						o		
Western Hemlock/Salal-Oregongrape	o	?	o		o	o		o
Western Hemlock/Salal/Oxalis		o						
Western Hemlock/Salal/Swordfern	+				o			o
Western Hemlock/Swordfern-Foamflower	o	?			o			o
Western Hemlock/Swordfern-Oxalis	o				o			+

[1] AROB--*Armillaria obscura*, HEAN--*Heterobasidion annosum*, PHWI--*Phellinus wierii*, VEWA--*Verticicladiella wageneri*, PHSC--*Phaeolus schwienitzii*, PHPI--*Phellinus pini*, FOOF--*Fomitopsis officionalis*, ARCA6--*Arceuthobium campylopodum* f. *tsugensis*
"o"--recorded for type at least once; "+"--consistently occurred; "?"--questionable identification.

1. Root Disease Pathogens

Root disease pathogens are important components of forest ecosystems. They aid recycling of nutrients, create forest openings for wildlife and may play a role in succession. In intensively managed forests, root diseases account for much of the individual tree mortality. There are three common root diseases on the Olympic National Forest, laminated root rot, Armillaria root disease, and annosus root disease. One less common root disease, black stain root disease, is showing up on Douglas-fir plantations. See Hadfield *et al.* (1986) and Bega (1979) for discussions on root diseases.

Root diseases are recognized in forest stands by crown symptoms in trees and disease centers which create openings (Table 12). Crown symptoms can include reduced height growth, fading yellowish foliage, thinning crown, distress cone crop, and death. Disease centers are created when trees begin dying in a roughly concentric pattern as the disease moves from tree to tree via root contacts. Usually, the tree which has been dead the longest is in the center with recent dead trees peripheral to it. Trees with crown symptoms are between dead trees and healthy trees. In plantations the center of the disease pocket may be an infected stump left from the previous stand. The fungi that cause Armillaria and annosus root disease and laminated root rot can persist in stumps for many years, black stain root disease does not persist after tree death.

Crown symptoms and disease centers indicate possible root disease, but do not necessarily indicate the causal agent. One must look closely for signs of the disease, which means digging around the base of infected or recent dead trees and examining the larger roots. Table 12 indicates signs and symptoms of four common root diseases. Forest openings or group killings by insects or abiotic factors usually kill all trees at once, root disease kills trees over time.

Table 12. Symptoms and signs of four important forest root diseases of the Olympic National Forest (from Hadfield *et al.* 1986).

Symptoms and Signs	Laminated root rot	Armillaria root disease	Annosus root disease	Black stain root disease
Reduced height growth	x	x	x	x
Yellow foliage	x	x	x	x
Slow loss of foliage	x	x	x	x
Distress cones	x	x	x	x
Slow crown decline	x	x	x	x
Rapid tree death		x		x
Dead tree, no foliage loss		x		
Abundant basal resin flow		x		
Black stain in sapwood				x
Roots rotted	x		x	
Windthrown live trees	x		x	
Insect galleries under bark	x	x	x	x
Golden mushrooms on tree base	x			
Mycelial fans		x		
Rhizomorphs		x		
Leathery conks			x	
Setal hyphae	x			
Ectotrophic mycelium	x			
Creamy leathery pustules on roots			x	
Laminated decay with pits on both sides of sheets	x			
Laminated decay with pits on only one side of sheets			x	
Yellow, stringy decay with black zone lines		x		
White, stringy decay with black specks			x	

Trees differ in susceptibility to disease. Table 13 lists the relative susceptibility of conifers to damage by the four common root diseases on the Olympic National Forest. This table describes the likelihood of damage occurring should a particular tree come in contact with a disease organism.

Armillaria root disease, caused by *Armillaria obscura* (syn. *Armillaria mellea*), is the most common root disease on the Olympic National Forest. It is most important in young-growth Douglas-fir plantations (Morrison 1981, Hadfield *et al.* 1986). On most sites, mortality from Armillaria occurs in stands by the time they are about 30 years old. On some drier sites it may persist and be a problem into older ages. In old-growth it is endemic and occurs most commonly on suppressed trees of silver fir, western hemlock and occasionally Douglas-fir.

Armillaria kills trees by girdling the root collar (Bega 1979). It can also be present in the root system of a tree and not kill it. In this case it can kill individual roots and thereby reduce the growth and vigor of the tree. It spreads from tree to tree via root to root contacts or by rhizomorphs which grow through the soil (from an infected tree to a previously uninfected one) (USDA n.d., Morrison 1981). As the disease spreads from tree to tree it forms a pocket of dead and dying trees (Bega 1979). In plantations the stump of a previously infected tree may be the center of a new disease pocket. It can persist in dead trees or stumps for many years, living off of the dead wood. This can easily carry over the disease from generation to generation. Removing infected stumps before planting, growing less susceptible species, cultivating mixed species stands or thinning (and possibly fertilizing) to maintain vigor in trees can all be used to control the spread of Armillaria in second-growth stands (USDA n.d., Morrison 1981, Hadfield *et al.* 1986). Mechanical damage from thinning can weaken trees and increase their susceptibility to diseases including Armillaria.

Table 13. Relative susceptibility of conifers on the Olympic National Forest to damage by four common root diseases (based on Hadfield *et al.* 1986).

Host	Laminated root rot	Armillaria root disease	Annosus root disease	Black stain root disease
Abies amabilis	2	2	1	4
A. grandis	1	1	1	4
A. lasiocarpa	2	2	2	4
Pinus contorta	3	2	2	3
P. monticola	3	2	3	4
Picea sitchensis	3	2	3	4
Pseudotsuga menziesii	1	2*	3	1
Thuja plicata	4	2	3	4
Tsuga heterophylla	2	2	2**	3
T. mertensiana	1	2	1	3

Relative susceptibility: 1=severely damaged, 2=moderately damaged, 3=seldom damaged, 4=not damaged

* Douglas-fir is moderately damaged up to age 25, then susceptibility decreases

** Western hemlock is not severely damaged until it exceeds 150 years

Stress is an important factor determining whether trees will be killed by Armillaria root disease (Wargo and Shaw 1985, Hadfield *et al.* 1986). Low quality sites, off-site stock, and poorly planted seedlings are often cited as causing trees to be susceptible to this root disease. Symptoms which may indicate the presence of Armillaria include pockets of trees with decreased vigor, crown thinning, yellow foliage, basal resin discharge or distress cone crops. Positive identification can be made by removing the bark at the root collar and looking for the distinctive white mycelial fans in the cambium or inner bark. Black shoestring-like rhizomorphs may also be found under the bark of the lower bole or on roots. Fruiting bodies can be found in the fall. They are gilled mushrooms which occur in clusters at or near the base of infected trees (Morrison 1981).

Armillaria was most commonly observed on trees in the Western Hemlock Zone, less commonly in the Silver Fir Zone, and not at all in the Mountain Hemlock Zone (Table 11). Within the Western Hemlock Series, Western Hemlock/Salal, Western Hemlock/Salal-Oregongrape, Western Hemlock/Rhododendron-Salal, Western Hemlock/Rhododendron and Western Hemlock/Salal/Swordfern most commonly had disease centers present. Trees in these disease centers were 40-60 years old and did not appear to be developing resistance to the disease. This infers that silviculturists should use more caution when entering dry site stands with known infection centers than in the more mesic stands.When Armillaria was found in old-growth stands, it was on suppressed or dying trees. We observed only one old-growth stand of western hemlock which had a root rot pocket where large western hemlock were dying.

Laminated root rot, caused by *Phellinus weirii*, is the most serious root disease of Douglas-fir (Hadfield 1985). On the Olympic National Forest the disease readily infects and kills Douglas-fir and other highly susceptible species such as mountain hemlock and silver fir (Table 13). It is currently most important in second-growth Douglas-fir planted on sites where laminated root rot was already present.

Laminated root rot is endemic to Northwest forests especially where Douglas-fir grows. After logging, laminated root rot can remain in stumps up to 50 years depending on the size of the stump. Infection can occur in the next stand of trees via root contacts with the infected stump. Infection usually occurs when highly susceptible tree species come in contact with laminated root rot. Growth loss, root and butt rot, windthrow and tree killing are probable occurrences (Hadfield 1985).

Laminated root rot causes death of inner bark in roots and root crowns of trees, and a wood decay of roots and the lower bole (Bega 1979). When trees are less than 10 years old they usually are killed soon after coming in contact with the disease (Hadfield 1985). Older trees may last 30 or more years before dying. Douglas-fir, if older than 40 years when it contacts the disease, usually will not be killed before normal harvest age, but growth loss may occur due to root killing, and secondary attack by bark beetles is possible. Windthrow is also common because of decayed roots.

In sapling stands, laminated root rot is difficult to detect. It appears to affect scattered individual trees rather than groups of trees (Hadfield 1985). Somewhat circular openings are created in pole-sized and larger stands as the disease progresses from an infected stump in all directions via root graphs. Trees with fading yellowish foliage, thinning crowns, distress cone crops and reduced terminal growth are often beside dead trees. The center of the disease pocket is often occupied by trees that have been dead the longest. Patches of windthrown trees leaning in several directions (as opposed to leaning all one direction as caused by high winds) indicate possible root disease (Hadfield 1985).

Positive identification of laminated root rot may be made by examining uprooted trees for the characteristic laminated decay, which is pitted and separates at the annual rings. Reddish whiskery mycelium called setal hyphae will be present between the laminations (Hadfield 1985). Laminated root rot is the probable disease if the roots have all broken off at the root crown creating a root "ball". A white to grayish mycelium may be found on the surface of bark on roots infected with laminated root rot. A buff colored, flat sporophore may develop on the lower sides of down trees or on exposed roots close to the ground (Hadfield *et al.* 1986). This fruiting body is uncommon, however.

Laminated root rot was found in Douglas-fir on Western Hemlock/Salal and Western Hemlock/Salal-Oregongrape types (Table 11). We expect it to be most common in the Western Hemlock Series in types where Douglas-fir is a major successional species. However, laminated root rot is a secondary pathogen on western hemlock and silver fir and a primary pathogen of mountain hemlock (Hadfield *et al.* 1986) (Table 13). The extent of the disease in stands of the Silver Fir Series and Mountain Hemlock Series is unknown.

Management of laminated root rot is complex. Laminated root rot is considered a disease of the site because spores are not a major mode of dispersal (Hadfield *et al.* 1986). The fungus does not grow through soil, but spreads by mycelia on or within roots (Hadfield *et al.* 1986). Management does not seek to control the disease but seeks to manage the site (Thies 1984). Treatments differ at each stage of stand development. Hadfield (1985) gives management recommendations for reducing losses from this disease.

Annosus root disease, caused by *Heterobasidion annosum* (*Fomes annosus*), is an important root disease and stem decay on the Olympic National Forest. It is most common on western hemlock, silver fir and mountain hemlock (Hadfield *et al.* 1986). It seldom kills trees outright, but causes root and butt rot, and stem decay which slows growth, weakens trees, and causes volume losses. In old-growth western hemlock, annosus root disease is common and causes significant losses to decay (Goheen *et al.* 1980). Hadfield *et al.* (1986) state the disease will not be a problem in short rotation western hemlock, but Driver and Edmonds (1970), Wallis and Morrison (1975), and Chavez *et al.* (1980) suggest it may be more of a problem as management intensifies.

Areas where annosus root disease are most likely to be a problem are in the wetter types of the Western Hemlock Series, such as Western Hemlock/Swordfern-Oxalis, Western Hemlock/Oxalis and Sitka Spruce/Swordfern-Oxalis. These are among the most productive types on the Forest (Tables 143, 113, 81) and are areas where natural regeneration favors western hemlock. In these situations overstocking can easily occur and will often require precommercial thinning. Thinning will promote the spread of the disease (Wallis and Reynolds 1970, Wallis and Morrison 1975) but this can be minimized by thinning as early as possible, reducing the damage to residual trees, by removing damaged trees, and by favoring thick barked or more resistant species (Table 13) (Wallis and Morrison 1975, Hadfield *et al.* 1986).

Annosus root disease spreads by spores and root contacts (Hadfield *et al.* 1986). In intensively managed forests, annosus root disease is commonly associated with infected stumps from the previous stand and with cut stumps from commercial and precommercial thinning. The disease can pass from old infected stumps to new trees via root contacts. Spores, which are present throughout the year, land on freshly cut thinning stumps and colonize the root system (Russell *et al.* 1973). The roots then act as infection courts to nearby healthy trees through root contacts (Wallis and Reynolds 1970). Precommercial thinning as early as possible may reduce stump infections of healthy trees (Wallis and Morrison 1975). In addition, damage to residual trees from thinning causes wounds which are often colonized by annosus root disease (Goheen *et al.* 1980).

Annosus root disease was found in western hemlock, silver fir and mountain hemlock. Because of the difficulty in diagnosing this disease, no real pattern of habitat distribution was apparent to us. However, annosus root disease should be expected anywhere western hemlock, silver fir and mountain hemlock grow. As stands become intensively managed, annosus root disease probably will increase in importance because of increases in available substrate caused by thinning and tree wounding (Wallis and Morrison 1975).

Identification of annosus root disease can be difficult on the Olympic National Forest because crown symptoms and tree killing does not usually occur (Hadfield *et al.* 1986). Windthrow or secondary attack by bark beetles may be associated with this disease. For positive identification, look for the characteristic white, stringy rot, which may be flecked with black specks, or the perennial, flat to button to bracket-shaped conks in hollows, crotches or on root collars of dead trees (USDA n.d.). The conks are uniform white throughout, tan above and white below with a sterile margin between.

Black stain root disease, caused by *Verticicladiella wageneri* (also *Ceratocystis wageneri*), is not currently considered a major problem on the Olympic National Forest. It is increasing in Douglas-fir plantations in the Pacific Northwest (Hadfield *et al.* 1986) and can be expected to increase on this Forest also. The major host species of this disease is Douglas-fir, but mountain hemlock, western hemlock, and western white pine are occasionally infected (Table 13). The disease is most common in 10-30 year old

Douglas-fir plantations (USDA n.d.). Douglas-fir over 30 years old is thought to develop resistance to the disease (Hadfield *et al.* 1986).

Black stain root disease is a vascular wilt-type disease (Hadfield *et al.* 1986). It infects roots where it spreads throughout the sapwood of the root system, root crown and lower bole (Bega 1979). Infection causes a visible decline in tree crown, terminal growth is reduced, needles become shorter, chlorotic, and the host dies. The fungus does not decay wood (Bega 1979).

The disease spreads in several ways. Long distance dispersal involves insects, primarily root-feeding bark beetles (*Hylastes* sp.) and weevils (*Steremnius* sp. and *Pissodes* sp.) (Hadfield *et al.* 1986). Fruiting bodies form in insect galleries and spores adhere to dispersing insects. The insects usually attack low vigor trees and hence the disease is associated with stressed trees in disturbed sites (Hadfield *et al.* 1986). In addition, thinning stumps are colonized by the insects, which has become a major mode of entry of this disease into plantations. Short distance spread occurs through root contacts and fungal growth through soil (Hadfield *et al.* 1986). Infection then occurs regardless of host vigor and distinct disease centers develop (Hadfield *et al.* 1986).

Identification of black stain root disease (Table 12) can be made by chopping into lower stems or roots and looking for a dark-brown to purple stain in sapwood (Hadfield *et al.* 1986). Stain may not be visible in the outer most ring of xylem, but will be evident in older sapwood (Hadfield *et al.* 1986). The stain is usually restricted to one or two annual rings. Armillaria root rot, and bark beetles that attack the upper stem, often secondarily attack trees infected with black stain. See Hadfield *et al.* (1986) and Hansen *et al.* (1988) for management recommendations.

2. Heart and Butt Rots

Heart and butt rots are an important part of the forest ecosystem, as they aid in the recycling of organic matter and nutrients. However, some fungal decays can attack live trees through wounds, broken tops, dead stems, or roots. These are the decays of concern to foresters because they cause degrade of lumber and may cause stem breakage and windthrow. Decay organisms are not usually a problem in young-growth stands. In general, they become important in stands older than 120 years and in thinned stands where trees are wounded.

Heart and butt rots of major importance on the Olympic National Forest (Table 10) are brown cubical butt rot (*Phaeolus schweinitzii*) on Douglas-fir, annosus root rot (decays stems too) (*Heterobasidion annosum*) on western hemlock, mountain hemlock and silver fir, red ring rot (*Phellinus pini*), (the most important decay in the Pacific Northwest), on Douglas-fir, western hemlock and mountain hemlock, brown trunk rot (*Fomitopsis officionalis*) on Douglas-fir, and rusty-red stringy rot (*Echinodontium tinctorum*) on silver fir, western hemlock and mountain hemlock. Armillaria root disease (*Armillaria obscura*) decays the lower bole of most conifers when present. Crumbly brown rot (*Fomitopsis pinicola*) (Figure 31) is the most common conk (red belt fungus) observed in the forest, but rarely attacks live trees. Long pocket rot (*Hericium abietis*) (coral fungus) has been found to cause decay in large old-growth silver fir and western hemlock, especially in the Matheny area. For a good discussion of these decays and photographs see USDA (n.d.) and Bega (1979).

Brown cubical butt rot is one of the most important butt and lower stem decays of old-growth Douglas-fir (Hadfield *et al.* 1986). It was common in old-

Figure 31. Photo of the conk of *Fomitopsis pinicola* on western hemlock log.

growth stands of Douglas-fir in Western Hemlock/Rhododendron-Salal, Western Hemlock/Rhododendron, Western Hemlock/Salal, Western Hemlock/Salal-Oregongrape, Western Hemlock/Salal/Swordfern, Western Hemlock/Swordfern-Oxalis, Western Hemlock/Swordfern-Foamflower, Silver Fir/Beargrass, Silver Fir/Rhododendron and Silver Fir/Rhododendron-Alaska Huckleberry associations on the Olympic National Forest (Table 11). The most reliable evidence of its presence are the conks which are most common on the ground near infected trees or at tree bases (USDA n.d., Hadfield *et al.* 1986). Stem breakage may occur above ground (Hadfield *et al.* 1986) and carpenter ants may be associated with the decay.

Red ring rot is the most common stem decay of conifers in the Pacific Northwest and enormous volumes of wood are decayed by this fungus (USDA n.d.). We consistently found fruiting bodies on live Douglas-fir, western hemlock and mountain hemlock in stands 85 to 540 years old. On Douglas-fir we found red ring rot on drier habitats of Douglas-fir/Kinnikinnick, Douglas-fir/Oceanspray-Baldhip Rose, Douglas-fir/Salal, Western Hemlock/Rhododendron-Salal, Western Hemlock/Rhododendron, Western Hemlock/Salal-Oceanspray, Western Hemlock/Salal, Western Hemlock/Salal- Oregongrape, and Silver Fir/Rhododendron Associations (Table 11).

3. Dwarf Mistletoe

Hemlock dwarf mistletoe, *Arceuthobium campylopodum* f. *tsugensis* = *A. tsugensis*, is a parasitic plant that attacks stems of western hemlock and mountain hemlock (Shea and Stewart 1972, Hawksworth and Weins 1972). It occasionally attacks silver fir and subalpine fir (USDA n.d.). Its root system penetrates into the stem of the live tree causing swelling, deformation and brooming (USDA n.d.). In especially severe cases tree tops or whole trees may be killed (Bega 1979). Most damage occurs in multistoried stands with a susceptible understory and an infected overstory (USDA n.d.). See Shea and Stewart (1972) and Russell (1976) for management recommendations.

The plants are leafless green shoots about 2 inches long. Flowers are wind and insect pollinated. Seeds are explosively discharged and sticky. Basal cups are present after plants have fallen from stems, and they can be used in identification when found on swollen stems and witches brooms on the ground beneath infected trees (Shea and Stewart 1972).

Hemlock dwarf mistletoe is most common in old-growth stands of the Sitka Spruce, Western Hemlock and Silver Fir Series, particularly in stands with a large component of western hemlock in Environmental Zones 0-5. We occasionally found dwarf mistletoe on western hemlock in Environmental Zones 6-10, and on mountain hemlock. When dwarf mistletoe occurs in natural stands less than 100 years old, western hemlock was at least 90 percent canopy cover. These stands often originated from windthrow. Plant associations most likely to have hemlock dwarf mistletoe are Sitka Spruce/Swordfern-Oxalis, Western Hemlock/Salal/Swordfern, Western Hemlock/Alaska Huckleberry-Salal, Western Hemlock/Swordfern-Oxalis, Western Hemlock/Oxalis, Western Hemlock/Alaska Huckleberry/Oxalis, Silver Fir/Alaska Huckleberry-Salal, Silver Fir/Alaska Huckleberry, Silver Fir/Salal/Oxalis, Silver Fir/Swordfern, Silver Fir/Swordfern-Oxalis, Silver Fir/Oxalis and Silver Fir/Alaska Huckleberry/Oxalis (Table 11).

4. Insects

Few damaging insects are present on the Olympic National Forest. Major devastating outbreaks have not been recorded. Six insects are considered potential pests on the Olympic National Forest, based on historical evidence for this coastal region. They are the Douglas-fir beetle, silver fir beetle, western blackheaded budworm, hemlock looper, balsam woolly aphid, and the spruce weevil (Table 10). Of these, only the balsam woolly aphid is not endemic. See Furniss and Carolin (1977) for a discussion of these insects.

The Douglas-fir beetle and silver fir beetle are scolytid bark beetles which burrow beneath the bark of trees, feed on cambium, and lay eggs. The larvae that hatch feed on cambium also, and characteristic gallery patterns are left behind. They usually attack trees weakened by root disease or other factors. The hemlock looper and blackheaded budworm are moths whose larvae are catepillar defoliators. The balsam woolly aphid feeds on stems, branches and twigs. The insect covers itself with a woolly substance. Bole and crown infestations occur on true firs, especially silver fir at low elevations. The spruce weevil attacks terminal shoots of Sitka spruce, primarily in plantations.

ANIMALS

Mammals

Mammals are an important part of the ecosystems of the Olympic National Forest. They are selective in what they eat, and can have a significant impact on the composition of different communities. They are also selective about the communities they use for hiding and thermal cover, and for breeding. Some species such Roosevelt elk are relatively selective about which community they use. Others such as black-tailed deer or Douglas squirrel are more ubiquitous.

There are 63 species of mammals which are known to occur on the Olympic National Forest (Table 14) (Guenther and Kucera 1978). Eleven of these occurred commonly on our Intensive plots. Others undoubtedly used the sample plots or were even on the plot at the time of sampling. However, if the animals or their signs were not visible or readily identifiable, they were not recorded. For example, we recorded few microtines in the course of the sampling, yet they are common forest mammals, they are mostly subterranean in their habits, therefore were seldom seen or recorded.The opening to their nests were often observed, but were not recorded. Nocturnal mammals such as bats and flying squirrels were similarly not recorded. Some species such as the Olympic marmot and beaver use predominantly non-forest habitats and therefore were seldom recorded on forest plots.

Most of the mammal records were based on evidence of browsing, grazing, scat or trails. About two thirds of the Intensive plots showed some signs of browsing or grazing. It was not always possible to tell what had done the browsing but in most cases it was either deer or elk. Deer browsing was recorded on over a third of the plots, while elk browsing was recorded on a fourth of the plots. Observations of ungulate browse were recorded on other plots without distinguishing between deer or elk. Only a small fraction of the plots showed signs of both deer and elk. Browsing or grazing from mountain beaver, mountain goats, porcupines and Douglas squirrels was also recorded .

Deer showed preference for drier site communities such as those in the Western Hemlock/Salal, Western Hemlock/Salal-Oregongrape Associations, plus the Douglas-fir and Subalpine Fir Series. Elk showed a preference for the Sitka Spruce, wet Western Hemlock and Mountain Hemlock Series. Deer and elk signs were both encountered with a low frequency in the Silver Fir Associations. Douglas squirrel was the third most commonly recorded mammal species. However, it showed little preference for any association.

Table 14. Mammals of the Olympic National Forest.

Opossum	*Didelphis virginiana*
Masked Shrew	*Sorex cinereus*
Vagrant Shrew	*Sorex vagrans*
Dusky Shrew	*Sorex obscurus*
Water Shrew	*Sorex palustris*
Pacific Water Shrew	*Sorex bendirii*
Trowbridge's Shrew	*Sorex trowbridgii*
Shrew-Mole	*Neurotrichus gibbsii*
Townsend's Mole	*Scapanus townsendii*
Coast Mole	*Scapanus orarius*
Little Brown Myotis	*Myotis lucifugus*
Yuma Myotis	*Myotis yumanensis*
Keen's Myotis	*Myotis keenii*
Long-eared Myotis	*Myotis evotis*
Long-legged Myotis	*Myotis volans*

Table 14. (cont.) Mammals of the Olympic National Forest.

California Myotis	*Myotis californicus*
Silver-haired Bat	*Lasionycteris noctivagans*
Big Brown Bat	*Eptesicus fascus*
Hoary Bat	*Lasiurus cinereus*
Townsend's Big-eared Bat	*Plecotus townsendii*
Brush Rabbit	*Sylvilagus bachmani*
Snowshoe Hare	*Lepus americanus*
Mountain Beaver	*Aplodontia rufa*
Yellowpine Chipmunk	*Eutamias amoenus*
Townsend's Chipmunk	*Eutamias townsendii*
Olympic Marmot	*Marmota olympus*
Douglas Squirrel	*Tamiasciurus douglasii*
Northern Flying Squirrel	*Glaucomys sabrinus*
Northern Pocket Gopher	*Thomomys talpoides*
Western Pocket Gopher	*Thomomys mazama*
Beaver	*Castor canadensis*
Deer Mouse	*Peromyscus maniculatus*
Bushy-tailed Woodrat	*Neotoma cinerea*
Southern Red-backed Vole	*Clethrionomys gapperi*
Western Red-backed Vole	*Clethrionomys occidentalis*
Heather Vole	*Phenacomys intermedius*
Townsend's Vole	*Microtus townsendii*
Long-tailed Vole	*Microtus longicaudus*
Creeping Vole	*Microtus oregoni*
Muskrat	*Ondatra zibethicus*
Black Rat	*Rattus rattus*
Norway Rat	*Rattus norvegicus*
House Mouse	*Mus musculus*
Pacific Jumping Mouse	*Zapus trinotatus*
Porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Red Fox**	*Vulpes vulpes*
Black Bear	*Ursus americanus*
Raccoon	*Procyon lotor*
Marten	*Martes americana*
Fisher	*Martes pennanti*
Ermine	*Mustela erminea*
Longtail Weasel	*Mustela frenata*
Mink	*Mustela vison*
Western Spotted Skunk	*Spilogale gracilis*
Striped Skunk	*Mephitis mephitis*
River Otter	*Lutra canadensis*
Mountain Lion	*Felis concolor*
Bobcat	*Felis rufus*
Harbor Seal	*Phoca vitulina*
Roosevelt Elk	*Cervus elaphus roosevelti*
Columbian Black-tailed Deer	*Odocoileus hemionus columbianus*
Mountain Goat	*Oreamnos americanus*

** Recently introduced into the lowlands of the Olympic Peninsula (Aubry 1984).

Birds

Birds are an important component of the ecosystems of the Olympic National Forest. They don't appear to have as much immediate impact on the plant communities as mammals, but many of them such as the winter wren, Vaux's swift, the woodpeckers, thrushes and warblers, consume large quantities of insects. Others such as pine siskin, red crossbill, dark-eyed junco and chickadees feed heavily on seeds, especially in the fall. They appear to play a major role in maintaining the balance between various components of the ecosystems and in the nutrient cycling of the forest. There are 32 common birds which were recorded regularly on Intensive plots during 1985 and 1986 (Table 15). There are a total of 183 birds known to occur on the Forest, plus an additional 32 saltwater species which are known from the vicinity of the Forest, especially near Seal Rock (Table 171 p. 475).

Table 15. Seasonality, habitat, food preference and nest habits of common breeding forest birds on the Olympic National Forest.

SPECIES	SEASONALITY and HABITAT [1]	NEST	FOOD
Sharp-shinned Hawk	PR; YF to OG, all Series	stick nest in conifer	small birds
Red-tailed Hawk	PR; CC to OG, prefers open areas, all Series	large stick nest in large tree	small mammals, other vertebrates
Blue Grouse	PR; SS to OG, all Series	on ground	insects, berries, seeds, subalpine fir buds and needles
Ruffed Grouse	PR; SS to OG, prefers SA and deciduous, all Series but TSME and ABLA2	on ground	Ranunculus leaves, berries, deciduous twigs and buds
Band-tailed Pigeon	SR; YF to OG conifer, all Series but TSME and ABLA2	twig platform in conifer	fruits, seeds, buds and blossoms
Western Screech- Owl	PR; YF to OG, PISI, TSHE and PSME Series	cavity in tree	insects and small mammals
Vaux's Swift	SR; MA to OG conifer, all Series but ABLA2 and upper TSME, prefers OG	dish, inside wall of hollow tree	aerial insects
Rufous Hummingbird	SR; CC to OG, all Series	cup in small tree or shrub	nectar and insects

[1] **Seasonality and Habitat Codes**

PR = permanent resident, SR = summer resident, CC = clearcut, GF = grass-forb,

SS = shrub-seedling, SA = sapling, YF = young forest, MF = mature forest, OG = old-growth forest.

Table 15. (cont.) Seasonality, habitat, food preference and nest habits of common breeding forest birds on the Olympic National Forest.

SPECIES	SEASONALITY and HABITAT [1]	NEST	FOOD
Red-breasted Sapsucker	PR; YF to OG, all Series but ABLA2 and upper TSME	excavated cavity in dead tree	sap and ants
Hairy Woodpecker	PR; YF to OG, all Series but ABLA2	excavated cavity in dead tree	wood-boring beetles and larvae, ants
Northern Flicker	PR; CC to OG, all Series, prefers open areas, edges	excavated cavity in dead tree	ants, ground beetles, fruits, seeds
Pileated Woodpecker	PR; MF to OG conifer, all Series but ABLA2 and TSME	excavated cavity in large dead tree	carpenter ants, wood boring beetle larvae
Olive-sided Flycatcher	SR; CC to OG conifer, all Series, prefers edges and openings	cup on conifer branch	aerial insects, mostly Hymenoptera
Western Flycatcher	SR; YF to OG, all Series but ABLA2 and upper TSME	cup on bank, small tree, stump	insects, mostly Hymenoptera and Diptera
Gray Jay	PR; YF to OG conifer, all Series	stick nest high in conifer	omnivorous, insects, carrion, fruit, etc.
Steller's Jay	PR; YF to OG conifer, all Series but ABLA2, TSME	stick nest in conifer	insects, fruit
Common Raven	PR; CC to OG, all Series	stick nest-large tree or on cliff	carrion, berries, small animals
Chestnut-backed Chickadee	PR; YF to OG conifer, all Series	excavated cavity or old nuthatch cavity	foliage and bark insects, conifer seeds
Red-breasted Nuthatch	PR; YF to OG conifer, all Series	excavated cavity in dead tree	bark and foliage insects and spiders, conifer seeds
Brown Creeper	PR; YF to OG conifer, all Series but ABLA2 and TSME	behind flap of bark on dead or dying tree	bark spiders and insects
Winter Wren	PR; CC to OG, all Series	cup in stump, rootball or log	insects and spiders near and on forest floor.

[1] **Seasonality and Habitat Codes**

PR = permanent resident, SR = summer resident, CC = clearcut, GF = grass-forb.

SS = shrub-seedling, SA = sapling, YF = young forest, MF = mature forest, OG = old-growth forest.

Table 15. (cont.) Seasonality, habitat, food preference and nest habits of common breeding forest birds on the Olympic National Forest. [2]

SPECIES	SEASONALITY and HABITAT [1]	NEST	FOOD
Golden-crowned Kinglet	PR; YF to OG conifer, all Series	cup at end of conifer branch	foliage insects
Swainson's Thrush	SR; SA to OG, all Series but TSME and ABLA2, prefers dense deciduous understory	cup in low tree or shrub	insects of forest floor and understory
Hermit Thrush	SR; SA to OG conifer, all Series but PISI	cup on ground, low tree or shrub	insects of forest floor and understory
American Robin	PR; GF to OG, all Series, prefers edges and openings	cup in tree or shrub	worms, insects, fruits
Varied Thrush	PR; YF to OG conifer, all Series	cup in small tree	forest floor invertebrates, seeds and fruits
Townsend's and Hermit Warblers	SR; YF to OG conifer, TSHE, PSME, ABAM, lower TSME	cup in conifer	foliage insects of canopy
Wilson's Warbler	SR; SS to OG, all Series but TSME and ABLA2, prefers deciduous understory	cup in conifer insects	understory foliage
Song Sparrow	PR; GF to YF conifer, all deciduous, wet conifer of low elevation, all Series but TSME, ABLA2	cup on ground	insects, weed and grass seeds, berries
Dark-eyed Junco	PR; CC to OG, all Series, prefers edges and openings	cup on ground	insects, weed and conifer seeds
Red Crossbill	PR; YF to OG conifer, prefers OG, all Series	platform on conifer branch	conifer seeds
Pine Siskin	PR; YF to OG conifer, deciduous, also in winter, all Series	platform on conifer branch	foliage insects; seeds of conifer, alder, weeds, grass

[1] **Seasonality and Habitat Codes**
PR = permanent resident. SR = summer resident, CC = clearcut. GF = grass-forb,
SS = shrub-seedling. SA = sapling, YF = young forest. MF = mature forest, OG = old-growth forest.

[2]This table was prepared by Chris Chappell. He acknowledges the contributions made by Paul Meehan-Martin, plus L.F. Ruggiero, K.B. Aubry, D.A. Manuwal, and the Pacific Northwest Experiment Station Old-Growth Wildlife Habitat Program.

Amphibians and Reptiles

There are 23 species of amphibians and reptiles known to occur on the Olympic National Forest (Table 16) (Guenther and Kucera 1978, Nussbaum *et al.* 1983, W. Leonard and K. McAllister pers. comm.). Many of these are species of specialized habitats and were not encountered in the sampling. Many others, especially the salamanders, undoubtedly occur frequently on plots in some types, but were not observed or recorded. They live under logs and forest debris, in cool damp habitats and are seldom seen unless a concerted effort is made to uncover them. Those species encountered and recorded on the plots included roughskin newt, common garter snake, Pacific tree frog and red-legged frog.

Table 16. Amphibians and reptiles of the Olympic National Forest.

Common Name	Species	Abundance and Habitat [1]
Northwestern Salamander	*Ambystoma gracile*	C--Sea level to well up in the mountains, seldom seen, occasionally in ponds, often under logs
Long-toed Salamander	*Ambystoma macrodactylum*	C--Mostly seen in ponds at low to mid-elevations, most commonly occurring underground. N and SW part of the Forest
Cope's Giant Salamander	*Dicamptodon copei*	C--Streams and seepages in moist coniferous forests, up to 4000', occasional in ponds
Olympic Salamander	*Rhyacotriton olympicus*	C--Small salamander of small mountain streams, up to 3500'
Ensatina (salamander)	*Ensatina eschscholtzii*	C--Mainly found in forests, occasionally in clearings, under leaf litter and logs in spring and fall, underground in summer
Van Dyke's Salamander	*Plethodon vandykei*	U--Seepages and streamside talus, up to 4500'
Western Redback Salamander	*Plethodon vehiculum*	C--Dense conifer forest under leaf litter and logs, up to 3800'
Roughskin Newt	*Taricha granulosa*	VC--Mesophytic conifer or hardwood forest, up to 5000', sometimes in lakes or sluggish streams
Western Toad	*Bufo boreus*	VC--Terrestrial, occasional to high mountain areas, nocturnal during dry weather
Pacific Treefrog	*Hyla regilla*	VC--Very common, sea level to high montane, mostly terrestrial but breeding in shallow water, nocturnal in dry weather
Tailed Frog	*Ascaphus truei*	C--Fast flowing streams in forested areas, up to timberline, sensitive to water temperature, especially in clearcuts
Red-legged Frog	*Rana aurora*	VC--Usually terrestrial but close to streams or ponds in dry weather
Cascade Frog	*Rana cascadae*	U--Ponds or sphagnum meadows, fairly high in the mountains
Bullfrog	*Rana catesbeiana*	U--Introduced, aquatic, usually of low elevations
Spotted Frog	*Rana pretiosa*	?--Marshy edges of ponds or in algae-grown overflow pools, occasional around high mountain lakes in Oregon, Olympic Peninsula, but not known from Olympic National Forest. Possibly extirpated.
Painted Turtle	*Chrysemys picta*	?--Marshy ponds, slow moving streams, low elevations on Olympic Peninsula,not known from Olympic National Forest
Northern Aligator Lizard	*Elgaria coerulea*	U--Known from margins of conifer forests and in cut-over areas along the NandE fringe of the Forest, up to 5000' in Oregon but much lower in Washington
Western Fence Lizard	*Sceloporus occidentalis*	?--Dry bouldery areas, farmlands and fence-rows, known from Olympic Peninsula but not Olympic National Forest
Rubber Boa	*Charina bottae*	U--Varied habitats, sea level up to high mountains.
Gopher Snake	*Pituophis melanoleucus*	?--Listed by Nussbaum et al. (1983), but probably does not occur on the Olympic Peninsula (W. Leonard 1988, personal communication).
Northwestern Garter Snake	*Thamnophis ordinoides*	C--Meadows and brushy areas along edges of forests, sea level up to moderate elevations.
Common Garter Snake	*Thamnophis sirtalis*	VC--Wet meadows and along water courses, into deep confierous forests.
Western Garter Snake	*Thamnophis elegans*	?--Terrestrial, but often near water or in damp meadows, Olympic Peninsula but possibly not on Olympic National Forest

[1] Abundance codes: VC=very common C=common U=uncommon ?=May not occur on Forest

METHODS

Sample Design

The sample design included both Reconnaissance and Intensive plots distributed over the landscape in a systematic design. This design called for one Reconnaissance plot near the center of each section of land on the Forest, for a total of about 1000 plots. In addition, 400-600 Intensive plots would be located at previously unfilled locations in this systematic sample or randomly in selected associations and/or age classes (Figure 32). In a subsample of these Intensive plots, 60-100 soil pits would be dug. Also 400-600 Reconnaissance plots would be placed in non-forested communities. Even though the basic sample design approximated a systematic sample in a statistical sense, it was hoped that this design would not only give a good representation of the potential vegetation of the Forest without sampler bias, but would yield at least 10 old-growth plots and one soil pit per association. This did not happen, as some minor types were undersampled. An attempt was made in establishing the Intensive plots to even out this plot distribution by association. An attempt was also made to put many of the Intensive plots in age classes younger than old-growth in order to help develop the productivity, potential and constraint information for each type.

Plot Design

Several different kinds and sizes of plots were used during the course of this project. Basically there were two types of plots, the Reconnaissance (Recon) plot and the Intensive plot. The Recon plot was used during the earlier stages of the project to gain extensive information which could be used to develop the basic classification. The Intensive Plot was used to help analyze the environmental and biological relationships of each association and to better develop the potentials and constraints.

The layout of the plot was fixed-area and circular. Early in the project a 500 sq. meter plot was standard, with smaller (250 sq. meter) or larger (1000 sq. meter) plots being used where the structural or spatial relationships in the community warranted. Later this size was converted to the English size equivalents of 1/10, 1/5 and 2/5 acre plots (see Table 148 p. 421). When Intensive plots were used, the standard was 1/5 acre, but the sampling goal was a plot which included about 50 trees on the tree measurement part of the plot. Plot size was adjusted accordingly. Few plots in the data base include fewer than 40 trees and many contain over 80.

Analysis

Analysis of the sampled data to develop an association classification and the accompanying ecological and environmental relationships, plus development of their potentials and constraints is very complex and virtually impossible to describe in much detail here. What follows is a short discussion of the more important of these methods. It should be noted that because of the size of the data base and the complexity of the analysis, this project in its present scope would have been impossible without the use of modern computers.

Classification

Methods for classifying vegetation into types are described by many authors including Mueller-Dombois and Ellenberg (1974) and Braun-Blanquet (1932). We used a three-stage analysis to produce this association classification. Only the first of these stages is used by classical phytosociologists. The last two stages are used so that the associations represent meaningful relationships to the environment and for management. These stages are:

1. Develop a floristic based classification using cluster analysis, similarity analysis, ordinations and association tables.

2. Test the classification against known or inferred environmental variables to be sure the "types" represent relatively small segments of the environment.

3. Test the productivity potentials and inferred constraints against management standards to be sure that each association is useful for management.

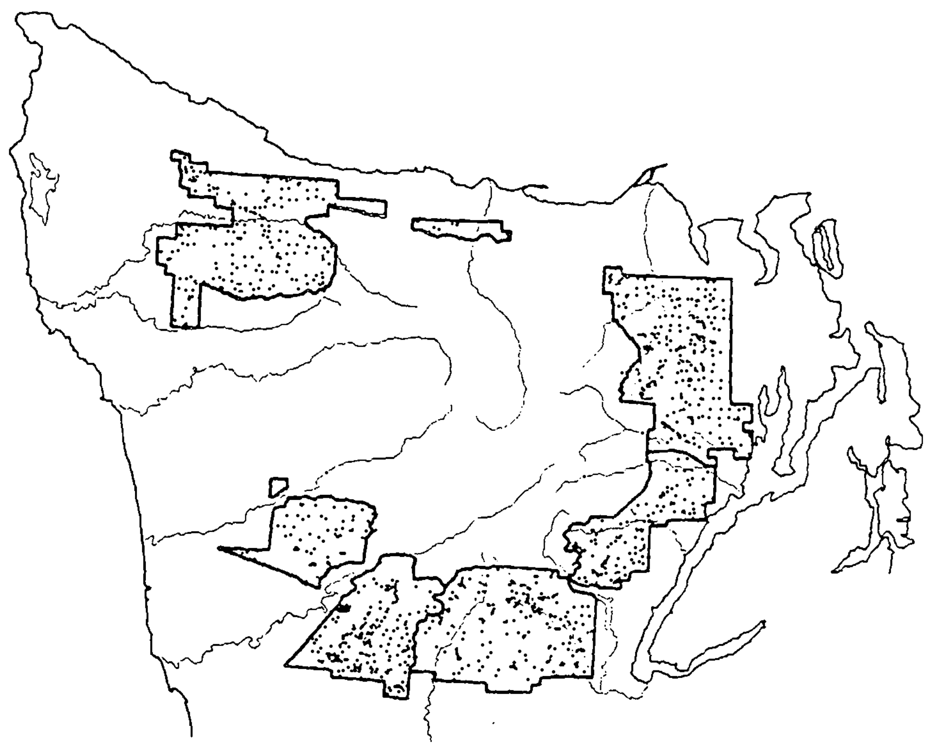


Figure 32. Map of plot locations (Reconnaissance and Intensive plots) on the Olympic National Forest.

Each of these three stages functions as a sieve through which the classification must pass. The first stage however, turned out to be the major sieve, for 90 percent of the final classification was determined after this stage. The later two stages only served to confirm what was found through stage 1. In a few cases two floristically similar types were eventually separated because these were shown to represent significantly different environments or significantly different timber productivities.

In stage 1 we began by doing agglomerative cluster analysis techniques (Romesburg 1984) as developed by Volland and Connelly (1978). The resulting clusters (types) were fed into an association table routine. Plots were regrouped using this technique until floristic differences within groups and floristic similarities between some members of different groups could be reconciled. Similarity tables using a modification of the Bray-Curtis index of similarity (Dick-Peddie and Moir 1970):

$$\mathbf{sim = 2\ min\ (a\ or\ b)/a + b}$$

were utilized to analyze difficult situations. Ordinations were tested on some data sets but did not offer additional information over what was gained from the cluster analysis-similarity analysis-association table approaches.

Timber Productivity Analysis

There are numerous methods for estimating the timber productivity potential for a site. But none are consistently reliable. We have used the following methods for at least some situations in this guide.

1. Site Index

Site index is the height of dominant and codominant trees in a stand at a given base age. This concept has been used for many years and permeates the forestry literature. It is a well accepted index of site yield capability. Although this concept is widely used, there are several assumptions that affect the calculation and interpretation of a site index value. First, it is species specific. Only curves derived for a particular species should be used, since shape of the height/age curve varies by species. Furthermore, each curve specifies which trees to measure and which base age to use. Some specify dominant trees only, some dominants and codominants, and others may specify the tallest 40 trees per acre. Base age may be 50 or 100 (or sometimes

20) and be based on total age or breast height age. Other assumptions affect the interpretation of site index. One assumption that is widely held, is that site index is independent of stocking. This can be viewed in two ways, one that trees grow to the same height at a given age regardless of the relative stocking of the stand. Data from this project suggests that the range of stocking where height growth is unaffected may be narrower than previously thought. Another view is that stockability is proportional to site index, *i.e.* there is a narrow and consistent range of potential stocking (and therefore yield) that is associated with each site index (or site class). Data from eastern Oregon and Montana suggests, at least for drier sites, that a wide range of stockability may be associated with a single site index class.

We have calculated site index for as many species as was appropriate in each sampled stand. To do this we used the equations given in Appendix 4 (pp. 490-493) applied to the appropriate trees for each plot. The resulting site index values are given in the timber productivity tables for each association. In addition, these site index values were used to derive yield estimates for each association in the cases where suitable yield tables were available. Curves were derived from those yield tables which listed site index and potential yield at age of culmination of mean annual increment. These curves are given in Figure 189 (p. 496).

2. Growth Basal Area (GBA)

Growth Basal Area (GBA) is an index of forest stand stockability (Hall 1983, 1987). It uses the relationship between current radial increment of dominant trees, current total stand basal area and age, to index the capability of a site to support and grow wood volume. This relationship is relatively independent of stand density except at extreme conditions, and can be used in combination with site index to appraise the capability of a site for timber production. In concept it is not unlike Reinecke's (1933) Stand Density Index which used number of trees per area at an average stand diameter of 10", Wiley's (1978b) Growing Stock Index which is the basal area a stand may be expected at attain at a given index age (often 50 years), or Curtis' (1982) Relative Density, which relates average tree diameter and stand basal area. All these relationships attempt to index the relationship between tree size, number, growth and stand growth.

The concept of Growth Basal Area assumes that for a given site and age, radial increment of dominant trees will vary in a mathematically predictable way with stand basal area. This relationship holds that as stand basal area increases, radial increment of dominant trees decreases. GBA also holds that for a given basal area and age, radial increment of dominant trees will vary relative to the quality of the site for stockability. This is different from the quality of a site to grow taller trees, which is usually indexed by dominant tree height at a base age, *i.e.*, site index. Lastly, GBA holds that these relationships vary with age of the stand. Therefore, GBA is a way of comparing stockability of different kinds of sites by determining the stand basal area which will support a constant amount of radial growth. This radial growth is established to be 1/2 inch of radial increment in 10 years (which is equal to one inch of diameter growth, or 10/20 of an inch of radial increment). Thus on a better site, 1/2 inch of radial increment/decade might be possible at 400 sq ft/ac of basal area, while on a poorer site the same radial growth would be possible at only 200 sq ft/ac of basal area.

Determining GBA--To estimate GBA for a stand, select five dominant trees per plot. Increment core each tree to determine total age and 10-year radial increment (measured in 20ths inch). Determine current stand basal area in the vicinity of each sampled tree, or for the plot as a whole.

For each sampled tree use the radial increment to determine the GBA conversion factor from Figure 33 (or equation 4 p. 494). Multiply this number (usually from 0.7 to 2.0 by the estimate of stand basal area (sq ft/ac). For example, if the basal area around the sampled tree is 270 sq ft/ac and the radial increment is 18 20ths, multiply 1.4 (conversion factor for 18 20ths) by 270. This yields an uncorrected GBA estimate of 378 sq ft/ac.

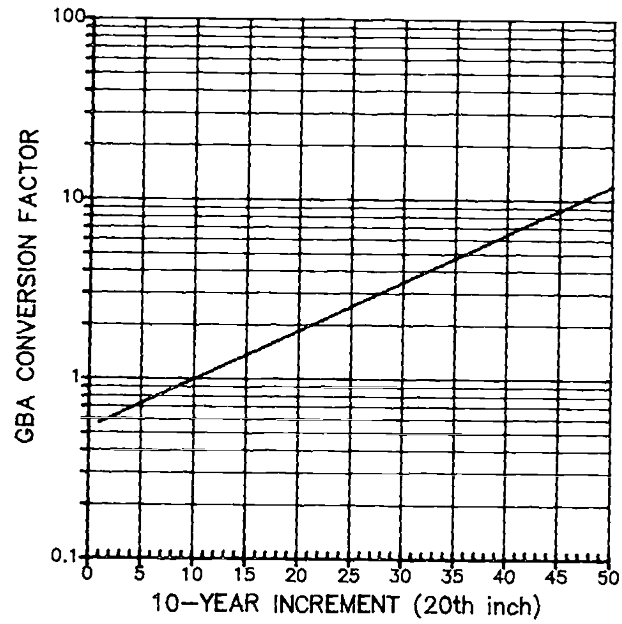


Figure 33. GBA conversion factor curve.

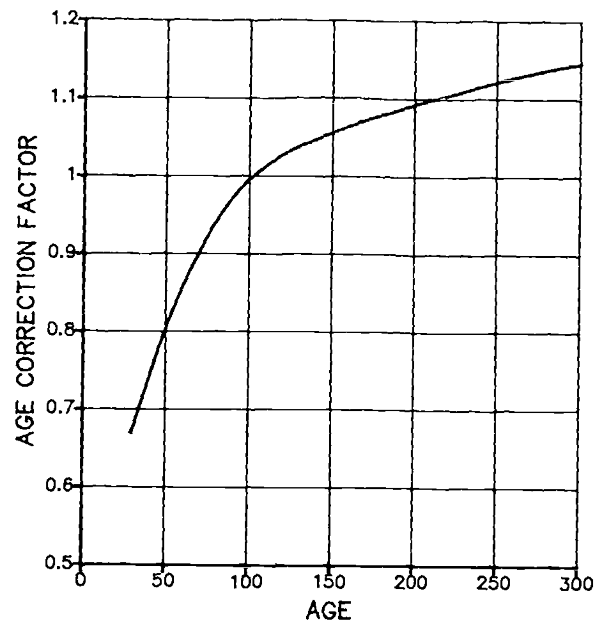


Figure 34. GBA age correction factor.

Next adjust for stand age by applying the correction factor from Figure 34 (or equation 4 p. 494). This number can vary from about 0.9 to 1.2 for stands 40 to 200 years old. In the example above, the tree was 150 years. The correction factor for this age is 1.08. The corrected GBA is finally calculated to be (1.08 x 270) 408 sq ft/ac. Repeat this process on the other four trees. The resulting average of these five trees is the GBA for the stand, *i.e.* the basal area which should allow these trees on this site to grow 1 inch in diameter in 10 years.

Application of GBA--Growth Basal Area is used primarily for indexing stockability and as a measure of relative stand productivity. A GBA of 600 is very high and a GBA of 50 is very low. It may be used to compare the relative stockabilities of different kinds of sites. For example, sites characterized by the Ponderosa pine/wheatgrass (Pipo/Agsp) and Ponderosa pine/elk sedge (Pipo/Cage) associations in the Blue Mountains of Oregon (Hall 1983) both have an average site index of 60 feet at 100 years. However the GBA for the Pipo/Agsp type is 35 sq ft/ac, and 90 sq ft/ac for the Pipo/Cage type. Although the site index values suggest that each of these kinds of sites should be equally productive, Pipo/Cage has 2.5 times the stockability of Pipo/Agsp.

Growth Basal Area may be used to adjust yield table values which are based only on height growth potential. In the above example, normal yield table basal area for Ponderosa pine site index 60 is 169 sq ft/ac. However, if stands of Pipo/Cage (GBA = 90 sq ft/ac) are considered "normal", then stands of Pipo/Agsp with GBA of only 35 sq ft/ac would be expected to have only 39% of the yield table values for Ponderosa pine.

3. Site Index-Yield Table

This method is used when site index curves and corresponding yield tables are available. For lowland Douglas-fir we used McArdle and Meyer's (1930) site index curve (base 100) and yield table (all trees >1" DBH), King's (1966) site index curves (base 50, breast height age), and DFSIM (Curtis *et al.* 1981) yield model. (Figure 189 p. 496) gives site index and corresponding yield values.) In some cases we used the high elevation site index curves developed by Curtis *et al.* (1974) for Douglas-fir.

For western hemlock we used Barnes (1962) site index curves and yield table. We also used Wiley's site index curves (1978a) and yield table (1978b) for comparison. The yield table of Chambers and Wilson (1978) uses Barnes (1962) site index curves (adjusted for base 50 age) and appears to be an improvement over Barnes' yield table because it takes stocking into consideration. However their yield table only covers the age range from 30-100 years. For high elevation western hemlock, Barnes (1962) curves and yield table was used, however upper slope conditions are different from lower elevation coastal areas, and the use of this yield table for these stands may give an over-estimate of productivity potential.

For red alder we used the site index curves (base 50) and yield table of Worthington *et al.* (1960). We chose not to use the more recent site index curves of Harrington and Curtis (1986) because they are presented in base 20 format. The yield table of Chambers (1983) is an improvement over Worthington *et al.* (1960), but represents a narrower age range and therefore was not used.

For Sitka spruce we used the site index curves and the yield table of Meyer (1937). His curves use base 100 and the yield table is all trees > 2.6" DBH. The site index curves of Hegyi *et al.* (1981) were used in some situations not covered by the curves mentioned above.

For silver fir and mountain hemlock, suitable site index curves and yield tables are not available. We used McArdle and Meyer's (1930) site index curves to get a first approximation. However these curves consistently overestimate the height of dominant and codominant trees at 100 years. We also tried the curves of Hegyi *et al.* (1981). These seemed somewhat better although even better site index curves for this area are badly needed. We used site index values of Hegyi *et al.* (1981) and the DFSIM model (Curtis *et al.* 1981) to estimate potential yield. Some model outputs were adjusted based on stand basal area values. This approach is weak but is probably the best site index-yield table estimate available. Empirical yield curves based on local plots should give better estimates, except that natural stands of critical ages (50-150 years) are very rare on the Forest.

4. Site Index-Growth Basal Area (SI-GBA)

This method was originally developed by Hall (1983) for eastern Oregon. More recently Lillybridge and Williams (1984) and Topik *et al.* (1986) have applied it to northeastern Washington and western Oregon. In this approach, site index (base 100) is multiplied by Growth Basal Area (GBA) and a coefficient (k), which varies between .0025 and .005. This coefficient appears to vary relative to moisture regime and productivity. The better the site the lower the k value. We have used a k of .003 for SI-GBA calculations throughout this guide. However further studies will probably show that good site Douglas-fir stands should use a k of .0025 and poor sites should use a k of .004 or even .005. A sample of intensive plots (Figure 35) shows the relationship between SI-GBA estimates of productivity potential and the more classical site index-yield table approach. At yields greater than 150 cu ft per year, the relationship falls apart, suggesting that some additional factor may need to be considered on better sites. It should also not be inferred that yields from yield tables are without error, or that one site index represents one yield potential. There is probably a range in stockability associated with any site index. SI-GBA is an attempt to deal with this variability in stockability. The relationship between stockability and SI-GBA, though well documented for eastside forests, is yet undetermined for westside forests.

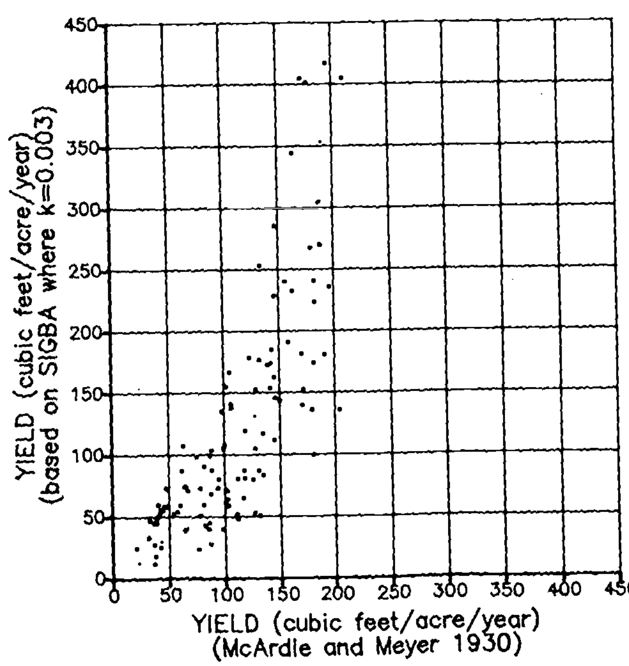


Figure 35. Comparison of yields from SI-GBA and yield table methods.

5. Empirical Yield

This method takes gross volume and age data from Intensive plots, 30 to 300 years old, and fits a volume-age curve to the data. These results often compared favorably to the site index-yield table estimates but not with the SI-GBA estimates.

In all cases we tried to estimate the potential yield at age of culmination of mean annual increment (CMAI) for all trees including tops and stumps. In some cases the potential and empirical yield values are different, and are so noted in the text. Net merchantable yields are expected to be less than the potential yields given in this guide.

At the very best, our methods for estimating potential yield are weak, especially for the Silver Fir and Mountain Hemlock Zones. A certain amount of caution needs to be used whenever one is interpreting potential yield values, especially when using the site index-yield table approach.

Soil Methods

1. Soil Pit Location and Profile Description

One hundred soil pits were dug on the Forest from 1983 to 1986. An attempt was made to distribute the pits across the Forest geographically (Figure 36) and to represent the vegetational diversity as well as possible (Table 152 p. 433). The pits were located on a proportion of Intensive plots. They were placed well away from plot center with the intention of describing the soil of that vegetational unit. This differs from the usual methods used by soil scientists interested in taxonomic considerations by focusing on the vegetation and not the soil per se. The intent here was to better understand those characteristics of the soil which influence the composition of the vegetation. Most of the data which are generally used to describe and classify soils (Soil Survey Staff 1975) were also taken.

The pits were dug at least one meter deep where possible and from 50 to 100 cm on a side. Mineral horizon thickness was measured in centimeters and moist Munsell color (Munsell Soil Color Charts 1975), mottles, texture, structure, consistence, coarse fragments, roots, pores and boundaries were described for each horizon (Soil Survey Staff 1975, 1981). In addition, rooting depth, total depth

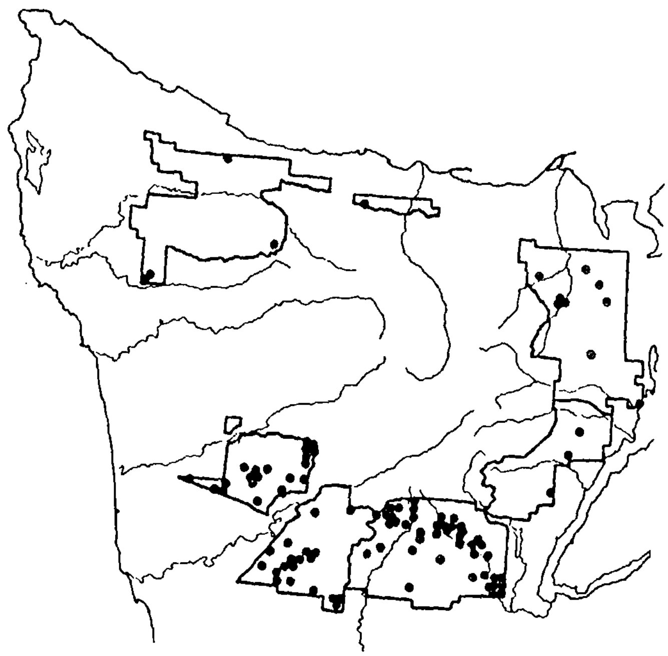


Figure 36. Map of soil pit locations.

and parent material were recorded for the pit and percent cover of bare ground, gravel, rock, bedrock and moss were recorded for the plot. Rooting depth was considered to be the depth above which 90% of all roots were present. Effective depth and effective rooting depth were calculated by subtracting the coarse fragment fraction from one and multiplying by the depth. The O layer was described as O1 or O2 and notes were taken concerning its composition, thickness and extent to which roots penetrated. General notes about the pit and the geology were also recorded on the cards to aid in later interpretation of the data.

2. Soil Nutrients

A soil sample was taken from 20 cm in the pit and mixed with two other 20 cm soil samples from elsewhere on the plot for nutrient analysis. This was done on 49 of the pits, but samples were also taken from plots without pits to make a total of 80 nutrient analyses plots. The goal was to sample the densest part of the rooting zone. The composite samples were mixed in plastic bags and air dried in the office before sending them to the Oregon State University Soil Testing Lab for analysis. The methods used follow Methods of Soil Analysis (Horneck *et al.* in press) (Table 160 p. 440). Samples were analyzed for pH, P, K, Ca, Mg, OM%, TN%, SO4, Na, B, Zn, Cu, and Mn. The nutrient data are summarized by plant association in Tables 153 and 154 (pp. 434-435).

3. Soil Temperature

Soil temperature was recorded on 783 plots using a 20 cm (8 in) soil temperature probe. Each record consists of 1 to 3 averaged measurements from the plot. In addition, 97 measurements from 20 cm, 91 from 50 cm, 10 from 100 cm, and 19 from various depths greater than 50 cm have been recorded from soil pits. These measurements were recorded from May to October, 1981-86, with 572 records in June, July and August in stands with closed canopies (Table 159 p. 439).

The summertime data from closed canopy stands were sorted into groups by environmental zones and month, and then into 1000 foot elevational bands within these groups. Means of each of these groups were calculated, so for each month and zone, there was a mean temperature for each elevation band. A linear regression was fit to each of these data sets to produce monthly lapse rates for each zonal group for each summer month. Temperature patterns for the rest of the year were estimated from data from following three sources. Soil temperature was recorded at 20 cm in Olympia for one year to provide a low elevation measurement. Temperatures of mid- and upper elevations were estimated with data from Mt. Rainier (Greene and Klopsch 1985) and data from Mt. Baker (Naslund 1985). The annual temperature cycle was then modeled on these data (Figure 29 p. 46). The average annual temperature was estimated by averaging the monthly data from these graphs. In addition, summer and winter means were calculated.

To determine the soil temperature regime, the annual average temperature and the difference between summer and winter temperature are needed at 50 cm depth. Temperature measurements from soil pits at depths of 20 cm, 50 cm and greater than 50 cm were stratified by zonal groups and elevation band. These data were averaged by depth and linearly regressed to approximate a profile and determine the temperature difference between 20 cm and 50 cm depths. According to Soil Taxonomy (Soil Survey Staff 1975) the temperature at 50 cm is expected to be 1.5 degrees C lower than 20 cm in the summer, and 1.5 degrees higher than at 20 cm in the winter. Figure 37 shows the difference between summer and winter soil temperature at 50 cm, by environmental zone.

Graphs of annual average lapse rates by groups of zones and mean difference between summer and winter temperature by elevation are shown in Figure 37. These data were then used to formulate the model given in Figure 28 (p. 45) for determination of the soil temperature regime.

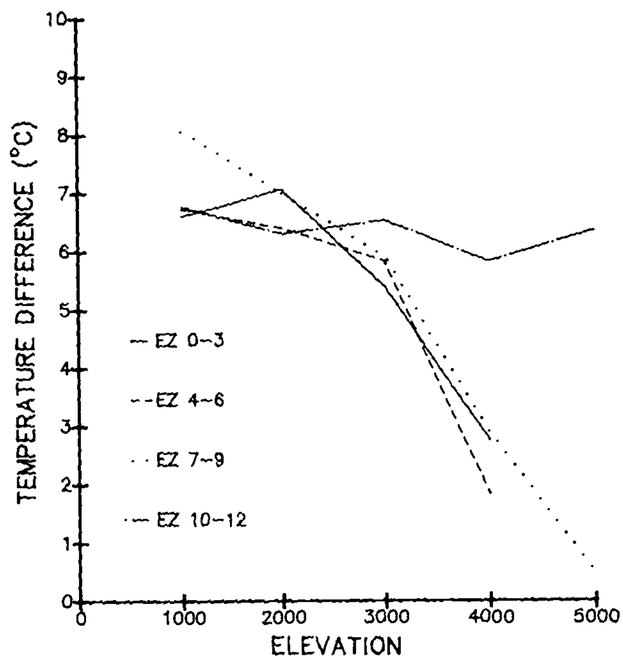


Figure 37. Difference between summer and winter soil temperature at 50 cm depth, by environmental zone.

4. Soil Moisture

Data from the profile descriptions were analyzed to estimate the relative contribution of the soil to the water balance of the community. The average texture of the rooting zone was assigned a percent of available water based on procedures presented in Brady (1974). The effective rooting depth was multiplied by this percentage to give a value which represents the potential storage of available water in the mineral rooting zone. This was also done for the organic rooting zone using a percent available water value equal to that of clay to reflect both the high water holding capacity of organic matter and its high wilting coefficient. The potential storage of the mineral soil and organic layer were then added to give a value approximating the total potential available water of the soil. These values were then averaged by association (Tables 157 and 158, pp.

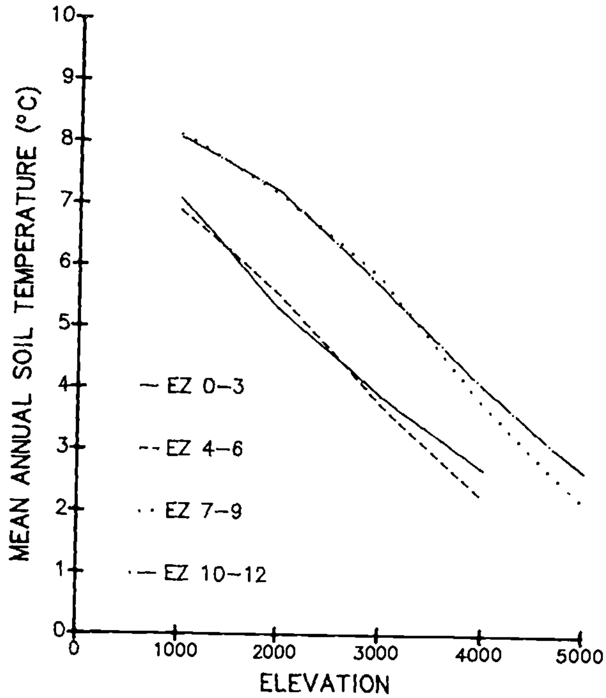


Figure 38. Mean annual soil temperature by elevation and environmental zone.

437-438). Since different soils occur in different topographic positions, they have different opportunities to receive water from the landscape. For example, a very gravelly sandy soil with little ability to hold water, may be wet more often than a clay soil, simply because it is in a position to receive more runoff or subirrigation. This is what we refer to as topographic moisture. Topographic moisture is a value between 1 and 9, where 1 would be equivalent to a dry, steep, rocky ridgetop and 9 would be an aquatic environment (see Table 146 p. 417). It is an attempt to rank each site with respect to the tendency for precipitation to be redistributed by topography. Tables 155-158 (pp. 436-438) arrange the types along three potential moisture gradients.

5. Soil Classification

An attempt was made to classify soils to the Great Group using profile descriptions and Soil Taxonomy (Soil Survey Staff 1975). These are reported in Table 150 (p. 431) in taxonomic hierarchy and Table 151 (p. 432) by plant association. The classifications presented in these lists should be regarded as tentative.

Construction of Keys

Construction of keys to the series or association is a critical step in developing and implementing a classification such as this one. While the key is not intended to be the classification, it is important in helping to define the limits of associations. Once the classification is determined, the key will make it possible for many people to readily use and understand it. Building a good key is often a process of trial and error. Certain principles have evolved over the years which make key building easier and more consistent. Some of these are summarized here:

1. Keys must be unambiguous.
2. Associations indicated by species with the narrowest ecological amplitude should key out first. These are usually very dry or very wet site species.
3. The dichotomous key is preferred but not necessary.
4. Any association may key out at more than one place in the key.
5. Do not allow communities to "fall between the cracks." Everything must key out, even if it keys out to "unknown".

SECTION 2

- Introduction to the Classification
- Keys to the Series
- Series Descriptions
- Keys to the Associations
- Association Descriptions

INTRODUCTION TO THE CLASSIFICATION

The "Forested Plant Associations of the Olympic National Forest" is a tool to use in identifying a plant association in the field and to use in making decisions about management of the plant association. Section 2 presents the classification of potential natural plant communities for the forested land of the Olympic National Forest. This classification consists of a hierarchy of two levels. The categories at the bottom level are called plant associations. These plant associations are aggregated into a more general level called vegetation series (or simply, series). Both of these levels represent abstract grouping of natural plant communities at their potential or "climax" stage of successional development. The land area where a series predominates is called the vegetation zone and has the same name as the series it represents. For example, the Silver Fir Series is a taxonomic grouping of silver fir dominated associations. The land area where the Silver Fir Series predominates is called the Silver Fir Zone. Therefore, the series is a taxonomic category and the zone is a geographical or mapping unit.

The association is named for the climax stage, but also includes all successional stages leading to the climax. This name takes the form of a binomial. It consists of one dominant climax tree species as the first part of the binomial, and one or more ground vegetation species as the second part of the name. Only one tree species is used, although in most cases on the Olympic National Forest, there are two or more tree species which codominate in the climax stage.

Section 2 consists of three basic elements:

1. A classification of potential forest communities (plant associations). The classification is a hierarchy which consists of series and plant associations. It is also a concept of how all the climax forest communities relate to each other and to their environment.

2. A key to the forest series and associations. This key is a tool to help determine which plant association a particular community (stand) belongs to. In this sense, it is a tool to identifying an association, but it is not the classification.

3. Descriptive information about each association. This includes the floristic components of the association, its environment, soils and potential productivity. This information is used to help identify the association but also to help apply the association concept to the solution of management problems.

How to Identify the Plant Association

To identify a particular stand, the following procedure should be used:

1. Locate the stand to be identified.

2. Determine the number of sample points to be taken in the stand. One is sufficient if the stand is all one association. Several may be needed if more than one association occurs.

3. Each sample point will be a plot of some fixed size. An area from 1/20 to 1/5 acre works well.

4. Identify all indicator species on the plot.

5. Estimate the cover for each indicator species (see Appendix 1 p. 420).

6. Go to the series key on page 88. Begin at the top and work through the key until the series is determined. Check the identification against the appropriate series description.

7. If the community is well developed or over 80 years old, then go to the association key for the appropriate series.

8. Work through the association key carefully, noting all situations where there was some question about which way to go in the key. This key should lead to the name of one association that best fits the field conditions you are dealing with.

9. Go to the appropriate association description. Compare what was found on the plot (and in the stand as a whole) to the descriptions and tables. Refer to the species abundance tables

following the series descriptions or in the association descriptions. If there is some question about the identity of the association, try the key again. If the ground cover is sparse, see the "Depauperate" type descriptions or determine why the cover is sparse.

10. Check the information to see if the stand fits the expectations for that association.

11. At this point 90 percent or more of the stands should be properly identified.

12. Once the association is identified, there are three sources of information that can be used in relating the association to management:

    A. This plant association guide gives information about the composition, environment and management responses of each particular association.

    B. Other research may relate species suitability, ecology, management responses, insect and disease relations, soil, environment, nutrient relations, or growth and yield.

    C. Local knowledge may be the greatest source of information about individual associations in an area. As stand exams, silvicultural prescriptions, inventories, and administrative studies become stratified and coded by plant association, this knowledge will be available to users of the plant association concept.

Some difficult stand conditions will be encountered. One such condition is where the stand is too young to have developed a mature understory, or the climax tree indicators are not present. In this case the user must apply local knowledge or extrapolate from nearby stand conditions to be able to properly identify the association. Another stand condition which will be difficult to key out is where the stand is more mature, but the ground vegetation is still depauperate (*i.e.* sparse). The association key will lead to the Silver Fir/Depauperate or Western Hemlock/Depauperate Association. However, the user must determine if the ground vegetation is sparse due to dense tree stocking or heavy litter, or due to the environment. In the first two cases the stand should not be identified as a depauperate type. The user should try to determine what the ground vegetation would be under more normal stand conditions and identify the association based on that.

Keys are presented to help identify the series and associations. They apply to climax or stable-state vegetation. The series key is presented below and on page 501 in the appendix. The association keys are presented in each of the appropriate series discussions and also beginning on page 501. These are dichotomous keys but are not presented in the classical format. The second lead in the key is omitted. In this sense, the second lead is always assumed to be "not as above," and lets the reader go immediately to the next lead in the key. For example, in the series key below, the first lead is mountain hemlock (TSME) greater than or equal to 10 percent cover (in the mature or climax stand condition). If the statement is true, then the stand in question has keyed to the Mountain Hemlock Series, if the statement does not fit the stand in question, then the reader should go to the next lead in the key and repeat.

KEY TO FOREST SERIES OF THE OLYMPIC NATIONAL FOREST

Mountain Hemlock ≥ 10% cover	Mountain Hemlock Series (TSME)	p. 109
Silver Fir ≥ 10% cover	Silver Fir Series (ABAM)	p. 139
Sitka Spruce ≥ 10% cover	Sitka Spruce Series (PISI)	p. 243
Western Hemlock and/or Western Redcedar ≥ 10% cover	Western Hemlock Series (TSHE)	p. 277
Douglas-fir ≥ 10% cover	Douglas-fir Series (PSME)	p. 89
Subalpine Fir ≥ 10% cover	Subalpine Fir Series (ABLA2)	p. 253

DOUGLAS-FIR SERIES

DOUGLAS-FIR SERIES
Pseudotsuga menziesii
PSME

The Douglas-fir Series (Zone) covers about 4200 acres (0.6%) of the Olympic National Forest (Figure 39). It occupies middle elevation sites on south facing slopes in dry areas. It is most common in Environmental Zone 12 in the upper Dungeness River drainage. At higher elevations in the Dungeness drainage it is replaced by the Subalpine Fir Zone. On moister sites it is replaced by the Western Hemlock Zone. The productivity and stockability in this series is low.

The climate of the Douglas-fir Zone is dry temperate to almost continental. Winter and summer temperatures are quite variable from day to night and from season to season. Soil drought is common and extended. Winter snowpacks, even high in the mountains, are light and transient. Therefore, soil is poorly insulated from the extremes of winter. Precipitation is usually less than 40 inches annually and/or the site is very dry topographically. There is very little "precipitation" from tree drip and the humidity tends to be low.

Soils are cool and dry with a thin O horizon and only modest development of mineral horizons. An A horizon is usually present but is not very high in organic matter or nitrogen. These soils are the least acidic (pH 5.6) of any series, and were also highest in potassium, phosphorus, calcium and magnesium of any series. The texture is often coarse with many large fragments. They typically occupy mid-to upper slopes in dry topographic positions. The regolith is usually shallow to moderately deep colluvium and a variety of bedrocks are possible.

The soil moisture regime is xeric which indicates there is a pronounced summer drought. The soil temperature regime is frigid, which means that the average annual temperature is less than 8 deg C and the summer-winter fluctuation at 50 cm is greater than 5 deg C. It is likely that the soil temperature fluctuates quite widely in this series. Because of the sparse canopy and tendency of these stands to be on south-facing slopes, soil temperatures can become quite high during the summer.

The organic layer for associations in the Douglas-fir Series is mostly a mull although duff mulls may also occur. The O2 horizon is thinner (1.2 cm) than that found in other series. The factors most likely to cause such a thin O2 layer are low productivity, a shorter fire return period and favorable conditions for rapid decomposition.

Inceptisols comprised 60% of our sample and entisols the other 40%. There was no indication of development of spodosols. The comparatively high pH and mineral nutrient levels indicate that little leaching is going on compared to the other series.

The dominant tree species are Douglas-fir or lodgepole pine. Madrone, western hemlock, western white pine, western redcedar or Rocky Mountain juniper may also occur. This series is too dry for most Pacific Northwest conifers.

Root disease problems may include Armillaria root disease and laminated root rot in Douglas-fir. Both of these diseases may impact regeneration and productivity. Black stain root disease may be present in Douglas-fir plantations. Heart and butt rots of potential importance are red ring rot, brown trunk rot and brown cubical butt rot, especially in old-growth stands. Red ring rot may be the most important decay in the Douglas-fir Series.

Insect problems can include western blackheaded budworm on Douglas-fir and Douglas-fir beetle on stressed, windthrown, or diseased Douglas-fir.

Potential yield for associations in the Douglas-fir Series was estimated using three methods. The first method is the site index-yield table approach using the site index curve and yield table of McArdle and Meyer (1930) and the site index curve of King (1966) and the DFSIM model (Curtis *et al.* 1981). The second method used an empirical volume curve which was generated from the plot data. The third method was the SI-GBA method of Hall (1983, 1987). Since all stands for all associations were predominantly Douglas-fir, and the site quality of this series is low, it is not surprising that there is a good correspondence between the three methods. For example, for the Douglas-fir/Salal Association the three potential yield estimates were 48, 56, and 63 cubic feet per acre per year.

Three Plant Associations are recognized in the Douglas-fir Series. These are described by 48 Reconnaissance and Intensive plots taken from 1979 to 1986. Environmental values and mean relative cover values for these associations are summarized in Tables 17 and 18 (pp. 94-95). The three associations are presented in alphabetical order by common name on pages 96-107. They can be identified by using the following key. (See page 88 for explanation of how to use this abbreviated key).

Key to Plant Associations of the Douglas-fir Series

Salal $\geq$5%	PSME/GASH	p. 104
Kinnikinnick $\geq$5%	PSME/ARUV	p. 96
Oceanspray and Baldhip Rose $\geq$5%, Western Fescue $\geq$1%	PSME/HODI-ROGY	p. 100

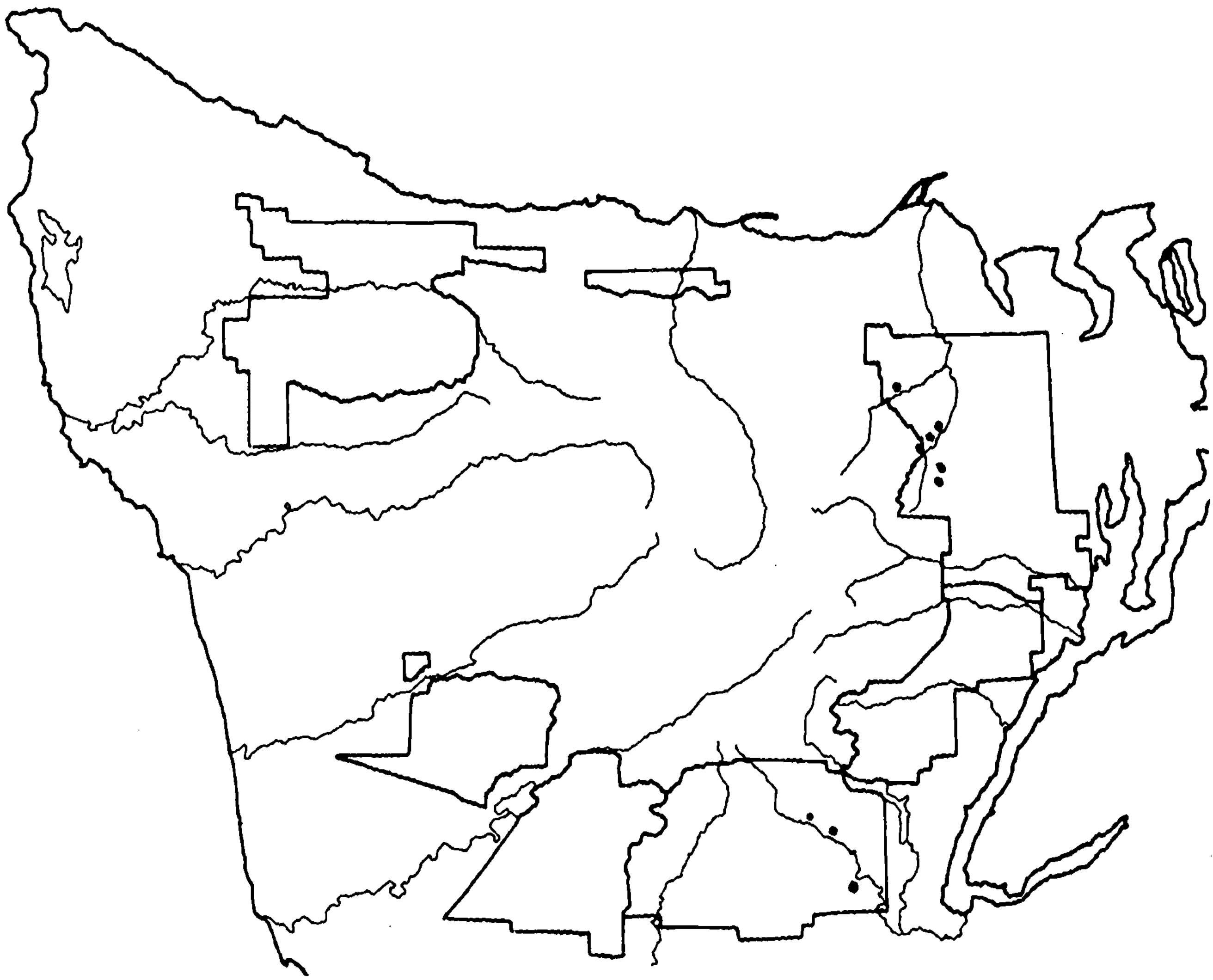


Figure 39. Map of the Douglas-fir Zone on the Olympic Peninsula.

Table 17. Environmental values for associations in the Douglas-fir Series. Slope, elevation and topographic moisture are mean values for the sample.

ENVIRONMENTAL VALUES	ASSOCIATIONS PSME/ARUV	PSME/HODI-ROGY	PSME/GASH
ECOCLASS Code[1]	CDS6 51	CDS2 21	CDS2 55
Number of plots[2]	8	25	15
Aspect	SE-SW	SE-SW	SE-SW
Slope (%)	53	61	52
Elevation (ft.)	3894	2996	1888
Environmental Zone[3]	12 (9,11)	11,12 (8)	8-11 (12)
Topographic Moisture[4]	3.0	3.6	3.6
Soil Moisture Regime[5]	xeric	xeric	xeric
Soil Temperature (deg C) [6]	13.2 (4)	12.7 (12)	12.0 (7)
Soil Temperature Regime[7]	frigid	frigid	frigid
Lichen line (ft.)	2	4	

[1] See Table 161 p. 443

[2] Number of plots includes all successional stages sampled.

[3] See Figure 24 p. 40. and discussion p. 38.

[4] See discussion p. 84. Table 146 p. 417.

[5] See discussion p. 44.

[6] Summer soil temperature at 20 cm for mature and old growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.

[7] See discussion p. 44-45.

Table 18. Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Douglas-fir Series. Cover values based on stands >150 years.

		ASSOCIATIONS		
		PSME/ ARUV	PSME/ HODI-ROGY	PSME/ GASH
ECOCLASS Code		CDS8 51	CDS2 21	CDS2 55
Number of plots		7	17	7
TREES				
ABGR	Grand fir		6 (35)	
ABLA2	Subalpine fir	1 (14)		
ACMA	Bigleaf maple			
ARME	Madrone		25 (5)	6 (14)
CONU	Pacific dogwood			7 (28)
JUSC	Rocky Mountain juniper	3 (14)	4 (11)	
PICO	Lodgepole pine	29 (42)		
PIMO	Western white pine	1 (28)	2 (5)	4 (28)
PSME	Douglas-fir	49(100)	73(100)	71(100)
PYFU	Western crabapple		1 (5)	
QUGA	Garry oak		3 (5)	
RHPU	Cascara			
TABR	Pacific yew		2 (17)	
THPL	Western redcedar		8 (5)	6 (14)
TSHE	Western hemlock	2 (28)	4 (35)	3 (71)
SHRUBS and HERBS				
ACCI	Vine maple			18 (57)
ACGL	Douglas maple	5 (14)	8 (41)	4 (28)
ACMI	Yarrow	1 (42)	2 (41)	1 (14)
ACTR	Vanillaleaf	1 (14)	8 (52)	1 (14)
ADBI	Pathfinder		2 (82)	1 (14)
ALCE	Nodding onion	1 (14)	1 (23)	
AMAL	Serviceberry	2 (28)	1 (58)	1 (57)
ANLY2	Lyall's anemone	1 (28)	1 (11)	
ARCO3	Hairy manzanita	1 (14)	1 (17)	7 (28)
ARUV	Kinnikinnick	20(100)	1 (29)	19 (42)
ARMA3	Bigleaf sandwort	1 (57)	2 (82)	1 (28)
BENE	Oregongrape	5 (71)	4 (88)	15 (85)
BRVU	Columbia brome	4 (14)	8 (88)	1 (14)
CASC2	Scouler's harebell	1 (42)	2 (76)	1 (42)
CARO	Ross sedge		1 (11)	1 (14)
CHME	Little prince's pine		1 (5)	1 (28)
CHUM	Prince's pine	1 (71)	1 (70)	1 (85)
COCO2	Hazelnut			2 (14)
ELGL	Blue wildrye	6 (14)	3 (41)	
ERLA	Woolly sunflower	1 (28)	1 (17)	
FEOC	Western fescue	2 (71)	5 (82)	3 (71)
FRVE	Woods strawberry	1 (42)	2 (76)	1 (14)
GASH	Salal		1 (23)	56(100)
GATR	Fragrant bedstraw		1 (35)	
GOOB	Rattlesnake-plantain	1 (14)	1 (47)	1 (57)
HIAL	White hawkweed	1(100)	1 (94)	1 (85)
HODI	Oceanspray	4 (85)	9(100)	4 (57)
JUCO4	Common juniper	1 (42)	2 (29)	
LANE	Nuttall's peavine		2 (35)	
LIBO2	Twinflower	1 (14)	1 (29)	3 (57)
LOCI	Orange honeysuckle	1 (28)	1 (52)	1 (14)
LOMA2	Martindale's lomatium	1(100)	1 (11)	1 (14)
LOUT2	Utah honeysuckle		5 (5)	
LULA	Subalpine lupine	20 (14)		
LYAM	Skunkcabbage			1 (14)
MOPA	Littleleaf montia	1 (14)	1 (29)	1 (14)
NONE	Woodland beardtongue	1 (42)		2 (28)
OSCH	Sweet cicely		1 (52)	
PAMY	Pachistima	1 (85)	3 (29)	1 (14)
POMU	Swordfern	1 (14)	1 (52)	4 (71)
PTAQ	Bracken fern		1 (5)	1 (28)
RHMA	Rhododendron			7 (28)
ROGY	Baldhip rose	2 (85)	7 (94)	2 (71)
RUUR	Trailing blackberry		1 (5)	1 (57)
SYMO	Creeping snowberry	1 (85)	5 (88)	2 (42)
TRCA	Tall trisetum		1 (17)	
TRLA2	Starflower	1 (42)	2 (70)	2 (71)
VAPA	Red huckleberry	1 (14)	1 (17)	2 (71)
VIAM	American vetch		1 (35)	
VISE	Evergreen violet		1 (11)	1 (14)
XETE	Beargrass			1 (71)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 165 p. 452-453 for mean absolute cover values.

[2] Constancy is the percentage of plots for that association where the species occurred.

DOUGLAS-FIR/KINNIKINNICK

Pseudotsuga menziesii/Arctostaphylos uva-ursi
PSME/ARUV CDS6 51

The Douglas-fir/Kinnikinnick Association is an uncommon type of dry areas and topographically dry sites, high elevations and low timber productivity. It is found mainly on the Quilcene District (Figure 40). Soils are shallow, coarse and immature, derived from very stony colluvium, and appear to be particularly low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 19) is kinnikinnick (ARUV). Other shrubs may include Oregongrape (BENE), oceanspray (HODI), baldhip rose (ROGY) and creeping snowberry (SYMO). Herbs are sparse and may include western fescue (FEOC), Martindale's lomatium (LOMA2) and white hawkweed (HIAL). The tree layer is dominated by Douglas-fir and sometimes lodgepole pine (Figure 41). Rocky Mountain juniper and western white pine are occasionally found. Old-growth stands in this type are less than 300 years old. Brush competition is not usually significant, however because of the harshness of the site, regeneration is often very slow.

Ground mosses and lichens are sparse, except in some open, rocky stands. *Rhacomitrium canascens* is the most common ground moss. Nitrogen-fixing lichens such as *Peltigera aphthosa* and *Lobaria pulmonaria* can occur. Epiphytic lichens are conspicuous and often abundant. *Alectoria sarmentosa*, *Bryoria* spp., *Hypogymnia imshaugii*, *H. enteromorpha* and *Platismatia glauca* are the most common.

Successional Relationships

There are two probable successional pathways for this type. One dominated by Douglas-fir, the other by lodgepole pine. Later seral stages are dominated by Douglas-fir. Western hemlock may occur in very small amounts, usually in wet microsites in the stand.

Other Biota

Deer signs are frequently recorded on this type, with signs of recent activity observed in August. Commonly browsed species include oceanspray, baldhip rose, pachistima (PAMY), red huckleberry and Oregongrape. Douglas squirrel and snowshoe hare can also occur. Birds commonly observed include red-breasted nuthatch, chestnut-backed chickadee, golden-crowned kinglet and gray jay.

Table 19. Common plants in the PSME/ARUV Association, based on stands >150 years (n=7).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	48.7	48.7	100	20-80
lodgepole pine	PICO	12.6	29.3	42	0-50
bitter cherry	PREM	0.7	2.5	28	0-3
western hemlock	TSHE	0.6	2.0	28	0-2
western white pine	PIMO	0.3	1.0	28	0-1
GROUND VEGETATION					
kinnikinnick	ARUV	20.4	20.4	100	3-40
Martindale's lomatium	LOMA2	1.3	1.3	100	1-2
white hawkweed	HIAL	1.0	1.0	100	1-1
oceanspray	HODI	3.7	4.3	85	0-15
baldhip rose	ROGY	1.9	2.2	85	0-4
creeping snowberry	SYMO	1.0	1.2	85	0-2
pachistima	PAMY	0.9	1.0	85	0-1
Oregongrape	BENE	3.7	5.2	71	0-20
western fescue	FEOC	1.6	2.2	71	0-5
prince's pine	CHUM	0.9	1.2	71	0-2
bigleaf sandwort	ARMA2	0.6	1.0	57	0-1

Environment and Soils

This type is found on moderately steep to steep, straight to convex mid-slopes to ridgetops. The soils form in rocky colluvium and are probably shallow with a low water holding capacity. The O layer is thin reflecting a high fire frequency, low productivity and probably a rapid decomposition rate. According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), soils in this type tend to be shallow residual or colluvial gravelly or very gravelly loams in areas of extensive rock outcrops. They are well drained and highly permeable. The mean soil temperature was 13.2 deg C (55.8 deg F) which was the warmest Douglas-fir summer temperature. Due to a higher elevation (3908 ft) and very little snowpack, this soil is probably quite cold in the winter and therefore the most extreme of the Douglas-fir Series. The temperature regime is frigid and the moisture regime xeric.

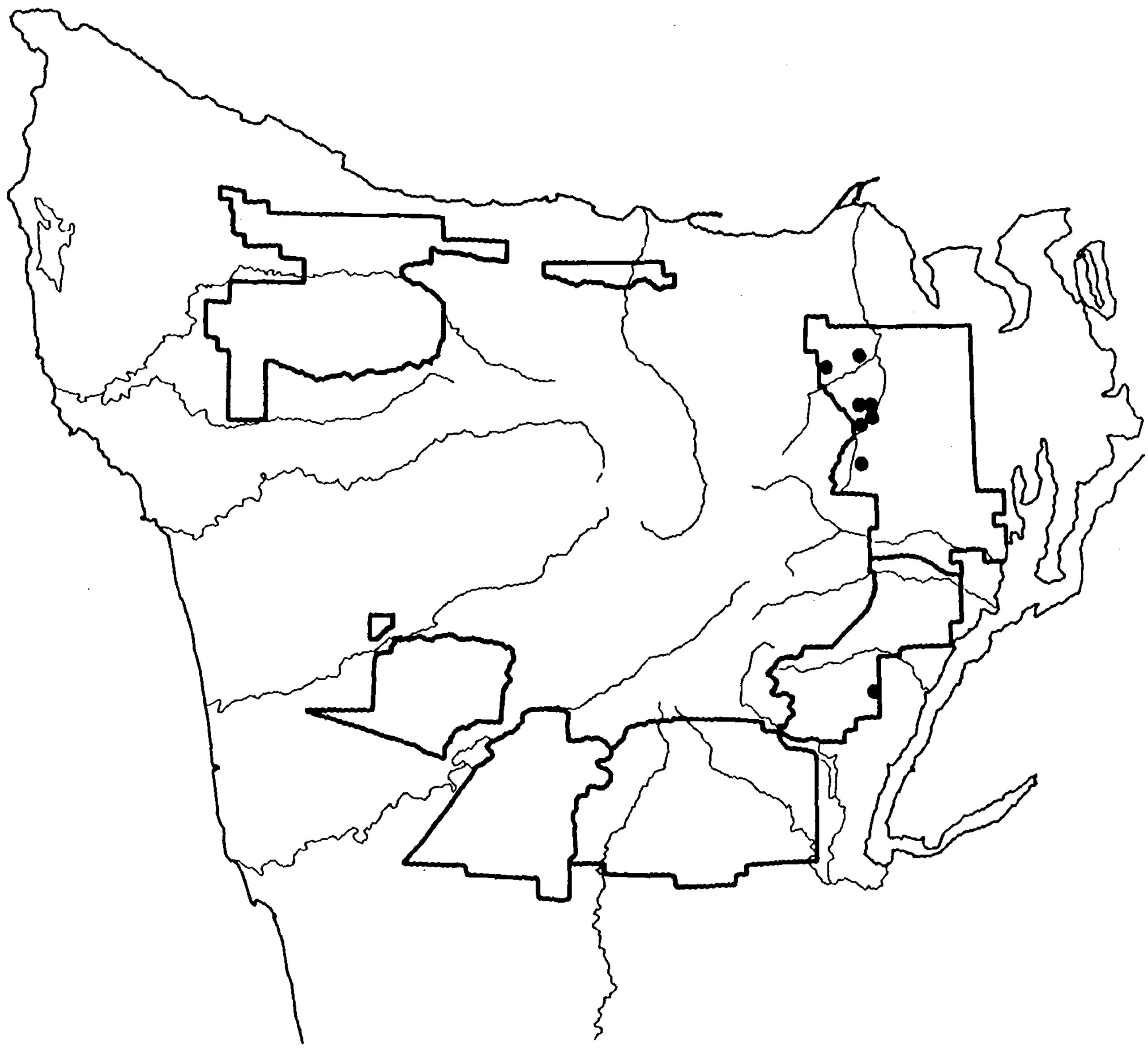


Figure 40. Map of plot locations for the Douglas-fir/Kinnikinnick Association.

Timber Productivity

Timber productivity of this type is very low. This is due to the dryness of the site and poor soils. Site index of measured stands averaged 41 (base 100). The productivity potential using the site index-yield table approach was 20 cu ft/ac/yr. The stockability of these sites is low. The empirical yield for stands of this association was 19 cu ft/ac/yr (Table 20).

Management Considerations

Management considerations for this type include minimizing site disturbance and protecting shallow unstable soil. Natural stocking levels are low. Because of the ridgetop positions and dry southerly exposures where this type usually occurs, there is an increased susceptibility to snow and wind damage. Regeneration can be slow and unpredictable. This association represents environmental conditions which are extreme for the Olympic Peninsula.

Root disease problems in this type may include Armillaria root disease and laminated root rot in Douglas-fir. Both these diseases may significantly impact regeneration and productivity on this association. Black stain root disease may be present in Douglas-fir plantations. Heart and butt rots of potential importance are red ring rot, brown trunk rot and brown cubical butt rot, especially in old-growth stands. Red ring rot may be the most important decay.

Insect problems on this series can include western blackheaded budworm tip killing Douglas-fir and Douglas-fir beetle on stressed, windthrown, or diseased Douglas-fir.

Table 20. Timber productivity values for the Douglas-fir/Kinnikinnick Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI[6]	SDI[7]	GBA TREES	GBA[8]	SIGBA[9]	EMAI[10]
Douglas-fir (McArdle[1])	5	22	41	6	20	253	19	119	14	19
Douglas-fir (McArdle[2])	4	4	42	13	21					
Douglas-fir (Curtis[3])	5	22	43	6		253	19	116	14	
Douglas-fir (King[4])	2	5	33	6	21					
Lodgepole Pine (Hegyi[5])	2	9	46	10	17	298	9	104	14	
Subalpine Fir (Hegyi[5])	1	1	55		25	203				

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[4] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[5] Base age 100, Total age (Hegyi et al. 1979).

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Comparison with Similar Types

Similar types include Douglas-fir/Salal which occurs on slightly moister sites at lower elevations, and the Western Hemlock/Beargrass type which occurs on similar sites but in areas with more precipitation. It is also related to the Western Hemlock/Rhododendron/Beargrass type which occurs on moister sites. The Douglas-fir/Kinnikinnick Association is previously described by Henderson and Peter (1983a) and Smith and Henderson (1986) in the Olympics. A similar type is described by Franklin *et al.* (1988) in Mt. Rainier National Park. On the Willamette National Forest, Hemstrom *et al.* (1987) recognized the Grand fir/Kinnikinnick type which has many similarities to our Douglas-fir/Kinnikinnick Association.

Figure 41. Photo of the Douglas-fir/Kinnikinnick Association, upper Gold Creek, Quilcene District.

DOUGLAS-FIR/OCEANSPRAY-BALDHIP ROSE

Pseudotsuga menziesii/Holodiscus discolor-Rosa gymnocarpa
PSME/HODI-ROGY CDS2 21

The Douglas-fir/Oceanspray-Baldhip Rose Association is a type of dry areas, warm soils, and low timber productivity. It is found at moderate elevations mostly in the upper Dungeness River area of the Quilcene District (Figure 42). Soils are shallow, derived from very stony colluvium, and appear to be well drained. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 21) are oceanspray (HODI), Oregongrape (BENE) and baldhip rose (ROGY). Creeping snowberry (SYMO) is common in young stands. Herbs are sometimes sparse but may include Columbia brome (BRVU), vanillaleaf (ACTR), pathfinder (ADBI), Scouler's harebell (CASC2) and western fescue (FEOC). Douglas maple (ACGL) occurs in some stands. The tree layer is dominated by Douglas-fir, with an occasional grand fir, western redcedar, western hemlock, madrone or yew (Figure 43). Old-growth stands in this type are less than about 300 years old, having originated from fires about 90 and 280 years ago.

Ground mosses are moderately common in this type averaging 28% cover. The most common moss is *Hylocomium splendens*; others cryptogams which occur frequently are *Rhytidiadelphus triquetrus*, *Cladonia* spp. *Homalothecium megaptilum*, and the nitrogen-fixing lichens *Peltigera aphthosa*, *Peltigera* spp. and *Lobaria pulmonaria*. Epiphytic lichens are common, particularly *Alectoria sarmentosa*, *Bryoria* spp., *Platismatia glauca*, *P. herrei*, *Hypogymnia enteromorpha* and *H. physodes*.

Successional Relationships

There is one probable successional pathway for this type, dominated by Douglas-fir. Later seral stages are also dominated by Douglas-fir with small amounts of western hemlock and western redcedar.

Other Biota

Deer signs are frequently observed in this type and indicate heavy use. Recent activity was recorded in August. Commonly browsed species include baldhip rose, creeping snowberry, red huckleberry and Oregongrape. Snowshoe hare and Douglas squirrel may also occur. Birds frequently observed include red-breasted nuthatch, golden-crowned kinglet, common raven, gray jay and chestnut-backed chickadee. Pine siskin, American robin, dark-eyed junco, Steller's jay, olive-sided flycatcher and sharp-shinned hawk may also occur.

Table 21. Common plants in the PSME/HODI-ROGY Association, based on stands >150 years (n=17).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	73.2	73.2	100	10-95
grand fir	ABGR	2.2	6.2	35	0-12
western hemlock	TSHE	1.5	4.3	35	0-20
Pacific yew	TABR	0.4	2.3	17	0-4
Rocky Mtn. juniper	JUSC	0.5	4.0	11	0-5
GROUND VEGETATION					
oceanspray	HODI	8.6	8.6	100	1-60
baldhip rose	ROGY	6.7	7.1	94	0-20
white hawkweed	HIAL	0.9	1.0	94	0-1
Columbia brome	BRVU	6.8	7.7	88	0-35
creeping snowberry	SYMO	4.2	4.7	88	0-25
Oregongrape	BENE	3.2	3.6	88	0-15
western fescue	FEOC	4.4	5.3	82	0-15
pathfinder	ADBI	1.4	1.6	82	0-5
bigleaf sandwort	ARMA3	1.4	1.6	82	0-3
Scouler's harebell	CASC2	1.6	2.2	76	0-7
woods strawberry	FRVE	1.4	1.8	76	0-10
prince's pine	CHUM	0.9	1.3	70	0-4
starflower	TRLA2	1.1	1.6	70	0-3
serviceberry	AMAL	0.6	1.1	58	0-2
vanillaleaf	ACTR	3.2	6.1	52	0-40
orange honeysuckle	LOCI	0.5	1.0	52	0-1
sweet cicely	OSCH	0.6	1.2	52	0-2
swordfern	POMU	0.6	1.1	52	0-2

Environment and Soils

This association can be found on moderate to steep slopes. The regolith is usually colluvial but can be glacial and the bedrock can be metabasalt, sandstone or shale. Slope positions vary from ridgetops to lower slopes with a strong tendency toward convex surfaces. The soils exhibited many similarities in the three pits in this association. They generally have a moderately well expressed A horizon followed by one or more weak B horizons or an AC overlying the C. All surface layers were sandy loams and deeper horizons varied from loamy sands to sand. Structures were moderate to weak, fine to very fine subangular blocky or granular. Coarse fragments varied from 10% to 63%, averaging 49%. Two pits were classified as xerorthents and one as a xerumbrept. The rooting depth was equal to the depth of the pits (120 cm) with many very fine roots throughout the profile. Despite the average effective depth of 70 cm the water holding capacity is low due to the coarse texture. The O layer averaged only 2.7 cm with only 0.3 cm of it being O2. Reconnaissance plots occurred on a variety of Olympic Soil Resource Inventory types (Snyder *et al.* 1969), though most are colluvial inclusions in areas of extensive rock outcrop. These soils tend to be thin, well drained, highly permeable, gravelly to very gravelly loams. A number of plots fell on deep colluvial cobbly loams with compacted subsoils. The compaction makes these soils effectively shallower, but they are still well-drained and permeable. A few plots fell on glacial soils with thin to thick surface gravelly loams or sandy loams and thick gravelly sometimes compacted subsoils.

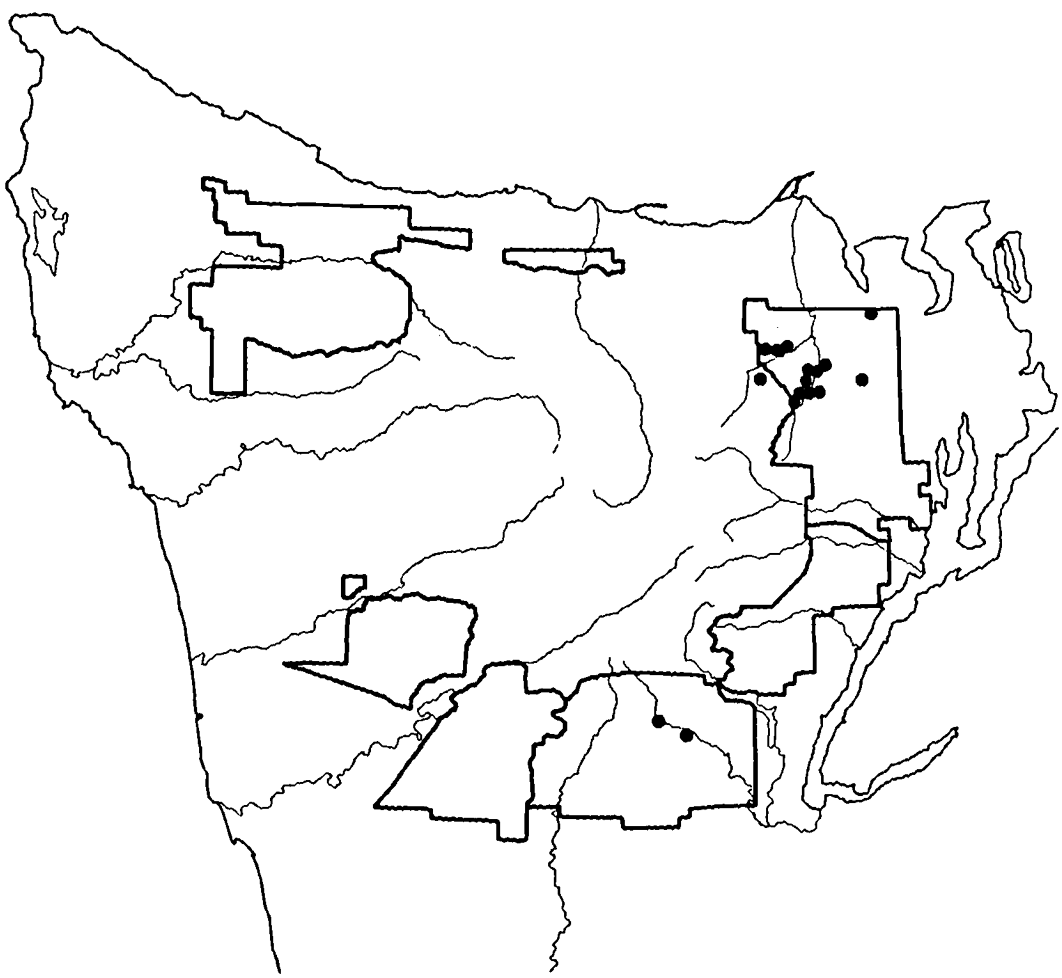


Figure 42. Map of plot locations for the Douglas-fir/Oceanspray-Baldhip Rose Association.

The mean soil temperature was 12.7 deg C (54.9 deg F) making this the second warmest Douglas-fir type in the summer. The temperature regime is warm frigid and the moisture regime is xeric.

Nutrient analysis indicate a high to very high phosphorus, potassium, calcium, magnesium and manganese, and low to very low sodium, boron, organic matter, nitrogen and sulfate. The pH was 5.8 which is one of the highest recorded on the Forest.

Timber Productivity

Timber productivity of this type is low (Site VI). Site index of measured stands averaged 71 (base 100). The productivity potential using the site index-yield table approach was 46 cu ft/ac/yr (Table 22). The stockability of these sites is low.

Management Considerations

Management considerations for this type include ensuring restocking and enhancement of soil nutrients, organic matter, and preservation of the shallow soil litter layer. Because of the moderately steep slope positions where this type often occurs, there is an increased problem from surface erosion and unraveling. Accumulated soil organic matter and nitrogen should be preserved, and the litter layer should be kept intact to help keep the unstable soil in place. The steepness of slope and instability of the soil may preclude commercial thinning on this type. Because of the warm exposed site conditions where this type occurs, it offers low to moderate wildlife values in mature and old-growth stands. Young growth stands sometimes offer moderate browse for deer. Game trails and scat are fairly common in this type, indicating that it gets some big game use. This type represents harsh growing conditions with severe limitations for the Forest. Regeneration following clearcutting has been very slow and sporadic.

Table 22. Timber productivity values for the Douglas-fir/Oceanspray-Baldhip Rose Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle[1])	11	61	71	9	46	441	52	265	57	48
Douglas-fir (McArdle[2])	7	7	73	14	50					
Douglas-fir (Curtis[3])	11	61	66	8		441	52	265	57	
Douglas-fir (King[4])	1	5	50		44					

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.
[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.
[3] Base age 100. Breast height age (Curtis et al. 1974). ages 25 to 400 years.
[4] Base age 50. Breast height age (King 1966). ages 25 to 120 years.
[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
[6] Stand Density Index (Reinecke 1933).
[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[8] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).
[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Root disease problems may include Armillaria root disease and laminated root rot in Douglas-fir. Both these diseases may significantly impact regeneration and productivity. Black stain root disease may be present in Douglas-fir plantations. Heart and butt rots of potential importance are red ring rot, brown trunk rot and brown cubical butt rot, especially in old-growth stands. Red ring rot may be the most important decay in this type.

Insect problems can include western blackheaded budworm tip killing Douglas-fir and Douglas-fir beetle on stressed, windthrown, or diseased Douglas-fir.

Comparison with Similar Types

Similar types include the Douglas-fir/Salal which occurs on slightly moister sites, Douglas-fir/Kinnikinnick type which occurs on drier, shallower soils at higher elevations, and the Western Hemlock/Salal-Oceanspray type which occurs in somewhat wetter areas. The Douglas-fir/Oceanspray-Baldhip Rose Association is only recognized in the Olympics (Henderson and Peter 1983a). It is similar, in some respects, to the Douglas-fir/Oceanspray-Oregongrape and Douglas-fir/Oceanspray/Grass types on the Willamette National Forest (Hemstrom *et al.* 1987).

Figure 43. Photo of the Douglas-fir/Oceanspray-Baldhip Rose Association, Dungeness River, Quilcene District.

DOUGLAS-FIR/SALAL
Pseudotsuga menziesii/Gaultheria shallon
PSME/GASH CDS2 55

The Douglas-fir/Salal Association is a type of moderately dry areas, warm soils, and low timber productivity. It is found on the Hood Canal and Quilcene Districts (Figure 44). Soils are shallow, derived from very stony colluvium, till or outwash, and appear to be well drained. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 23) is salal (GASH). Few herbs are found. Other shrubs include Oregongrape (BENE), kinnikinnick (ARUV), vine maple (ACCI) and occasionally rhododendron (RHMA) or oceanspray (HODI). The tree layer is dominated by Douglas-fir with small amounts of western hemlock, western redcedar, western white pine or Pacific dogwood (Figure 45). Old-growth stands in this type are less than about 300 years old, the oldest having originated from fires about 280 and 320 years ago.

Ground mosses can be abundant in this type, or sparse probably due to shading from the salal cover. *Hylocomium splendens* and *Eurhyncium oreganum* are common mosses, and the nitrogen-fixing lichen *Peltigera aphthosa* may occur. Epiphytic lichens and mosses are conspicuous and abundant. *Alectoria sarmentosa*, *Sphaerophorus globosus*, *Hypogymnia* spp., *Hypnum circinale* and crustose lichens are most common.

Successional Relationships

Early and late successional stages are dominated by Douglas-fir with minor amounts of western hemlock.

Other Biota

Deer signs are frequently recorded on this type and indicate heavy use. Signs of recent activity were observed in June and September. Commonly browsed species include red huckleberry (VAPA), serviceberry (AMAL) and beargrass (XETE). Douglas squirrel use is common in this type. One sighting was recorded of mountain beaver activity in June. One tree frog was observed. Birds commonly observed were red-breasted nuthatch, Steller's jay and dark-eyed junco. Rufous hummingbird may occasionally be seen and woodpecker workings on snags are sometimes present.

Environment and Soils

This type can be found on a wide variety of slopes, positions, regoliths and bedrock. Slope steepness ranged from 17-140%, positions from ridgetops to benches and toes, regolith was alpine or continental glacial, or colluvium, and bedrock included metabasalt, sandstone and shale. The soil itself is highly varied. Coarse fragments varied from 8-65% and surface texture varied from sandy clay loams to loamy sands. The total thickness of the O layer was similar in the two pits dug, but the O2 varied from a trace to 6 cm. In both pits, however the profiles were

Table 23. Common plants in the PSME/GASH Association, based on stands >150 years (n=7).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	70.6	70.6	100	55-90
western hemlock	TSHE	2.4	3.4	71	0-8
Pacific dogwood	CONU	1.9	6.5	28	0-8
western white pine	PIMO	1.0	3.5	28	0-5
GROUND VEGETATION					
salal	GASH	56.4	56.4	100	20-95
Oregongrape	BENE	12.4	14.5	85	0-60
prince's pine	CHUM	1.1	1.3	85	0-3
white hawkweed	HIAL	1.0	1.2	85	0-2
swordfern	POMU	2.7	3.8	71	0-15
western fescue	FEOC	2.1	3.0	71	0-10
red huckleberry	VAPA	1.4	2.0	71	0-5
baldhip rose	ROGY	1.1	1.6	71	0-2
starflower	TRLA2	1.1	1.6	71	0-3
beargrass	XETE	1.0	1.4	71	0-1
vine maple	ACCI	10.1	17.7	57	0-40
oceanspray	HODI	2.4	4.3	57	0-10
twinflower	LIBO2	1.6	2.8	57	0-8
serviceberry	AMAL	0.6	1.0	57	0-1
rattlesnake-plantain	GOOB	0.6	1.0	57	0-1
trailing blackberry	RUUR	0.6	1.0	57	0-1

rather weakly expressed. The A horizons are thin and faint and structures are moderate to weak, fine to very fine subangular blocky. Both soils are ochrepts. The major similarity between these soils is that they are dry, although they may be dry for very different reasons. The water holding capacity is generally low, but may be so due to coarse texture or high coarse fragment. Slope position and dry climate may allow this association to develop on soils with more favorable water holding capacities. Rooting depths were fairly great, averaging 74.5 cm. One pit had a dense mat of roots in the O2. Fine roots were numerous near the surface in both pits, but were also common near the bottom of the profile. This probably reflects the need to maintain a volume of roots in the deeper horizons which don't dry out as severely. The Olympic Soil Resourse Inventory (Snyder *et al.* 1969) also indicates a diversity of soils for this type. Soils where plots were located are glacial, colluvial and residual over metabasalts or sedimentary rocks. They are thin to thick gravelly or very gravelly loams or sandy loams. Drainage is usually good and permeability rapid. In some of the glacial soils, however compacted subsoils may cause imperfect drainage and slow permeability. The soil temperature averaged 12.0 deg C (53.6 deg F) for June and July which makes this the coolest summer temperature of the Douglas-fir types. The temperature regime is at the warm end of frigid and the moisture regime is xeric to dry udic. The nutrient analysis in the two pits indicate that these soils are high in phosphorus, potassium, calcium and magnesium, and low in organic matter, nitrogen and sulfate. Nutrient concentrations were among the lowest recorded. The pH was 5.2 which is about average for the Forest.

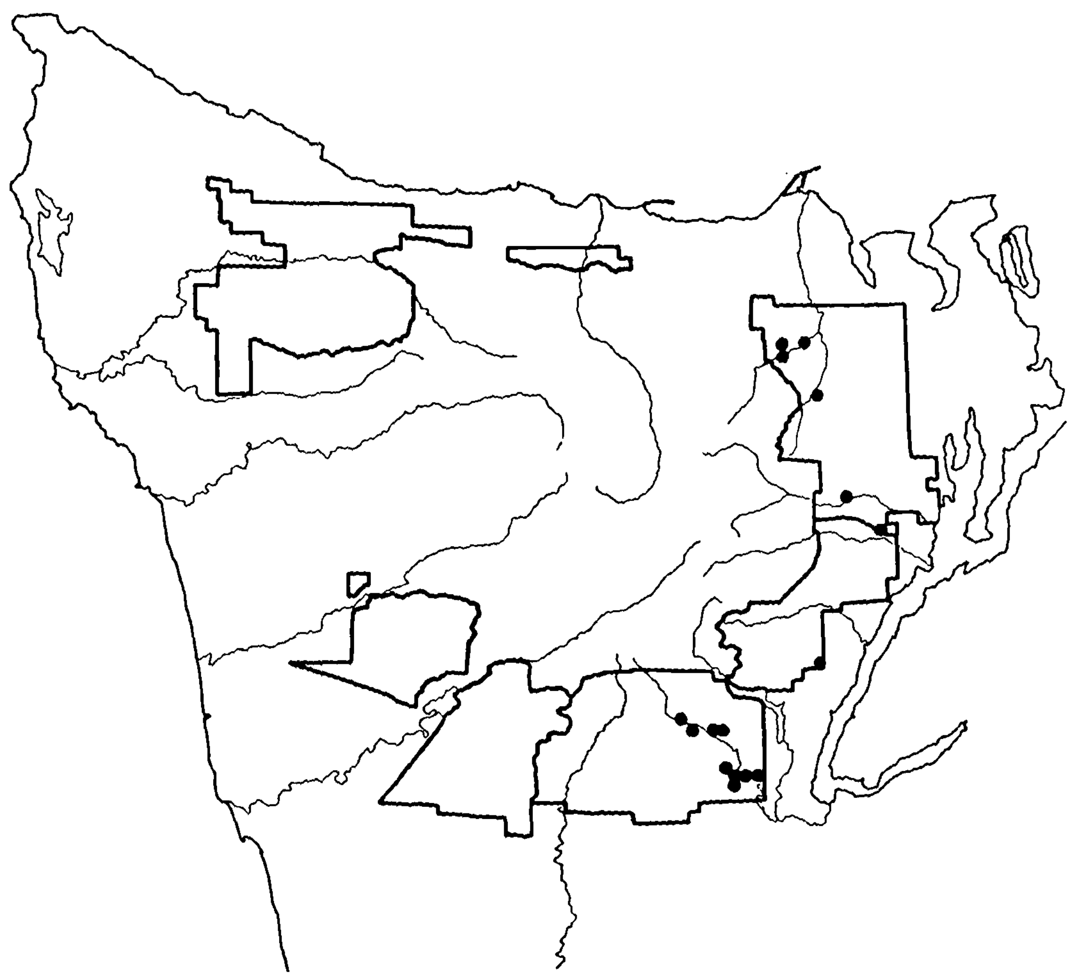


Figure 44. Map of plot locations for the Douglas-fir/Salal Association.

Timber Productivity

Timber productivity of this type is low (Site V). Site index of measured stands averaged 83 (base 100). The productivity potential using the site index-yield table approach was 63 cu ft/ac/yr (Table 24). The stockability of these sites is moderate to low.

Management Considerations

Management considerations for this type include ensuring restocking and enhancement of soil nutrients and organic matter. Accumulated soil organic matter and nitrogen should be protected. Salal competition can be significant and burning for brush control may be needed. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Because of the warm, exposed site conditions where this type occurs and the dense salal dominated ground vegetation, it offers low to moderate wildlife values in young and old-growth stands. Young growth stands often offer good browse for deer, particularly red huckleberry. Game trails and scat are uncommon in this type, indicating that it gets only irregular use.

Root disease problems may include Armillaria root disease and laminated root rot in Douglas-fir. Both these diseases may significantly impact regeneration and productivity. Black stain root disease may be present in Douglas-fir plantations. Heart and butt rots of potential importance are red ring rot, brown trunk rot and brown cubical butt rot, especially in old-growth stands. Red ring rot may be the most important decay.

Insect problems can include western blackheaded budworm tip killing Douglas-fir and Douglas-fir beetle on stressed, windthrown, or diseased Douglas-fir.

Table 24. Timber productivity values for the Douglas-fir/Salal Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI[5]	SDI[6]	GBA TREES	GBA[7]	SIGBA[8]	EMAI[9]
Douglas-fir (McArdle[1])	7	32	83	22	63	378	32	221	56	48
Douglas-fir (McArdle[2])	8	8	78	11	56					
Douglas-fir (Curtis[3])	7	32	86	28		378	32	221	56	
Douglas-fir (King[4])	3	13	59	24	59					

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.

[3] Base age 100. Breast height age (Curtis et al. 1974). ages 25 to 400 years.

[4] Base age 50. Breast height age (King 1966). ages 25 to 120 years.

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[6] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Comparisons with Similar Types

Similar types include Western Hemlock/Salal-Oregongrape which occurs on slightly moister sites; the Western Hemlock/Salal/Beargrass type, which occurs on slightly drier and shallower or coarser soils in areas of higher precipitation. It is also related to the Western Hemlock/Rhododendron-Salal type which occurs in drier areas, mostly on the Quilcene District. The Douglas-fir/Salal Association is previously recognized in the Olympics (Henderson and Peter 1983a) and on the Willamette National Forest (Hemstrom *et al.* 1987). It is similar to the Douglas-fir-Western Hemlock/Salal type of Smith and Henderson (1986).

Figure 45. Photo of the Douglas-fir/Salal Association, near Lake West, Hood Canal District.

MOUNTAIN HEMLOCK SERIES

MOUNTAIN HEMLOCK SERIES

Tsuga mertensiana
TSME

The Mountain Hemlock Series (Zone) covers about 22,000 acres (3%) of the Olympic National Forest (Figure 46). It occupies the upland areas around the Forest, above about 3300 feet elevation in the wetter environmental zones (Matheny Creek area), and above about 4000 feet elevation in the drier environmental zones (Duckabush River area). At lower elevations it is replaced by the Silver Fir Zone. In Environmental Zones 10, 11 and 12 (Quilcene District) it is replaced by the Subalpine Fir Zone at similar elevations. The Mountain Hemlock Series includes some of the least productive associations on the Forest. The productivity is very low and is mostly a function of snowpack depth and duration.

The climate can be characterized as cold temperate. Winter and summer temperatures are cold. Average January temperature is about -2 deg C (28 deg F). Summer temperature averages about 12 deg C (53 deg F). Precipitation varies from about 220 inches annually in the wetter areas of the Forest (Quinault District) to about 50 inches in the rainshadow area (Duckabush River area, Hood Canal District). In addition, fog and clouds can contribute a significant amount of "precipitation" in the form of tree drip during the summer. Snow accumulations are high, averaging greater than 10 feet (3 m). Winds are significant, especially on the south and western part of the Forest.

Soils are cold and moist with a well developed O horizon. When present, the A horizon tends to be high in organic matter and nitrogen compared to the other series. These soils are the most acidic (pH 4.2) of any series. The texture is often coarse with many large fragments and the soils are frequently very shallow. Topographically these soils occur on a wide range of slope positions at upper elevations across all but the northeastern part of the Peninsula. They are found on flat to very steep slopes, from bottom to ridgetop positions. They occupy mostly colluvial or alpine glacial regoliths and a variety of bedrocks.

The soil moisture regime is probably always udic which indicates the rooting zone is usually moist throughout the summer. The soil temperature regime is probably always cryic which means that the average annual temperature is less than 8 deg C and the summer-winter fluctuation at 50 cm is less than 5 deg C.

The organic layer is usually a mor although duff mulls also occur. The O2 which is dense and well decomposed averages 5.3 cm for stands older than 275 years. The well developed O horizons probably result from a cold climate, low soil pH and old age of the stands.

Spodosols comprise most of the soils sampled in this series with the remainder being inceptisols. The spodosols are generally fairly well developed. The tendency for more spodosols to form in this series than in any other series reflects an intense leaching environment caused by higher precipitation, lower evapotranspiration, and greater stand age and stability due to fewer fires.

The dominant tree species are silver fir and mountain hemlock. Douglas-fir, a long-lived seral species at lower elevations, is almost unknown in this series. Mountain hemlock, silver fir and Alaska yellowcedar dominate the climax stage of succession.

Root disease problems may include annosus root disease and rusty red stringy rot on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Potential yield is very difficult to accurately estimate for associations in the Mountain Hemlock Series. Growth patterns are strongly affected by the heavy snow and short growing season. Some site index curves are now available for silver fir (Hoyer and Herman in press, Hegyi *et al.* 1979) and for mountain hemlock (Hegyi *et al.* 1979). However, these curves have not been verified for this area. There are no yield tables for silver fir and/or mountain hemlock which can apply to this area. Also, there was a problem in trying to apply these curves to our plot data. Almost every community in the Mountain Hemlock Zone on the Olympic National Forest is older than 400 years. This made it impossible to accurately apply these site index curves to sampled stands. An empirical volume curve was generated from the Intensive plot data. It gave an estimate of 38 cu ft/ac/yr in 190 years for the Mountain Hemlock Zone. Considerably more data are needed even to verify this empirical estimate, let alone generate a yield table. However, this empirical yield value is consistent with other empirical yield estimates from the Mt. Baker-Snoqualmie National Forest.

Seven Plant Associations are recognized in the Mountain Hemlock Series on the Olympic National Forest. These are described by 67 Reconnaissance and Intensive plots taken from 1979 to 1985. Environmental values and mean relative cover values are summarized in Tables 25 and 26 (pp. 114-115). These associations are presented in alphabetical order by common name on pages 116-137, and can be identified by using the following key. (See page 88 for explanation of how to use this abbreviated key).

Key to Plant Associations of the Mountain Hemlock Series

Red Heather ≥10%, Blueleaf Huckleberry ≥10% .... TSME/PHEM-VADE p. 132

Avalanche Lily ≥5%, Alaska Huckleberry ≥10% .... TSME/VAAL/ERMO p. 120

Big Huckleberry ≥5%

- White Rhododendron ≥5% .... TSME/RHAL-VAME p. 136
- Alaska Huckleberry ≥5% .... TSME/VAME-VAAL p. 126
- Beargrass ≥5% .... TSME/VAME/XETE p. 130

Alaska Huckleberry ≥10%

- Beargrass ≥5% .... TSME/VAAL/XETE p. 124
- Beargrass <5% .... TSME/VAAL p. 116

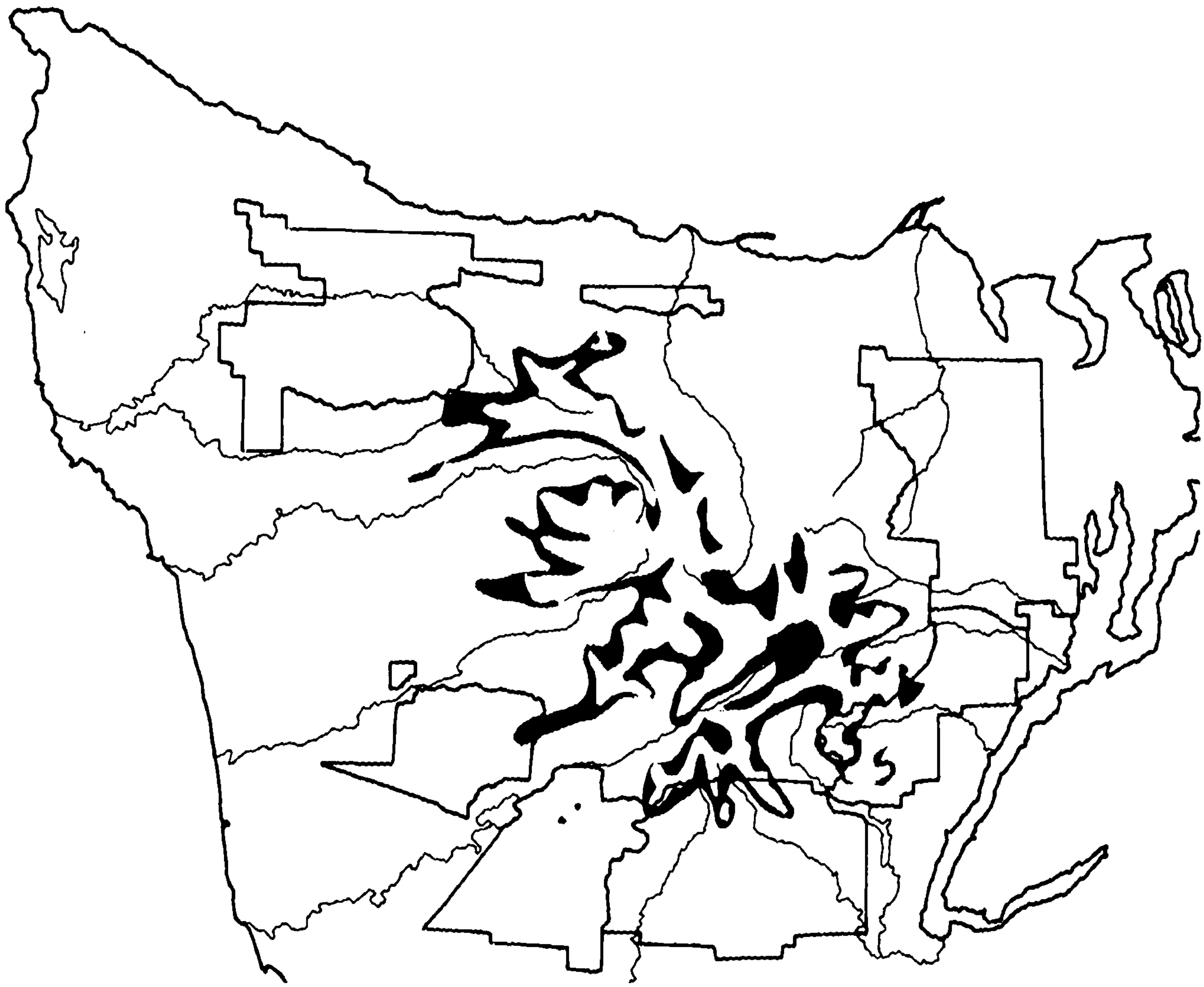


Figure 46. Map of the Mountain Hemlock Zone on the Olympic Peninsula.

Table 25. Environmental values for associations in the Mountain Hemlock Series. Slope, elevation and topographic moisture are mean values for the sample.

	ASSOCIATIONS						
ENVIRONMENTAL VALUES	TSME/ VAAL	TSME/ VAAL-ERMO	TSME/ VAAL-XETE	TSME/ VAME-VAAL	TSME/ VAME-XETE	TSME/ PHEM-VADE	TSME/ RHAL-VAME
ECOCLASS Code[1]	CMS2 41	CMS2 42	CMS2 43	CMS2 44	CMS2 45 (OLY)	CMS3 11	CMS3 12
Number of plots[2]	11	18	4	6	4	6	18
Aspect	W-SE	W-SE	NE-E,S	SE-S	SE-SW	SE,NW	NW-NE,SE-SW
Slope (%)	55	55	38	53	61	53	25
Elevation (ft.)	3522	3688	3368	3806	4671	4611	4501
Environmental Zone[3]	8 (2,3,5)	2.3 (0.5,6)	0,2,7,8	2,3,8	8	8 (3,7)	8,9 (10,12)
Topographic Moisture[4]	4.4	3.7	4.5	4.5	3.0	2.8	4.9
Soil Moisture Regime[5]	udic	udic	udic	udic	udic	udic	udic
Soil Temperature (deg C)[6]	10.5 (1)	10.3 (14)	8.1 (10)	8.4 (2)	9.1 (3)		8.5 (2)
Soil Temperature Regime[7]	cryic	cryic	cryic	cryic	cryic	cryic	cryic
Lichen line (ft.)	14.2	14.6	12.0	9.0		17.0	11.3

[1] See Table 161 p. 443
[2] Number of plots includes all successional stages sampled.
[3] See Figure 24 p. 40, and discussion p. 38.
[4] See discussion p. 84, Table 146 p. 417.
[5] See discussion p. 44.
[6] Summer soil temperature at 20 cm for mature and old-growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.
[7] See discussion p. 44-45.

Table 26. Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Mountain Hemlock Series. Cover values based on stands 150 years and older.

		ASSOCIATIONS						
		TSME/ VAAL	TSME/ VAAL/ERMO	TSME/ VAAL/XETE	TSME/ VAME-VAAL	TSME/ VAME/XETE	TSME/ PHEM-VADE	TSME/ RHAL-VAME
ECOCLASS Code		CMS2 41	CMS2 42	CMS2 43	CMS2 44	CMS2 45(OLY)	CMS3 11	CMS3 12
Number of plots		10	16	4	6	2	5	12
TREES								
ABAM	Silver fir	62(100)	44(100)	45(100)	38(100)	41(100)	9 (80)	46 (91)
ABLA2	Subalpine fir			12 (40)	34 (16)		15 (50)	
CHNO	Alaska yellowcedar	12 (40)	12 (75)	28 (50)	9(100)	30 (50)	7 (80)	20 (83)
PIAL	Whitebark pine							
PIMO	Western white pine				1 (16)			
PSME	Douglas-fir		1 (6)	7 (25)	2 (16)	25 (50)		5 (8)
TABR	Pacific yew		4 (6)		1 (16)			
THPL	Western redcedar	6 (10)	10 (6)					
TSHE	Western hemlock	14 (50)	12 (31)	12 (50)	8 (33)	10 (50)		21 (41)
TSME	Mountain hemlock	30(100)	34(100)	54(100)	24(100)	16(100)	25(100)	38(100)
SHRUBS and HERBS								
ACTR	Vanillaleaf	1 (10)	1 (6)			3 (50)		
ALSI	Sitka alder		6 (12)		1 (16)			6 (25)
ARLA	Mountain arnica						2 (40)	6 (16)
ARUV	Kinnikinnick					1 (50)		2 (8)
ATFI	Ladyfern	1 (30)		1 (25)				1 (8)
BLSP	Deerfern	1 (60)	2 (87)	2 (50)	1 (16)			
CABI	Marshmarigold	3 (10)		1 (25)			1 (20)	
CAME	White heather						10 (40)	3 (16)
CHME	Little prince's pine		1 (6)			1 (50)		
CHUM	Prince's pine					1 (50)		1 (8)
CLUN	Queen's cup	5 (60)	1 (6)	13 (50)		2 (50)		2 (16)
COCA	Bunchberry	3 (10)	2 (12)	3 (50)				
COME	Western coralroot	1 (20)	1 (12)					
CRCR	Parsley fern		1 (6)				1 (40)	1 (8)
ERMO	Avalanche lily	2 (50)	14(100)	2 (25)	2 (66)		4 (60)	4 (25)
GAOV	Slender wintergreen		1 (31)	1 (25)	1 (33)	1 (50)		
GOOB	Rattlesnake-plantain	1 (10)	1 (37)	1 (25)	1 (33)			1 (33)
GYDR	Oakfern	1 (10)	1 (12)					1 (8)
HYMO	Fringed pinesap	1 (10)	1 (6)		1 (33)			1 (16)
LIBO2	Twinflower	1 (10)	1 (6)	1 (25)				1 (8)
LICO3	Heart-leaf twayblade		1 (12)	1 (25)	1 (16)			1 (8)
LOMA2	Martindale's lomatium						2 (40)	1 (8)
LUPA	Small-flowered woodrush	1 (10)	1 (6)	1 (25)			1 (40)	1 (16)
LUPE	Partridgefoot	1 (10)	1 (6)				1 (40)	4 (8)
LYAM	Skunkcabbage			4 (25)				
MADI2	False lily-of-the-valley	5 (10)	1 (12)	3 (25)				
MEFE	Fool's huckleberry	3 (80)	2 (61)	4(100)	4(100)		2 (20)	9 (33)
NONE	Woodland beardtongue		1 (6)			1 (50)	1 (20)	1 (16)
OPHO	Devil's club	2 (20)						
PAMY	Pachistima		1 (6)				3 (40)	
PERA	Leafy lousewort						3 (20)	1 (16)
PHDI	Spreading phlox						3 (40)	1 (8)
PHEM	Red heather		2 (43)		3 (50)		35(100)	3 (50)
POMU	Swordfern	1 (10)	1 (25)					1 (8)
PYSE	Sidebells pyrola	1 (40)	1 (12)	1 (25)	1 (16)	3 (50)		1 (75)
RHAL	White rhododendron	4 (30)	6 (62)		2 (66)		1 (20)	22(100)
RULA	Trailing bramble	2 (40)	1 (31)	1 (25)	2 (33)		2 (20)	2 (66)
RUPE	Five-leaved bramble	15(100)	6 (93)	4(100)	2 (50)		3 (20)	6 (75)
RUSP	Salmonberry	2 (40)	1 (6)	1 (25)				
SAFE	Rusty saxifrage		1 (6)				1 (40)	1 (8)
SOSI	Mountain-ash	1 (40)	1 (43)	1 (50)	1 (50)	1 (50)		1 (41)
STRO	Rosy twisted-stalk	1 (50)	1 (18)	1 (25)				1 (8)
TITR	Three-leaved foamflower		1 (25)	1 (25)				
TIUN	Single-leaved foamflower	1 (50)	1 (37)					1 (8)
VAAL	Alaska huckleberry	45(100)	45(100)	39(100)	39 (66)	8 (50)	2 (20)	2 (41)
VADE	Blueleaf huckleberry				5 (16)		28 (80)	2 (8)
VAME	Big huckleberry	2 (70)	2 (75)	1 (75)	32(100)	38(100)	6(100)	14(100)
VAOV	Oval-leaf huckleberry	10 (70)	9 (93)	16 (50)	19(100)		20 (20)	5 (83)
VASI	Sitka valerian	2 (40)	1 (12)				5 (20)	4 (33)
VEVI	False hellebore	2 (20)	1 (6)	1 (25)				2 (25)
VISE	Evergreen violet		1 (18)					1 (33)
XETE	Beargrass	2 (20)	5 (56)	15(100)	6 (83)	23(100)	12 (80)	3 (66)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 166 p. 454 for mean absolute cover values.

[2] Constancy is the percentage of plots for that association where the species occurred.

MOUNTAIN HEMLOCK/ALASKA HUCKLEBERRY

Tsuga mertensiana/Vaccinium alaskaense

TSME/VAAL CMS2 41

The Mountain Hemlock/Alaska Huckleberry Association is one of the most common mountain hemlock associations on the Forest. It occurs mainly on cool, moist sites, with low timber productivity. It is found throughout the Forest, but mainly on Hood Canal and Soleduck Districts, and in the Humptulips drainage of the Quinault District (Figure 47). Soils are mostly deep, and derived from colluvium, or glacial till mixed with colluvium. Snow accumulates to considerable depth (10-15 feet) and usually melts off by early July. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has bumed rarely in the last 1000 years.

Floristic Composition

The dominant understory species (Table 27) are Alaska huckleberry (VAAL) and ovalleaf huckleberry (VAOV), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry usually becomes established quickly after clearcut or fire. Herbs and other shrubs are sometimes sparse, but may include fool's huckleberry (MEFE), five-leaved bramble (RUPE), and queen's cup (CLUN). The tree layer may be dominated by silver fir, mountain hemlock or Alaska yellowcedar (Figure 48), western redcedar or western hemlock can sometimes occur. Most areas of this type have not been cut over. Much of the type is over 500 years old.

Ground mosses are common, averaging 11% cover. The most frequently observed species were *Rhytidiopsis robusta*, *Dicranum* spp. and *Plagiothecium undulatum*. Epiphytic lichens are conspicuous and abundant, particularly *Alectoria sarmentosa* and *Platismatia glauca*. Other common epiphytes included *Sphaerophorus globosus*, *Hypogymnia* spp. and crustose lichens. Occasionally *Lobaria oregana* may occur.

Successional Relationships

The common successional pathway is dominated by silver fir and mountain hemlock. Climax stages are dominated by silver fir, mountain hemlock and Alaska yellowcedar.

Other Biota

Deer and elk sign were frequently recorded for this type, with recent activity of elk observed in late August. Salmonberry was the most common browse species, other species browsed included fireweed, fool's huckleberry, queen's cup, Sitka valerian and pioneer violet. Bear damage to silver fir was observed. Recent activity of Douglas squirrel was recorded in late August. Coyote scat was also recorded.

Red-breasted nuthatch, golden-crowned kinglet, chestnut-backed chickadee, American robin and warbler were the most common birds. Other species observed were hermit thrush, mountain chickadee, pine siskin, gray jay, red-tailed hawk, ruffed grouse and red-breasted sapsucker.

Table 27. Common plants in the TSME/VAAL Association, based on stands >150 years (n=10).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	61.9	61.9	100	25-99
mountain hemlock	TSME	30.0	30.0	100	13-80
western hemlock	TSHE	7.2	14.4	50	0-40
Alaska yellowcedar	CHNO	4.9	12.2	40	0-32
GROUND VEGETATION					
Alaska huckleberry	VAAL	45.0	45.0	100	10-90
five-leaved bramble	RUPE	14.6	14.6	100	1-35
fool's huckleberry	MEFE	2.1	2.6	80	0-10
oval-leaf huckleberry	VAOV	7.3	10.4	70	0-50
big huckleberry	VAME	1.1	1.6	70	0-3
queen's cup	CLUN	3.0	5.0	60	0-15
avalanche lily	ERMO	0.8	1.6	50	0-3
deerfern	BLSP	0.7	1.2	60	0-2
rosy twisted-stalk	STRO	0.7	1.4	50	0-3
single-leaved foamflower	TIUN	0.7	1.4	50	0-2

Environment and Soils

This type occurs on gentle to steep, straight lower to upper slopes usually in areas of extensive rock outcrops. The slope varied from 10% to 100% and averaged 55%. The regolith is colluvium derived from metabasalt or occasionally sedimentary rocks.

One soil pit dug in this type showed moderate soil development. The texture varied from clay loam in the top horizon to loamy sand in the deepest horizon. Coarse fragments averaged 41%. The O1 layer was thicker than average at 3 cm as was the O2 at 8 cm. The rooting depth was 50 cm but also extended into the O2. The water holding capacity is average over all types. This soil was classified a cryorthod.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, rapidly permeable, colluvial soils often in areas of extensive rock outcrop. Textures vary from sandy loams to loam and silt loam and the coarse fragment fraction. The coarse fragment fraction ranges from 15% to 65% near the surface and 35% to 85% in the subsoils.

The August soil temperature was 8.6 deg C (47.5 deg F) which is about average for the Mountain Hemlock Zone. The temperature regime is cryic and the moisture regime is udic.

Figure 47. Map of plot locations for the Mountain Hemlock/Alaska Huckleberry Association.

Timber Productivity

Timber productivity of this type is low. This is due to the moistness of the site, cool soils, and relatively short growing season. Site index was not calculated for this type because suitable site index curves are not available and because most sampled stands were older than 400 years. The productivity potential was estimated for all Mountain Hemlock Zone types using the empirical volume curve method (see Figure 191 p. 498). It is estimated to be about 38 cu ft/ac/yr in about 190 years. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking and brush control. Maintenance of soil nutrients and organic matter is less critical in this type than other types, since these sites contain hundreds of years' accumulation of nutrients and organic matter. Response to fertilizer in this type is still unknown. This type occurs in mid- to high elevation areas and along cool slopes where deer and elk range, and riparian management are not critical. Douglas-fir is virtually unknown on this type and there is considerable doubt whether it can grow here under the current climatic regime. Silver fir or mountain hemlock are the preferred species. Alaska huckleberry can pose brush problems. Regeneration and early height growth is slow.

Root disease problems may include annosus root disease and rusty red stringy rot on mountain hemlock and silver fir and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include Mountain Hemlock/Alaska Huckleberry-Big Huckleberry on slightly drier sites, the Mountain Hemlock/Alaska Huckleberry/Avalanche Lily type in wetter areas, and the Mountain Hemlock/Alaska Huckleberry/Beargrass type on drier and warmer sites. It is floristically similar to Silver Fir/Alaska Huckleberry and Silver Fir/Alaska Huckleberry/Queen's Cup at lower elevations. The Mountain Hemlock/Alaska Huckleberry Association is recognized throughout the Cascades and Olympics of Washington. The type is not yet recognized in Oregon, however, the plot data of Dyrness *et al.* (1976) suggests that fragments of it might occur as far south as the H.J. Andrews Experimental Forest. It was not recognized by Franklin *et al.* (1988) in Mt. Rainier National Park. However their Alaska Yellowcedar/Oval-leaf Huckleberry and Silver Fir/Alaska Huckleberry types are represented by plots which could fall in our Mountain Hemlock/Alaska Huckleberry Association. This type is recognized as Silver Fir/Oval-leaf Huckleberry and the Mountain Hemlock-Silver Fir/Alaska Huckleberry-Fool's Huckleberry community types by del Moral *et al.* (1976) for the Middle Fork of the Snoqualmie River. It is recognized as the Silver Fir-Mountain Hemlock/Alaska Huckleberry Association in the Olympic National Park by Smith and Henderson (1986). It is recognized in the Cascades by Henderson and Peter (1981c,d, 1982b, 1983b, 1984, 1985). It is not recognized in British Columbia but appears to be represented in the "Vaccinio-Tsugetum mertensiana Association" of Brooke *et al.* (1970).

Figure 48. Photo of the Mountain Hemlock/Alaska Huckleberry Association, Mt.Tebo, Hood Canal District.

MOUNTAIN HEMLOCK/ALASKA HUCKLEBERRY/AVALANCHE LILY

Mertensiana/Vaccinium alaskaense/Erythronium montanum
TSME/VAAL/ERMO CMS2 42

The Mountain Hemlock/Alaska Huckleberry/Avalanche Lily Association is a common Mountain Hemlock Zone type in the high precipitation areas on the Forest. It occurs on cool, moist but well-drained sites, with moderately low timber productivity. It is found mainly on Quinault District (Figure 49). Soils are mostly deep, and derived from colluvium or glacial till. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely if at all in the last 1000 years.

Floristic Composition

The dominant understory species (Table 28) are Alaska huckleberry (VAAL) and ovalleaf huckleberry (VAOV) which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry can become established quickly after clearcut or light fire. Other shrubs may include big huckleberry (VAME), sitka alder (ALSI) and fool's huckleberry (MEFE). Avalanche lily (ERMO), five-leaved bramble (RUPE), beargrass (XETE) and deerfern (BLSP) may also occur. The tree layer may be dominated by silver fir, mountain hemlock, or Alaska yellowcedar (Figure 50), or any combination of these trees. When stands in this type are understocked, a thick understory may develop. Douglas-fir is absent from this type and western redcedar is rare, as this type is too cool and wet for these species. Virtually none of this type has been cut over. Therefore, much of the type is still in old-growth, and many stands are over 500 years old.

Ground mosses are common, averaging 35% cover. *Rhytidiopsis robusta* was the most frequently recorded and often abundant ground moss. Other common species included *Dicranum* spp., *Rhytidiadelphus loreus*, and *Hypnum circinale* on woody debris. Occasionally, nitrogen-fixing lichens such as *Lobaria linita*, *Peltigera aphthosa* and other species of *Peltigera* may occur. Epiphytic lichens are conspicuous and abundant, particularly *Alectoria sarmentosa*. Other epiphytes observed were *Sphaerophorus globosus*, *Platismatia glauca*, *Bryoria* spp. and *Hypnum circinale*. *Lobaria oregana* may occur infrequently.

Successional Relationships

The successional pathway is usually dominated by silver fir and mountain hemlock. Climax stages are dominated by both silver fir and mountain hemlock, with significant amounts of Alaska yellowcedar in some stands.

Other Biota

Elk and bear sign were frequently recorded for this type, with sign of recent elk activity in early July. Alaska huckleberry was the only species with evidence of browse. Bear damage was observed on silver fir. Coyote scat, deer sign, Douglas squirrel and snowshoe hare were also recorded.

Red-breasted nuthatch, pine siskin and gray jay were the most common birds recorded. Other birds observed were American robin, varied thrush, hermit thrush, dark-eyed junco, band-tailed pigeon, nighthawk, rufous hummingbird, sapsucker activity on silver fir, western flycatcher, Steller's jay, common raven, common crow, chickadee, winter wren and golden-crowned kinglet.

Table 28. Common plants in the TSME/VAAL/ERMO Association, based on stands >150 years (n=16).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	44.0	44.0	100	15-75
mountain hemlock	TSME	33.7	33.7	100	15-70
Alaska yellowcedar	CHNO	9.1	12.2	75	0-30
western hemlock	TSHE	3.7	11.8	31	0-25
GROUND VEGETATION					
Alaska huckleberry	VAAL	44.7	44.7	100	5-95
avalanche lily	ERMO	13.6	13.6	100	4-40
oval-leaf huckleberry	VAOV	8.1	8.7	93	0-60
five-leaved bramble	RUPE	5.3	5.7	93	0-45
deerfern	BLSP	1.8	2.0	87	0-5
fool's huckleberry	MEFE	1.9	2.3	81	0-7
big huckleberry	VAME	1.6	2.2	75	0-10
white rhododendron	RHAL	3.9	6.2	62	0-30
beargrass	XETE	2.9	5.2	56	0-15

Environment and Soils

This type occurs on moderate to steep, concave or straight, mid- to upper slopes. The slope varied from 30% to 80% and averaged 55%. The regolith is colluvium derived from metabasalt, sandstone, or other sedimentary rocks.

Moderately well developed horizons were shown by six soil pits dug in this association. In most cases a clear illuvial horizon, which was sometimes albic, was present. Textures were loams and sandy loams and coarse fragments averaged 41%. Bedrock was encountered in all pits between 24 cm and 82 cm. The O1 layer was thick averaging 2.2 cm, and the O2 was thin averaging 4.8 cm. The rooting depth was 36.2 cm but also extended 4.8 cm into the O2. The apparent water holding capacity of this soil is average but because of the shallow rooting depth only a fraction of it is available. This is partially compensated for by the moist climate and a tendency for the type to occupy concave landforms in the otherwise dry upper slopes occupied by the type. One pit was classified a cryochrept, one a cryohumod and four were cryorthods.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are all shallow, well-drained, rapidly permeable, colluvial soils often in areas of extensive rock outcrop. Textures vary from silt loams and loams to clay loam. Coarse fragments range from 15% to 50% near the surface and 35% to 55% in the subsoil.

The soil temperature averaged 10.3 deg C (50.5 deg F) which is warm for the Mountain Hemlock Zone. The temperature regime is cryic and the moisture regime is udic.

Soil samples analyzed for nutrients show low calcium, magnesium, boron and copper compared to other types. The pH was 4.3 which is quite low compared to other plots from the Forest.

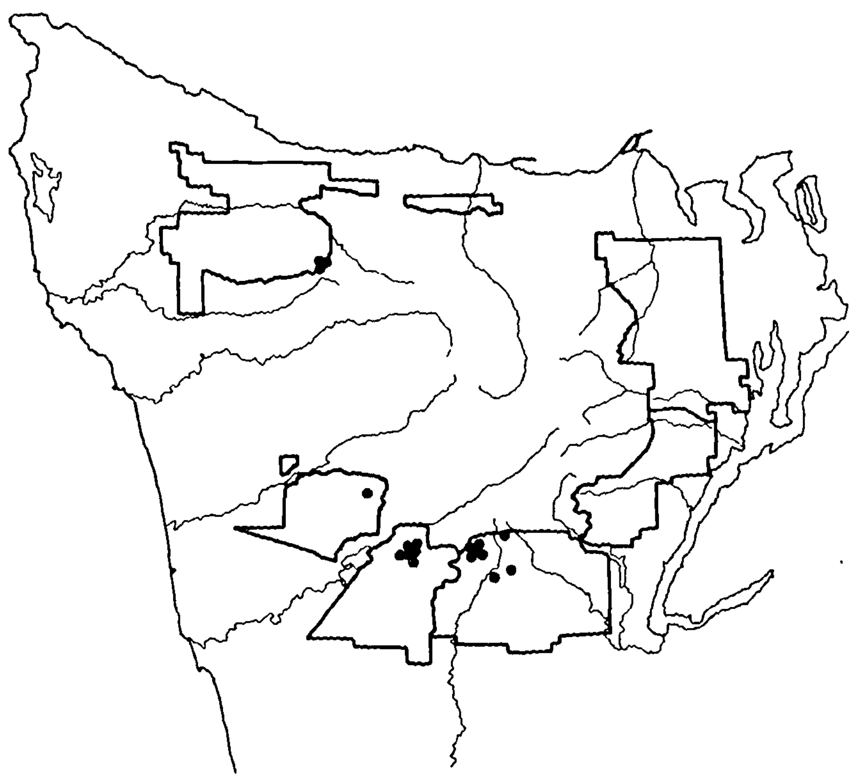


Figure 49. Map of plot locations for the Mountain Hemlock/Alaska Huckleberry/Avalanche Lily Association.

Timber Productivity

Timber productivity of this type is low. This is due to the wetness of the site, cool soils, and relatively short growing season. Site index of measured stands averaged 68 (base 100) for silver fir and 46 for mountain hemlock (Table 29). However, this was using low elevation site index curves whose shape overestimates the height of these trees at 100 years. The productivity potential of these stands is about 38 cu ft/ac/yr in about 190 years. The stockability of these sites is moderate to low, and small openings associated with wet spots are common.

Management Considerations

Management considerations for this type include elk habitat, and ensuring rapid suitable regeneration. Maintenance of soil nutrients and organic matter is less critical in this type than other types. Response to fertilizer in this type is still unknown. This type occurs in high, wet areas where elk summer range, and riparian and snowpack management are important. Douglas-fir is not know to occur on this type. Silver fir or mountain hemlock are the preferred species. Alaska huckleberry can pose brush problems. The productivity of this type is too low to warrant intensive forest management.

Root disease problems may include annosus root disease and rusty red stringy rot on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include the wet Alaska huckleberry types. The Mountain Hemlock/Alaska Huckleberry type occurs on lower elevation sites, or in areas with lower precipitation. The Mountain Hemlock/White Rhododendron-Big Huckleberry type occurs on sites in drier areas. The Silver Fir/Alaska Huckleberry/Avalanche Lily type occurs at lower elevations with warmer soils and less snow. The Mountain Hemlock/Alaska Huckleberry/Avalanche Lily Association is not recognized elsewhere. One plot was sampled in Olympic National Park (Smith and Henderson 1986) which represents this type, however, it was included within their Silver Fir-Mountain Hemlock/Five-leaved Bramble type.

Table 29. Timber productivity values for the Mountain Hemlock/Alaska Huckleberry/Avalanche Lily Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI[3]	SDI[4]	GBA TREES	GBA[5]	SIGBA[6]	EMAI[7]
Silver Fir (Hoyer[1])	3	12	68	17	42	559	5	519	98	38
Mountain Hemlock (Hegyi[2])	3	10	46	6		559	3	370	57	

[1] Base age 100. Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[2] Base age 100, Total age (Hegyi et al. 1979).

[3] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[4] Stand Density Index (Reinecke 1933).

[5] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[6] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[7] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 30 years old (see Figure 191 p. 498).

Figure 50. Photo of the Mountain Hemlock/Alaska Huckleberry/Avalanche Lily Association, Matheny Ridge, Quinault District.

MOUNTAIN HEMLOCK/ALASKA HUCKLEBERRY/BEARGRASS

Tsuga mertensiana/Vaccinium alaskaense/Xerophyllum tenax
TSME/VAAL/XETE CMS2 43

The Mountain Hemlock/Alaska Huckleberry/Beargrass Association is a minor type of easterly and southerly, well-drained sites at moderately low elevations in the Mountain Hemlock Zone. It has low timber productivity. It is common in the wetter and mesic climatic areas of the Olympics (Environmental Zones 0 to 9) (Figure 51). Soils are mostly shallow and derived from colluvium. The typical area of this type has burned rarely in the last 500 years. Management options are limited by the harsh climate.

Floristic Composition

Dominant understory species (Table 30) are Alaska huckleberry (VAAL), oval-leaf huckleberry (VAOV) and beargrass (XETE), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Beargrass, Alaska huckleberry and oval-leaf huckleberry can resprout or become established quickly after clearcut or fire. Other shrubs may include fool's huckleberry (MEFE) in small amounts. Queen's cup (CLUN) and trailing bramble (RULA), avalanche lily (ERMO) (in wetter zones) and deer fern (BLSP) can also occur. The tree layer is usually dominated by silver fir and mountain hemlock, with minor amounts of western hemlock or Alaska yellowcedar.

Cryptogam data are limited for this type. *Rhytidiopsis robusta* was the most common and abundant ground moss, *Rhytidiadelphus loreus* and *Hylocomium splendens* may also occur. *Alectoria sarmentosa* and *Platismatia glauca* were the most abundant epiphytic lichens, *Sphaerophorus globosus* and *Hypogymnia* spp. may occur.

Successional Relationships

The common successional pathway is dominated by silver fir and mountain hemlock. Climax stages are dominated by silver fir and mountain hemlock.

Other Biota

Wildlife observations are limited to two plots for this type. Elk use was heavy on one plot with evidence of browse on skunkcabbage and beargrass. Bear, Douglas squirrel and Cascade frog were also recorded. Bird observations are limited to one plot for this type where winter wren was observed.

Environment and Soils

This type occurs on gentle to steep, straight to convex, upper slopes often in areas of extensive rock outcrop. The slope varied from 9% to 77% and averaged 38%. The regolith is generally colluvial derived from metabasalt.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), this type usually occurs on shallow, well-drained, rapidly permeable, colluvial soils although it may also occur on deep glacial

Table 30. Common plants in the TSME/VAAL/XETE Association, based on stands >150 years (n=4).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
mountain hemlock	TSME	53.5	53.5	100	30-70
silver fir	ABAM	45.0	45.0	100	5-95
Alaska yellowcedar	CHNO	14.0	28.0	50	0-40
western hemlock	TSHE	5.8	11.5	50	0-15
GROUND VEGETATION					
Alaska huckleberry	VAAL	39.2	39.2	100	2-95
beargrass	XETE	14.5	14.5	100	8-30
fool's huckleberry	MEFE	4.3	4.3	100	1-12
five-leaved bramble	RUPE	4.3	4.3	100	1-10
big huckleberry	VAME	0.8	1.0	75	0-1
oval-leaf huckleberry	VAOV	8.0	16.0	50	0-30
queen's cup	CLUN	6.5	13.0	50	0-25
bunchberry	COCA	1.3	2.5	50	0-4
deerfern	BLSP	1.0	2.0	50	0-2
mountain-ash	SOSI	0.5	1.0	50	0-1

soils with compacted subsoils. The texture varies from loam and silt loams to sandy loams. Coarse fragments range from 15% to 50% near the surface and 35% to 75% in the subsoils for units in which data was given. Many plots fell in units mapped as extensive rock outcrop. These plots probably occupy inclusions of soil with very high coarse fragment fractions.

Two soil temperatures were taken in this type in August and September. The mean of these is 8.3 deg C (46.9 deg F) which is cool for the Mountain Hemlock Zone. The temperature regime is cryic and the moisture regime is udic.

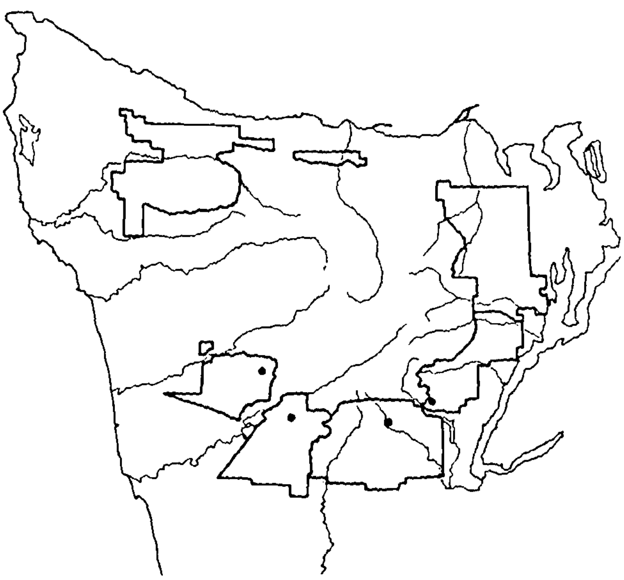


Figure 51. Map of plot locations for the Mountain Hemlock/Alaska Huckleberry/Beargrass Association.

Timber Productivity

Timber productivity of this type is low. This is due to the dryness of the site, moderately heavy snowpack and relatively short growing season. The productivity potential is about 30 cu ft/ac/yr in about 200 years based on empirical yield curves from the Cascades. The stockability of these sites is low, and regeneration is slow.

Management Considerations

Management considerations for this type include soil maintenance and stability, and ensuring suitable regeneration. The low productivity and long period of time to reach CMAI need to be considered when making management decisions in this type. Maintenance of soil nutrients and organic matter is more critical in this type than other Alaska Huckleberry types. This type occurs in high areas, and along upper slopes and ridgetops. Douglas-fir is not known to occur on this type. Silver fir or mountain hemlock are the preferred species. Beargrass and/or Alaska huckleberry can pose brush problems.

Root disease problems may include annosus root disease and rusty red stringy rot may be on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include the dry Alaska Huckleberry types. The Mountain Hemlock/Alaska Huckleberry/Beargrass type occurs on warmer exposures, on drier sites and at higher elevations. The Silver Fir/Alaska Huckleberry/Beargrass type occurs at lower elevations with less snow. The Mountain Hemlock/Alaska Huckleberry/Beargrass Association is not recognized elsewhere than in the Olympic Mountains. It was recognized as the Alaska Huckleberry Phase of the Silver Fir-Mountain Hemlock/Beargrass Association by Smith and Henderson (1986). It may be represented in the Snoqualmie River drainage of the Cascades.

MOUNTAIN HEMLOCK/BIG HUCKLEBERRY-ALASKA HUCKLEBERRY

Tsuga mertensiana/Vaccinium membranaceum-Vaccinium alaskaense

TSME/VAME-VAAL CMS2 44

The Mountain Hemlock/Big Huckleberry-Alaska Huckleberry Association is a minor type of cool, moist sites, high snowpacks and low timber productivity. It is found in the mesic climatic areas of the Olympics (Environmental Zone 8), particularly on the Hood Canal District (Figure 52), and occurs primarily along upper slopes just above the Silver Fir Zone. Soils are mostly shallow and derived from colluvium. They are often well drained. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely in the last 500 years. This type is much more common in the Cascades.

Floristic Composition

Dominant understory species (Table 31) are Alaska huckleberry (VAAL), oval-leaf huckleberry (VAOV) and big huckleberry (VAME), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Other shrubs may include blue-leaf huckleberry (VADE), mountain-ash (SOSI) and fool's huckleberry (MEFE). Beargrass (XETE) and avalanche lily (ERMO) can also occur. The tree layer is dominated by silver fir and mountain hemlock, with some Alaska yellowcedar (Figure 53). Stands in this type may be slow to regenerate. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over 500 years old.

Ground mosses are abundant on this type, averaging 26% cover. *Rhytidiopsis robusta* is the most frequent and abundant moss, *Dicranum* sp., *Rhytidiadelphus loreus*, and occasionally the nitrogen-fixing lichen, *Lobaria pulmonaria* may occur. We do not have intensive plot data for epiphytes, but the lichen flora is probably comparable to other Mountain Hemlock types.

Successional Relationships

Climax stages are dominated by both silver fir and mountain hemlock.

Other Biota

Wildlife observations are limited to two plots for this type. Deer, elk and Douglas squirrel were recorded. Beargrass had evidence of deer browse. Bird observations are limited to one plot for this type and include rufous hummingbird, woodpecker, western flycatcher, chestnut-backed chickadee, red-breasted nuthatch, brown creeper, golden-crowned kinglet, American robin, dark-eyed junco and pine siskin.

Table 31. Common plants in the TSME/VAME-VAAL Association, based on stands >150 years (n=6).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	37.5	37.5	100	13-55
mountain hemlock	TSME	24.2	24.2	100	11-45
Alaska yellowcedar	CHNO	9.0	9.0	100	5-15
western hemlock	TSHE	2.7	8.0	33	0-15
GROUND VEGETATION					
big huckleberry	VAME	31.7	31.7	100	5-50
fool's huckleberry	MEFE	4.2	4.2	100	1-10
beargrass	XETE	6.5	7.8	83	0-10
Alaska huckleberry	VAAL	25.8	38.7	66	0-60
white rhododendron	RHAL	1.3	2.0	66	0-3
avalanche lily	ERMO	1.0	1.5	66	0-2
red heather	PHEM	1.3	2.7	50	0-5
five-leaved bramble	RUPE	1.0	2.0	50	0-4
mountain-ash	SOSI	0.7	1.3	50	0-2

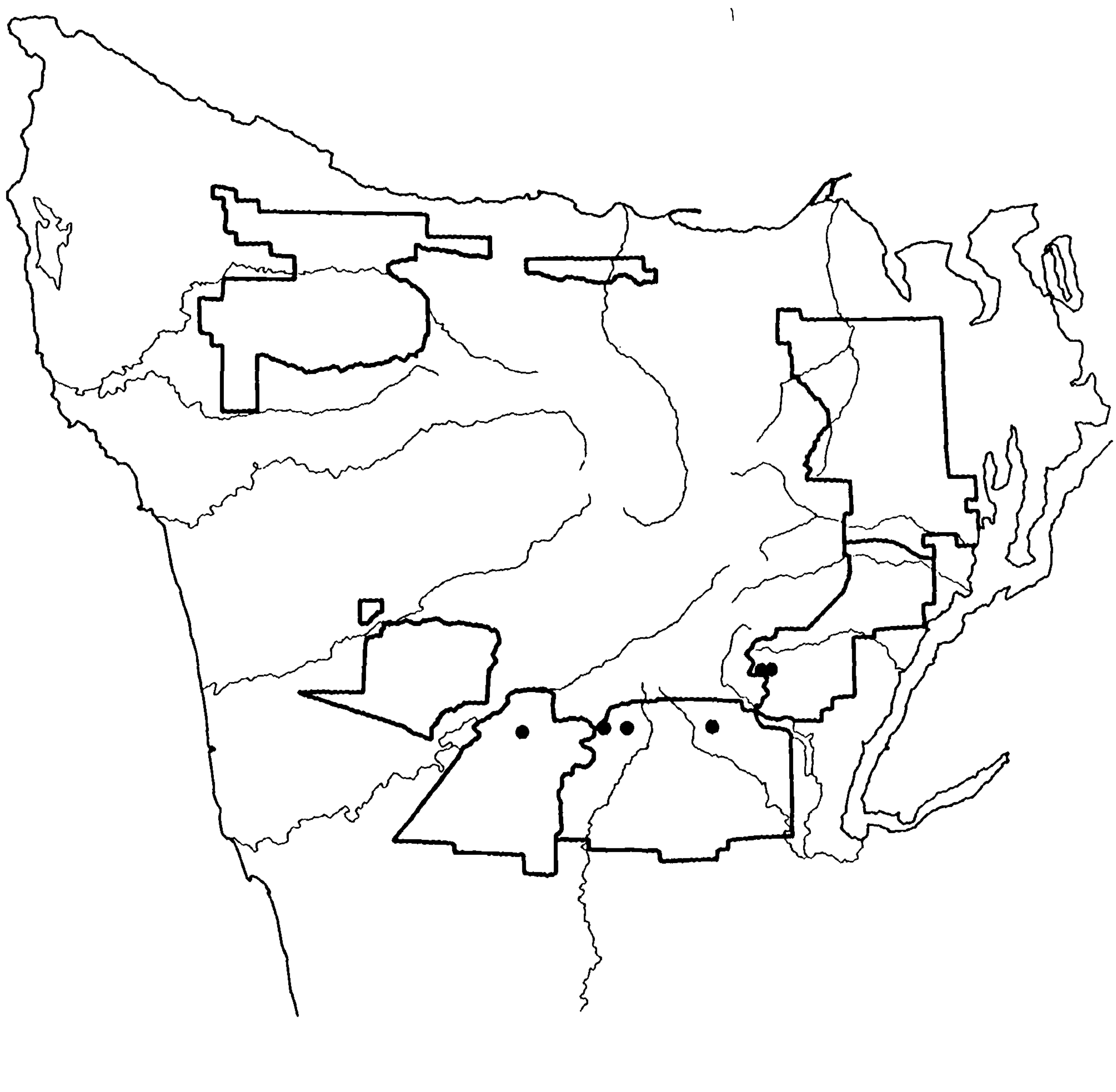


Figure 52. Map of plot locations for the Mountain Hemlock/Big Huckleberry-Alaska Huckleberry Association.

Environment and Soils

This type occurred on gentle to steep, straight lower to upper slopes and toe-slopes often in areas of extensive rock outcrop. The slope varied from 14% to 81% and averaged 53%. The regolith is colluvium derived from metabasalt or sandstone.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, rapidly permeable, colluvial soils. Textures vary from loam to silt loam. Coarse fragments range from 20% to 35% near the surface and 35% to 50% in the subsoil for units in which data is given. Many plots fell in units of extensive rock outcrop. Coarse fragments are probably much higher in these areas.

The mean soil temperature was 8.5 deg C (47.3 deg F) which is warm for the Mountain Hemlock Zone. The temperature regime is cryic and the moisture regime is udic.

Timber Productivity

Timber productivity of this type is low. This is due to the harshness of the site, cold soils, and relatively short growing season. Reliable site index values for mountain hemlock or silver fir are not available. The empirical yield is about 38 cu ft/ac/yr in about 190 years. The stockability of these sites is moderate to low.

Management Considerations

Management considerations for this type include control of brush competition and ensuring suitable regeneration. Maintenance of soil nutrients and organic matter is less critical in this type than other types. Response to fertilizer in this type is still unknown. This type occurs in low areas for the Mountain Hemlock Zone, and along upper slopes. Douglas-fir is not know to occur on this type, so may not be a management option. Silver fir or mountain hemlock are the preferred species. Big huckleberry and/or Alaska huckleberry can pose brush problems. Regeneration is slow and height growth of established seedlings is slow.

Root disease problems may include annosus root disease and rusty red stringy rot on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include the Mountain Hemlock/Alaska Huckleberry/Avalance Lily type which occurs in moister areas, and the Mountain Hemlock/Alaska Huckleberry/Beargrass and Silver Fir/Big Huckleberry/Beargrass types which occur on drier sites. The Mountain Hemlock/Big Huckleberry-Alaska Huckleberry Association occurs in the Cascades from about Mt. Adams northward and in the Olympics. It was recognized in the North Cascades (Henderson and Peter 1984, 1985), in British Columbia (Brooke *et al.* 1970), and as Silver Fir/Fool's Huckleberry in the Mt. Adams area (Franklin 1966).

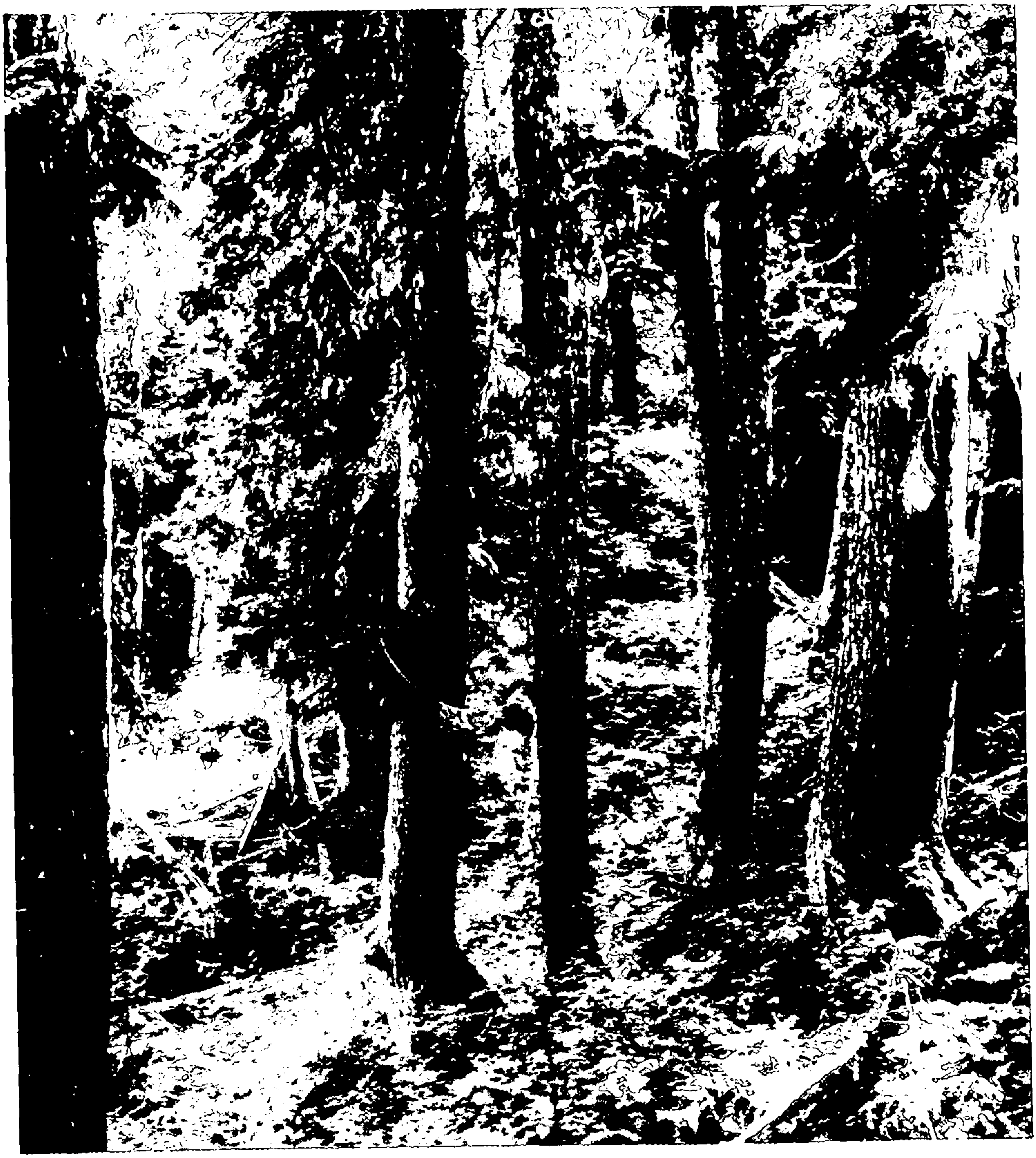


Figure 53. Photo of the Mountain Hemlock/Big Huckleberry-Alaska Huckleberry Association, Mildred Lakes, Hood Canal District.

MOUNTAIN HEMLOCK/BIG HUCKLEBERRY/BEARGRASS

Tsuga mertensiana/Vaccinium membranaceum/Xerophyllum tenax
TSME/VAME/XETE CMS2 45 OLY

The Mountain Hemlock/Big Huckleberry/Beargrass Association is a minor type of warm exposures, dry sites at upper elevations, heavy snowpacks, and low timber productivity. It is common in the mesic climatic areas of the Olympics (Environmental Zones 8 and 9), particularly on the Hood Canal District (Figure 54), and occurs primarily on southwestern aspects along the upper slopes of the Mountain Hemlock Zone. Soils are mostly shallow and derived from colluvium, and are often well drained. The typical area of this type has burned once or twice in the last 500 years.

Floristic Composition

Dominant understory species (Table 32) are big huckleberry (VAME) and beargrass (XETE), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Beargrass and big huckleberry can resprout or become established quickly after clearcut or fire. Other shrubs may include red heather (PHEM), blue-leaf huckleberry (VADE), mountain ash (SOSI) and fool's huckleberry (MEFE). The tree layer may be dominated by silver fir, mountain hemlock, or Alaska yellowcedar. Subalpine fir, Douglas-fir or western hemlock can also occur. Douglas-fir on this type are often very old, and may represent relics from an earlier climate. Stands in this type may be very slow to regenerate. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over than 300 years old. We do not have any data for cryptogams on this type.

Successional Relationships

The common successional pathway is dominated by silver fir and mountain hemlock in early stages. Climax stages are dominated silver fir, mountain hemlock and Alaska yellowcedar.

Other Biota

Wildlife observations are limited for this type, the only record was evidence of browse on big huckleberry. Bird observations are limited to one plot where Cooper's hawk and grouse were recorded.

Environment and Soils

This type occurred on moderate to steep, straight to convex slopes in almost any topographic position except wet ones, but usually in areas of extensive rock outcrops. The slope varied from 25% to 80% and averaged 61%. The regolith was colluvial or alpine glacial material derived from metabasalt or sedimentary rocks.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, rapidly permeable, colluvial soils in areas of extensive rock outcrop. Textures vary from loams and silt loams to sandy loams. The coarse fragment fraction is probably very high.

The mean soil temperature was 8.4 deg C (47.1 deg F) which is about average for the Mountain Hemlock Zone. The temperature regime is cryic and the moisture regime is udic.

Table 32. Common plants in the TSME/VAME/XETE Association, based on stands >150 years (n=2).

Common name	Abs. Code	Rel. Cover	Cover	Const	Range
TREES					
silver fir	ABAM	41.0	41.0	100	5-77
mountain hemlock	TSME	17.5	17.5	100	15-20
GROUND VEGETATION					
big huckleberry	VAME	37.5	37.5	100	30-45
beargrass	XETE	22.5	22.5	100	15-30
Alaska huckleberry	VAAL	4.0	8.0	50	0-8
sidebells pyrola	PYSE	1.5	3.0	50	0-3
mountain-ash	SOSI	0.5	1.0	50	0-1
wdland beardtongue	NONE	0.5	1.0	50	0-1

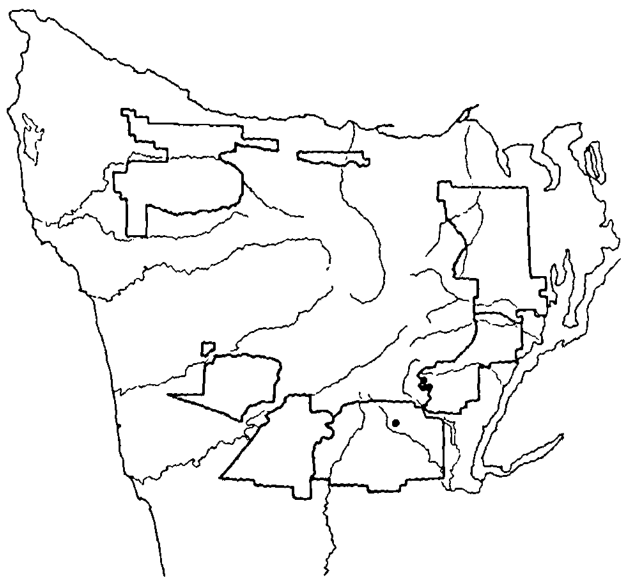


Figure 54. Map of plot locations for the Mountain Hemlock/Big Huckleberry/Beargrass Association.

Timber Productivity

Timber productivity of this type is very low. This is due to the relative dryness of the site in August, the well-drained soils, and relatively short growing season and cold soils. Reliable site index values for mountain hemlock or silver fir are not available. The productivity potential based on empirical curves from the Cascades is about 20 cu ft/ac/yr in about 220 years. The stockability of these sites is moderate to low.

Management Considerations

Management considerations for this type include soil maintenance and stability, and ensuring suitable regeneration. Maintenance of soil nutrients and organic matter is more critical in this type than other Mountain Hemlock types. Response to fertilizer in this type is still unknown. This type occurs in high areas for the Mountain Hemlock Zone, and along upper slopes and ridgetops. Regeneration in this type is very difficult and precludes most management decisions in this type. Noble fir can occur on this type in the Cascades. Douglas-fir is virtually unknown on this type. Silver fir or mountain hemlock are the preferred species. Beargrass and/or big huckleberry can pose brush problems.

Root disease problems may include annosus root disease and rusty red stringy rot on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include the Mountain Hemlock/Big Huckleberry-Alaska Huckleberry type which occurs on wetter sites, and the Mountain Hemlock/Alaska Huckleberry/Beargrass type which occurs on warmer and lower elevation sites. The Silver Fir/Alaska Huckleberry/Beargrass type occurs on moister sites at lower elevations. The Mountain Hemlock/Big Huckleberry/Beargrass Association occurs in the Cascades from about MacKenzie Pass (Hemstrom *et al.* 1982) north to about Stevens Pass where it is replaced by Mountain Hemlock/Big Huckleberry. It is represented on the H.J. Andrews Experimental Forest by the Silver Fir-Mountain Hemlock/Beargrass type (Dyrness *et al.* 1976). It was recognized in Olympic National Park by Smith and Henderson (1986) as the Silver Fir-Mountain Hemlock/Beargrass Association (Big Huckleberry phase). It was not recognized in Mt. Rainier National Park by Franklin *et al.* (1988), but their type, Silver Fir/Beargrass-Mountain Hemlock phase, represents some sites which could be called Mountain Hemlock/Big Huckleberry/Beargrass as defined here. It was recognized by Franklin (1966) in the Mt. Adams area as Silver Fir-Mountain Hemlock/Big Huckleberry. It has not yet been recognized on the Mt. Baker-Snoqualmie National Forest by this project, although it is expected to occur on the White River and North Bend Ranger Districts.

MOUNTAIN HEMLOCK/RED HEATHER-BLUELEAF HUCKLEBERRY

Tsuga mertensiana/Phyllodoce empetriformis-Vaccinium deliciosum

TSME/PHEM-VADE CMS3 11

The Mountain Hemlock/Red Heather-Blueleaf Huckleberry Association is a minor type of cool dry sites at upper elevations, and very low timber productivity. It is common in the mesic climatic areas of the Olympics (Environmental Zones 7-9), particularly on the Hood Canal District (Figure 55), and occurs on variable aspects primarily along the upper slopes of the Mountain Hemlock Zone. Soils are mostly shallow and immature, derived from colluvium or till, and are often well drained. The typical area of this type has not burned in the last 500 years. This type has been sensitive to climatic changes associated with the Little Ice Age.

Floristic Composition

Dominant understory species (Table 33) are red heather (PHEM) and blueleaf huckleberry (VADE), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Beargrass (XETE) and big huckleberry (VAME) can also occur and may become established quickly after fire. Other shrubs may include white rhododendron (RHAL) or mountain-ash (SOSI). The tree layer is dominated by mountain hemlock and/or silver fir; Alaska yellowcedar may also occur (Figure 56). Stands in this type may be very slow to regenerate. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over 300 years old, although trees are usually less than 60 feet tall and 16 inches in diameter.

Cryptogam data are limited for this type to one plot where ground moss was abundant with 60% cover. Epiphytic lichens included *Alectoria sarmentosa* and crustose lichens which were most abundant, *Platismatia glauca* and *Hypogymnia* spp. also occurred.

Successional Relationships

The common successional pathway is dominated by open meadow vegetation for long periods of time, followed by slow invasion of trees. Climax stages are dominated by silver fir, mountain hemlock and Alaska yellowcedar.

Other Biota

Wildlife observations are limited for this type. Deer sign and browse on blue-leaf huckleberry were observed. No bird observations were recorded.

Environment and Soils

This type occurs on moderate to steep, straight to convex upper slopes and ridgetops. The slope varied from 25% to 70% and averaged 53%. The regolith is colluvium or till derived from metabasalt or sandstone.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, highly permeable, colluvial soils in areas of extensive rock outcrop. Textures are loams and silt loams. Coarse fragments of these soil units range from 15% to 35% near the surface and 35% to 50% in the subsoils. Because the coarse fragment fraction appears to be higher than this in the field this type is probably occupying a rockier inclusion within this soil unit.

Table 33. Common plants in the TSME/PHEM-VADE Association, based on stands >150 years (n=5).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
mountain hemlock	TSME	25.0	25.0	100	15-30
silver fir	ABAM	7.0	8.8	80	0-20
Alaska yellowcedar	CHNO	5.8	7.3	80	0-10
subalpine fir	ABLA2	4.6	11.5	40	0-15
GROUND VEGETATION					
red heather	PHEM	34.8	34.8	100	4-60
big huckleberry	VAME	8.2	8.2	100	1-15
blueleaf huckleberry	VADE	22.0	27.5	80	0-55
beargrass	XETE	9.8	12.2	80	0-45
avalanche lily	ERMO	2.2	3.7	60	0-5

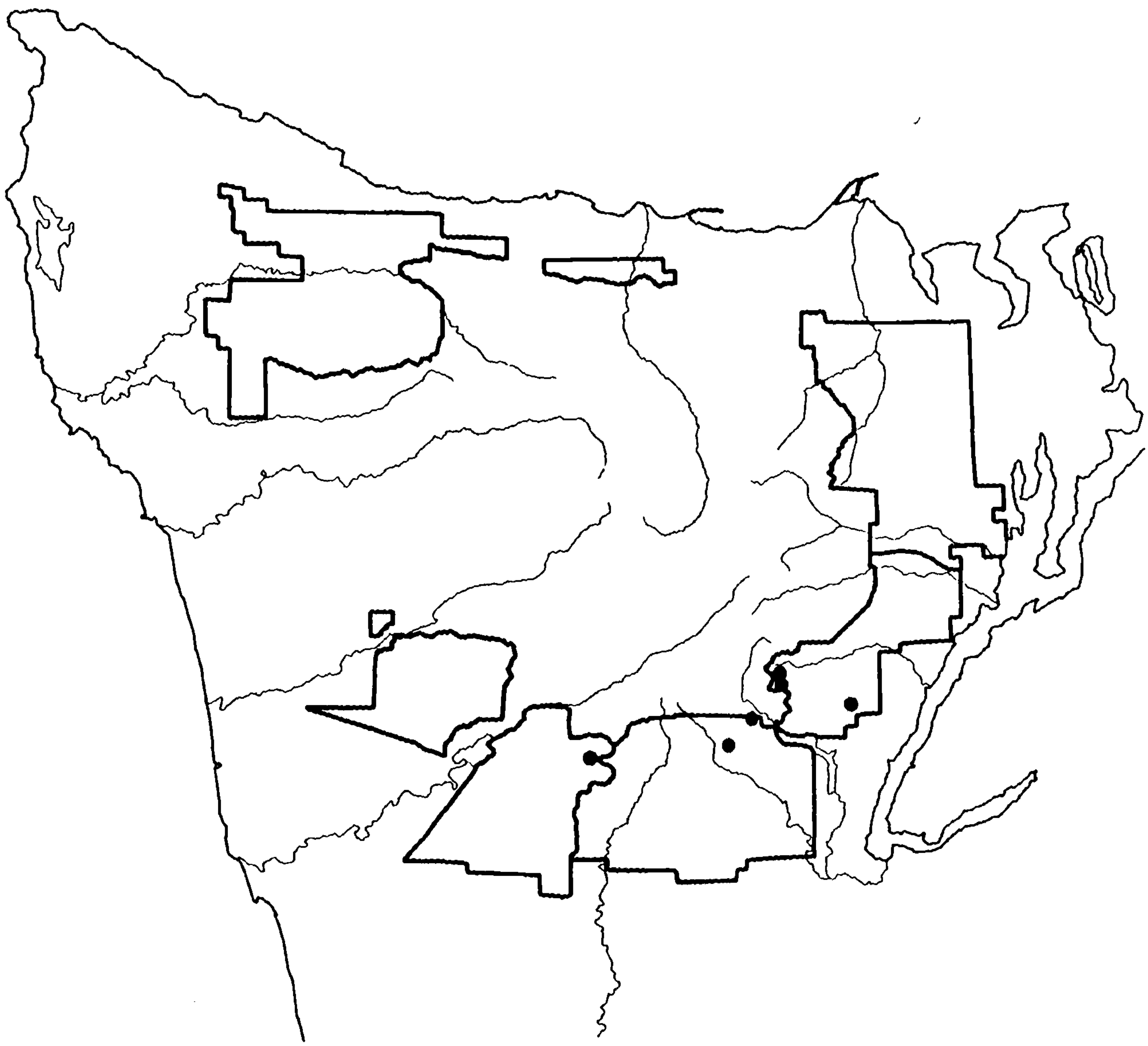


Figure 55. Map of plot locations for the Mountain Hemlock/Red Heather-Blueleaf Huckleberry Association.

The mean soil temperature was 9.1 deg C (48.4 deg F), which is warm for the Mountain Hemlock Zone. The temperature regime is cryic and the moisture regime is udic. No soil pits were dug in this association.

Timber Productivity

Timber productivity of this type is very low. This is due to the poor nutrient status of the site, cold soils that are well-drained, and a very short growing season. Site index of silver fir and mountain hemlock is not available for this association because of a lack of suitable site index curves, and because most trees sampled were over 400 years old. The productivity potential based on empirical curves from the Cascades is less than 20 cu ft/ac/yr in about 250 years. The stockability of these sites is low.

Management Considerations

Management considerations must recognize the extreme environment and low timber productivity for this type. Emphasis is usually given to maintenance of these communities for watershed, wildlife and recreational values.

Root disease problems may include annosus root disease on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots of importance may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Rusty red stringy rot may be on silver fir. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insect problems may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly the balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include Mountain Hemlock/Big Huckleberry-Alaska Huckleberry type which occurs on warmer sites at lower elevation, and Mountain Hemlock/White Rhododendron-Big Huckleberry which occurs on moister sites at lower elevations. The Mountain Hemlock/Red Heather-Blueleaf Huckleberry Association occurs sporadically south of the Columbia River in the Cascades, (although it is not yet formally recognized there), through the Cascades and Olympics of Washington and well into British Columbia. It is described as the Mountain Hemlock-Subalpine Fir/Red Heather Association in the Olympic National Park (Smith and Henderson 1986), on the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1982, 1983, 1984, 1985), in the Middle Fork of the Snoqualmie River (del Moral *et al.* 1976), and in British Columbia (Brooke *et al.* 1970). It is closely related to the non-forest Heather-Huckleberry type which occurs commonly in the Cascades north of Mt. Rainier National Park and the Olympics. It has some affinities to the forested Mountain Hemlock/White Rhododendron-Red Heather (Henderson and Peter 1984, 1985) in the Cascades and the Mountain Hemlock/White Rhododendron-Big Huckleberry in the Olympics.

Figure 56. Photo of the Mountain Hemlock/Red Heather-Blueleaf Huckleberry Association, Three Peaks, Hood Canal District.

MOUNTAIN HEMLOCK/WHITE RHODODENDRON-BIG HUCKLEBERRY

Tsuga mertensiana/Rhododendron albiflorum-Vaccinium membranaceum
TSME/RHAL-VAME CMS3 12

The Mountain Hemlock/White Rhododendron-Big Huckleberry Association is a minor type of well-drained sites at high elevations, heavy snowpacks, and low timber productivity. It is found in the drier climatic areas of the Olympics (Environmental Zones 8-10), particularly on the Hood Canal and Quilcene Districts (Figure 57). It occurs primarily along upper slopes on the leeward side of a major ridge. Soils are mostly shallow and usually derived from colluvium. The typical area of this type has burned rarely in the last 500 years. This type is much more common in the Cascades.

Floristic Composition

Dominant understory species (Table 34) are white rhododendron (RHAL) and big huckleberry (VAME), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Other shrubs may include oval-leaf huckleberry (VAOV) and fool's huckleberry (MEFE). Five-leaved bramble (RUPE), sidebells pyrola (PYSE) and beargrass (XETE) can also occur. The tree layer is dominated by silver fir and mountain hemlock, sometimes with Alaska yellowcedar, western hemlock or subalpine fir. Stands in this type may be very slow to regenerate. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over 500 years old.

Ground mosses are generally sparse on this type, but may be abundant on some sites. *Rhytidiopsis robusta* and *Dicranum* sp. were most common. Epiphytic lichens are conspicuous and abundant, particularly *Alectoria sarmentosa* and crustose species. *Bryoria* spp., *Hypogymnia* spp., *Plastimatia glauca*, *Sphaerophorus globosus*, and *Parmeliopsis hyperopta* may occur in moderate amounts.

Successional Relationships

Climax stages are dominated by mountain hemlock, silver fir and Alaska yellowcedar.

Other Biota

Wildlife observations are limited for this type, and include deer sign and browse on mountain-ash, bear damage to silver fir and mountain hemlock, and mountain beaver activity.

Bird observations are also limited, but chestnut-backed chickadee, golden-crowned kinglet, and gray jay were frequently recorded. Other birds include dark-eyed junco, red-breasted sapsucker, olive-sided flycatcher, Steller's jay, common raven, red-breasted nuthatch, brown creeper and red-shafted flicker.

Environment and Soils

This type occurs on gentle to moderate, concave or straight, lower to upper slopes, generally in areas of extensive rock outcrop. It shows a strong preference for concave microsites. The slope varied from 2% to 68% and averaged 44%. The regolith is colluvium derived from metabasalt or sandstone.

Table 34. Common plants in the TSME/RHAL-VAME Association, based on stands >150 years (n=12).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
mountain hemlock	TSME	37.9	37.9	100	15-80
silver fir	ABAM	42.1	45.9	91	0-90
Alaska yellowcedar	CHNO	16.8	20.2	83	0-50
western hemlock	TSHE	8.7	20.8	41	0-70
subalpine fir	ABLA2	5.6	33.5	16	0-65
GROUND VEGETATION					
white rhododendron	RHAL	22.1	22.1	100	2-30
big huckleberry	VAME	14.1	14.1	100	1-40
oval-leaf huckleberry	VAOV	4.5	5.4	83	0-15
five-leaved bramble	RUPE	4.3	5.7	75	0-30
sidebells pyrola	PYSE	0.8	1.1	75	0-2
beargrass	XETE	2.0	3.0	66	0-7
trailing bramble	RULA	1.3	1.9	66	0-3
red heather	PHEM	1.7	3.3	50	0-10

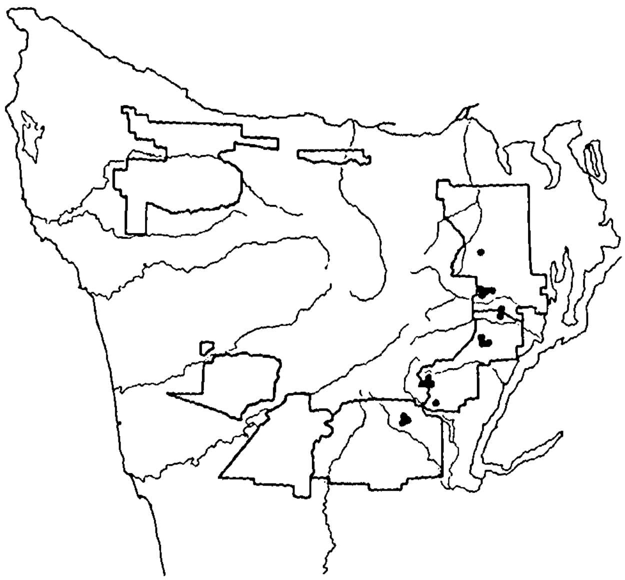


Figure 57. Map of plot locations for the Mountain Hemlock/White Rhododendron-Big Huckleberry Association.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, rapidly permeable, colluvial soils. The texture varies from loam and silt loam to sandy loam. Coarse fragments range from 15% to 50% near the surface and 35% to 75% in the subsoil. Many plots fell in units of extensive rock outcrop. Coarse fragments are probably much higher in these areas.

The mean summer soil temperature was 8.1 deg C (46.6 deg F) which is cool for the Mountain Hemlock Zone. The soil temperature regime is cryic and the moisture regime is udic.

Timber Productivity

Timber productivity of this type is low (Site V or VI). This is due to the cold soils, heavy snowpack and relatively short growing season. The productivity potential estimated from empirical volume curves from the Cascades is about 25 cu ft/ac/yr in about 220 years, while similar curves from the Olympics gave an empirical yield of 38 cu ft/ac/yr in 190 years. The stockability of these sites is low, as stands are usually patchy and open.

Management Considerations

The low productivity and long period of time to reach culmination of mean annual increment need to be considered when making any management decisions in this type. Douglas-fir is not known to occur on this type. Silver fir or mountain hemlock are the preferred species. Big huckleberry and/or white rhododendron can pose brush problems.

Root disease problems may include annosus root disease on mountain hemlock and silver fir, and laminated root rot on mountain hemlock and possibly silver fir. Heart and butt rots may be annosus root disease on mountain hemlock and silver fir, and red ring rot on mountain hemlock. Rusty red stringy rot may be on silver fir. Hemlock dwarf mistletoe may be present on mountain hemlock.

Insects may include western blackheaded budworm on mountain hemlock and silver fir, silver fir beetle on suppressed, windthrown, or diseased silver fir, and possibly balsam woolly aphid on silver fir.

Comparison with Similar Types

Similar types include Mountain Hemlock/Alaska Huckleberry on more mesic sites, and Mountain Hemlock/Alaska Huckleberry/Beargrass and Mountain Hemlock/Big Huckleberry/Beargrass types on drier sites. The Mountain Hemlock/White Rhododendron-Big Huckleberry Association occurs as far south as the Gifford Pinchot National Forest where it is recognized as the Mountain Hemlock/White Rhododendron Association (Brockway *et al.* 1983). It is represented by the Alaska Yellowcedar/White Rhododendron type in the Mt. Adams area (Franklin 1966). However, it was not recognized by Franklin *et al.* (1988) in Mt. Rainier National Park, although it probably occurs there. In the Cascades it was recognized as Mountain Hemlock/White Rhododendron by Henderson and Peter (1981c, 1981d, 1982b, 1983) and as Mountain Hemlock/White Rhododendron-Big Huckleberry (Henderson and Peter 1984, 1985). It is represented in British Columbia by the Mountain Hemlock/Big Huckleberry type (Brooke *et al.* 1970). It was recognized by Smith and Henderson (1986) in Olympic National Park as the Silver Fir-Mountain Hemlock/White Rhododendron Association.

SILVER FIR SERIES

SILVER FIR SERIES
Abies amabilis
ABAM

The Silver Fir Series (Zone) covers about 175,000 acres (27%) of the Olympic National Forest (Figure 58). It occupies the middle elevations and many mid-and upper slopes around the Forest, up to about 3000 feet elevation in the wetter environmental zones (Matheny Creek area), and to about 4000 feet in the driest part of its range (Dosewallips, Quilcene drainages). In Environmental Zones 10, 11 and 12 it disappears and is replaced by the upper Western Hemlock Zone and the Subalpine Fir Zone. At lower elevations it is usually replaced by the Western Hemlock Zone, and at higher elevations it is replaced by the Mountain Hemlock Zone. The Silver Fir Zone includes mostly moderate to low productivity land, however in some warmer and moist sites productivity potential is moderate to high. Productivity of associations within this series varies mostly with temperature and amount of soil drought.

The climate of the Silver Fir Zone is characterized as cool temperate. Winter temperatures are moderate and there is a moderate snowpack. Average January temperature is about 0 deg C (32 deg F). Summer air temperatures average about 14 deg C (58 deg F) which approximates the peak in summer soil temperatures at 8 inches (20 cm). Precipitation varies from about 200 inches in wetter zones at higher elevations to about 80 inches in drier zones. In addition, fog drip from trees can add several inches of "precipitation" in this zone.

Soils are typically cool and moist with a well developed O horizon. When present the A horizon tends to be high in organic matter. The texture is often coarse with many large fragments. Topographically they occur on a wide range of slope positions spanning mid-to upper elevations across the Olympic Peninsula. They occupy nearly all types of regolith and bedrock, the entire range of slopes from flat to very steep, and slope positions from bottoms to ridgetops.

The soil moisture regime is nearly always udic which indicates the rooting zone is usually moist throughout the summer. A few types are xeric (with a prominent summer drought) or aquic (saturated for extended periods). The soil temperature regime is nearly always frigid which means that the soil in the rooting zone is cool (less than 8 deg C) but the temperature varies more than 5 deg C at 50 cm from summer to winter. The temperature regime may occasionally be cryic which is also cool but with a greater than 5 deg C difference from winter to summer.

The organic layer is mostly a mor, although mulls and duff mulls also occur. The O2 layer averaged 4.1 cm in stands under 300 years old and 6.6 cm in stands over 300 years but the thickness in any one stand is quite variable. Causes of variability are climate, topographic configuration and stand history. Generally thicker layers accumulate in wetter and cooler areas. Stands originating following windthrow may inherit the previous O layer and the windthrown trees. Stands originating from fire may or may not inherit a previous O layer depending on the intensity of the fire and may inherit fire killed trees as well.

Over half the soils sampled in this series were inceptisols, over a third were spodosols and the remainder were entisols. The spodosols are generally weakly developed, while many inceptisols show signs of developing into spodosols. The tendency for more spodosols to form in this zone than in the Western Hemlock Zone reflects higher precipitation, lower evapotranspiration and greater stand age due to fewer fires. These factors result in a more intense leaching environment than in the Western Hemlock Zone and are reflected in the differences in soils. Only the Mountain Hemlock Zone has a more intense leaching environment than the Silver Fir Zone in the Olympic Mountains.

The dominant tree species are western hemlock and silver fir. Douglas-fir can occur on drier sites, especially in old-growth stands. Western redcedar and Alaska yellowcedar can both occur, as can mountain hemlock, western white pine and Pacific yew.

Root disease problems can include annosus root disease, Armillaria root disease, and laminated root rot. Annosus root disease is the most serious disease of the Silver Fir Zone, causing root, butt and stem decay of silver fir and western hemlock. Silver fir is particularly susceptible to this disease (Table 13). Armillaria root disease occurs throughout the Silver Fir Zone, killing mostly suppressed and stressed trees. It is particularly important in the drier types such as Silver Fir/Beargrass, Silver Fir/Rhododendron and Silver Fir/Salal, and in Douglas-fir plantations. Laminated root rot may be moderately destructive in silver fir and western hemlock stands. In associations that can support Douglas-fir, such as the rhododendron and salal types, laminated root rot may be very important.

Heart and butt rots of concern are red ring rot, annosus root disease, and rusty red stringy rot on western hemlock, annosus root disease, rusty red stringy rot and long pocket rot on silver fir, and red ring rot, brown trunk rot and brown cubical butt rot on Douglas-fir. Douglas-fir is most often found at the lower elevations and on drier types in the Silver Fir Series, such as the Silver Fir/Beargrass, Silver Fir/Rhododen- dron and Silver Fir/Salal Associations, and this is where these decays are most important.

Hemlock dwarf mistletoe is destructive to western hemlock in old-growth or multistoried stands in Environmental Zones 0-5, especially on the Silver Fir/Alaska Huckleberry/Oxalis, Silver Fir/Oxalis, Silver Fir/Swordfern-Oxalis and Silver Fir/Salal/Oxalis types.

Potential insect problems include western black-headed budworm on western hemlock, silver fir and Douglas-fir growing tips, hemlock looper on western hemlock foliage, Douglas-fir beetle on stressed, diseased or windthrown Douglas-fir, silver fir beetle on stressed, diseased or windthrown silver fir, and balsam woolly aphid on silver fir, particularly at lower elevations.

Potential yield for Silver Fir Associations is difficult to determine. Two recent site index curves (Hegyi *et al.* 1979, Hoyer and Herman in press) have represented progress in this field, but as of yet no yield tables or yield models have been developed which apply to the Silver Fir Zone in this area. We have tried several approaches to estimate yields for this series. These included using Barnes (1962) site index curve and yield table for western hemlock; Wiley's (1978a,b) site index curve (base 50) and yield table for western hemlock; Hoyer and Herman's (in press) site index curve, and McArdle and Meyer's (1930) site index curve and yield table for Douglas-fir. Site index was calculated for Douglas-fir using the high elevation curves of Curtis *et al.* (1974), but these site index values were not applied to a yield table. In addition we generated empirical curves of volume versus age from plot data (Figure 191) and used the SIGBA method of estimating potential yield (Hall 1983, 1987). These values are presented in the timber productivity tables for each association, when available. Some of these numbers are based on a very small sample size and therefore should be interpreted with caution.

Comparison of the different productivity estimates yielded some interesting results. The estimator closest to the overall average for these methods was the empirical approach from plot volume data. When comparing the various methods against this empirical curve, the Douglas-fir and silver fir estimates, as described above, are consistently less than the empirical value and the western hemlock estimates are consistently higher. These observations also point out one of the major problems in developing yield tables for the Silver Fir Zone, *i.e.* how to deal with mixed-species stands.

Twenty-three Plant Associations are recognized in the Silver Fir Series on the Olympic National Forest. These are described by 416 Reconnaissance and Intensive plots taken from 1979 to 1986. Environmental values and mean relative cover values for these associations are summarized in Table 35 and 36. The associations are presented in alphabetical order by common name on pages 152-241. They can be identified by using the following key. (See page 88 for explanation of how to use this abbreviated key).

Key to Plant Associations of the Silver Fir Series.

Skunkcabbage $\geq$5%	ABAM/LYAM	p. 226
Devil's Club $\geq$5%	ABAM/OPHO	p. 198
White Rhododendron $\geq$5% and Alaska Huckleberry $\geq$10%	ABAM/VAAL-RHAL	p. 184
Rhododendron $\geq$10%		
Alaska Huckleberry $\geq$5%	ABAM/RHMA-VAAL	p. 210
Alaska Huckleberry <5%	ABAM/RHMA	p. 206
Big Huckleberry $\geq$10% and Beargrass $\geq$5%	ABAM/VAME/XETE	p. 190
Oxalis $\geq$10%		
Salal $\geq$10%	ABAM/GASH-OXOR	p. 222
Swordfern $\geq$10%	ABAM/POMU-OXOR	p. 234
Alaska Huckleberry $\geq$5%	ABAM/VAAL/OXOR	p. 172
Alaska Huckleberry <5%	ABAM/OXOR	p. 202
Alaska Huckleberry $\geq$10%		
Oxalis $\geq$5%	ABAM/VAAL/OXOR	p. 172
Salal $\geq$5% and Deerfern $\geq$1%	ABAM/GASH/BLSP	p. 218
Beargrass $\geq$5%	ABAM/VAAL/XETE	p. 160
Avalanche Lily $\geq$1%	ABAM/VAAL/ERMO	p. 156
Oregongrape $\geq$5%	ABAM/VAAL-BENE	p. 168
Twinflower $\geq$3%	ABAM/VAAL/LIBO2	p. 180
Foamflower plus Rosy Twisted-stalk $\geq$3%	ABAM/VAAL/TIUN	p. 164
Queen's Cup, Bunchberry, Five-leaved Bramble and/or Deerfern $\geq$3%	ABAM/VAAL/CLUN	p. 176
Not as above	ABAM/VAAL	p. 152
Swordfern $\geq$10%	ABAM/POMU	p. 230
Salal $\geq$10%		
Deerfern $\geq$2%, Alaska Huckleberry or Red Huckleberry present	ABAM/GASH/BLSP	p. 218
Deerfern <2%	ABAM/GASH	p. 214
Beargrass $\geq$5%	ABAM/XETE	p. 186
Vanillaleaf plus Foamflower $\geq$5%, Rosy Twisted-stalk and/or Queen's cup usually present	ABAM/ACTR-TIUN	p. 238
Ground Cover <10%	ABAM/Dep.	p. 194

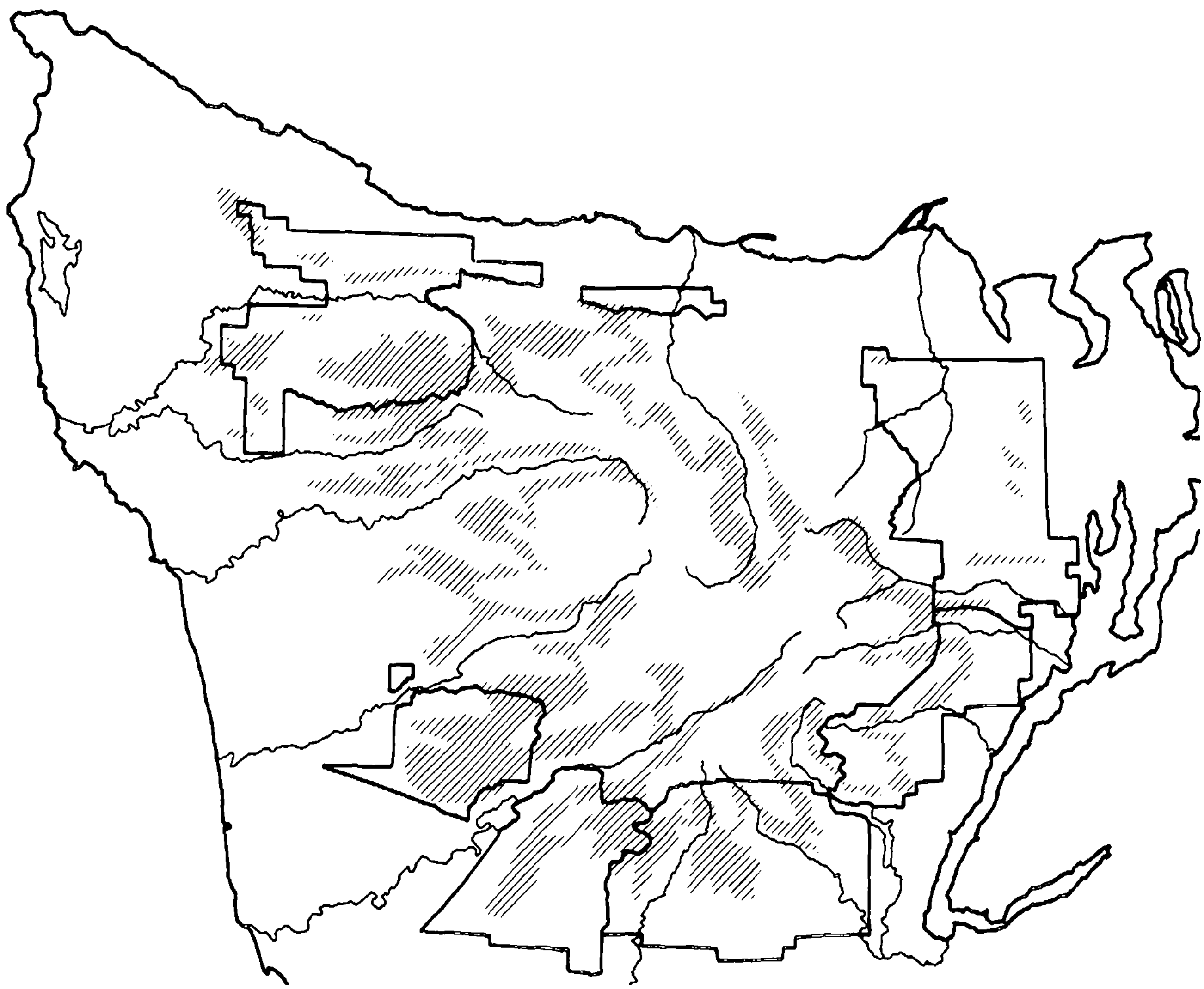


Figure 58. Map of the Silver Fir Zone on the Olympic Peninsula.

Table 35. Environmental values for associations in the Silver Fir Series. Slope, elevation and topographic moisture are mean values for the sample.

ENVIRONMENTAL VALUES	ABAM/ VAAL	ABAM/ VAAL/ERMO	ABAM/ VAAL/XETE	ABAM/ VAAL/TIUN	ABAM/ VAAL-BENE	ABAM/ VAAL/OXOR
ECOCLASS Code[1]	CFS2 12 (OLY)	CFS2 13	CFS2 14	CFS2 15	CFS2 16	CFS2 17
Number of plots[2]	31	17	13	21	9	38
Aspect	ALL	SE-NW	SW-NW, SE	W-S	SE-SW	W-S
Slope (%)	50	62	53	37	62	38
Elevation (ft.)	2531	3297	3238	2329	2339	1608
Environmental Zone[3]	0-8	3,0-6	8 (6-9)	0,3-6,8,9	5 (4,6,8)	0-6
Topographic Moisture[4]	4.4	4.1	3.7	5.7	4.7	5.1
Soil Moisture Regime[5]	udic	udic	udic	udic	udic	udic
Soil Temperature (deg C)[6]	10.7 (11)	9.2 (8)	7.8 (2)	10.6 (7)	10.0 (2)	10.7 (9)
Soil Temperature Regime[7]	frigid	cryic	frigid	frigid	frigid	frigid
Lichen line (ft.)		9.7	6		6.5	

ENVIRONMENTAL VALUES	ABAM/ VAAL/CLUN	ABAM/ VAAL/LIBO2	ABAM/ VAAL-RHAL	ABAM/ XETE	ABAM/ VAME/XETE	ABAM/ Dep.
ECOCLASS Code[1]	CFS2 18	CFS2 19	CFS2 20	CFF3 11	CFS2 11 (OLY)	CFF9 11
Number of plots[2]	41	16	4	6	7	18
Aspect	ALL	W-N	N-NE, SE, W	SE-SW	S (SW-NW)	S-NE
Slope (%)	55	54	64	54	62	57
Elevation (ft.)	2670	2641	4000	3440	4074	2427
Environmental Zone[3]	8 (0-9)	9 (3-10)	8,9	8 (7,9)	8 (9,10)	8 (0-11)
Topographic Moisture[4]	4.6	4.8	4.3	3.7	3.6	4.5
Soil Moisture Regime[5]	udic	udic	udic	udic	udic	udic
Soil Temperature (deg C)[6]	10.8 (11)	11.3 (4)	8.5 (2)	9.9 (4)	10.5 (3)	11.2 (10)
Soil Temperature Regime[7]	frigid	frigid	cryic	frigid	frigid	frigid
Lichen line (ft.)	7		10	8	6.5	

[1] See Table 161 p. 443
[2] Number of plots includes all successional stages sampled.
[3] See Figure 24 p. 40, and discussion p. 38.
[4] See discussion p. 84, Table 146 p. 417.
[5] See discussion p. 44.
[6] Summer soil temperature at 20 cm for mature and old-growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.
[7] See discussion p. 44-45.

Table 35 (cont.). Environmental values for associations in the Silver Fir Series. Slope, elevation and topographic moisture are mean values for the sample.

ENVIRONMENTAL VALUES	ASSOCIATIONS ABAM/ OPHO	ABAM/ OXOR	ABAM/ RHMA	ABAM/ RHMA-VAAL	ABAM/ GASH	ABAM/ GASH/BLSP
ECOCLASS Code[1]	CFS3 11 (OLY)	CFF1 11 (OLY)	CFS6 11 (OLY)	CFS6 12	CFS1 54 (OLY)	CFS1 55
Number of plots[2]	20	46	16	9	11	15
Aspect	E-W	NW-SE	ALL	SW-N, E	S-NW, E	SE-NW
Slope (%)	49	48	46	54	55	44
Elevation (ft.)	2394	1722	3125	3183	2263	1396
Environmental Zone[3]	2-5,7-9	1-3 (0-5)	9 (8,10)	8,9	4,6,9	0 (1,3-5)
Topographic Moisture[4]	6.5	4.5	4.6	4.7	4.1	4.4
Soil Moisture Regime[5]	aquic?	udic	udic	udic	udic	udic
Soil Temperature (deg C)[6]	10.0 (8)	11.7 (18)	10.3 (11)	9.3 (4)	11.9 (3)	11.1 (3)
Soil Temperature Regime[7]	frigid	frigid	frigid	frigid	frigid	frigid
Lichen line (ft.)		7	4.5			

ENVIRONMENTAL VALUES	ASSOCIATIONS ABAM/ GASH/OXOR	ABAM/ LYAM	ABAM/ POMU	ABAM/ POMU-OXOR	ABAM/ ACTR-TIUN
ECOCLASS Code[1]	CFS1 56	CFM1 11	CFF6 11	CFF6 12	CFF2 11
Number of plots[2]	19	2	14	31	12
Aspect	E-N	FLAT	NW-E	ALL	W-S
Slope (%)	44	7	59	54	45
Elevation (ft.)	1391	1815	1899	1474	3154
Environmental Zone[3]	1-5	1	3,4,6-9	2-4 (0-5)	8-10 (6)
Topographic Moisture[4]	4.6	8	5.4	5.2	5.7
Soil Moisture Regime[5]	udic	aquic	udic	udic	udic
Soil Temperature (deg C)[6]	13.4 (5)	-	11.7 (5)	11.9 (8)	10.2 (6)
Soil Temperature Regime[7]	frigid	frigid	frigid	frigid	frigid
Lichen line (ft.)			8		

[1] See Table 161 p. 443
[2] Number of plots includes all successional stages sampled.
[3] See Figure 24 p. 40, and discussion p. 38.
[4] See discussion p. 84, Table 146 p. 417.
[5] See discussion p. 44.
[6] Summer soil temperature at 20 cm for mature and old-growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.
[7] See discussion p. 44-45.

Table 36. Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on stands 150 years and older.

		ASSOCIATIONS					
		ABAM/ VAAL	ABAM/ VAAL/ERMO	ABAM/ VAAL/XETE	ABAM/ VAAL/TIUN	ABAM/ VAAL-BENE	ABAM/ VAAL/OXOR
ECOCLASS Code		CFS2 12 (OLY)	CFS2 13	CFS2 14	CFS2 15	CFS2 16	CFS2 17
Number of plots		18	15	10	19	8	29
TREES							
ABAM	Silver fir	50(100)	65(100)	39(100)	53(100)	40(100)	47(100)
ABLA2	Subalpine fir						
ACMA	Bigleaf maple						
ALRU	Red alder				5 (5)		
CHNO	Alaska yellowcedar	3 (11)	12 (46)	16 (30)	4 (15)		
CONU	Pacific dogwood						
PICO	Lodgepole pine						
PIMO	Western white pine						
PISI	Sitka spruce						6 (3)
PSME	Douglas-fir	24 (38)		16 (90)	9 (21)	12 (75)	1 (6)
TABR	Pacific yew	5 (16)	5 (6)	2 (10)			
THPL	Western redcedar	8 (38)	7 (20)	9 (50)	7 (26)	10 (12)	6 (24)
TSHE	Western hemlock	49(100)	27 (93)	46(100)	54 (94)	58(100)	72(100)
TSME	Mountain hemlock	7 (16)	6 (40)	3 (30)	2 (5)		
SHRUBS and HERBS							
ACCI	Vine maple	5 (22)	1 (20)	21 (40)	6 (31)	23(100)	3 (10)
ACTR	Vanillaleaf	1 (22)	2 (33)	1 (30)	2 (84)	4 (75)	2 (20)
ARCA6	Dwarf mistletoe					1 (12)	2 (3)
ATFI	Ladyfern	1 (5)	2 (26)		2 (73)		2 (65)
BENE	Oregongrape	1 (11)	1 (13)	2 (60)		15(100)	3 (10)
BLSP	Deerfern	1 (38)	2 (88)		4 (63)	2 (50)	3(100)
CHME	Little prince's pine	1 (22)	1 (6)	1 (10)	1 (10)	1 (50)	1 (3)
CHUM	Prince's pine	1 (11)		2 (30)	1 (10)	2 (37)	
CIAL	Enchanter's nightshade				1 (5)		
CLUN	Queen's cup	1 (61)	2 (93)	3 (60)	4 (63)	1 (62)	1 (58)
COCA	Bunchberry	1 (50)	1 (33)	1 (60)	2 (52)	1 (37)	2 (3)
COLA	Cutleaf goldthread	1 (22)	8 (20)		7 (36)	1 (62)	6 (31)
COME	Western coralroot	1 (22)	1 (6)	1 (50)	1 (5)	1 (25)	1 (3)
DIHO	Hooker's fairybell	1 (11)	1 (13)	4 (10)	2 (42)	2 (25)	1 (10)
DISM	Smith's fairybell				1 (5)		1 (31)
DRAU2	Woodfern				5 (5)		1 (20)
ERMO	Avalanche lily		2(100)	1 (10)			
GAOV	Slender wintergreen		1 (6)	3 (40)			
GASH	Salal	2 (16)		8 (40)	2 (15)	2 (62)	2 (31)
GATR	Fragrant bedstraw		1 (13)		2 (26)		1 (10)
GOOB	Rattlesnake-plantain	1 (11)	1 (26)		1 (10)	1 (12)	1 (3)
GYDR	Oakfern	1 (5)	2 (13)		4 (52)		1 (24)
HIAL	White hawkweed				1 (10)		1 (10)
HYMO	Fringed pinesap	1 (5)		1 (30)	1 (10)	1 (12)	1 (3)
LIBO2	Twinflower	1 (44)	1 (13)	2 (70)	2 (15)	10 (12)	2 (3)
LICA3	Western twayblade	1 (11)			1 (5)		1 (10)
LICO3	Heart-leaf twayblade	1 (11)	1 (13)	1 (30)	1 (15)		1 (3)
LUPA	Small-flowered woodrush	1 (11)	1 (13)		1 (26)		1 (34)
LYAM	Skunkcabbage						1 (6)
MADI2	False lily-of-the-valley	1 (33)	2 (46)	1 (10)	8 (47)		4 (75)
MEFE	Fool's huckleberry	1 (61)	2 (66)	2 (80)	3 (42)	1 (12)	4 (34)
MOSI	Candyflower				1 (15)		1 (13)
OPHO	Devil's club	1 (11)	1 (6)		1 (52)		2 (27)
OXOR	Oxalis	1 (16)	2 (6)		1 (5)		26(100)
POMU	Swordfern	1 (33)	1 (20)	1 (20)	3 (57)	4 (75)	3 (68)
PYPI	White-vein pyrola	1 (27)				1 (37)	1 (6)
PYSE	Sidebells pyrola	1 (38)	1 (20)	1 (20)	1 (31)	1 (12)	1 (3)
PYUN	Woodnymph	1 (16)	1 (6)				1 (41)
RHAL	White rhododendron						
RHMA	Rhododendron				1 (5)		
ROGY	Baldhip rose		1 (6)		1 (10)	1 (12)	
RULA	Trailing bramble	1 (11)	1 (6)	1 (70)	4 (15)		
RUPE	Five-leaved bramble	1 (38)	8 (60)	3 (40)	6 (73)		7 (68)
RUSP	Salmonberry	1 (11)	1 (20)		4 (68)	1 (12)	6 (72)
RUUR	Trailing blackberry				1 (15)	1 (12)	1 (13)
SARA	Red elderberry		1 (6)		1 (10)		1 (10)
SMST	Star-flowered solomon's seal	1 (11)	1 (20)	3 (10)	3 (42)	2 (25)	1 (10)
SOSI	Mountain-ash		1 (6)	1 (20)	1 (10)		
STAM	Clasping-leaved twisted-stalk	1 (5)	1 (13)		2 (15)	1 (25)	1 (17)
STRO	Rosy twisted-stalk	1 (33)	2 (73)		4 (73)	2 (12)	1 (62)
TITR	Three-leaved foamflower	1 (11)	2 (26)	1 (10)	5 (73)	2 (25)	2 (79)
TIUN	Single-leaved foamflower	1 (11)	3 (20)	1 (10)	3 (47)	1 (25)	
TRCE	Nodding trisetum				1 (21)		1 (27)
TRLA2	Starflower	1 (5)	1 (6)	1 (10)	1 (5)	1 (12)	1 (10)
TROV	Trillium	1 (38)	1 (33)	1 (40)	1 (52)	1 (75)	1 (48)
VAAL	Alaska huckleberry	35(100)	58(100)	42(100)	39(100)	11(100)	23(100)
VAME	Big huckleberry	1 (5)	2 (33)	2 (80)		1 (12)	
VAOV	Oval-leaf huckleberry	3 (7)	8 (40)	4 (40)	8 (21)		1 (17)
VAPA	Red huckleberry	4 (72)	1 (6)	3 (50)	3 (63)	12(100)	9 (72)
VASI	Sitka valerian		2 (26)	2 (10)	1 (10)		
VEVI	False hellebore		1 (13)	1 (10)	2 (21)		1 (3)
VISE	Evergreen violet	1 (11)		1 (40)	1 (42)	1 (25)	2 (24)
XETE	Beargrass	1 (16)	2 (6)	20(100)		2 (25)	

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 167 p. 456 for mean absolute cover values.
[2] Constancy is the percentage of plots for that association where the species occurred.

Table 36. (cont.) Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ VAAL/CLUN	ABAM/ VAAL/LIBO2	ABAM/ VAAL-RHAL	ABAM/ XETE	ABAM/ VAME/XETE	ABAM/ Dep.
ECOCLASS Code		CFS2 18	CFS2 19	CFS2 20	CFF3 11	CFS2 11 (OLY)	CFF9 11
Number of plots		31	11	4	5	2	14
TREES							
ABAM	Silver fir	57(100)	42(100)	44(100)	13(100)	50(100)	81(100)
ABLA2	Subalpine fir					5 (50)	2 (7)
ACMA	Bigleaf maple		1 (9)				
ALRU	Red alder						
CHNO	Alaska yellowcedar	26 (6)	10 (18)	8(100)			
CONU	Pacific dogwood						
PICO	Lodgepole pine						
PIMO	Western white pine						
PISI	Sitka spruce						
PSME	Douglas-fir	9 (19)	22 (63)	5 (25)	38(100)	25 (50)	20 (42)
TABR	Pacific yew	7 (9)	8 (18)				4 (14)
THPL	Western redcedar	4 (38)	15 (72)	5 (25)	2 (20)	10 (50)	4 (21)
TSHE	Western hemlock	57(100)	43(100)	48(100)	68(100)	43(100)	64(100)
TSME	Mountain hemlock	7 (12)	10 (9)	4 (75)	1 (20)	15 (50)	
SHRUBS and HERBS							
ACCI	Vine maple	14 (25)	11 (45)		4(100)		2 (7)
ACTR	Vanillaleaf	4 (29)	5 (36)	1 (50)	14 (60)		1 (21)
ARCA8	Dwarf mistletoe	2 (12)					
ATFI	Ladyfern	2 (6)	1 (18)	1 (50)	1 (20)		1 (7)
BENE	Oregongrape	1 (25)	1 (45)	1 (25)	6(100)		1 (21)
BLSP	Deerfern	3 (77)	2 (45)	1 (25)			2 (42)
CHME	Little prince's pine	1 (22)	1 (27)	1 (25)	1 (60)		1 (14)
CHUM	Prince's pine	1 (12)	2 (27)		2 (20)		1 (7)
CIAL	Enchanter's nightshade						
CLUN	Queen's cup	4 (87)	3 (90)	2(100)	3 (40)		1 (28)
COCA	Bunchberry	3 (38)	2 (45)	1 (75)	2 (40)		1 (7)
COLA	Cutleaf goldthread	2 (12)	2 (9)				
COME	Western coralroot	1 (16)	1 (18)		1 (20)		1 (14)
DIHO	Hooker's fairybell	1 (12)	1 (36)				
DISM	Smith's fairybell	1 (6)	1 (9)				
DRAU2	Woodfern	1 (3)					
ERMO	Avalanche lily						
GAOV	Slender wintergreen			1 (25)			
GASH	Salal	2 (19)	3 (36)		1 (60)		1 (21)
GATR	Fragrant bedstraw	1 (6)					1 (7)
GOOB	Rattlesnake-plantain	1 (9)	1 (18)				1 (7)
GYDR	Oakfern	1 (9)	2 (9)	3 (25)			
HIAL	White hawkweed	1 (3)	1 (27)	1 (25)	1 (20)		1 (7)
HYMO	Fringed pinesap	1 (9)	1 (9)		1 (40)		
LIBO2	Twinflower	1 (25)	17(100)	3 (75)	1 (60)		1 (28)
LICA3	Western twayblade	1 (19)	1 (27)				1 (14)
LICO3	Heart-leaf twayblade	1 (3)	1 (18)				
LUPA	Small-flowered woodrush	1 (8)	1 (9)	1 (25)			1 (7)
LYAM	Skunkcabbage						
MADI2	False lily-of-the-valley	3 (32)	1 (18)				1 (28)
MEFE	Fool's huckleberry	2 (41)	2 (45)	5 (75)	1 (20)	5 (50)	1 (28)
MOSI	Candyflower						
OPHO	Devil's club	2 (12)	1 (27)				2 (14)
OXOR	Oxalis	1 (12)					1 (7)
POMU	Swordfern	1 (32)	2 (90)	1 (25)	1(100)		1 (28)
PYPI	White-vein pyrola	1 (22)			1 (20)		1 (14)
PYSE	Sidebells pyrola	1 (25)	2 (27)	1(100)	2 (40)	1(100)	1 (28)
PYUN	Woodnymph	1 (18)	1 (9)	1 (25)			1 (57)
RHAL	White rhododendron	1 (3)	1 (9)	18(100)		1 (50)	2 (7)
RHMA	Rhododendron	2 (6)	2 (18)	15 (25)	7 (20)		2 (14)
ROGY	Baldhip rose	1 (3)	1 (9)		1 (80)		
RULA	Trailing bramble	2 (25)	2 (38)	3 (75)	1 (20)	1(100)	1 (7)
RUPE	Five-leaved bramble	3 (74)	10 (45)	7(100)			1 (42)
RUSP	Salmonberry	1 (29)	1 (27)	1 (25)			1 (7)
RUUR	Trailing blackberry	3 (12)	1 (9)		1 (20)		1 (7)
SARA	Red elderberry	1 (6)		1 (25)			1 (7)
SMST	Star-flowered solomon's seal	2 (12)	1 (9)		5 (20)		
SOSI	Mountain-ash	1 (6)			1 (20)	1 (50)	
STAM	Clasping-leaved twisted-stalk	1 (9)		1 (25)			
STRO	Rosy twisted-stalk	1 (51)	1 (36)	4 (25)	1 (20)		1 (35)
TITR	Three-leaved foamflower	1 (35)	3 (63)	1 (25)	1 (20)		1 (57)
TIUN	Single-leaved foamflower	1 (16)	2 (18)	2 (75)	1 (20)		1 (7)
TRCE	Nodding trisetum			1 (25)			
TRLA2	Starflower	1 (6)					1 (14)
TROV	Trillium	1 (25)	1 (63)	1 (25)	1 (40)		1 (71)
VAAL	Alaska huckleberry	41 (96)	18(100)	15(100)	2 (60)	1(100)	1 (78)
VAME	Big huckleberry	2 (22)	5 (18)	3 (75)	1 (80)	11(100)	1 (7)
VAOV	Oval-leaf huckleberry	14 (12)	2 (18)	15 (75)	1 (20)		1 (7)
VAPA	Red huckleberry	7 (70)	12 (81)	2 (25)	1 (60)		1 (57)
VASI	Sitka valerian	5 (6)		2 (25)			1 (7)
VEVI	False hellebore	1 (3)	1 (9)	2 (50)	1 (40)		2 (7)
VISE	Evergreen violet	1 (29)	1 (36)	1 (75)	1 (40)		1 (14)
XETE	Beargrass	1 (9)	2 (18)	3 (75)	21(100)	21(100)	1 (7)

1 Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 167 p. 456 for mean absolute cover values.

2 Constancy is the percentage of plots for that association where the species occurred.

Table 36. (cont.) Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ OPHO	ABAM/ OXOR	ABAM/ RHMA	ABAM/ RHMA-VAAL	ABAM/ GASH	ABAM GASH/BLSP
ECOCLASS Code		CFS3 11 (OLY)	CFF1 11 (OLY)	CFS6 11 (OLY)	CFS6 12	CFS1 54 (OLY)	CFS1 55
Number of plots		15	19	9	5	8	13
TREES							
ABAM	Silver fir	47(100)	51(100)	25(100)	33(100)	31(100)	54(100)
ABLA2	Subalpine fir						
ACMA	Bigleaf maple						1 (7)
ALRU	Red alder	1 (6)					
CHNO	Alaska yellowcedar	8 (6)		6 (11)			
CONU	Pacific dogwood						1 (7)
PICO	Lodgepole pine						
PIMO	Western white pine			1 (11)			
PISI	Sitka spruce		1 (5)				8 (7)
PSME	Douglas-fir	11 (26)	5 (5)	17(100)	22(100)	23 (62)	1 (7)
TABR	Pacific yew	2 (20)	6 (5)	3 (33)	3 (40)	13 (25)	2 (15)
THPL	Western redcedar	5 (46)	14 (31)	9 (88)	25 (80)	18 (67)	11 (53)
TSHE	Western hemlock	50 (93)	53(100)	69(100)	67(100)	47(100)	60(100)
TSME	Mountain hemlock	4 (13)					
SHRUBS and HERBS							
ACCI	Vine maple	3 (20)	33 (10)	3 (33)		14 (37)	9 (15)
ACTR	Vanillaleaf	1 (60)	3 (36)	2 (22)	2 (40)	1 (12)	4 (7)
ARCA6	Dwarf mistletoe		3 (21)	1 (11)			3 (30)
ATFI	Ladyfern	3 (73)	1 (52)		1 (20)		1 (15)
BENE	Oregongrape	3 (6)	2 (31)	1 (77)	3 (80)	5 (67)	5 (30)
BLSP	Deerfern	3 (66)	2 (84)	1 (11)	1 (20)	1 (25)	4(100)
CHME	Little prince's pine	1 (6)	1 (5)	1 (33)	1 (60)	1 (25)	1 (15)
CHUM	Prince's pine	1 (6)		1 (55)	1 (20)	1 (62)	
CIAL	Enchanter's nightshade		2 (10)				
CLUN	Queen's cup	2 (66)	2 (36)	1 (33)	1 (60)		3 (46)
COCA	Bunchberry	2 (26)	2 (5)	2 (44)	3 (60)	1 (12)	16 (30)
COLA	Cutleaf goldthread	1 (6)	1 (36)			1 (12)	2 (7)
COME	Western coralroot	1 (6)	1 (10)	1 (55)	1 (60)	1 (12)	
DIHO	Hooker's fairybell	1 (26)	1 (15)				1 (7)
DISM	Smith's fairybell	2 (20)	1 (36)				
DRAU2	Woodfern	1 (20)	1 (15)				
ERMO	Avalanche lily						
GAOV	Slender wintergreen	1 (6)					
GASH	Salal	4 (6)	3 (15)	1 (33)	3 (20)	47(100)	23(100)
GATR	Fragrant bedstraw	2 (33)	1 (5)			1 (12)	1 (7)
GOOB	Rattlesnake-plantain		1 (15)		1 (20)	1 (25)	1 (15)
GYDR	Oakfern	3 (46)	1 (5)				
HIAL	White hawkweed	1 (13)	1 (5)		1 (20)	1 (12)	1 (15)
HYMO	Fringed pinesap	1 (6)	1 (5)	1 (33)	1 (20)		
LIBO2	Twinflower	1 (6)	5 (5)	2(100)	10 (80)	12 (37)	3 (30)
LICA3	Western twayblade	1 (6)		1 (11)	1 (20)	1 (12)	1 (7)
LICO3	Heart-leaf twayblade	1 (13)	1 (10)			1 (37)	2 (23)
LUPA	Small-flowered woodrush	1 (20)	1 (21)				1 (7)
LYAM	Skunkcabbage		1 (5)				1 (7)
MADI2	False lily-of-the-valley	3 (40)	5 (68)				4 (53)
MEFE	Fool's huckleberry	2 (40)	5 (10)	1 (11)		1 (25)	3 (38)
MOSI	Candyflower	3 (20)	2 (42)				1 (7)
NONE	Woodland beardtongue			1 (11)		2 (12)	1 (7)
OPHO	Devil's club	12(100)	1 (36)		2 (20)	3 (12)	2 (7)
OXOR	Oxalis	37 (20)	43(100)				1 (23)
POMU	Swordfern	2 (66)	3 (78)	1 (33)	2 (20)	2 (62)	2 (61)
PYPI	White-vein pyrola	1 (6)	1 (5)	1 (22)			1 (15)
PYSE	Sidebells pyrola	2 (13)	1 (5)	1 (44)	1 (20)	1 (25)	
PYUN	Woodnymph	1 (20)	1 (26)			1 (25)	1 (30)
RHAL	White rhododendron						
RHMA	Rhododendron			44(100)	26(100)		
ROGY	Baldhip rose	1 (13)		1 (33)		1 (12)	1 (7)
RULA	Trailing bramble	1 (13)		1 (44)	2 (20)		
RUPE	Five-leaved bramble	2 (53)	2 (21)	1 (22)	6 (60)		3 (46)
RUSP	Salmonberry	4 (73)	3 (47)		1 (20)	2 (12)	2 (23)
RUUR	Trailing blackberry	2 (6)	1 (21)	1 (11)		1 (12)	2 (15)
SARA	Red elderberry	5 (46)	1 (15)		1 (20)		
SMST	Star-flowered solomon's seal		1 (15)	2 (11)		1 (12)	1 (7)
SOSI	Mountain-ash	1 (6)					
STAM	Clasping-leaved twisted-stalk	1 (53)	1 (10)				1 (7)
STRO	Rosy twisted-stalk	1 (40)	1 (15)	1 (22)			1 (15)
TITR	Three-leaved foamflower	5 (80)	1 (73)	1 (11)	2 (40)	1 (25)	1 (46)
TIUN	Single-leaved foamflower	2 (13)					
TRCE	Nodding trisetum		1 (21)				
TRLA2	Starflower	1 (6)	1 (5)	1 (22)	1 (20)		3 (7)
TROV	Trillium	1 (53)	1 (78)	1 (33)	1 (40)	1 (12)	1 (15)
VAAL	Alaska huckleberry	21 (86)	2 (78)	1 (77)	18(100)	3 (75)	21 (92)
VAME	Big huckleberry			1 (23)	1 (40)		
VAOV	Oval-leaf huckleberry	20 (20)	2 (5)	1 (11)	1 (20)		6 (15)
VAPA	Red huckleberry	2 (60)	3 (84)	1 (55)	7(100)	9(100)	11(100)
VASI	Sitka valerian	1 (20)					
VEVI	False hellebore						
VISE	Evergreen violet	1 (40)	1 (31)	1 (55)	1 (20)	1 (25)	1 (23)
XETE	Beargrass			4 (22)	15 (20)	3 (25)	30 (7)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 167 p. 456 for mean absolute cover values.
[2] Constancy is the percentage of plots for that association where the species occurred.

Table 36. (cont.) Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS				
		ABAM/ GASH/OXOR	ABAM/ LYAM	ABAM/ POMU	ABAM/ POMU-OXOR	ABAM/ ACTR-TIUN
ECOCLASS Code		CFS1 56	CFM1 11	CFF6 11	CFF6 12	CFF2 11
Number of plots		7	2	8	24	7
TREES						
ABAM	Silver fir	22(100)	21(100)	37(100)	26(100)	48(100)
ABLA2	Subalpine fir					
ACMA	Bigleaf maple					
ALRU	Red alder		12(100)			
CHNO	Alaska yellowcedar					1 (14)
CONU	Pacific dogwood					
PICO	Lodgepole pine					
PIMO	Western white pine					
PISI	Sitka spruce	4 (14)			1 (4)	
PSME	Douglas-fir			17 (82)	8 (12)	18 (71)
TABR	Pacific yew	2 (14)	5 (50)	4 (37)		
THPL	Western redcedar	34 (57)	49(100)	25 (87)	6 (54)	8 (42)
TSHE	Western hemlock	85(100)	51(100)	82(100)	75(100)	40(100)
TSME	Mountain hemlock					6 (14)
SHRUBS and HERBS						
ACCI	Vine maple			6 (25)	4 (20)	2 (14)
ACTR	Vanillaleaf	1 (14)		10 (62)	15 (16)	12(100)
ARCA8	Dwarf mistletoe	3 (42)		1 (12)	2 (16)	4 (14)
ATFI	Ladyfern	1 (28)	1 (50)	1 (37)	1 (66)	3 (57)
BENE	Oregongrape	12 (85)		4 (62)	3 (33)	3 (42)
BLSP	Deerfern	5(100)	3(100)	5 (87)	2 (91)	1 (28)
CHME	Little prince's pine			1 (12)		1 (14)
CHUM	Prince's pine			2 (25)		1 (28)
CIAL	Enchanter's nightshade		2 (50)		2 (4)	1 (14)
CLUN	Queen's cup	3 (14)	1(100)	2 (62)	2 (20)	5(100)
COCA	Bunchberry	1 (14)	2(100)	4 (37)	1 (8)	4 (42)
COLA	Cutleaf goldthread	2 (85)	3(100)	1 (25)	1 (54)	
COME	Western coralroot				1 (4)	1 (14)
DIHO	Hooker's fairybell	1 (42)		1 (25)	1 (37)	
DISM	Smith's fairybell			1 (25)	1 (29)	1 (42)
DRAU2	Woodfern			1 (12)	1 (33)	1 (14)
ERMO	Avalanche lily		1 (50)			
GAOV	Slender wintergreen					
GASH	Salal	19(100)	15(100)	3 (50)	2 (45)	1 (14)
GATR	Fragrant bedstraw			1 (25)	1 (4)	1 (28)
GOOB	Rattlesnake-plantain	1 (14)		1 (25)	1 (4)	
GYDR	Oakfern				3 (4)	7 (42)
HIAL	White hawkweed				1 (4)	1 (14)
HYMO	Fringed pinesap	1 (14)			1 (4)	
LIBO2	Twinflower	1 (14)	1(100)	19 (25)		7 (57)
LICA3	Western twayblade			1 (25)		1 (14)
LICO3	Heart-leaf twayblade	1 (14)	1 (50)	1 (12)	1 (4)	1 (14)
LUPA	Small-flowered woodrush	1 (28)	1 (50)	1 (12)	1 (50)	1 (42)
LYAM	Skunkcabbage	2 (28)	11(100)		1 (4)	
MADI2	False lily-of-the-valley	10 (57)	3(100)	1 (37)	2 (37)	1 (14)
MEFE	Fool's huckleberry	6 (42)	5(100)	1 (25)	1 (29)	1 (14)
MOSI	Candyflower	1 (14)	1 (50)			1 (14)
OPHO	Devil's club	1 (28)		2 (37)	1 (33)	2 (57)
OXOR	Oxalis	36(100)		1 (12)	39(100)	
POMU	Swordfern	5 (85)	1 (50)	13(100)	18(100)	1 (71)
PYPI	White-vein pyrola	1 (14)			1 (8)	1 (14)
PYSE	Sidebells pyrola					1 (42)
PYUN	Woodnymph	1 (14)	1 (50)	1 (12)	1 (20)	1 (28)
RHAL	White rhododendron					3 (28)
RHMA	Rhododendron			1 (12)		
ROGY	Baldhip rose					2 (14)
RULA	Trailing bramble					2 (42)
RUPE	Five-leaved bramble	1 (28)	3(100)	1 (12)	1 (25)	5 (71)
RUSP	Salmonberry	2 (57)	2 (50)	1 (12)	2 (54)	2 (28)
RUUR	Trailing blackberry	2 (28)		1 (37)	1 (25)	
SARA	Red elderberry			1 (12)	1 (16)	1 (42)
SMST	Star-flowered solomon's seal	2 (28)		1 (25)		9 (28)
SOSI	Mountain-ash					1 (14)
STAM	Clasping-leaved twisted-stalk		1(100)	1 (25)	1 (12)	1 (14)
STRO	Rosy twisted-stalk		2(100)	1 (82)	1 (16)	4 (71)
TITR	Three-leaved foamflower	2 (57)	1 (50)	3 (87)	1 (95)	4 (85)
TIUN	Single-leaved foamflower			1 (37)		7 (42)
TRCE	Nodding trisetum		1 (50)		1 (16)	1 (14)
TRLA2	Starflower				1 (8)	1 (14)
TROV	Trillium	1 (57)		1 (50)	1 (58)	1 (71)
VAAL	Alaska huckleberry	8 (85)	18(100)	3 (50)	4 (70)	2 (42)
VAME	Big huckleberry			1 (12)	2 (8)	2 (42)
VAOV	Oval-leaf huckleberry	1 (14)	5(100)			4 (28)
VAPA	Red huckleberry	12(100)	1 (50)	3(100)	3 (91)	1 (71)
VASI	Sitka valerian					1 (14)
VEVI	False hellebore					1 (28)
VISE	Evergreen violet	4 (42)		1 (62)	1 (50)	1 (71)
XETE	Beargrass		5 (50)			1 (14)

1- Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 187 p. 456 for mean absolute cover values.
2- Constancy is the percentage of plots for that association where the species occurred.

SILVER FIR/ALASKA HUCKLEBERRY

Abies amabilis/Vaccinium alaskaense

ABAM/VAAL CFS2 12 (OLY)

The Silver Fir/Alaska Huckleberry Association is an important type on the Forest. It occurs mainly on cool, moist sites, with moderate timber productivity. It is found throughout the Forest, mainly on Hood Canal and Soleduck Districts, and in the Humptulips drainage of the Quinault District (Figure 59). It is very similar to the Silver Fir/Alaska Huckleberry/Queen's Cup type. Soils are mostly deep, and derived from colluvium, or glacial till mixed with colluvium. Snow accumulates to moderate depths (5-10 feet) and usually melts off by early June. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely in the last 1000 years. Silver fir and western hemlock are the preferred timber species.

Floristic Composition

The dominant understory species is Alaska huckleberry (VAAL)(Table 37), which is usually present in all ages of stands, although it may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry usually becomes established quickly after clearcut or fire. Herbs and other shrubs are sparse, but may include red huckleberry (VAPA), five-leaved bramble (RUPE), queen's cup (CLUN) and deerfern (BLSP). Pioneer herbs may include fireweed (EPAN) or pearly everlasting (ANMA). The tree layer may be dominated by silver fir or western hemlock; western redcedar or Douglas-fir may also occur (Figure 60). Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over 500 years old. Areas that have been cut support stands which are mostly less than 35 years old.

Ground mosses are generally abundant in this type. *Rhytidiopsis robusta* is the most common and abundant moss; *Plagiothecium undulatum, Rhytidiadelphus loreus* and *Eurhynchium oreganum* may also occur. *Hypnum circinale* and *Scapania bolanderi* are common on rotting wood. Epiphytes may be abundant in old-growth stands, particularly *Alectoria sarmentosa*. Other common species include the nitrogen-fixer *Lobaria oregana, Sphaerophorus globosus, Hypogymnia* spp. and *Hypnum circinale*.

Successional Relationships

The common successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock. Many older stands have relict Douglas-fir trees or snags. These trees are older than 600 years and date to the end of the Medieval Optimum and the beginning of the Little Ice Age. Douglas-fir has survived in some plantations, but little natural regeneration occurs in this type. Ages of silver fir trees in older stands are up to 500 years. This indicates that the area where this association occurs has been silver fir climax for many centuries.

Table 37. Common plants in the ABAM/VAAL Association, based on stands >150 years (n=18).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	50.4	50.4	100	20-96
western hemlock	TSHE	49.4	49.4	100	6-99
Douglas-fir	PSME	9.4	24.3	38	0-90
western redcedar	THPL	3.1	8.0	38	0-20
mountain hemlock	TSME	1.1	6.7	16	0-15
Pacific yew	TABR	0.8	4.7	16	0-9
Alaska yellowcedar	CHNO	0.3	3.0	11	0-3
GROUND VEGETATION					
Alaska huckleberry	VAAL	35.3	35.3	100	5-65
red huckleberry	VAPA	2.6	3.6	72	0-20
queen's cup	CLUN	0.8	1.4	61	0-3
fool's huckleberry	MEFE	0.8	1.4	61	0-2
bunchberry	COCA	0.5	1.0	50	0-1

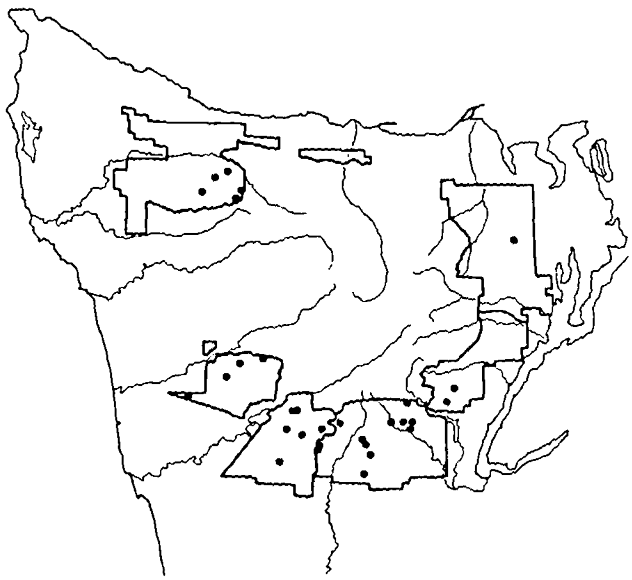


Figure 59. Map of plot locations for the Silver Fir/ Alaska Huckleberry Association.

Other Biota

Deer, elk, mountain beaver and bear signs were frequently observed on this type, with recent activity of deer recorded in early summer. Commonly browsed species were Alaska huckleberry, red huckleberry, fool's huckleberry and salmonberry. Other browse species include devil's club, vine maple, salal, sedge, baldhip rose, Douglas-fir, western redcedar and silver fir. Bear damage was noted on silver fir and Douglas-fir. Other wildlife observations were recorded for Douglas squirrel, chipmunk, snowshoe hare, porcupine and tree frog.

Birds frequently observed on this type were winter wren, red-breasted nuthatch, American robin, varied thrush, dark-eyed junco, rufous hummingbird, golden-crowned kinglet, brown creeper, western flycatcher and gray jay. Other birds include pileated woodpecker, red-breasted sapsucker, western wood pewee, Steller's jay, common raven, common crow, chestnut-backed chickadee, blue grouse, band-tailed pigeon, red-shafted flicker, downy woodpecker, Swainson's thrush, warblers, song sparrow, purple finch and pine siskin.

Environment and Soils

This type occurs on gentle to steep, lower to upper slopes, ridgetops and benches. The slope ranged from 2% to 140% and averaged 50%. Regolith consists mostly of colluvial material derived from metabasalt or sandstone, although glacial material is also possible.

Two pits dug in this type showed a moderate amount of soil development. Textures ranged from clay and sandy loam at the surface to clay loam and loamy sand in the subsoil. The O1 was thicker than average at 3.9 cm and the O2 varied greatly from 1 to 48 cm. The rooting depth averaged 56 cm in the mineral soil, but also extended up into the entire O2. Water holding capacity of the mineral soil is below average, but is considerably above average if the holding capacity of the organic layer is included. The low water holding capacity of the mineral soil is due to a very high coarse fragment fraction (74%). Earthworms were found in one of these pits. One pit was classified as a haplorthod and the other as a dystrochrept.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils are generally shallow, well-drained, rapidly permeable, colluvial soils. Some may be deep glacial or colluvial soils with compacted or cemented subsoils rendering them effectively shallow. Textures range from silt loams to clay loams or occasionally sandy loams. Coarse fragments range from 10% to 70% near the surface to 35% to 85% in the subsoil.

The mean soil temperature was 10.7 deg C (51.3 deg F), which is about average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

One pit was analyzed for soil nutrients. It showed relatively high zinc, calcium and sodium compared to other types. The pH was 5.0, which is about average for the series, but low for the Forest.

Timber Productivity

Timber productivity of this type is moderate (Site III). Site index of old-growth Douglas-fir averaged 134 (base 100) and 113 for western hemlock (Table 38). The productivity potential using the site index-yield table approach was 136 cu ft/ac/yr for Douglas-fir and 127-182 cu ft/ac/yr for silver fir and western hemlock. Empirical yield estimated for this association was 121 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking and brush control. Maintenance of soil nutrients and organic matter is less critical in this type than other types. Response to fertilizer in this type is still unknown, although sampled areas showed high accumulated nitrogen and organic matter and low pH. Experience has shown that Douglas-fir survival is not good and that snow breakage is common on planted Douglas-fir. Salmonberry and/or Alaska huckleberry can pose brush problems.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease is probably the most important heart and butt rot of older stands on this type. Hemlock dwarf mistletoe may be present in older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and balsam woolly aphid on silver fir, especially at lower elevations.

Table 38. Timber productivity values for the Silver Fir/Alaska Huckleberry Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI[8]	SDI[9]	GBA TREES	GBA[10]	SIGBA[11]	EMAI[12]
Douglas-fir (McArdle[1])	3	13	134	20	136	232				121
Douglas-fir (McArdle[2])	3	3	116	31						
Douglas-fir (Curtis[3])	3	13	145	15		232				
Douglas-fir (King[4])	2	10	103	10	141					
Western Hemlock (Barnes[5])	7	7	113	45	166			474	161	
Western Hemlock (Wiley[6])	5	16	86	19	182	359	6	474		121
Silver Fir (Hoyer[7])	8	31	127	14	127	316	14	528	206	121

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[4] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[5] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[6] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[7] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[8] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[9] Stand Density Index (Reinecke 1933).

[10] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[11] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[12] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include the Silver Fir/Alaska Huckleberry/Queen's Cup Association which is very similar and may be only slightly warmer and moister. The Silver Fir/Alaska Huckleberry-Oregongrape type occurs on drier and warmer sites. The Silver Fir/Alaska Huckleberry/Foamflower type occurs on moister and more productive sites. The Silver Fir/Alaska Huckleberry Association is widely recognized in Washington and Oregon and is represented in British Columbia. This type is treated differently in different areas. In earlier reports of this project it was much more broadly defined (Henderson and Peter 1981a,b,c,d, 1982a,b). Elsewhere in Oregon (Dyrness *et al.* 1976, Hemstrom *et al.* 1982) and in Washington (Franklin 1966, Franklin *et al.* 1988, del Moral *et al.* 1976) it is recognized as a broad type (roughly equivalent to Silver Fir/Alaska Huckleberry, Silver Fir/Alaska Huckleberry/Queen's Cup, Silver Fir/Alaska Huckleberry-Oregongrape, Silver Fir/Alaska Huckleberry-Salal and Silver Fir/Alaska Huckleberry/Twinflower as recognized here). The Silver Fir/Alaska Huckleberry Association as recognized here is much more restrictive and is similar to the Silver Fir-Western Hemlock/Moss type (Henderson and Smith 1986) in Olympic National Park and the Zonal Hemlock (Amabilis fir)-*Vaccinium*-Moss Ecosystem in British Columbia (Haeussler *et al.* 1982).

Figure 60. Photo of the Silver Fir/Alaska Huckleberry Association, Elk Creek, Hood Canal District.

SILVER FIR/ALASKA HUCKLEBERRY/AVALANCHE LILY

Abies amabilis/Vaccinium alaskaense/Erythronium montanum

ABAM/VAAL/ERMO CFS2 13

The Silver Fir/Alaska Huckleberry/Avalanche Lily Association is an important type in the high precipitation areas on the Forest. It occurs primarily on cool, moist sites, with moderate timber productivity. It is found mainly in the upper Wynoochee Valley (Figure 61). Soils are mostly deep, and derived from colluvium or glacial till. Soils appear to be moderately high in organic matter and nitrogen.

Floristic Composition

The dominant understory species (Table 39) is Alaska huckleberry (VAAL), which is usually present in all ages of stands, although it may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry can become established quickly after clearcut or light fire. Other shrubs may include oval-leaf huckleberry (VAOV) and fool's huckleberry (MEFE). Avalanche lily (ERMO), five-leaved bramble (RUPE), bunchberry (COCA), queen's cup (CLUN) and deerfern (BLSP) may also occur. The tree layer may be dominated by silver fir, western hemlock, or Alaska yellowcedar, or any combination of these trees (Figure 62). Western redcedar or mountain hemlock can also occur. Douglas-fir is virtually absent from this type. When tree cover is light, a thick understory may develop. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth successional condition, and many stands are over than 500 years old.

Ground mosses were generally abundant on this type, although some plots had sparse coverage of cryptogams. There is limited data available on the occurrence of species, however *Rhytidiopsis robusta* was the most common moss. Other species include *Plagiothecium undulatum*, *Dicranum* sp., and *Hypnum circinale* and *Scapania bolanderi* on rotting wood. Epiphytes may be abundant, especially *Alectoria sarmentosa*. Other common epiphytes include *Sphaerophorus globosus*, *Hypnum circinale*. Occasionally *Lobaria oregana* may occur.

Successional Relationships

The successional pathway is usually dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock, with significant amounts of Alaska yellowcedar in some stands. Young stands are mostly silver fir. In older stands the age of silver fir trees is often in the range of 340 to 550 years, indicating that these sites have been silver fir climax for a very long time, including most of the Little Ice Age.

Other Biota

Elk signs were recorded, with evidence of recent grazing activity in early summer. Alaska huckleberry, mountain hemlock and western hemlock had evidence of browse. Coyote scat, bear sign, small mammal activity and tree frog were observed.

Bird observations are limited to two plots for this type; nesting gray jays, red-breasted nuthatch, and varied thrush were recorded.

Table 39. Common plants in the ABAM/VAAL/ERMO Association, based on stands >150 years (n=15).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	64.7	64.7	100	40-97
western hemlock	TSHE	25.3	27.1	93	0-75
Alaska yellowcedar	CHNO	5.5	11.9	46	0-40
mountain hemlock	TSME	2.5	6.2	40	0-10
western redcedar	THPL	1.4	7.0	20	0-15
GROUND VEGETATION					
Alaska huckleberry	VAAL	57.9	57.9	100	8-95
avalanche lily	ERMO	2.4	2.4	100	1-9
queen's cup	CLUN	2.1	2.3	93	0-8
deerfern	BLSP	1.5	1.8	86	0-4
five-leaved bramble	RUPE	6.1	7.7	80	0-40
rosy twisted-stalk	STRO	1.1	1.5	73	0-3
fool's huckleberry	MEFE	1.3	1.9	66	0-5

Environment and Soils

This type occurs on flat to steep, straight to concave, mid- to upper slopes and ridgetops. Slopes ranged from 0% to 95% and averaged 62%. The regolith was mostly colluvium derived from metabasalt, sandstone, or shale.

Four pits were dug in this type showing moderate to strong soil development. An E horizon, which was albic in some cases, had developed in each pit.

The texture ranged from sandy loam to clay loam. The O1 was 0.4 cm thick, which is much thinner than average and the O2 was 5 cm, which is about average. The rooting zone averaged 50.9 cm, which is a little less than average and extended 4.5 cm into the O2. Coarse fragments were higher than average at 46.4%.

The water holding capacity is somewhat higher than average due to the generally fine soil texture. The classification of these pits were 3 cryorthods and 1 haplorthod.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), this type occurs on shallow, rapidly permeable, well-drained colluvium. Textures range from loam to clay loam. Coarse fragments ranged from 10% to 50% near the surface and 40% to 60% in the subsoils.

The mean soil temperature was 9.2 deg C (48.6 deg F), which makes this one of the cooler types in the Silver Fir Zone. The temperature regime is probably lower cryic and the moisture regime is udic.

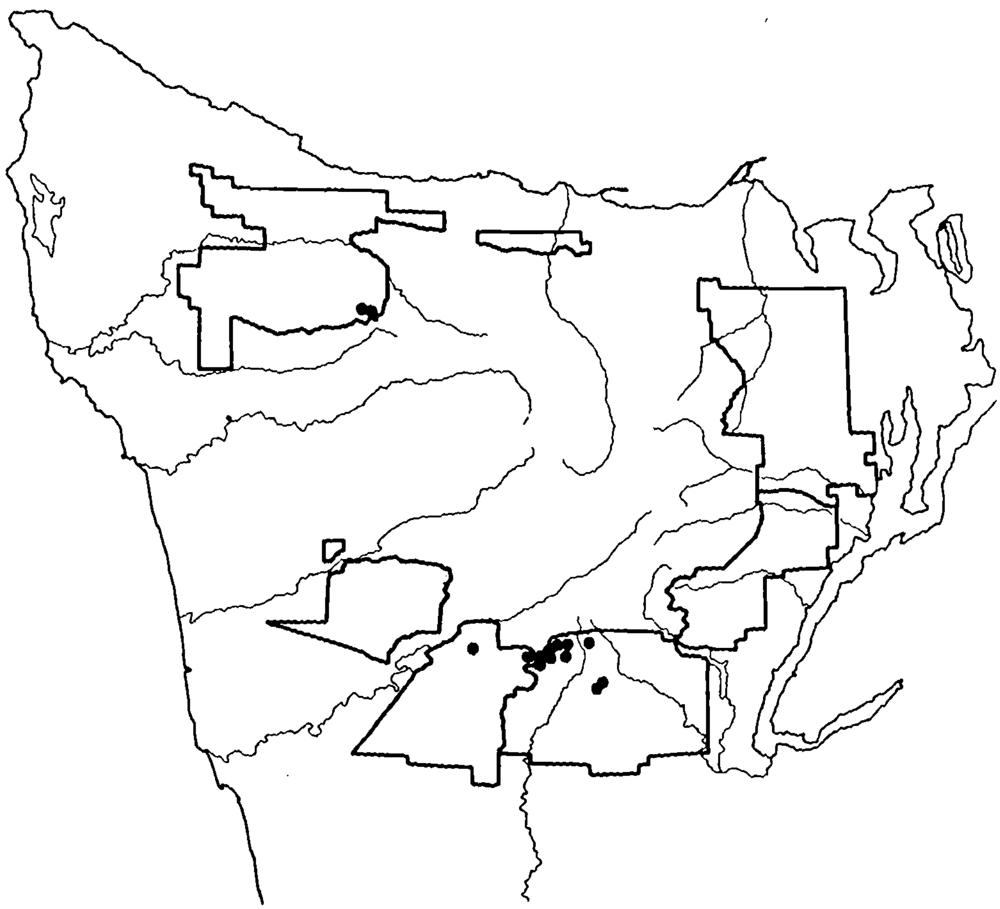


Figure 61. Map of plot locations for the Silver Fir/Alaska Huckleberry/Avalanche Lily Association.

Timber Productivity

Timber productivity of this type is apparently low (Site IV). Site index of measured stands averaged 108 (base 100) for silver fir. The productivity potential using the site index-yield table approach was 98 cu ft/ac/yr (Table 40). However, the yield table used in this calculation tends to underestimate potential yield in these situations. Barnes' (1962) or Wiley's (1978b) yield table values would have been considerably higher, probably close to the empirical yield value for this association of 183 cu ft/ac/yr. The stockability of these sites is moderate, although small openings associated with wet spots are common.

Management Considerations

Management considerations for this type include elk habitat, and ensuring rapid suitable regeneration. Response to fertilizer in this type is still unknown. This type occurs in high, wet areas where elk summer range is important. Douglas-fir is not known to occur on this type. Silver fir or western hemlock are the preferred species. Alaska huckleberry can pose brush problems.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease is probably the most important heart and butt rot of older stands on this type. Hemlock dwarf mistletoe may be present in older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and balsam woolly aphid on silver fir, especially at lower elevations.

Table 40. Timber productivity values for the Silver Fir/Alaska Huckleberry/Avalanche Lily Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [2]	SDI [3]	GBA TREES	GBA[4]	SIGBA[5]	EMAI[6]
Silver Fir (Hoyer[1])	2	9	108	24	98	550	9	560	182	183

[1] Base age 100. Breast height age (Hoyer and Herman, in press). ages 25 to 400 years.

[2] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[3] Stand Density Index (Reinecke 1933).

[4] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[5] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[6] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 30 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Alaska Huckleberry and Silver Fir/Alaska Huckleberry/Queen's Cup types which occur on warmer and somewhat drier or lower elevation sites. The Silver Fir/White Rhododendron-Alaska Huckleberry type occurs on sites in drier areas. The Mountain Hemlock/Alaska Huckleberry/Avalanche Lily type occurs at higher elevations with colder soils and more snow. The Silver Fir/Alaska Huckleberry/Avalanche Lily Association is not previously recognized, and may only occur in the western Olympics.

Figure 62. Photo of the Silver Fir/Alaska Huckleberry/Avalanche Lily Association, Matheny Creek, Quinault District.

SILVER FIR/ALASKA HUCKLEBERRY/BEARGRASS

Abies amabilis/Vaccinium alaskaense/Xerophyllum tenax
ABAM/VAAL/XETE CFS2 14

The Silver Fir/Alaska Huckleberry/Beargrass Association is a major type of warm dry sites at moderate elevations in the Silver Fir Zone. It has moderately low timber productivity. It is common in the mesic climatic areas of the Olympics (Environmental Zones 6 to 9) (Figure 63), occurring primarily along upper slopes. Soils are mostly shallow and derived from colluvium. They are often well drained. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely in the last 500 years.

Floristic Composition

Dominant understory species are Alaska huckleberry (VAAL) and beargrass (XETE) (Table 41), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Beargrass, Alaska huckleberry and vine maple (ACCI) can resprout or become established quickly after clearcut or fire. Other shrubs may include Oregongrape (BENE), fool's huckleberry (MEFE) and salal (GASH) in small amounts. Queen's cup (CLUN) and trailing bramble (RULA) often occur. The tree layer is usually dominated by silver fir and western hemlock, with minor amounts of Douglas-fir, western redcedar, or Alaska yellowcedar (Figure 64). Stands in this type may be slow to regenerate. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over 500 years old.

Ground moss cover is abundant on this type. *Rhytidiopsis robusta* is the most common and abundant moss, *Dicranum* sp. is also common. Common epiphytes include *Alectoria sarmentosa* which was most abundant, *Hypogymnia enteromorpha, Platismatia glauca* and *Parmeliopsis hyperopta.*

Successional Relationships

The common successional pathway is dominated by Douglas-fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock. Even though many of the stands of this association are very old (*i.e.* greater than 600 years), silver fir trees date mostly from near the end of the Little Ice Age. These trees are mostly less than 220 years, with few as old as 260.

Other Biota

Wildlife observations include evidence of browse on Alaska huckleberry and beargrass, recent browse activity of Douglas squirrel in early September, and sign of recent snowshoe hare activity in early June.

Birds observed were woodpecker, gray jay, chestnut-backed chickadee, red-breasted nuthatch, brown creeper and golden-crowned kinglet.

Table 41. Common plants in the ABAM/VAAL/XETE Association, based on stands >150 years (n=10).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	46.3	46.3	100	30-67
silver fir	ABAM	38.8	38.8	100	7-71
Douglas-fir	PSME	14.5	16.1	90	0-50
western redcedar	THPL	4.4	8.8	50	0-30
Alaska yellowcedar	CHNO	4.7	15.7	30	0-29
mountain hemlock	TSME	0.8	2.7	30	0-4
Pacific yew	TABR	0.2	2.0	10	0-2
GROUND VEGETATION					
Alaska huckleberry	VAAL	41.4	41.4	100	10-90
beargrass	XETE	19.6	19.6	100	4-30
fool's huckleberry	MEFE	1.2	1.5	80	0-4
twinflower	LIBO2	1.1	1.6	70	0-3
bunchberry	COCA	0.7	1.2	60	0-2
trailing bramble	RULA	0.8	1.1	70	0-2
queen's cup	CLUN	1.8	3.0	60	0-8
red huckleberry	VAPA	1.4	2.8	50	0-10
Oregongrape	BENE	1.2	2.0	60	0-5
big huckleberry	VAME	1.2	2.0	60	0-3
western coralroot	COME	0.5	1.0	50	0-1

Environment and Soils

This type occurs on gentle to steep, straight to concave, mid- to upper slopes. Slopes ranged from 17% to 79% and averaged 51%. The regolith is colluvium derived from metabasalt or rarely sedimentary rock.

Although no pits were dug in this type, it is expected that it occurs on a well-drained soil with a high coarse fragment fraction on the basis of pits dug in similar types.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils are shallow, well-drained, rapidly permeable, colluvial soils. The texture varies from sandy loam to clay loam. The coarse fragments range from 10% to 50% near the surface and 40% to 75% in the subsoil.

The mean soil temperature was 7.8 deg C (46 deg F), which makes this one of the coldest of the Silver Fir Zone types. The temperature regime is lower cryic or upper frigid and the moisture regime is probably udic.

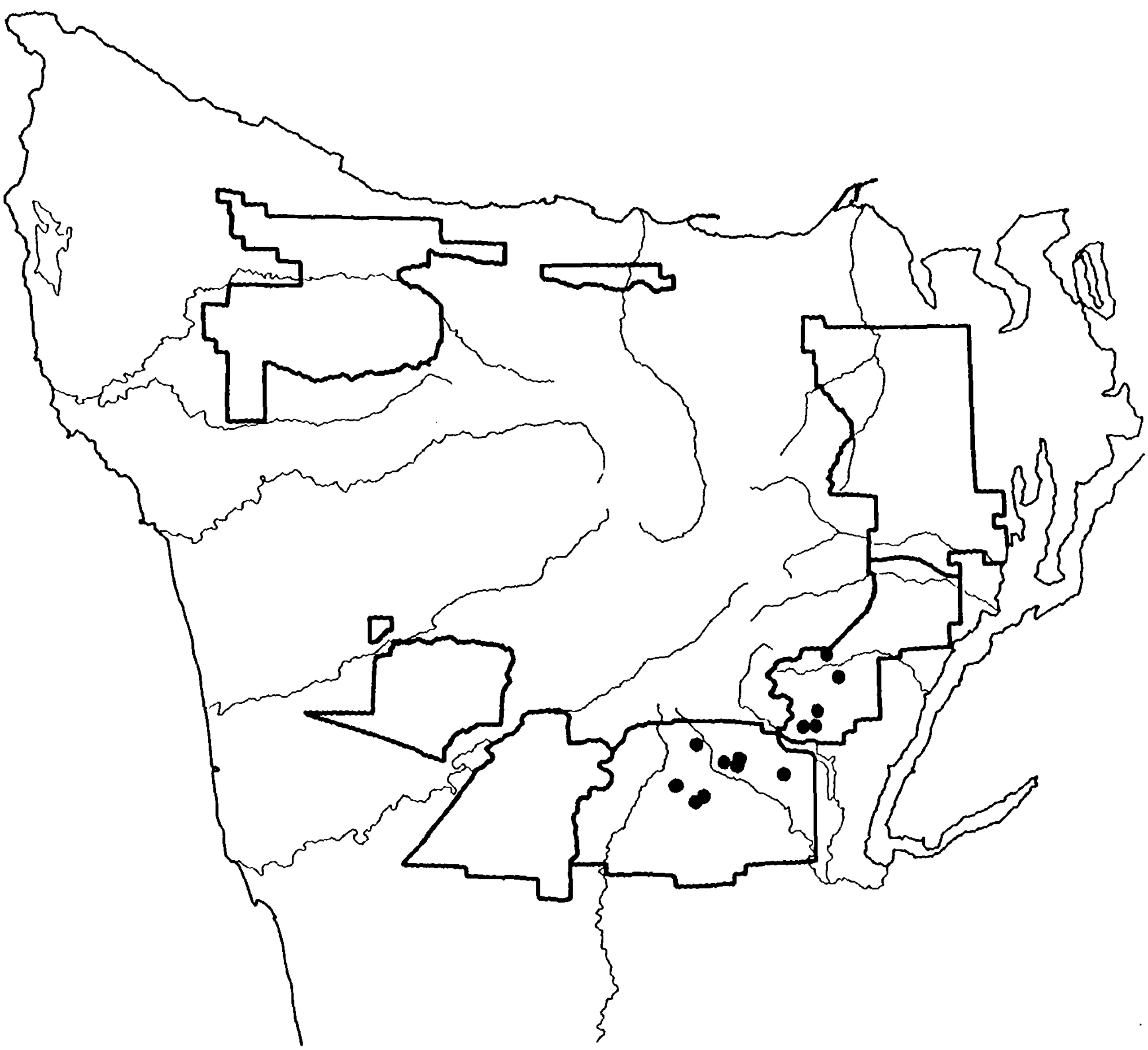


Figure 63. Map of plot locations for the Silver Fir/Alaska Huckleberry/Beargrass Association.

Timber Productivity

Timber productivity of this type is moderate to low (Site IV). This is due to the dryness of the site, well-drained soils, and relatively short growing season. Site index averaged 114 (base 100) (Table 42). The productivity potential using the site index-yield table approach was 105 cu ft/ac/yr. The empirical yield estimate was 87 cu ft/ac/yr. The stockability of these sites is moderate to low.

Management Considerations

Management considerations for this type include soil maintenance and stability, and ensuring suitable regeneration. Maintenance of soil nutrients and organic matter is more critical in this type than other Alaska Huckleberry types. Response to fertilizer in this type is still unknown. This type occurs in high areas, and along upper slopes and ridgetops. In contrast to many silver fir associations Douglas-fir can be cultivated here, therefore it can be considered a management option. Silver fir, western hemlock or Douglas-fir are the preferred species. Beargrass and/or Alaska huckleberry can pose competition problems.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease probably is the most important heart and butt rot of older stands on this type. Hemlock dwarf-mistletoe may be present in older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and balsam woolly aphid on silver fir, especially at lower elevations.

Table 42. Timber productivity values for the Silver Fir/Alaska Huckleberry/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA [6]	SIGBA [7]	EMAI [8]
Douglas-fir (McArdle[1])	1	5	114	8	105	792	5	442	151	87
Douglas-fir (McArdle[2])	3	3	100	6						
Douglas-fir (Curtis[3])	1	5	94	7		792	5	442	151	

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.

[3] Base age 100. Breast height age (Curtis et al. 1974). ages 25 to 400 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[7] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[8] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include the dry Alaska Huckleberry types. The Silver Fir/Alaska Huckleberry/Twinflower, and Silver Fir/Alaska Huckleberry-Oregongrape types occur on warmer, moister, and lower elevation sites. The Western Hemlock/Alaska Huckleberry/Beargrass type occurs at lower elevations with less snow. The Silver Fir/Rhododendron type occurs in drier areas north of the Hamma Hamma River. The Silver Fir/Alaska Huckleberry/Beargrass Association is not previously recognized. It was included in the Silver Fir/Alaska Huckleberry Association (Henderson and Peter 1981a,c,d) in the Olympics and Cascades. In the southern Washington Cascades and in Oregon it is most similar to the Silver Fir/Alaska Huckleberry/Bunchberry Dogwood Association (Brockway *et al.* 1983, Hemstrom *et al.* 1982).

Figure 64. Photo of the Silver Fir/Alaska Huckleberry/Beargrass Association, Mt. Tebo, Hood Canal District.

SILVER FIR/ALASKA HUCKLEBERRY/FOAMFLOWER

Abies amabilis/Vaccinium alaskaense/Tiarella unifoliata

ABAM/VAAL/TIUN   CFS2 15

The Silver Fir/Alaska Huckleberry/Foamflower Association is a common type of moist sites at middle elevations, and moderate timber productivity. It is found mostly in the mesic climatic areas of the Olympics (Figure 65). Soils are mostly deep, moderately fine textured, and derived from colluvium or glacial till. They are sometimes subirrigated and may occur along toe-slopes, or in areas of high precipitation. Moderate snowpacks accumulate in this type during the winter. Little of this type has burned in the last 500 years, and most old-growth of this type is very old.

Floristic Composition

Dominant understory species are Alaska huckleberry (VAAL) and foamflower (TIUN and TITR) (Table 43), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry and salmonberry (RUSP) often resprout rapidly after clearcut or fire, and sword fern (POMU) is usually present in small amounts. Other shrubs may include oval-leaf huckleberry (VAOV) and red huckleberry (VAPA). Deerfern (BLSP), queen's cup (CLUN), five-leaved bramble (RUPE), and rosy twisted-stalk (STRO) may also occur. Early seral species can include salmonberry (RUSP) and thimbleberry (RUPA). The tree layer may be dominated by silver fir or western hemlock (Figure 66).

Ground mosses are abundant in this type. *Rhytidiopsis robusta* is the most common and abundant moss. Other common species include *Plagiothecium undulatum*, *Hypnum circinale* and *Scapania bolanderi* on rotting wood. Occasionally *Lobaria linita* occurs on rocks or lower boles of silver fir. Epiphytic mosses and lichens are conspicuous and abundant, particularly *Alectoria sarmentosa*. Other common species include *Hypnum circinale*, *Sphaerophorus globosus*, *Platismatia glauca*, *Hypogymnia* spp., crustose lichens, and occasionally *Lobaria oregana*.

Successional Relationships

Climax stages are dominated by silver fir and western hemlock, usually with small amounts of western redcedar. The occasional Douglas-fir is usually very old, dating from the Medieval Optimum. Measured silver fir trees were up to 540 years old, with many stems in the 150-250 year age class.

Other Biota

Wildlife observations include elk and mountain beaver activity, with sign of recent elk activity observed in late August. Douglas squirrel sign was recorded on one plot.

Bird observations are limited to one plot in this type where dark-eyed junco was recorded.

Table 43. Common plants in the ABAM/VAAL/TIUN Association, based on stands >150 years (n=19).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	52.6	52.6	100	15-80
western hemlock	TSHE	50.7	53.5	94	0-90
western redcedar	THPL	1.9	7.2	26	0-15
Douglas-fir	PSME	1.8	8.8	21	0-20
Alaska yellowcedar	CHNO	0.6	4.0	15	0-5
GROUND VEGETATION					
Alaska huckleberry	VAAL	39.4	39.4	100	2-90
vanillaleaf	ACTR	1.8	2.1	84	0-10
five-leaved bramble	RUPE	4.7	6.4	73	0-15
three-leaved foamflower	TITR	4.0	5.4	73	0-30
single-leaved foamflower	TIUN	1.4	3.0	47	0-10
rosy twisted-stalk	STRO	2.7	3.7	73	0-20
ladyfern	ATFI	1.6	2.2	73	0-10
salmonberry	RUSP	2.5	3.7	68	0-20
deerfern	BLSP	2.6	4.2	63	0-15
queen's cup	CLUN	2.3	3.6	63	0-8
red huckleberry	VAPA	1.6	2.6	63	0-5
swordfern	POMU	1.5	2.5	57	0-7
oakfern	GYDR	1.9	3.6	52	0-15
bunchberry	COCA	1.1	2.1	52	0-4
devil's club	OPHO	0.7	1.3	52	0-2
trillium	TROV	0.5	1.0	52	0-1

Environment and Soils

This type occurs on gentle to steep, straight mid-slopes and toe-slopes. The slope varied from 3% to 85% and averaged 37%. The regolith is mostly colluvium derived from metabasalt or sandstone, but the type occasionally occurs on glacial or alluvial materials.

Three soil pits dug in this type show weak to moderate soil development. Textures ranged from loam to sandy clay loam and the coarse fragment fraction was near average at 43%. The O1 layer was thin at 1.3 cm and the O2 was quite thick at 11.3 cm. Bedrock was never encountered in the pits, but in one case a hardpan occurred at 38 cm. The rooting depth is less than average at 49.3 cm, but roots also extend up 5 cm into the O2. The water holding capacity is above average due to the fine texture. Moisture on this site is further enhanced by the moist climate and topographic position.

Plots in this type occurred mostly on shallow, well-drained, rapidly permeable, colluvial soils according to the Olympic Soil Resource Inventory (Snyder *et al.* 1969). Textures of these soils range from loam to silt loam or occasionally sandy loam. The coarse fragments range from 15% to 65% near the surface to 35% to 85% in the subsoils.

The mean soil temperature was 10.6 deg C (51.5 deg F), which is near average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

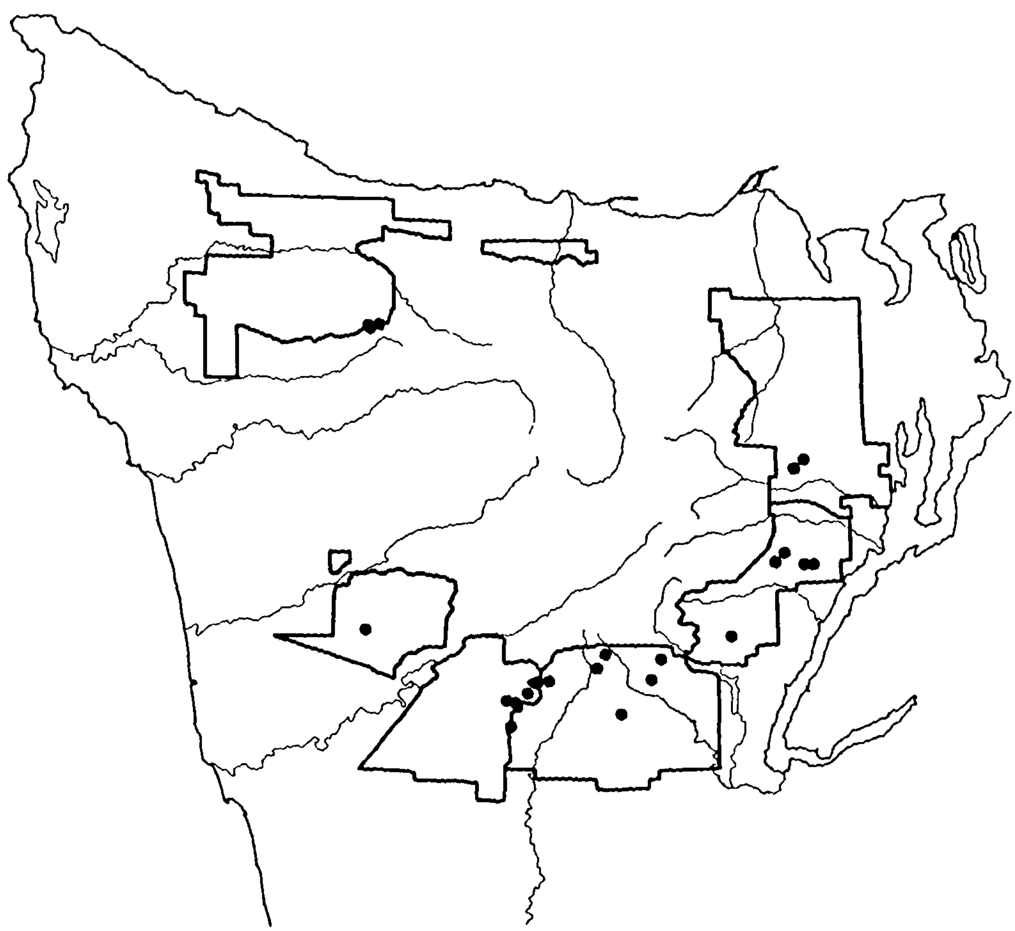


Figure 65. Map of plot locations for the Silver Fir/Alaska Huckleberry/Foamflower Association.

Timber Productivity

Timber productivity of this type is moderate (Site III), although various indicators do not agree (Table 44). Site index for Douglas-fir in measured stands over 400 years old averaged 140 (base 100). Site index was 133 for western hemlock and 101 for silver fir. The productivity potential using the site index-yield table approach was 89 cu ft/ac/yr for silver fir and 202 cu ft/ac/yr for western hemlock. The western hemlock estimate, since it is for low elevation coastal stands, is expected to be about 30% too high. The silver fir estimate is based on Douglas-fir yield tables and is expected to be about 20% too low. The best (concensus) estimate for yield of silver fir and western hemlock is 121 to 124 cu ft/ac/yr. The stockability of these sites appears to be moderate. Western hemlock and silver fir are the preferred species on this type.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking. It is also important to maintain soil nutrients and organic matter. The available data indicate that moderate stocking levels could be maintained. Accumulated soil organic matter and nitrogen should be preserved by reducing burning sites in this type. However, in some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Advance regeneration, when present after cutting, should be preserved if possible. Response to fertilizer in this type is still unknown. Wildlife values are low.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe usually may occur in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Table 44. Timber productivity values for the Silver Fir/Alaska Huckleberry/Foamflower Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [3]	SDI [4]	GBA TREES	GBA	SIGBA	EMAI [5]
Western Hemlock (Barnes[1])	3	3	133	20	205					121
Silver Fir (Hoyer[2])	2	6	101	2	89	342				121

[1] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[3] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[4] Stand Density Index (Reinecke 1933).

[5] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Alaska Huckleberry/Oxalis which occurs in wetter areas, and Silver Fir/Alaska Huckleberry/Queen's Cup which occurs on drier sites and in slightly drier areas. The Silver Fir/Alaska Huckleberry/Foamflower Association is not previously recognized. In earlier classifications on the Olympic and Mt. Baker-Snoqualmie National Forest it was included in the broadly defined Silver Fir/Alaska Huckleberry Association (Henderson and Peter 1981a,b,c,d, 1982a,b). It is most similar to what is called Silver Fir/Foamflower in Mt. Rainier National Park (Franklin *et al.* 1988), on the Gifford Pinchot National Forest (Franklin 1966, Brockway *et al.* 1983), and on the Mt. Hood and Willamette National Forest (Hemstrom *et al.* 1982). Their Silver Fir/Foamflower type is drier, however, than our Silver Fir/Alaska Huckleberry/Foamflower Association.

Figure 66. Photo of the Silver Fir/Alaska Huckleberry/Foamflower Association, Three Peaks, Hood Canal District.

SILVER FIR/ALASKA HUCKLEBERRY-OREGONGRAPE
Abies amabilis/Vaccinium alaskaense-Berberis nervosa
ABAM/VAAL-BENE CFS2 16

The Silver Fir/Alaska Huckleberry-Oregongrape Association occurs mainly on warm, moderately dry sites with moderately low timber productivity. Elevation is low compared to other Silver Fir/Alaska Huckleberry types. It is found mainly on the Hood Canal and Soleduck Districts (Figure 67). Soils are mostly shallow, and derived from colluvium or glacial till. They are often well drained. The typical area of this type has burned rarely in the last 500 years.

Floristic Composition

The dominant understory species (Table 45) are Alaska huckleberry (VAAL), Oregongrape (BENE) and red huckleberry (VAPA), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry often becomes established quickly after clearcut or fire. Other shrubs may include salal (GASH). Vanillaleaf (ACTR) and swordfern (POMU) may also occur. Pioneer communities may include vine maple (ACCI), fireweed (EPAN) or pearly everlasting (ANMA). The tree layer is dominated by western hemlock and silver fir, with smaller amounts of Douglas-fir and western redcedar (Figure 68).

Ground mosses are generally sparse on this type, however, they can range from 1% to 80% cover. The average cover for our plots was 20%. There are no data available on individual species, or epiphytic mosses and lichens.

Successional Relationships

Successional pathways are dominated by Douglas-fir and western hemlock, or silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock.

Other Biota

No wildlife or bird observations are recorded for this type.

Table 45. Common plants in the ABAM/VAAL-BENE Association, based on stands >150 years (n=8).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	56.0	56.0	100	27-75
silver fir	ABAM	39.5	39.5	100	10-81
Douglas-fir	PSME	8.9	11.8	75	0-25
GROUND VEGETATION					
vine maple	ACCI	22.9	22.9	100	5-60
Oregongrape	BENE	15.1	15.1	100	3-40
red huckleberry	VAPA	11.9	11.9	100	1-20
Alaska huckleberry	VAAL	11.0	11.0	100	4-35
vanillaleaf	ACTR	3.3	4.3	75	0-15
swordfern	POMU	2.6	3.5	75	0-7
trillium	TROV	0.8	1.0	75	0-1
salal	GASH	1.5	2.4	62	0-4
cutleaf goldthread	COLA	0.9	1.4	62	0-3
queen's cup	CLUN	0.8	1.2	62	0-2
deerfern	BLSP	0.8	1.5	50	0-3
little prince's pine	CHME	0.5	1.0	50	0-1

Environment and Soils

This type occurs on moderate to steep, straight to concave, mid to lower slopes. The slope ranged from 42% to 92% and averaged 62%. The regolith was colluvium of metabasaltic or sedimentary origin.

Two soil pits dug in this type show moderate soil development. Textures ranged from sandy loam to clay loam. The O1 was very thin at 0.9 cm and the O2 thick at 7 cm. The rooting depth was 76 cm, but extended 7 cm into the O2. Coarse fragments averaged 62%, which is considerably higher than average. The water holding capacity of the soil is about average for the Silver Fir Zone due in part to the thick O2 layer. Both pits were classified as dystrochrepts.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils are shallow, well-drained, rapidly permeable colluvial soils ranging in texture from loam to silt loam. Coarse fragments ranged from 20% to 50% near the surface to 35% to 50% in the subsoils.

The mean soil temperature was 10.0 deg C (50.0 deg F), which is about average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

Figure 67. Map of plot locations for the Silver Fir/Alaska Huckleberry-Oregongrape Association.

Timber Productivity

Timber productivity of this type is moderate (Site IV), although good timber productivity indicators are lacking. Site index of old-growth Douglas-fir averaged 126 (base 100), and 130 for western hemlock. The productivity potential using the empirical approach was 121 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking and maintenance of soil nutrients and organic matter. This type occurs in upper slope areas at the lower elevational range for silver fir. Douglas-fir can be cultivated on this type but not with great success. Silver fir or western hemlock are the preferred species. Alaska huckleberry can pose brush problems. Wildlife values are relatively low.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease probably is the most important heart and butt rot of older stands on this type. Hemlock dwarf mistletoe may be present in older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and balsam woolly aphid on silver fir, especially at lower elevations.

Comparison with Similar Types

Similar types include the dry Silver Fir/Alaska Huckleberry/Twinflower type, which occurs on similar habitats. Also, the Western Hemlock/Alaska Huckleberry-Oregongrape type occurs on warmer and somewhat lower elevation sites. The Silver Fir/Alaska Huckleberry/Queen's Cup type occurs on moister sites and generally higher elevations. The Silver Fir/Alaska Huckleberry-Oregongrape Association appears to be restricted to the Olympics and Cascades in Washington State. It was previously recognized as the Silver Fir/Alaska Huckleberry habitat type Oregongrape phase in Mt. Rainier National Park (Franklin *et al.* 1988). It may be represented in the Silver Fir/Alaska Huckleberry/Bunchberry Dogwood Association on the Gifford Pinchot National Forest (Brockway *et al.* 1983). On the Mt. Baker-Snoqualmie and Olympic National Forests it was previously included in the more broadly defined Silver Fir/Alaska Huckleberry type (Henderson and Peter 1981a,b,c,d, 1982a,b, 1983a,b, 1984, 1985).

Figure 68. Photo of the Silver Fir/Alaska Huckleberry-Oregongrape Association, Le Bar Pass, Hood Canal District.

SILVER FIR/ALASKA HUCKLEBERRY/OXALIS
Abies amabilis/Vaccinium alaskaense/Oxalis oregana
ABAM/VAAL/OXOR CFS2 17

The Silver Fir/Alaska Huckleberry/Oxalis Association is a major type of moist sites at low elevations, and moderately high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault and Soleduck Districts (Figure 69). This type occurs along toe-slopes, or in areas of high precipitation, high humidity, or fog. Soils are mostly deep and moderately fine textured, and derived from colluvium, outwash or glacial till. Soils appear to be moderately high in organic matter and nitrogen. Only moderate snowpacks accumulate in this type during the winter. The typical area of this type has burned very seldom in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

Dominant understory species (Table 46) are Alaska huckleberry (VAAL) and oxalis (OXOR), which are usually present in all ages of stands, although they may be inconspicuous or absent in young stands or in densely stocked second growth. Alaska huckleberry and salmonberry (RUSP) often resprout rapidly after clearcut or fire, and swordfern is usually present in small amounts. Other species may include red huckleberry (VAPA) and deerfern (BLSP). Five-leaved bramble (RUPE), false lily-of-the-valley (MADI2), and cutleaf goldthread (COLA) may also occur. Early seral species can include salmonberry, cat's ear (HYRA), fireweed (EPAN) and pearly everlasting (ANMA). The tree layer is usually dominated by silver fir and western hemlock (Figure 70), although Douglas-fir (mostly in plantations) or western redcedar may occur.

Ground mosses are abundant on this type, although species diversity appears to be low on the plots sampled. The common species are *Rhytidiadelphus loreus*, *Eurhynchium oreganum* and *Hylocomium splendens*. *Lobaria linita* may occasionally occur on the base or boles of silver fir, or on rocks. The common epiphyte is *Isothecium stoloniferum*, which is often abundant. *Lobaria oregana* may occur, as well as *Sphaerophorus globosus*.

Successional Relationships

Climax stages are dominated by silver fir and western hemlock. Douglas-fir is rare, dating from when the climate was warmer and/or drier. Silver fir ages were up to 360 years, but in many cases were apparently among the oldest trees in the stand.

Other Biota

Wildlife observations were frequent for elk on this type, with evidence of browse on red huckleberry, Alaska huckleberry, salmonberry and swordfern. Mountain beaver activity and browse on saplings was observed. Douglas squirrel was recorded.

Bird observations were limited to two plots for this type where varied thrush, Swainson's thrush, winter wren and red-shafted flicker were recorded.

Table 46. Common plants in the ABAM/VAAL/OXOR Association, based on stands >150 years (n=29).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	72.3	72.3	100	18-99
silver fir	ABAM	46.5	46.5	100	18-88
western redcedar	THPL	1.4	5.7	24	0-10
Douglas-fir	PSME	0.1	1.0	6	0-1
GROUND VEGETATION					
oxalis	OXOR	25.7	25.7	100	1-90
Alaska huckleberry	VAAL	23.0	23.0	100	2-75
deerfern	BLSP	2.7	2.7	100	1-7
three-leaved foamflower	TITR	1.8	2.3	79	0-10
false lily-of-the valley	MADI2	2.6	3.5	75	0-15
red huckleberry	VAPA	6.1	8.5	72	0-50
salmonberry	RUSP	4.5	6.2	72	0-40
five-leaved bramble	RUPE	4.6	6.7	68	0-80
swordfern	POMU	1.8	2.6	68	0-6
ladyfern	ATFI	1.1	1.7	65	0-10
rosy twisted-stalk	STRO	0.9	1.4	62	0-3
queen's cup	CLUN	0.8	1.4	58	0-3

Environment and Soils

This type occurs on flat to steep, straight to concave, lower to upper slopes and toe-slopes. The slope varies from 0% to 95% and averages 38%. The regolith is usually colluvium derived from metabasalt or sandstone, but may also be of alpine glacial origin.

Two soil pits dug in this type show weak to moderate soil development. Texture varied from sandy loam to clay and coarse fragments averaged 24%, which is less than average. The O1 layer was very thin at 0.5 cm and there was no O2 layer even in the oldest stand measured which was 130 years old.

The rooting depth was 40 cm which is less than average. The water holding capacity is higher than average due to fine texture and low coarse fragments, but because of the shallow rooting depth, less than average is available to the plants.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), most of these are shallow, well-drained, rapidly permeable, colluvial soils. There are also a number of deep glacial soils with compacted subsoils which may or may not be well drained. Textures vary from silty clay loams and loams to clay loams and occasionally sandy loams. The coarse fragment fraction ranged from 5% to 50% near the surface to 20% to 85% in the subsoils.

The mean soil temperature was 10.7 deg C (51.2 deg F) which is average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

One pit was analyzed for nutrients. It showed low phosphorus, magnesium, zinc and manganese, compared to other types. The pH was 5.4 which is about average for the Silver Fir Zone.

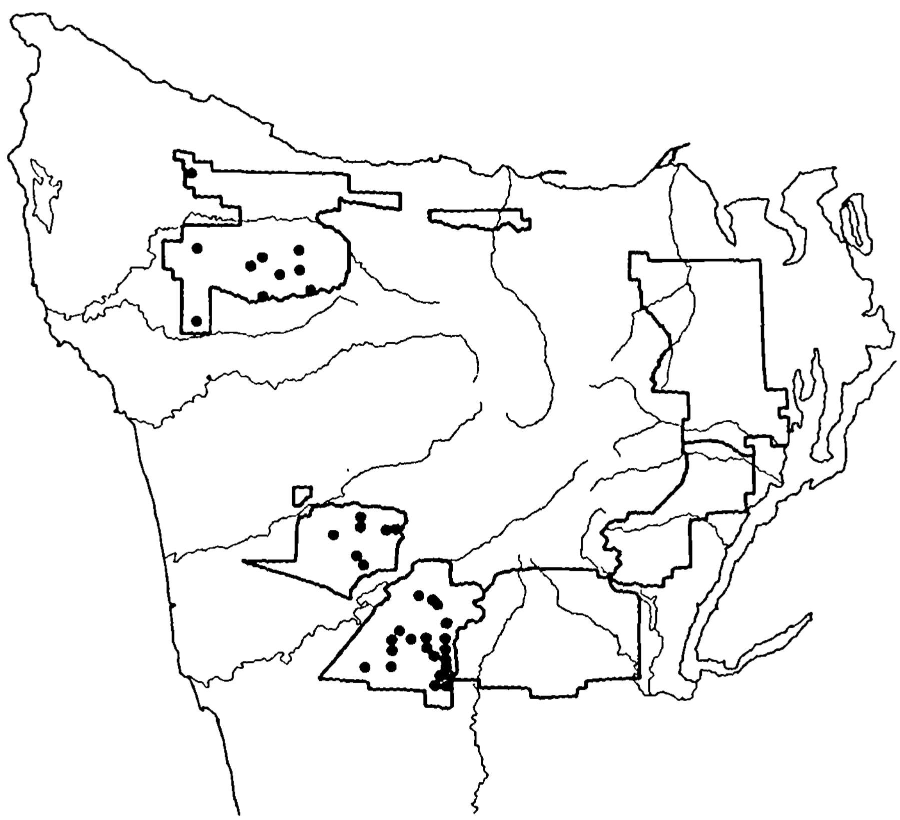


Figure 69. Map of plot locations for the Silver Fir/Alaska Huckleberry/Oxalis Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index for western hemlock averaged 133 (base 100). The productivity potential using the site index-yield table approach averaged 170 cu ft/ac/yr (Table 47). The empirical yield estimate for this type is 183 cu ft/ac/yr. The stockability of these sites is high. Western hemlock and silver fir are the preferred species on much of this type.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking due to potential brush problems. Accumulated soil organic matter and nitrogen should be preserved by reducing burning sites in this type. However, in some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Response to fertilizer in this type is still unknown. Many oxalis types show very low amounts of calcium and phosphorus. This may be limiting growth or affecting tree development on these sites. We recommend that fertilizer applications on this type include calcium and phosphorus. Wildlife values can be moderately high especially for elk.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe is usually common in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Table 47. Timber productivity values for the Silver Fir/Alaska Huckleberry/Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA [6]	SIGBA [7]	EMAI [8]
Western Hemlock (Barnes[1])	10	10	133	17	205			627	250	
Western Hemlock (Wiley[2])	1	3	99		201	400	4	627		
Silver Fir (Hoyer[3])	5	20	136	40	135	442	12	672	267	183

[1] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 50, Breast height age (Wiley 1978a,b) ages 25 to 120 years.

[3] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[7] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[8] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Alaska Huckleberry/ Foamflower on wetter and higher elevation sites, and Silver Fir/Devil's Club on much wetter sites but usually in drier environmental zones. The Silver Fir/ Alaska Huckleberry/Oxalis Association is not previously recognized. In earlier classifications it was included with the Silver Fir/Oxalis Association on the Quinault District (Henderson and Peter 1981b), and with the Silver Fir/Alaska Huckleberry Association on the Soleduck District (Henderson and Peter 1982a). It is closely related to the Silver Fir/Oxalis Association on the Mt. Hood National Forest (Hemstrom *et al.* 1982).

Figure 70. Photo of the Silver Fir/Alaska Huckleberry/Oxalis Association, Salmon River, Quinault District.

SILVER FIR/ALASKA HUCKLEBERRY/QUEEN'S CUP
Abies amabilis/Vaccinium alaskaense/Clintonia uniflora
ABAM/VAAL/CLUN CFS2 18

The Silver Fir/Alaska Huckleberry/Queen's Cup Association is an important type on the Forest. It occurs primarily on cool, moist sites, with moderate timber productivity. It is found mainly on Hood Canal, Quinault and Soleduck Districts (Figure 71), mostly on north or east aspects and at middle elevations within the Silver Fir Zone. Soils tend to be moderately deep and are derived from colluvium, or glacial till mixed with colluvium. Snow accumulates to moderate depths (5-10 feet) and persists until May. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely in the last 1000 years.

Floristic Composition

The dominant understory species (Table 48) is Alaska huckleberry (VAAL), which is usually present in all ages of stands, although it may be inconspicuous or absent in densely stocked second growth. Other shrubs may include red huckleberry (VAPA) and vine maple (ACCI). Queen's cup (CLUN), deerfern (BLSP), bunchberry (COCA), five-leaved bramble (RUPE) and rosy twisted-stalk (STRO) are usually present. Early seral species may include fireweed (EPAN), false lily-of-the-valley (MADI2), salmonberry (RUSP), and deerfem (BLSP). The tree layer is dominated by silver fir and western hemlock (Figure 72). Western redcedar, Douglas-fir, Pacific yew or mountain hemlock may be present in old-growth stands in small amounts.

Ground moss cover may be moderate to abundant on this type. The common species include *Rhytidiopsis robusta*, *Plagiothecium undulatum*, *Hypnum circinale* on rotting wood, *Hylocomium splendens* and *Dicranum* sp. Data are limited for epiphytes, however *Platismatia glauca* and *Alectoria sarmentosa* appear to be common species, and *Lobaria oregana* and *Sphaerophorus globosus* may also occur.

Successional Relationships

The common successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock. An occasional old Douglas-fir can be found. These trees date to the end of the Medieval Optimum and are presumed to be relicts of a warmer and drier climate. Silver fir trees in stands of this association can be very old. Many trees were aged between 260 and 650 years. This indicates that at least most areas of this association have been silver fir climax through the Little Ice Age.

Other Biota

Deer, elk and mountain beaver sign were frequently recorded for this type. Browsed species include red huckleberry, Alaska huckleberry, salmonberry, western hemlock, western redcedar and silver fir. Porcupine damage to Douglas-fir was recorded on two plots. Douglas squirrel was also observed.

Birds frequently recorded were winter wren, western flycatcher, red-breasted nuthatch and varied thrush. Other birds include red-shafted flicker, gray jay, common raven, chestnut-backed chickadee, golden-crowned kinglet, Swainson's thrush, American robin, pine siskin, red-tailed hawk, olive-sided flycatcher, Steller's jay, brown creeper, band-tailed pigeon, rufous hummingbird and purple finch.

Table 48. Common plants in the ABAM/VAAL/CLUN Association, based on stands >150 years (n=31).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	56.8	56.8	100	10-99
western hemlock	TSHE	56.8	56.8	100	3-99
western redcedar	THPL	1.5	4.0	38	0-8
Douglas-fir	PSME	1.7	9.0	19	0-25
mountain hemlock	TSME	0.9	7.0	12	0-10
Pacific yew	TABR	0.7	7.0	9	0-12
Alaska yellowcedar	CHNO	1.6	25.5	6	0-50
GROUND VEGETATION					
Alaska huckleberry	VAAL	39.7	41.0	96	0-95
queen's cup	CLUN	3.4	3.9	87	0-20
deerfern	BLSP	2.5	3.2	77	0-15
five-leaved bramble	RUPE	2.4	3.3	74	0-10
red huckleberry	VAPA	4.7	6.6	70	0-50
rosy twisted-stalk	STRO	0.5	1.0	51	0-1
bunchberry	COCA	1.3	3.3	38	1-10

Environment and Soils

This type occurs on flat to steep, straight to convex, mid- to upper slopes. The slope varied from 0% to 100% and averaged 55%. The regolith is most commonly colluvium derived from metabasalt or sedimentary rocks and less commonly alpine or continental glacial deposits.

Four pits dug in this type showed moderate to strong soil development. Two of the four had albic horizons. Textures ranged from clay loam to silt loam. The O1 was about average in thickness at 2.9 cm and the O2 a little thicker than average at 6.5 cm. The rooting zone went to 51.5 cm as well as 6.5 cm into the O2. Coarse fragments averaged 34%, which is average for the Silver Fir Zone. The water holding capacity is higher than average for this zone due to the finer texture and thicker O2 layer. Two of the pits were classified as haplohumods, one as a haplorthod and one as a dystrochrept.

Plots in this type occurred on soils which were described as shallow, well-drained and rapidly permeable colluvial soils or deep glacial soils according to the Olympic Soil Resource Inventory (Snyder *et al.* 1969). Textures varied from sandy loams to clay loams. Coarse fragments ranged from 10% to 65% near the surface to 10% to 100% in the subsoil.

The mean soil temperature was 10.8 deg C (51.4 deg F), which is about average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

One sample was analyzed for nutrients. It showed relatively high organic matter, total nitrogen and sodium, and relatively low boron and manganese compared to other types. The pH was 5.0, which is near average for the Silver Fir Zone.

Figure 71. Map of plot locations for the Silver Fir/Alaska Huckleberry/Queen's Cup Association.

Timber Productivity

Timber productivity of this type is moderate (Site III). Site index averaged 115 (base 100) for western hemlock and 111 for silver fir. The productivity potential using the site index-yield table approach was 104 cu ft/ac/yr for silver fir and 170 cu ft/ac/yr for western hemlock (Table 49). The empirical yield value for this association was 121 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type include ensuring regeneration and regulating stocking. Maintenance of soil nutrients and organic matter is important but less critical than other types. Response to fertilizer in this type is still unknown. This type usually has high nitrogen and organic matter in the soil. It occurs on mid-slope positions and on cool northerly aspects where elk winter range and riparian management are not important. There is some use by deer, elk or bear, and the huckleberries and salmonberry provide browse and fruit for animals and birds. Douglas-fir apparently cannot be cultivated on this type. Silver fir or western hemlock are the preferred species. Salmonberry and/or Alaska huckleberry can pose brush problems.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease is probably the most important heart and butt rot of older stands on this type. Hemlock dwarf mistletoe may be present in older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and balsam woolly aphid on silver fir, especially at lower elevations.

Table 49. Timber productivity values for the Silver Fir/Alaska Huckleberry/Queen's Cup Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [3]	SDI [4]	GBA TREES	GBA[5]	SIGBA[6]	EMAI[7]
Western Hemlock (Barnes[1])	3	3	115	31	170			364	126	
Silver Fir (Hoyer[2])	4	16	111	26	104	383	5	364	135	121

[1] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[3] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[4] Stand Density Index (Reinecke 1933).

[5] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[6] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[7] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Alaska Huckleberry, which occurs on somewhat cooler sites. The Silver Fir/Alaska Huckleberry-Oregongrape type which occurs on warmer and somewhat lower elevation sites. The Silver Fir/Alaska Huckleberry/Foamflower type occurs on moister and more productive sites. The Silver Fir/Alaska Huckleberry/Queen's Cup Association is not previously recognized. In previous reports it was included in the more broadly defined Silver Fir/Alaska Huckleberry type (Henderson and Peter 1981a,b,c,d, 1982a,b, 1983a,b, 1984, 1985). It is a common type found through much of the Olympics and Cascades of Washington. In Olympic National Park it is included within the Silver Fir-Western Hemlock/Five-leaved Bramble and Silver Fir-Western Hemlock/Alaska Huckleberry types (Smith and Henderson 1986). Floristically it is very similar to what is called the Silver Fir-Western Hemlock type by Fonda and Bliss (1969). Although their Silver Fir-Western Hemlock community type is roughly comparable to our Silver Fir Series and therefore is much broader in definition than our Silver Fir/Alaska Huckleberry/Queen's Cup Association. Their assertion that this type is limited in extent in the Olympic Mountains, however, could not apply to either our Silver Fir Series or our Silver Fir/Alaska Huckleberry/Queen's Cup Association, both of which are very common. In the Snoqualmie River drainage it was included with the Silver Fir-Western Hemlock/Alaska Huckleberry type (del Moral *et al.* 1976). In Mt. Rainier National Park it appears to be represented in the Silver Fir/Alaska Huckleberrry, Five-leaved Bramble Phase, the Silver Fir/Alaska Huckleberry and the Silver Fir/Fool's Huckleberry types (Franklin *et al.* 1988). On the Gifford Pinchot National Forest it is included in the Silver Fir/Fool's Huckleberry and Silver Fir/Alaska Huckleberry types (Franklin 1966), and is similar to the Silver Fir/Alaska Huckleberry/Bunchberry Dogwood Association (Brockway *et al.* 1983).

Figure 72. Photo of the Silver Fir/Alaska Huckleberry/Queen's Cup Association, Matheny Creek, Quinault District.

SILVER FIR/ALASKA HUCKLEBERRY/TWINFLOWER
Abies amabilis/Vaccinium alaskaense/Linnaea borealis
ABAM/VAAL/LIBO2 CFS2 19

The Silver Fir/Alaska Huckleberry/Twinflower Association is a minor type of moderate to low timber productivity. It is found at somewhat lower elevations than other Silver Fir/Alaska Huckleberry types, and in mesic environmental zones scattered throughout the Forest (Figure 73). Soils are derived mostly from colluvium. The typical area of this type has burned rarely in the last 500 years.

Floristic Composition

Dominant understory species (Table 50) are Alaska huckleberry (VAAL), red huckleberry (VAPA) and twinflower (LIBO2), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry and twinflower become established quickly after clearcut or fire. Other species may include vine maple (ACCI), five-leaved bramble (RUPE), queen's cup (CLUN), bunchberry (COCA), foamflower (TITR, TIUN), vanillaleaf (ACTR) and swordfern (POMU). The tree layer may be dominated by western hemlock, silver fir, western redcedar and Douglas-fir or any combination of these trees (Figure 74).

Ground mosses are very abundant on this type, ranging from 6% to 95% coverage, with an average of 50%. Common species include *Rhytidiopsis robusta*, *Eurhynchium oreganum*, *Dicranum* sp., *Hylocomium splendens*, *Peltigera* sp., and *Hypnum circinale* and *Scapania bolanderi* on rotting wood. Data are limited for epiphytes, but *Platismatia glauca*, *Hypogymnia enteromorpha* appear to be common, along with *Alectoria sarmentosa* and *Sphaerophorus globosus*.

Successional Relationships

Successional pathways are dominated by Douglas-fir and western hemlock, or silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock.

Other Biota

Wildlife observations indicated a low level of usage by ungulates. Some elk browsing and scat were recorded. Other evidence of browsing may have been from deer. Red huckleberry, Alaska huckleberry and devil's club showed evidence of browse. Most plots included records of burrows, which were either mountain beaver or snowshoe hare. Hare scat and Douglas-squirrel were each recorded on one plot.

Birds frequently observed were chestnut-backed chickadee, golden-crowned kinglet and rufous hummingbird. Other birds recorded were western flycatcher, gray jay, Steller's jay, red-breasted nuthatch, varied thrush, hermit thrush, song sparrow, dark-eyed junco and pine siskin.

Table 50. Common plants in the ABAM/VAAL/LIBO2 Association, based on stands >150 years (n=11).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	43.1	43.1	100	16-84
silver fir	ABAM	41.9	41.9	100	14-84
western redcedar	THPL	10.9	15.0	72	0-26
Douglas-fir	PSME	14.2	22.3	63	0-30
Alaska yellowcedar	CHNO	1.8	10.0	18	0-10
Pacific yew	TABR	1.4	7.5	18	0-10
GROUND VEGETATION					
Alaska huckleberry	VAAL	17.5	17.5	100	1-30
twinflower	LIBO2	16.9	16.9	100	2-45
queen's cup	CLUN	3.0	3.3	90	0-15
swordfern	POMU	1.5	1.6	90	0-3
red huckleberry	VAPA	9.8	12.0	81	0-35
three-leaved foamflower	TITR	1.6	2.6	63	0-8

Environment and Soils

This type occurs on moderate to steep, mid-slopes and toe-slopes. The slope varied from 22% to 100% and averaged 54%. The regolith was usually colluvium derived from metabasalt.

Our plots occurred on soils which are described as shallow, well-drained, rapidly permeable colluvial soils according to the Olympic Soil Resource Inventory (Snyder *et al.* 1969). Textures of these soils varied from sandy loam to loam. Coarse fragments range from 30% to 70% near the surface to 35% to 85% in the subsoil.

The mean soil temperature was 11.3 deg C (52.3 deg F), which is warm for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

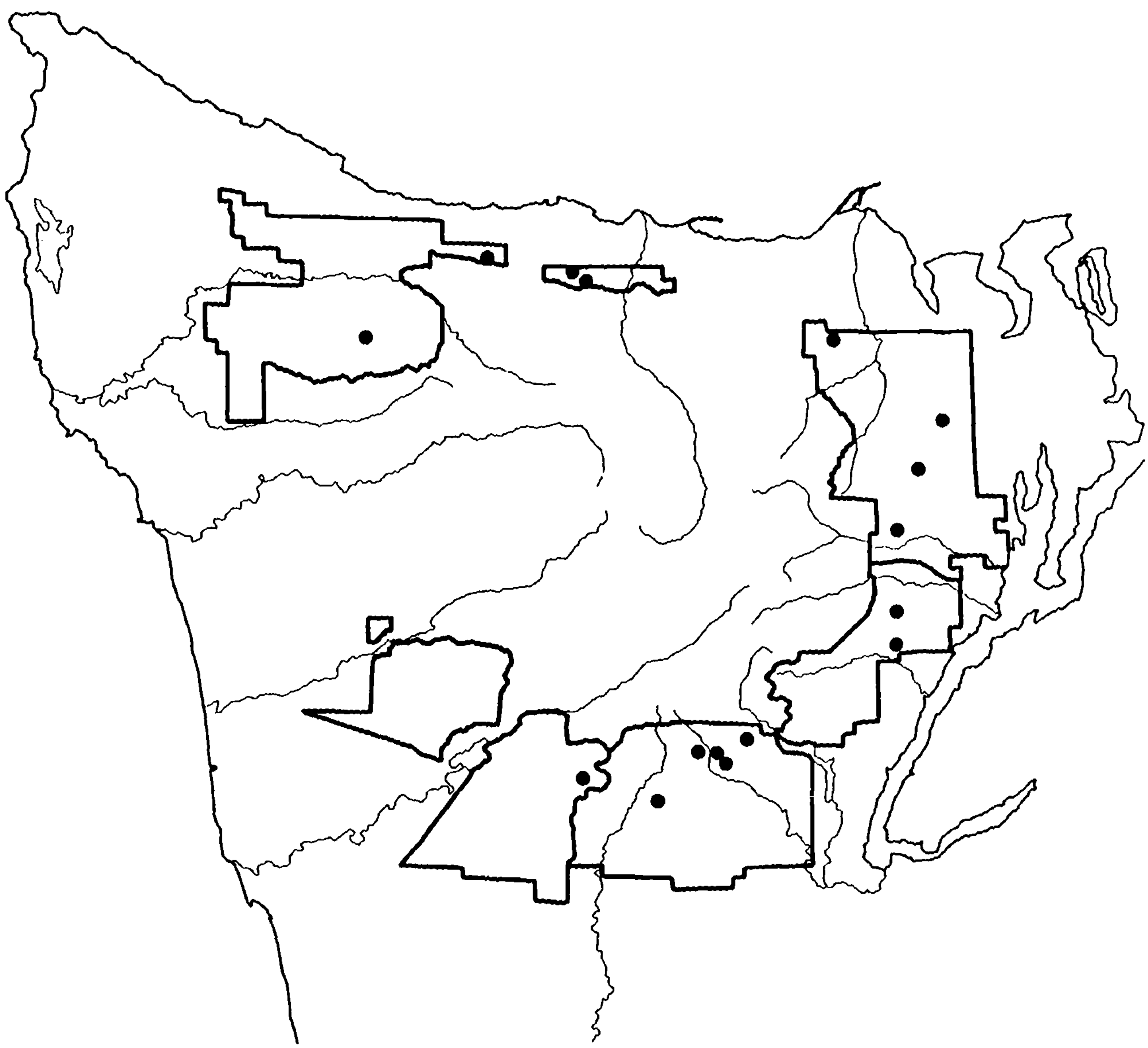


Figure 73. Map of plot locations for the Silver Fir/Alaska Huckleberry/Twinflower Association.

Timber Productivity

Timber productivity of this type is moderate to low (Site III or IV). This is due to the site being relatively cool and dry, and to the relatively short growing season. Site index of measured stands averaged 143 (base 100) for Douglas-fir, 112 for western hemlock and 115 for silver fir (Table 51). The productivity potential using the site index-yield table approach was 142 cu ft/ac/yr for Douglas-fir, and averaged 141 cu ft/ac/yr for western hemlock and silver fir. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type includes ensuring adequate stocking. Response to fertilizer in this type is still unknown. This type occurs in areas along mid- and upper slope positions. Douglas-fir can be cultivated on this type, but with only moderate success. Silver fir or western hemlock are the preferred species, or a mix of silver fir, western hemlock and Douglas-fir. Alaska huckleberry can pose brush problems.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease is probably the most important heart and butt rot of older stands on this type. Hemlock dwarf mistletoe may be present in older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and balsam woolly aphid on silver fir, especially at lower elevations.

Table 51. Timber productivity values for the Silver Fir/Alaska Huckleberry/Twinflower Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA[10]	EMAI
Douglas-fir (McArdle[1])	2	5	143	32	147	115	2	356	129	
Douglas-fir (McArdle[2])	3	3	116	29	142					
Douglas-fir (Curtis[3])	2	5	129	4		115	2	356	129	
Western Hemlock (Barnes[4])	3	3	112	22	164			200	67	
Western Hemlock (Wiley[5])	2	8	62	8	150	170	5	200		
Silver Fir (Hoyer[6])	3	7	115	7	109	136	3	380	125	

1 Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

2 Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

3 Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

4 Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

5 Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

6 Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

7 Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

8 Stand Density Index (Reinecke 1933).

9 Growth Basal Area (Hall 1987) (see Table 174 p. 494).

10 Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include Western Hemlock/Alaska Huckleberry-Oregongrape, which occurs on drier and somewhat lower elevation sites. The Silver Fir/Alaska Huckleberry/Queen's Cup type occurs on moister and more productive sites and usually without Douglas-fir. The Silver Fir/Alaska Huckleberry/Twinflower Association is not previously recognized. In previous classifications by this project it was included in the broadly defined Silver Fir/Alaska Huckleberry Association (Henderson and Peter 1981a,c,d, 1982a, 1983). In Oregon it may be represented in the Silver Fir/Alaska Huckleberry/Bunchberry Dogwood Association (Hemstrom *et al.* 1982, Brockway *et al.* 1983, Dyrness *et al.* 1976).

Figure 74. Photo of the Silver Fir/Alaska Huckleberry/Twinflower Association, Elk Creek, Hood Canal District.

SILVER FIR/ALASKA HUCKLEBERRY-WHITE RHODODENDRON

Abies amabilis/Vaccinium alaskaense-Rhododendron albiflorum

ABAM/VAAL-RHAL CFS2 20

The Silver fir/White Rhododendron-Alaska Huckleberry Association is a minor type of cold dry sites, and low timber productivity. It is found mostly in the mesic climatic areas of the Olympics (Environmental Zones 8 and 9), particularly on the Hood Canal District (Figure 75). Soils are mostly shallow and derived from colluvium. These sites are often well drained, but accumulate deep snowpacks. Most of this type has not burned in the last 500 years.

Floristic Composition

Dominant understory species (Table 52) are Alaska huckleberry (VAAL) and white rhododendron (RHAL), which are usually present in all ages of stands. Other shrubs may include oval-leaf huckleberry (VAOV) and fool's huckleberry (MEFE). Five-leaved bramble (RUPE), queen's cup (CLUN), twinflower (LIBO2) and beargrass (XETE) often occur. The tree layer is dominated by silver fir and western hemlock, with minor amounts of Alaska yellowcedar and mountain hemlock. Stands in this type may be slow to regenerate. Most stands are over 500 years old.

Ground moss coverage is moderate to high on this type, with an average of 35%. We do not have data on individual ground moss species, or epiphytic mosses and lichens for this association.

Successional Relationships

The common successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock. The areas where this association occur appear to be either too high or too cool for Douglas-fir.

Other Biota

Wildlife observations are limited to one plot, where coyote scat and mountain beaver or snowshoe hare burrows were observed. There are no bird observations for this type.

Environment and Soils

This type occurs on moderate to steep straight or concave, mid- to upper slopes. Slopes varied from 44% to 100% and averaged 64%. Bedrock is metabasalt and regolith is colluvium.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969) the soils in this type tend to be well-drained, rapidly permeable gravelly soils with loam to sandy loam textures. They are shallow colluvial soils. Coarse fragments range from 35% to 50% near the surface and 50% to 75% in the subsoil.

Table 52. Common plants in the ABAM/VAAL-RHAL Association, based on stands >150 years (n=4).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	47.5	47.5	100	30-70
silver fir	ABAM	43.7	43.7	100	10-80
Alaska yellowcedar	CHNO	8.3	8.3	100	1-25
mountain hemlock	TSME	2.8	3.7	75	0-5
GROUND VEGETATION					
white rhododendron	RHAL	18.2	18.2	100	8-30
Alaska huckleberry	VAAL	14.5	14.5	100	8-25
five-leaved bramble	RUPE	6.5	6.5	100	2-15
queen's cup	CLUN	2.0	2.0	100	1-4
sidebells pyrola	PYSE	1.3	1.3	100	1-2
oval-leaf huckleberry	VAOV	11.2	15.0	75	0-20
fool's huckleberry	MEFE	3.5	4.7	75	0-10
trailing bramble	RULA	2.5	3.3	75	0-5
twinflower	LIBO2	2.0	2.7	75	0-5
big huckleberry	VAME	2.0	2.7	75	0-6
beargrass	XETE	2.0	2.7	75	0-4
single-leaved foamflower	TIUN	1.3	1.7	75	0-2
bunchberry	COCA	0.8	1.0	75	0-1
evergreen violet	VISE	0.8	1.0	75	0-1
false hellebore	VEVI	0.8	1.5	50	0-2
vanillaleaf	ACTR	0.5	1.0	50	0-1
ladyfern	ATFI	0.5	1.0	50	0-1

Figure 75. Map of plot locations for the Silver Fir/ Alaska Huckleberry-White Rhododendron Association.

The mean soil temperature was 8.5 deg C (47.3 deg F) which is cold for the Silver Fir Zone. The temperature regime is cryic or upper frigid and the moisture regime is udic.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the coldness of the site and relatively short growing season. Site index for one sampled plot was 85 (base 100) for western hemlock and 98 for Douglas-fir. The productivity potential using the site index-yield table approach was 64-83 cu ft/ac/yr. The stockability of these sites is moderate to low.

Management Considerations

Management considerations for this type include ensuring rapid suitable regeneration and controlling brush competition. This type occurs in high areas for the Silver Fir Zone, and in areas of heavy snow accumulation often along upper slopes and ridgetops. Douglas-fir cannot be easily cultivated on this type. Silver fir or western hemlock are the preferred species. White rhododendron and/or Alaska huckleberry can pose brush problems.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, and rusty red stringy rot on silver fir and western hemlock.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock and silver fir.

Comparison with Similar Types

Similar types include the Silver Fir/Alaska Huckleberry/Queen's Cup and the Silver Fir/Alaska Huckleberry Associations on warmer and lower elevation sites, and the Silver Fir/Alaska Huckleberry/ Beargrass type at lower elevations but on drier sites. The Mountain Hemlock/White Rhododendron-Big Huckleberry type occurs at higher elevations. The Silver Fir/Alaska Huckleberry-White Rhododendron Association is not previously reported for the Olympic Mountains. It is similar to the Silver Fir/ White Rhododendron Association in Mt. Rainier National Park (Franklin *et al.* 1988) and on the Gifford Pinchot National Forest (Brockway *et al.* 1983). It is related to the Alaska Yellowcedar/White Rhododendron type of Franklin (1966). It is also similar to the Silver Fir/White Rhododendron/Queen's Cup Association on the Willamette National Forest (Hemstrom *et al.* 1982).

SILVER FIR/BEARGRASS

Abies amabilis/Xerophyllum tenax
ABAM/XETE CFF3 11

The Silver Fir/Beargrass Association is an uncommon type of topographically dry areas, cold soils at middle to upper elevations, and low timber productivity. It is found mainly on the Hood Canal District (Figure 76) on southwest aspects. Soils are shallow, derived from very stony colluvium, and appear to be low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 53) is beargrass (XETE). Shrubs may include Oregongrape (BENE), red huckleberry (VAPA), salal (GASH) and vine maple (ACCI). Herbs may include vanillaleaf (ACTR) and little prince's pine (CHME). The tree layer is usually dominated by Douglas-fir and western hemlock with smaller amounts of silver fir (Figure 77). Old-growth stands in this type are often about 300 years old, having originated from a fire about 320 years ago. Many stands begin with a moderate component of beargrass following fire, which may impede restocking.

Ground mosses are generally sparse on this type. Common species include *Rhytidiopsis robusta*, *Dicranum* sp.; *Hypnum circinale* and *Scapania bolanderi* may occur on rotting wood. Epiphytic lichens are common, *Alectoria sarmentosa*, *Platismatia glauca*, *Hypogymnia* spp. and crustose species are most abundant.

Successional Relationships

There are two probable successional pathways for this type. One dominated by Douglas-fir, the other by western hemlock. Later seral stages are often dominated by both Douglas-fir and western hemlock; western hemlock and silver fir dominate the climax stand. Ages of silver fir in this type are mostly less than 160 years, even in older stands. This indicates that much of this type was probably climax western hemlock and western redcedar during the Little Ice Age (*i.e.* prior to 200 years ago).

Other Biota

Wildlife observations are limited to two plots for this type. Deer sign was frequent, with recent activity in early September. Browsed species were beargrass, vine maple, red huckleberry, swordfern and Oregongrape.

Birds observed include red-breasted nuthatch, red-tailed hawk, varied thrush, dark-eyed junco, pine siskin, chestnut-backed chickadee, winter wren and red-shafted flicker.

Table 53. Common plants in the ABAM/XETE Association, based on stands >150 years (n=5).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	68.0	68.0	100	45-90
Douglas-fir	PSME	36.0	36.0	100	15-70
silver fir	ABAM	12.6	12.6	100	7-30
GROUND VEGETATION					
beargrass	XETE	20.6	20.6	100	5-35
Oregongrape	BENE	6.0	6.0	100	2-12
vine maple	ACCI	4.4	4.4	100	1-10
swordfern	POMU	1.0	1.0	100	1-1
big huckleberry	VAME	0.8	1.0	80	0-2
baldhip rose	ROGY	0.8	1.0	80	0-1
vanillaleaf	ACTR	8.4	14.0	60	0-35
Alaska huckleberry	VAAL	1.2	2.0	60	0-2
salal	GASH	0.8	1.3	60	0-2
little prince's pine	CHME	0.6	1.0	60	0-1
twinflower	LIBO2	0.6	1.0	60	0-1
red huckleberry	VAPA	0.6	1.0	60	0-1

Environment and Soils

This type occurs on moderately steep, straight to convex, mid- to upper slopes. Slopes ranged from 35% to 67% and averaged 54%. It is found mostly on basaltic colluvium.

Two soil pits dug in this type show rather weak soil development. Textures varied from sandy loam to extremely gravelly clay loam. The O1 averaged 2.3 cm and the O2 averaged 4.7 cm which is thinner than average for other types. The rooting depth was to 49 cm (which is shallower than average for all types) but also extended up 4.8 cm into the O2. Coarse fragments averaged 66% which is much higher than average. Low water holding capacity due to the high coarse fragment fraction combined with a droughty topographic position make this one of the driest types in the Silver Fir Zone. These pits were classified as dystrochrepts.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, rapidly permeable, colluvial soils. They tend to be gravelly loam and silt loams in areas of frequent rock outcrop. Coarse fragments range from 15% to 50% near the surface to 35% to 80% in the subsoils.

Soil temperature averaged 9.9 deg C (49.8 deg F), which is cool for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is probably xeric.

One plot was analyzed for nutrients. It showed very low phosphorus, potassium, calcium and magnesium compared to other other types and relatively high sulfate and copper. The pH was 5.0 which is about average for the Silver Fir Zone.

Figure 76. Map of plot locations for the Silver Fir/Beargrass Association.

Timber Productivity

Timber productivity of this type is low (Site VI). This is due to the dryness of the site and cold soils. Site index of Douglas-fir averaged 85 (base 100), while western hemlock was 64 and silver fir was 83. The productivity potential using the site index-yield table approach averaged 95 cu ft/ac/yr (Table 54). The empirical yield estimate for this association was 87 cu ft/ac/yr. The stockability of these sites is low.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking and enhancement of soil nutrients, organic matter, and preservation of the shallow unstable soil. Because of the ridgetop positions where this type usually occurs, there is an increased susceptibility to snow and wind damage which often limits the growth and survival of Douglas-fir. Accumulation of soil organic matter and nitrogen should be protected, and the litter layer should be kept intact to help keep the shallow, unstable soil in place. Advance regeneration of silver fir and western hemlock, if present, should be preserved. This type represents growing conditions and limitations which are severe for the Silver Fir Zone.

Root disease problems can include all three major diseases; laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir, silver fir, and western hemlock, and annosus root disease on western hemlock and silver fir. Armillaria may pose the most serious threat to Douglas-fir regeneration on this type. Laminated root rot may be damaging to Douglas-fir and may moderately damage silver fir and western hemlock on this type. Heart and butt rots may include red ring rot damaging Douglas-fir and western hemlock, brown trunk rot and brown cubical butt rot may be present on old-growth Douglas-fir.

Insect problems may include balsam woolly aphid on silver fir at lower elevations, western blackheaded budworm on Douglas-fir, silver fir, and western hemlock, hemlock looper on western hemlock. Silver fir beetle may be on suppressed or diseased silver fir and Douglas-fir beetle on diseased, stressed, or windthrown Douglas-fir.

Table 54. Timber productivity values for the Silver Fir/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle[1])	4	17	85	20	65	687	17	399	104	87
Douglas-fir (Curtis[2])	4	17	79	15		687	17	399	104	
Western Hemlock (Wiley[3])	2	4	64	26	155	728	6	860		
Silver Fir (Hoyer[4])	2	7	83	41	65	728	7	396	108	87

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.
[2] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.
[3] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.
[4] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.
[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
[6] Stand Density Index (Reinecke 1933).
[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[8] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).
[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Big Huckleberry/ Beargrass which occurs on slightly moister sites at higher elevations and on colder soils; and the Silver Fir/Alaska Huckleberry/Beargrass type at lower elevations with less snow and warmer soil temperatures. It is also related to the Silver Fir/ Rhododendron type which occurs on similar sites but farther north along the eastern front of the Olympic Mountains. The Silver Fir/Beargrass Association is previously recognized on the White River District, Mt. Baker-Snoqualmie National Forest by Henderson and Peter (1981c). A similar type (Silver Fir/Beargrass, Western Hemlock phase) is recognized in Mt. Rainier National Park by Franklin *et al.* (1988) but their type is unlike ours in that it has considerable big huckleberry. We would thus call it Silver Fir/Big Huckleberry/Beargrass which is a closely related type and is widely recognized (see page 190).

Figure 77. Photo of the Silver Fir/Beargrass Association, Le Bar Pass, Hood Canal District.

SILVER FIR/BIG HUCKLEBERRY/BEARGRASS

Abies amabilis/Vaccinium membranaceum/Xerophyllum tenax
ABAM/VAME/XETE   CFS2 11 (OLY)

The Silver Fir/Big Huckleberry/Beargrass Association is a minor type of warm dry sites at upper elevations, and low timber productivity. It occurs mainly in Environmental Zones 8 and 9, particularly on the Hood Canal District (Figure 78), and on southern aspects and upper slopes. Soils are mostly shallow and derived from colluvium, and are often well drained. The typical area of this type has burned once or twice in the last 500 years.

Floristic Composition

Dominant understory species (Table 55) are big huckleberry (VAME) and beargrass (XETE), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Beargrass and big huckleberry can resprout or become established quickly after clearcut or fire. Other species may include Alaska huckleberry (VAAL), sidebells pyrola (PYSE), and trailing bramble (RULA). The tree layer may be dominated by western hemlock, silver fir or occasionally mountain hemlock (Figure 79). Stands in this type may be slow to regenerate. Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over than 300 years old.

Ground mosses are generally sparse on this type, although they may be abundant in some sites. *Rhytidiopsis robusta* is the most common and abundant moss, *Dicranum* sp. and *Rhytidiadelphus loreus* may also occur. Epiphytic lichens are generally conspicuous, particularly *Alectoria sarmentosa*, which is often abundant. Other species which may occur include *Platismatia glauca*, *Hypogymnia enteromorpha*, *Parmeliopsis hyperopta*, and species of crustose lichens.

Successional Relationships

The common successional pathways are dominated by silver fir and western hemlock. Climax stages are dominated by silver fir and western hemlock.

Other Biota

Wildlife observations are limited to two plots for this type, where deer sign and Douglas squirrel were observed. Bird observations were recorded on two plots and include gray jay, chestnut-backed chickadee, red-breasted nuthatch and golden-crowned kinglet.

Table 55. Common plants in the ABAM/VAME/XETE Association, based on stands >150 years (n=2).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	50.0	50.0	100	20-80
western hemlock	TSHE	42.5	42.5	100	35-50
GROUND VEGETATION					
beargrass	XETE	20.5	20.5	100	1-40
big huckleberry	VAME	10.5	10.5	100	1-20
sidebells pyrola	PYSE	1.0	1.0	100	1-1
trailing bramble	RULA	1.0	1.0	100	1-1
Alaska huckleberry	VAAL	1.0	1.0	100	1-1

Environment and Soils

This type occurs on moderate to very steep upper slopes of various configurations. Slopes ranged from 11% to 150% and averaged 63%. It is found mostly on colluvium of metabasaltic or sandstone origin.

One pit was dug which had a thin, sandy loam surface layer and gravelly, cobbly, stony sand subsurface layers. The O1 was 3.0 cm and the O2 was 3.0 cm, which is thinner than average. The rooting depth was 50 cm which is a little less then average and roots also extended 3 cm into the O2. The coarse fragment fraction of 70% is much higher than average. Coarse texture and high coarse fragments made this a dry soil. Droughty soil conditions and a dry topographic position combine to make soils in this type the driest in the Silver Fir Zone. This pit was classified as a xerorthent.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are shallow, well-drained, rapidly permeable, colluvial soils in areas of frequent rock outcrops. They are gravelly and very gravelly, sandy loams and loams. Coarse fragments range from 35% to 50% near the surface to 50% to 75% in the subsoils.

Soil temperatures averaged 10.5 deg C (50.9 deg F) which is about average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is probably xeric.

One plot was analyzed for nutrients. It showed low zinc and calcium compared to other types. The pH was 4.9 which is slightly more acid than average for the Silver Fir Series.

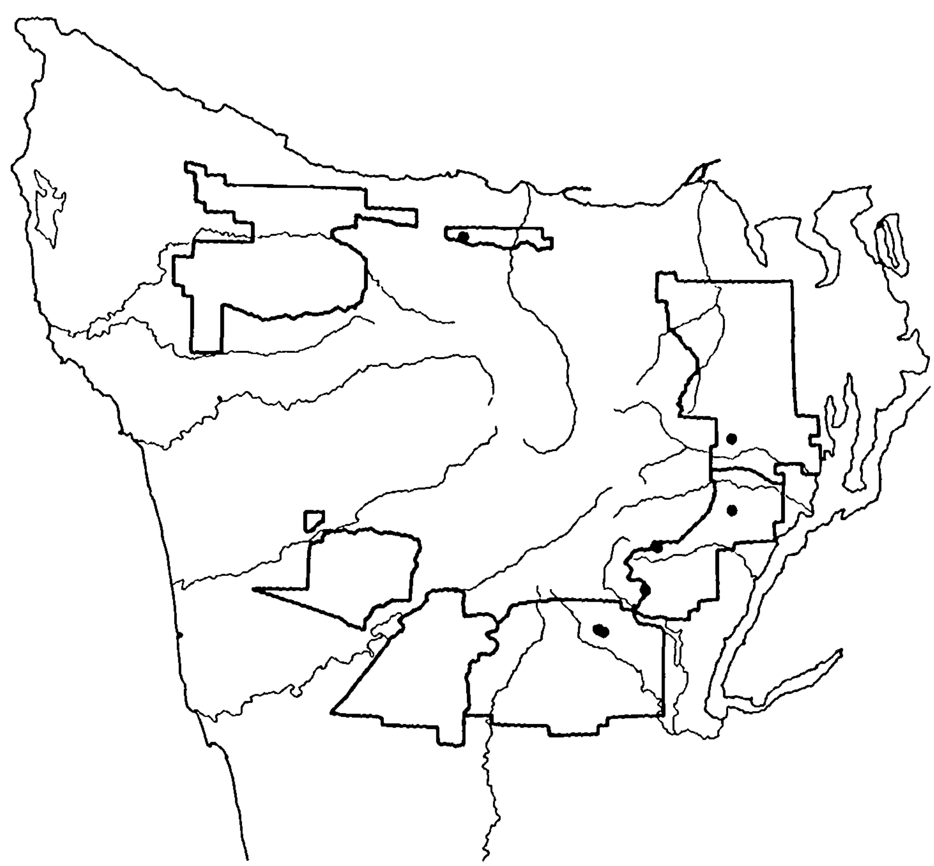


Figure 78. Map of plot locations for the Silver Fir/Big Huckleberry/Beargrass Association.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the dryness of the site, relatively short growing season and cold soils. Site index of silver fir averaged 83 (Table 56) and western hemlock was 73 (based on one tree). The productivity potential using the site index-yield table approach 63 cu ft/ac/yr for silver fir. The empirical yield estimate for this association was 87 cu ft/ac/yr. The stockability of these sites is moderate to low.

Management Considerations

Management considerations for this type include soil maintenance and stability, and ensuring suitable regeneration. Maintenance of soil nutrients and organic matter is more critical in this type than other Silver Fir types. Regeneration in this type is often difficult. Saving advance regeneration by not broadcast burning is often the preferred silvicultural treatment. Noble fir occurs commonly on this association in the Cascades on volcanic bedrock. This could be a management option to consider on this Forest. Douglas-fir cannot be easily cultivated on this type. Silver fir or western hemlock are the preferred species. Beargrass and/or big huckleberry can pose brush problems.

Root disease problems can include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir, silver fir and western hemlock, and annosus root disease on western hemlock and silver fir. Armillaria may pose the most serious threat to Douglas-fir regeneration on this type. Laminated root rot may be damaging to silver fir and western hemlock on this type. Heart and butt rots may include red ring rot on western hemlock.

Insect problems may include balsam woolly aphid on silver fir at lower elevations, western blackheaded budworm on Douglas-fir, silver fir, and western hemlock, hemlock looper on western hemlock. Silver fir beetle may be on suppressed or diseased silver fir.

Table 56. Timber productivity values for the Silver Fir/Big Huckleberry/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI[2]	SDI[3]	GBA TREES	GBA[4]	SIGBA[5]	EMAI[6]
Silver Fir (Hoyer[1])	2	8	83	15	63	517	8	308	75	87

[1] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[2] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[3] Stand Density Index (Reinecke 1933).

[4] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[5] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[6] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include the Silver Fir/Big Huckleberry type which occurs on similar sites. The Silver Fir/Beargrass type occurs on warmer, drier and lower elevation sites. The Silver Fir/Alaska Huckleberry/Beargrass type occurs in moister areas at lower elevations. The Silver Fir/Big Huckleberry/Beargrass Association is widely distributed from the Cascades of central Oregon northward to about Stevens Pass. It is recognized by Hemstrom *et al.* (1982) on the Willamette and Mt. Hood National Forest and by Brockway *et al.* (1983) on the Gifford Pinchot National Forest Franklin (1966) described an Silver Fir-Western Hemlock/Big Huckleberry type for his Mt. Rainier Province which is very similar to our Silver Fir/Big Huckleberry/Beargrass type.

Figure 79. Photo of the Silver Fir/Big Huckleberry/Beargrass Association, ridge between Dosewallips River and Tunnel Creek, Quilcene District.

SILVER FIR/DEPAUPERATE

Abies amabilis/Depauperate
ABAM/Dep. CFF9 11

The Silver Fir/Depauperate Association is a limited type of special habitats, comprised of those stands with a ground vegetation which is too sparse to key to any of the other recognized types. A sparse ground vegetation can be due to excessive shading from a dense overstory, a deep litter layer, or from an unusual combination of site factors which is too limiting for most shrubs and herbs. In the former two cases, with a more normal stand history or different stand conditions, the type would be easily determined. In practice one has to either find more sparsely stocked areas in the stand and determine the type from those "holes" in the canopy, or use local knowledge of the site factors to predict which combination of shrubs and herbs might have developed under more normal conditions. In such cases one should try to properly place the stand in the classification without having used the key. In the latter case, where a sparse ground vegetation cover is due to site (not stand) conditions, the stand truely belongs to the Depauperate type. The Silver Fir/Depauperate Association in this latter sense is a type usually of dry micro-sites in moderately dry areas, although this is quite variable. Most of our plots in this type occurred on the Soleduck District (Figure 80). It often occurs near the tops of ridges or along upper slopes. In these cases there is ample light passing throught the tree canopy and there is a thin enough litter layer to not impede development of a ground vegetation.

Floristic Composition

Total ground cover is often only 2 or 3 percent. Many different species can occur, but each one with limited cover (Table 57). Alaska huckleberry (VAAL) and red huckleberry (VAPA) were the most common shrubs, although Oregongrape (BENE) also occurred. Herbs included trillium (TROV), sidebells pyrola (PYSE), woodnymph (PYUN), deerfern (BLSP), three-leaved foamflower (TITR) and western coralroot (COME). The tree layer is dominated by silver fir and western hemlock (Figure 81). Douglas-fir, western redcedar and Pacific yew may also occur.

Ground moss cover may be sparse to abundant on this type, ranging from 3 to 99 percent cover. The most common mosses are *Rhytidiopsis robusta*, *Hylocomium splendens* and *Eurhynchium oreganum*. Epiphytes may be conspicuous and abundant. *Alectoria sarmentosa*, *Isothecium stoloniferum* and *Sphaerophorus globosus* commonly occur. The nitrogen-fixer *Lobaria oregana* may be present.

Successional Relationships

Silver fir and western hemlock dominate both seral and climax stages. Western redcedar and Douglas-fir can sometimes occur.

Other Biota

The only wildlife observation for this type was woodpecker activity on a western hemlock snag.

Table 57.Common plants in the ABAM/Depauperate Association, based on stands >150 years (n=14).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	63.9	63.9	100	15-95
silver fir	ABAM	61.0	61.0	100	15-99
Douglas-fir	PSME	8.7	20.3	42	0-55
western redcedar	THPL	0.9	4.0	21	0-6
Pacific yew	TABR	0.6	4.0	14	0-6
GROUND VEGETATION					
Alaska huckleberry	VAAL	0.9	1.2	78	0-2
trillium	TROV	0.7	1.0	71	0-1
red huckleberry	VAPA	0.7	1.3	57	0-2
woodnymph	PYUN	0.6	1.0	57	0-1
three-leaved foamflower	TITR	0.6	1.0	57	0-1
deerfern	BLSP	0.7	1.7	42	0-5
Oregongrape	BENE	0.3	1.3	21	0-2
sidebells pyrola	PYSE	0.3	1.0	28	0-1
western coralroot	COME	0.1	1.0	14	0-1

Environment and Soils

This type occurs on gentle to steep, generally straight slopes. It occurs on nearly any slope position except toe-slopes and bottoms, but favors mid- to upper slopes. The slope ranged from 5 to 79% and averaged 57%. The regolith was most often colluvial sandstone or basalt, but occasionally may be alpine or continental glacial.

The Olympic Soil Resource Inventory (Snyder *et al.* 1969) describes these soils as generally shallow, well-drained, rapidly permeable, colluvial soils or deep glacial soils that are well drained and permeable in the surface, but with compacted or otherwise restricted subsoils. Textures range from sandy loam to clay loam. Coarse fragments range from 10% to 70% near the surface to 10% to 100% in the subsoils.

The soil temperature averaged 8.5 deg C (47.3 deg F), which is one of the coldest soils in the Silver Fir Zone. The temperature regime is upper frigid to cryic and the moisture regime is udic.

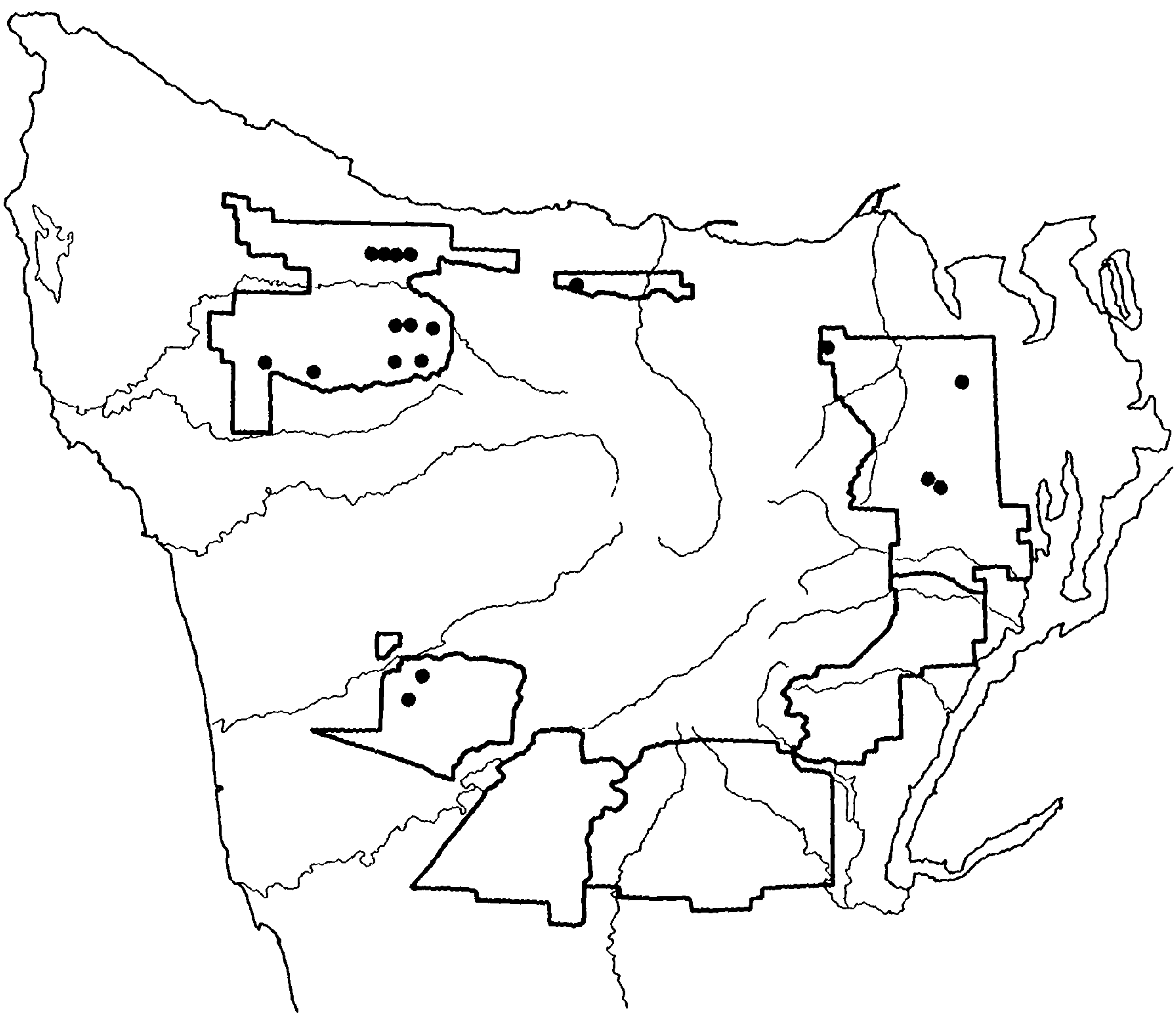


Figure 80. Map of plot locations for the Silver Fir/Depauperate Association.

Timber Productivity

This type has a low productivity potential (Site IV) and usually is difficult to regenerate. It has a moderate to low stockability and low wildlife values. Site index for Douglas-fir was 113 and western hemlock was 143. The productivity potential using the site index-yield table approach was 103 cu ft/ac/yr for Douglas-fir and 224 cu ft/ac/yr for western hemlock (Table 58).

Management Considerations

Management considerations for this type are similar to those for the Silver Fir/Alaska Huckleberry-Oregongrape Association.

Root disease problems can include all three major diseases: laminated root rot, on Douglas-fir, Armillaria root disease on Douglas-fir, silver fir and western hemlock, and annosus root disease on western hemlock and silver fir. Laminated root rot may be damaging to Douglas-fir and may moderately damage silver fir and western hemlock on this type. Heart and butt rots may include red ring rot on western hemlock, brown trunk rot and brown cubical butt rot may be present on old-growth Douglas-fir.

Insect problems may include balsam woolly aphid on silver fir, western blackheaded budworm on Douglas-fir, silver fir, and western hemlock, hemlock looper on western hemlock. Silver fir beetle may be on suppressed or diseased silver fir and Douglas-fir beetle on diseased, stressed, or windthrown Douglas-fir.

Table 58. Timber productivity values for the Silver Fir/Depauperate Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [3]	SDI	GBA TREES	GBA	SIGBA	EMAI
Douglas-fir (McArdle[1])	7	7	113	34	103					
Western Hemlock (Barnes[2])	3	3	143	17	224					

[1] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[3] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

Comparison with Similar Types

Silver Fir/Depauperate is closely related to Silver Fir/Alaska Huckleberry, Silver Fir/Alaska Huckleberry-Oregongrape, Silver Fir/Big Huckleberry/Beargrass, and Silver Fir/Beargrass Associations, which can all occur on similar sites. This type was previously recognized in the Olympics by Henderson and Peter (1981a,b, 1982a, 1983a) and in the Cascades by Henderson and Peter (1981c,d, 1982b, 1983b, 1984, 1985). It closely resembles the 'Dry Hemlock-Moss Ecosystem Association described by Haeussler *et al.* (1982) for British Columbia.

Figure 81. Photo of the Silver Fir/Depauperate Association, Le Bar Pass, Hood Canal District.

SILVER FIR/DEVIL'S CLUB
Abies amabilis/Oplopanax horridum
ABAM/OPHO   CFS3 11 (OLY)

The Silver Fir/Devil's Club Association is a minor type of cool, wet sites, and moderate timber productivity. It is found throughout much of the Forest (Figure 82). Its apparently limited distribution in wetter areas of the Forest is thought to be related to elk browsing on devil's club. Its limited distribution in drier part of the Forest is due to lack of suitable habitat. Soils are mostly shallow, moderately fine textured, and derived from colluvium or alluvium. They are irrigated from an adjacent stream or spring. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely in the last 1000 years.

Floristic Composition

The dominant understory species (Table 59) is devil's club (OPHO), which is usually present in all ages of stands, although it may be inconspicuous or absent in young stands. Salmonberry (RUSP) can become established quickly after clearcut or fire. Alaska huckleberry (VAAL) is common in some stands of this association. Common herbs include foamflower (TITR), swordfern (POMU), ladyfern (ATFI), deerfern (BLSP) and oakfern (GYDR). The tree layer is usually dominated by silver fir and western hemlock (Figure 83), and occasionally small amounts of western redcedar, Alaska yellowcedar or Douglas-fir. Stands in this type are sometimes understocked. Few areas of this type have been cut over or burned. Those that have been cut over usually occur as small pockets in stands which are mainly other types.

Ground mosses may be sparse to abundant on this type, ranging from 5% to 80% cover. No data are available regarding species presence or abundance, or species of epiphytic mosses and lichens.

Successional Relationships

Climax stages are dominated by both silver fir and western hemlock, with small amounts of western redcedar or Alaska yellowcedar.

Other Biota

Wildlife observations were only recorded on one plot for this type. There were a number of silver fir with bear damage. Devil's club had evidence of browsing. Racoon tracks were observed. The only record of birds was a sharp-shinned hawk seen above the plot.

Table 59. Common plants in the ABAM/OPHO Association, based on stands >150 years (n=15).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	46.7	46.7	100	8-90
western hemlock	TSHE	46.5	49.8	93	0-99
western redcedar	THPL	2.5	5.3	46	0-15
Douglas-fir	PSME	2.8	10.5	26	0-30
Pacific yew	TABR	0.3	1.7	20	0-2
mountain hemlock	TSME	0.5	4.0	13	0-7
GROUND VEGETATION					
devil's club	OPHO	11.7	11.7	100	2-75
Alaska huckleberry	VAAL	18.1	20.9	86	0-75
three-leaved foamflower	TITR	3.8	4.8	80	0-15
salmonberry	RUSP	3.1	4.3	73	0-10
ladyfern	ATFI	1.8	2.5	73	0-8
deerfern	BLSP	2.1	3.2	66	0-5
swordfern	POMU	1.3	2.0	66	0-10
queen's cup	CLUN	1.1	1.7	66	0-3
red huckleberry	VAPA	1.2	2.0	60	0-5
vanillaleaf	ACTR	0.9	1.4	60	0-3
five-leaved bramble	RUPE	1.1	2.1	53	0-4
clasping-leaved twisted-stalk	STAM	0.6	1.1	53	0-2
trillium	TROV	0.5	1.0	53	0-1

Environment and Soils

This type occurs on gentle to steep concave or straight mid- to lower slopes, benches and bottoms. There is a strong preference for concave microsites and lower slopes. The slope ranged from 3% to 90% and averaged 49%. The regolith is generally colluvium of metabasaltic or sedimentary origin, although glacial and alluvial materials also occur.

No pits were dug in this type, although this type has been observed to occur on a wide variety of soils. The predominant factor seems to be saturation with moving water most or all of the year. According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), our plots from this type occur on many of their soil units. This may be misleading, however. This community occupies seeps and other small wet areas that would be difficult to map and are therefore simply included in larger mapping units.

The mean summer soil temperature was 10 deg C (50 deg F), which is near average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic or aquic.

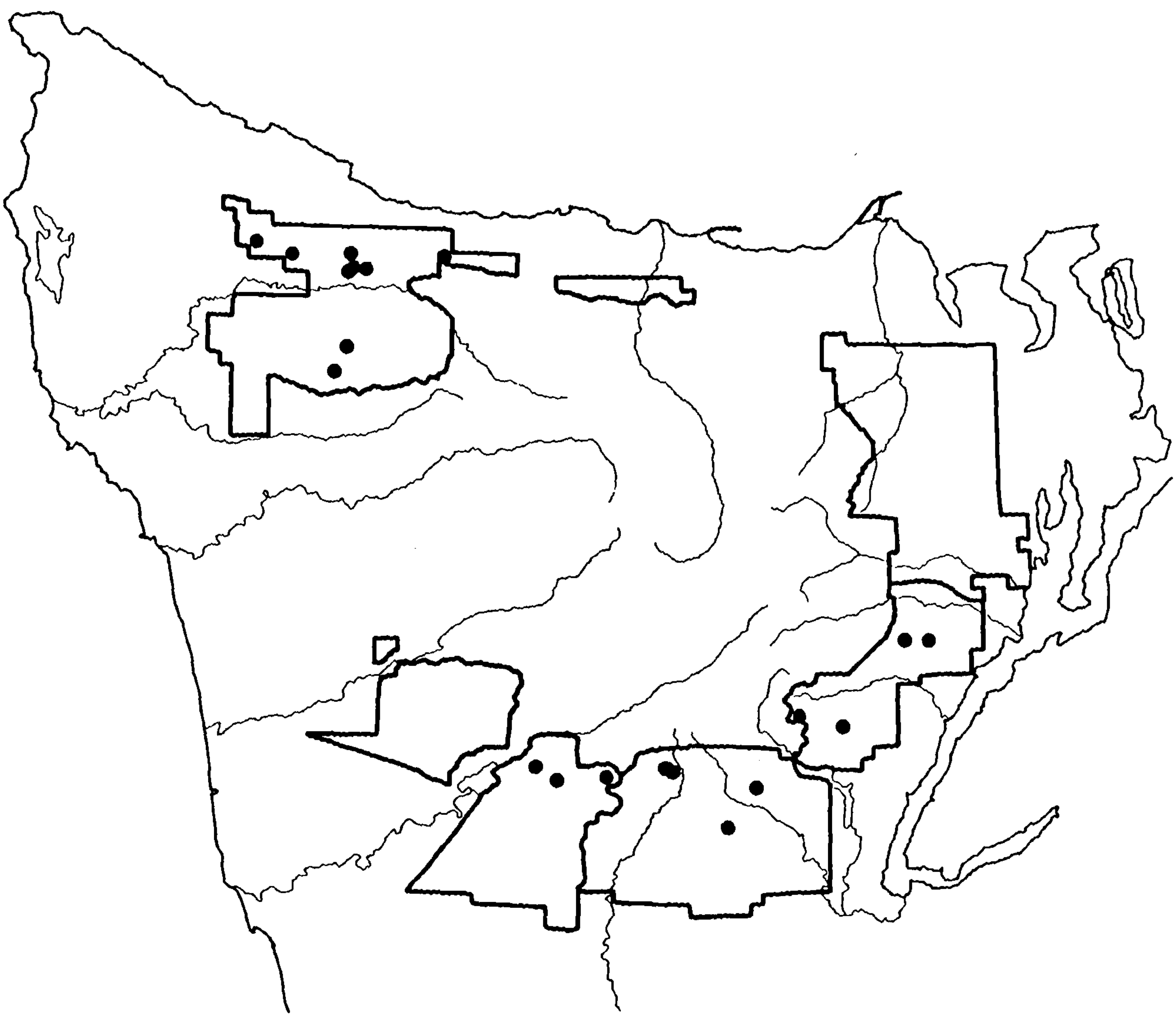


Figure 82. Map of plot locations for the Silver Fir/Devil's Club Association.

Timber Productivity

Timber productivity of this type is apparently moderate (Site III). However, because of the great age and irregular stand structure the productivity potential of this type is relatively unknown. Based on a limited sample, the site index for Douglas-fir was 123, 121 for western hemlock, and 118 for silver fir. The corresponding yield table estimates of productivity are 120, 172-182 and 114 cu ft/ac/yr (Table 60). The stockability of these sites is apparently low, due to their riparian locations. This type represents more restrictive management opportunities than other types in the same area.

Management Considerations

The main management consideration for this type is riparian and wildlife management. It is important to maintain soil and ground vegetation intact to protect stream channels.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe may occur in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Table 60. Timber productivity values for the Silver Fir/Devil's Club Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI
Douglas-fir (McArdle[1])	2	2	123	18	120					
Western Hemlock (Barnes[2])	4	4	121	21	182			335	122	
Western Hemlock (Wiley[3])	1	2	79		172	393	2	335		
Silver Fir (Hoyer[4])	1	5	118		114	393	5	471	167	

[1] Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 100, Total age (Barnes 1962). Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[4] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[6] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include Silver Fir/Skunkcabbage which occurs in wet sites with deep organic soils, and Western Hemlock/Devil's Club at lower elevations. The Silver Fir/Devil's Club Association is widely recognized in Washington and Oregon. It was recognized in the Olympics by Henderson and Peter (1982a, 1983a) and in the Cascades (1981d, 1982b, 1983b, 1984, 1985). It was not recognized by Smith and Henderson (1986) or Fonda and Bliss (1969). In the Snoqualmie River drainage the Western Hemlock-Western Redcedar/Alaska Huckleberry/Deerfern type of del Moral *et al.* (1976) apparently includes plots which we call Silver Fir/Devil's Club. It was recognized by Franklin *et al.* (1988) in Mt. Rainier National Park and on the Gifford Pinchot National Forest by Franklin (1966) and Brockway *et al.* (1983). It was also recognized on the Willamette and Mt. Hood National Forest by Hemstrom *et al.* (1982). It is similar to the Alaska Yellowcedar/Devil's Club type of Dyrness *et al.* (1976) in the H.J. Andrews Experimental Forest. In British Columbia, Haeussler *et al.* (1982) recognize an analogous type.

Figure 83. Photo of the Silver Fir/Devil's Club Association, Matheny Ridge, Quinault District.

SILVER FIR/OXALIS
Abies amabilis/Oxalis oregana
ABAM/OXOR CFF1 11 (OLY)

The Silver Fir/Oxalis Association is a major type of moist sites at low elevations, and moderately high timber productivity. It is common in the wetter climatic areas of the Olympics, on the Quinault and Soleduck Districts (Figure 84). Soils are mostly deep and moist, and derived from colluvium, outwash or glacial till. They appear to be moderately high in organic matter and nitrogen, but low in calcium and phosphorus. Little snow accumulates in this type compared to other Silver Fir types. Soil temperatures are colder than in the Western Hemlock/Oxalis type. This type has burned very seldom in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

The dominant understory species (Table 61) is oxalis (OXOR), which is usually present in all ages of stands, although it may be inconspicuous or absent in young stands or in densely stocked second growth. Other shrubs may include red huckleberry (VAPA) and Alaska huckleberry (VAAL). Swordfern (POMU) deerfern (BLSP), false lily-of-the-valley (MADI2), and foamflower (TITR) may also occur. Early seral species include fireweed (EPAN), pearly everlasting (ANMA), cats ear (HYRA), salmonberry (RUSP) and oxalis (OXOR). The tree layer is dominated by silver fir and western hemlock (Figure 85), western redcedar can occur in small amounts. Stands in this type and related types can become overstocked following blowdown. When overstocking occurs it is usually associated with a thick duff layer and sparse ground vegetation.

Ground mosses are generally sparse on this type, with total moss cover ranging from 1% to 15%. The most common and abundant moss is *Eurhynchium oreganum*. *Hylocomium splendens*, *Plagiothecium undulatum*, *Rhytidiadelphus loreus*, *Peltigera aphthosa* and *Peltigera* sp. may occasionally occur. There are limited data available for epiphytic mosses and lichens. *Isothecium stoloniferum* appears to be the most common and abundant moss. Other species which may occur in small amounts are *Alectoria sarmentosa*, *Sphaerophorus globosus*, *Scapania bolanderi*, and the nitrogen-fixer *Lobaria oregana*.

Successional Relationships

The successional pathway is usually dominated by silver fir and western hemlock. Climax stages are dominated by western hemlock and silver fir with some western redcedar. Douglas-fir occurs in some plantations less than 35 years old, but is virtually absent from all ages of old-growth. Silver fir trees are often about as old as the stand, indicating that existing stands of this association began with a component of silver fir.

Table 61. Common plants in the ABAM/OXOR Association, based on stands >150 years (n=19).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	52.7	52.7	100	20-90
silver fir	ABAM	51.1	51.1	100	14-99
western redcedar	THPL	4.4	13.8	31	0-60
GROUND VEGETATION					
oxalis	OXOR	42.6	42.6	100	1-90
red huckleberry	VAPA	2.1	2.5	84	0-20
deerfern	BLSP	1.9	2.3	84	0-9
swordfern	POMU	2.1	2.7	78	0-5
Alaska huckleberry	VAAL	1.8	2.3	78	0-4
trillium	TROV	0.8	1.0	78	0-1
three-leaved foamflower	TITR	1.1	1.4	73	0-2
false lily-of-the valley	MADI2	3.2	4.7	68	0-25
ladyfern	ATFI	0.6	1.2	52	0-2

Other Biota

Wildlife observations were frequently recorded for elk, bear and porcupine on this type. Commonly browsed species were red huckleberry, Alaska huckleberry and salmonberry; western hemlock and western redcedar, elderberry, skunkcabbage, swordfern and oval-leaf huckleberry were also browsed. Bear and porcupine damage was frequently observed on Douglas-fir, western hemlock and silver fir. Mountain beaver activity and evidence of browse on salmonberry was recorded. Deer, Douglas squirrel and snowshoe hare were also noted.

Bird observations include varied thrush, pileated woodpecker, chickadee, red-breasted nuthatch, winter wren, Steller's jay, western flycatcher, Swainson's thrush, and woodpecker activity on a western hemlock snag.

Environment and Soils

This type occurs on flat to steep, lower to upper slopes of any configuration, but most often straight. The slope varied from 0% to 95% and averaged 48%. The regolith is most commonly colluvium from metabasalt or sandstone, or can be alpine or continental glacial deposits.

The five soil pits in this type showed poor to moderate soil development. Texture varied from sandy loam to clay and coarse fragments averaged 10.8%, which is considerably less than average. The O1 layer was thin at 1.0 cm and the O2 was a little thin at 4.0 cm, although these thicknesses probably reflect the relatively young age of the stands sampled. Bedrock was only encountered in one pit at 88 cm. The water holding capacity of these soils is well above average due largely to the low coarse fragment fraction. Soil moisture is further enhanced in

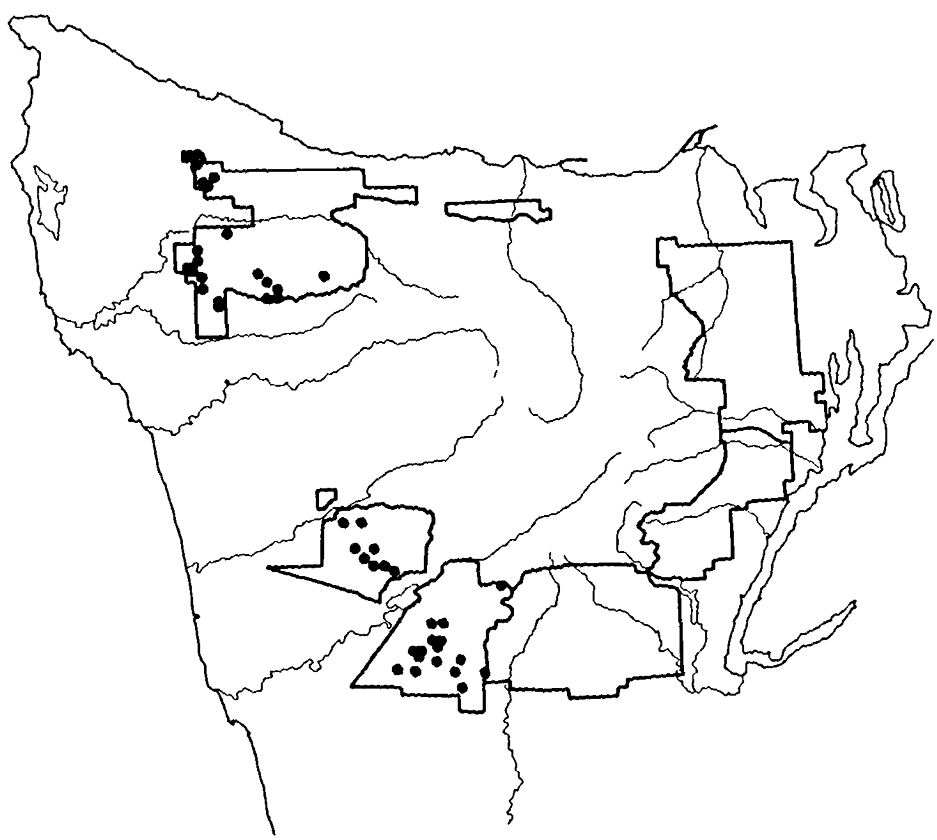


Figure 84. Map of plot locations for the Silver Fir/Oxalis Association.

this type by the moist maritime climate, although this is countered somewhat by the sometimes dry topographic position occupied by the association. Two of the pits were classified haplumbrepts, one a haplorthod and two dystrochrepts.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils are commonly shallow, well-drained, rapidly permeable, colluvial soils. Deep glacial soils with or without subsoil compaction, but commonly with moderate or slow subsoil permeability are also fairly common. Textures range from silt loams and silty clay loams to clay loams and occasionally sandy loams. The coarse fragments range from 5% to 65% near the surface to 20% to 85% in the subsoils.

The mean soil temperature was 11.7 deg C (53.1 deg F), which is warm for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

Nutrient analysis of four samples indicated low calcium, phosphorus and potassium, and high nitrogen and boron. The pH was 4.6, which is low for the series.

Timber Productivity

Timber productivity of this type is high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index for Douglas-fir in measured stands averaged 157 (base 100), 139 for western hemlock and 150 for silver fir (Table 62). The productivity potential using the site index-yield table approach was 163, 209 and 157 cu ft/ac/yr. The empirical yield estimate which was based mostly on stands of western hemlock and silver fir was 183 cu ft/ac/yr. The stockability of these sites is high. Productivity potential for western hemlock and silver fir is higher than for Douglas-fir. Western hemlock and silver fir are the preferred species on much of this type.

Management Considerations

Management considerations for this type include manipulation of species composition and regulation of stocking. The available data indicate that high stocking levels could be maintained especially in mixed stands of silver fir and western hemlock. Accumulated soil organic matter and nitrogen should

Table 62. Timber productivity values for the Silver Fir/Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA [10]	EMAI [11]
Douglas-fir (McArdle[1])	4	14	157	33	163	373				183
Douglas-fir (Curtis[2])	4	14	155	18		373				
Douglas-fir (King[3])	1	4	115		169	499				
Western Hemlock (Barnes[4])	12	12	139	33	216			441	184	
Western Hemlock (Wiley[5])	4	17	105	9	209	562	16	441		183
Silver Fir (Hoyer[6])	6	16	150	11	157	434	13	565	261	183

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[7] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[8] Stand Density Index (Reinecke 1933).

[9] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[10] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[11] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

be preserved by reducing burning sites in this type. However, in some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Many oxalis types show very low amounts of calcium and phosphorus. This may be limiting growth or affecting tree development on these sites. We recommend that any fertilizer applications on this oxalis type include calcium and phosphorous. Wildlife values can be moderately high, especially for elk winter range.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe is usually common in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Comparison with Similar Types

Similar types include the Western Hemlock/Oxalis type at lower elevations, the Silver Fir/Swordfern-Oxalis and Silver Fir/Salal/Oxalis types in drier areas or on drier sites. The Silver Fir/Oxalis Association is recognized on the Mt. Hood National Forest in Oregon (Hemstrom *et al.* 1982), and in the western Olympics (Henderson and Peter 1981a,b, 1982a), where Smith and Henderson (1986) recognized an Silver Fir-Western Hemlock/Oxalis type, while Fonda and Bliss (1969) called it Silver Fir-Western Hemlock/Oxalis.

Figure 85. Photo of the Silver Fir/Oxalis Association, Higley Peak, Quinault District.

SILVER FIR/RHODODENDRON

Abies amabilis/Rhododendron macrophyllum

ABAM/RHMA CFS6 11 (OLY)

The Silver Fir/Rhododendron Association is a type of moderately dry areas (Environmental Zones 8-11), cold soils, and moderate to low timber productivity. It is found in the rainshadow area of the Forest (Figure 86). Soils are usually very stony colluvium, till or outwash, and appear to be well drained. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites. Some stands of recent fire origin have large amounts of residual woody material. Much of the area which is now Silver Fir/ Rhododendron Association was probably Western Hemlock/Rhododendron during the Little Ice Age (see pages 30, 32, and 55).

Floristic Composition

The dominant understory species (Table 63) is rhododendron (RHMA). Few other shrubs or herbs are found, of these the most common are red huckleberry (VAPA), Alaska huckleberry (VAAL), Oregongrape (BENE) and twinflower (LIBO2). Many stands begin with a moderate component of rhododendron, twinflower, fireweed (EPAN) and pearly everlasting (ANMA) following fire, which may impede restocking. The tree layer is dominated by silver fir and western hemlock, with smaller amounts of western redcedar and Douglas-fir (especially in older stands) (Figure 87). Old-growth stands in this type are often about 300 years old, having originated from fires about 280 and 320 years ago.

Ground mosses are generally abundant on this type, ranging from 4% to 75% cover, with an average of 34%. The most common and abundant mosses are *Hylocomium splendens*, *Rhytidiopsis robusta* and *Eurhynchium oreganum*. Other commonly occurring species with lower coverage are *Plagiothecium undulatum*, *Dicranum* sp., and *Hypnum circinale* and *Scapania bolanderi* on rotting wood. Epiphytic lichens may be conspicuous and abundant. The common species include *Platismatia glauca*, *Alectoria sarmentosa*, *Hypogymnia enteromorpha*, *Parmeliopsis hyperopta*, and crustose lichens. Less frequent species include *Bryoria* spp., *Sphaerophorus globosus* and *Hypogymnia imshaugii*.

Successional Relationships

Under the current climatic regime there are two possible successional pathways for this type. One dominated by silver fir and western hemlock, and the other with Douglas-fir plus silver fir and/or western hemlock. Silver fir, western hemlock and western redcedar will ultimately dominate the climax stand. Although Douglas-fir is a significant component of old-growth stands, it is not common in some young-growth stands. In old-growth stands where Douglas-fir dominates, silver fir trees are mostly less than 150 years. This indicates that much of the area where this association occurs was Western Hemlock Zone prior to about 150 years ago.

Table 63. Common plants in the ABAM/RHMA Association, based on stands >150 years (n=9).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	69.4	69.4	100	40-90
silver fir	ABAM	24.6	24.6	100	8-70
Douglas-fir	PSME	17.3	17.3	100	1-35
western redcedar	THPL	7.6	8.5	88	0-20
Pacific yew	TABR	1.0	3.0	33	0-4
GROUND VEGETATION					
rhododendron	RHMA	43.8	43.8	100	3-95
twinflower	LIBO2	2.0	2.0	100	1-5
Oregongrape	BENE	1.1	1.4	77	0-3
Alaska huckleberry	VAAL	1.0	1.3	77	0-2
red huckleberry	VAPA	0.8	1.4	55	0-2
prince's pine	CHUM	0.6	1.0	55	0-1
western coralroot	COME	0.6	1.0	55	0-1
evergreen violet	VISE	0.6	1.0	55	0-1

Other Biota

Douglas squirrel were observed on all plots in this type. Deer sign was recorded, including browse on red huckleberry and Pacific yew. Recent mountain beaver activity was noted in early August. Chipmunk were also recorded.

Birds frequently observed were golden-crowned kinglet, chesnut-backed chickadee and red-breasted nuthatch. Other birds recorded include gray jay, Steller's jay, olive-sided flycatcher, hermit thrush, varied thrush, red-tailed hawk, blue grouse, band-tailed pigeon, red-shafted flicker, common raven and winter wren.

Environment and Soils

This type occurs on gentle to steep, straight lower to upper slopes and benches. The slope ranged from 7% to 90% and averaged 46%. Regolith is usually colluvial of basaltic origin, but may also be glacial.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these are mostly shallow, well-drained colluvial soils with rapid permeability. The type also occurs on deep glacial soils with compacted or cemented subsoil rendering them effectively shallow. These soils are also well-drained and rapidly permeable in surface layers, but moderately slowly permeable in subsoils. Textures range from silty clay loam to sandy loam. Coarse fragments range from 15% to 70% near the surface to 35% to 80% in the subsoil.

The soil temperature averaged 10.3 deg C (50.5 deg F), which makes this type a little cool for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

Figure 86. Map of plot locations for the Silver Fir/Rhododendron Association.

Timber Productivity

Timber productivity of this type is moderate to low (Site IV). Site index of Douglas-fir averaged 128, while western hemlock was 118 and silver fir was 107 (Table 64). The productivity potential of this type is difficult to assess because of the apparent change from Western Hemlock Zone (and therefore Douglas-fir dominance) to Silver Fir Zone. Productivity potential using the site index-yield table approach was 122, 155 and 98 cu ft/ac/yr respectively. The site index curve of Curtis *et al.* (1974) for upper elevation Douglas-fir was also used, it gave a site index of 113. The empirical yield estimate for this association was 109 cu ft/ac/yr.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking (otherwise rhododendron brush competition is a problem), and enhancement of soil nutrients and organic matter. Advanced regeneration (if present), soil organic matter and nitrogen should be preserved. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Because of the exposed site conditions and often densely stocked stand conditions, this type offers low to moderate wildlife values in young and old-growth stands. Young-growth stands can offer some browse for deer. Game trails and scat are uncommon in this type, indicating that it gets only irregular use. In contrast to most Silver Fir associations, Douglas-fir can grow here. Preferred species are Douglas-fir, western hemlock and/or silver fir.

Root disease problems can include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir, silver fir and western hemlock, and annosus root disease on western hemlock and silver fir. Armillaria may pose the most serious threat to Douglas-fir regeneration on this type. Black stain root disease may occur in Douglas-fir plantations. Laminated root rot may be damaging to Douglas-fir and may moderately damage silver fir and western hemlock on this type. Heart and butt rots may include red ring rot on Douglas-fir and western hemlock, and brown trunk rot and brown cubical butt

Table 64. Timber productivity values for the Silver Fir/Rhododendron Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [8]	SDI [9]	GBA TREES	GBA [10]	SIGBA [11]	EMAI [12]
Douglas-fir (McArdle[1])	4	17	128	50	122	509	16	411	127	109
Douglas-fir (McArdle[2])	4	4	115	10						
Douglas-fir (Curtis[3])	4	17	113	27		509	16	411	127	
Douglas-fir (King[4])	1	5	71		67					
Western Hemlock (Barnes[5])	2	2	118	16	176			480	170	
Western Hemlock (Wiley[6])	2	6	66	11	155	693	6	480		
Silver Fir (Hoyer[7])	3	11	107	19	98	513	8	361	109	109

[1] Base age 100, Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[4] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[5] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[6] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[7] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[8] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[9] Stand Density Index (Reinecke 1933).

[10] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[11] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[12] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 30 years old (see Figure 191 p. 498).

rot on old Douglas-firs. Red ring rot may reduce growth of Douglas-fir on this type. Hemlock dwarf mistletoe may occur occasionally.

Insect problems may include balsam woolly aphid on silver fir, western blackheaded budworm on Douglas-fir, silver fir, and western hemlock, hemlock looper on western hemlock. Silver fir beetle may be on suppressed or diseased silver fir and Douglas-fir beetle on diseased, stressed, or windthrown Douglas-fir.

Comparison with Similar Types

Similar types include Silver Fir/Rhododendron-Alaska Huckleberry Association which occurs on slightly moister sites. It is also related to the Western Hemlock/Rhododendron-Salal and Western Hemlock/Rhododendron types which occur at lower elevations, mostly on the Hood Canal and Quilcene Districts. The Silver Fir/Rhododendron Association is not recognized elsewhere. It may occur as far south as the Mt. Hood National Forest. However, the closest type in that area is Silver Fir/Rhododendron-Oregongrape (Hemstrom *et al.* 1982). It was previously recognized by Henderson and Peter (1983a), but as a much broader type than used here.

Figure 87. Photo of the Silver Fir/Rhododendron Association, Mt. Crag, Quilcene District.

SILVER FIR/RHODODENDRON-ALASKA HUCKLEBERRY

Abies amabilis/Rhododendron macrophyllum-Vaccinium alaskaense
ABAM/RHMA-VAAL CFS6 12

The Silver Fir/Rhododendron-Alaska Huckleberry Association is a type of dry areas, infertile soils and moderate to low timber productivity. It is common in the rainshadow area of the Olympics, particularly on the Hood Canal and Quilcene Districts (Figure 88). Soils are sometimes shallow, but not stony, and are derived mostly from colluvium. They appear to be particularly low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

Dominant understory species (Table 65) are rhododendron (RHMA) and Alaska huckleberry (VAAL), although in densely stocked stands these indicator species may be inconspicuous or absent. Other shrubs may include Oregongrape (BENE) and red huckleberry (VAPA). Twinflower (LIBO2) and five-leaved bramble (RUPE) may also occur. The tree layer is dominated by silver fir and western hemlock with smaller amounts of Douglas-fir and western redcedar (Figure 89). Frequent fires have occurred in this type over the last 500 years.

Ground mosses and lichens are common and often abundant, with total cryptogam cover averaging 32%, and ranging from 3% to 95% cover. *Rhytidiopsis robusta* and *Hylocomium splendens* are the most common and abundant mosses. Other common species, but with low abundance include *Dicranum* sp., *Eurhynchium oreganum*, *Cladonia* spp., and *Hypnum circinale* and *Scapania bolanderi* on rotting wood. Epiphytic lichens are present on this type, but generally are not abundant. The commonly occurring species are *Hypogymnia enteromorpha*, *Alectoria sarmentosa*, *Parmeliopsis hyperopta*, *Usnea* sp. and crustose lichens.

Successional Relationships

Many stands begin with a moderate component of rhododendron and huckleberry following fire. As the canopy develops during the middle stages of succession, understory vegetation decreases in response to low light levels. As old-growth develops and tree mortality opens the canopy, ground vegetation dominated by rhododendron and Alaska huckleberry is reestablished. There are two recognized successional pathways for this type. Seral stages are dominated by Douglas-fir and western hemlock, or by silver fir and western hemlock. Western hemlock and silver fir dominate the climax stand. Silver fir trees are mostly less than 160 years in old-growth stands in this association, but some older trees do occur. This indicates that these areas were probably silver fir potential well into the Little Ice Age, in contrast to the other rhododendron-dominated associations.

Other Biota

Wildlife observations include sign of deer, bear and mountain beaver, all of which had recent activity recorded in mid-June. Deer browse was observed on red huckleberry and rhododendron; bear browse was noted on silver fir and western redcedar. Douglas squirrel sign was common.

Table 65. Common plants in the ABAM/RHMA-VAAL Association, based on stands >150 years (n=5).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	67.0	67.0	100	40-90
silver fir	ABAM	33.0	33.0	100	5-50
Douglas-fir	PSME	22.2	22.2	100	1-35
western redcedar	THPL	20.2	25.2	80	0-50
Pacific yew	TABR	1.0	2.5	40	0-3
GROUND VEGETATION					
rhododendron	RHMA	25.6	25.6	100	8-65
Alaska huckleberry	VAAL	18.0	18.0	100	10-25
red huckleberry	VAPA	7.4	7.4	100	2-10
twinflower	LIBO2	8.0	10.0	80	0-25
Oregongrape	BENE	2.6	3.3	80	0-5
five-leaved bramble	RUPE	3.6	6.0	60	0-15
bunchberry	COCA	1.8	3.0	60	0-7
little prince's pine	CHME	0.8	1.3	60	0-2
queen's cup	CLUN	0.8	1.3	60	0-2
pink wintergreen	PYAS	0.8	1.3	60	0-2
western coralroot	COME	0.6	1.0	60	0-1

Birds frequently observed were golden-crowned kinglet, dark-eyed junco, varied thrush, hermit thrush and common crow. Other birds observed include Hammond's and olive-sided flycatcher, band-tailed pigeon, rufous hummingbird, gray jay, black-capped and chesnut-backed chickadee, winter wren, red-breasted nuthatch and woodpeckers.

Environment and Soils

This type occurs on gentle to steep, straight, upper to lower slopes. Slopes ranged from 5% to 72% and averaged 54%. The regolith was colluvium of basaltic origin.

Two pits dug in this type show moderate soil development. Texture ranged from sand to sandy clay loam. The O1 was 2.5 cm and the O2 was 5.0 cm, which are both about average. The rooting depth was to 62.5 cm, which is almost average, but also extended 5 cm into the O2. Coarse fragments averaged 28%, which is less than average. Fractured basalt bedrock was encountered in one pit at 66 cm.

This type is dry, not because of the soil water holding capacity, which is above average, but because of its topographic position and climate. One pit was classified as haplorthod and one as dystrochrept.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), nearly all of these soils are shallow, well-drained, rapidly permeable, colluvial soils ranging from loam to sandy loam. Coarse fragments ranged from 35% to 70% near the surface to 35% to 85% in the subsoils. They often occur in areas of frequent rock outcrop.

The mean summer soil temperature was 9.3 deg C (48.7 deg F), which makes this one of the cooler soils in the Silver Fir Zone. The temperature regime is cool frigid and the moisture regime is probably dry udic.

Two soil nutrient analyses showed higher than average phosphorus, potassium, calcium and magnesium, and lower than average nitrogen, sulfate and boron. The pH averaged 5.6 which is well above the series average.

Figure 88. Map of plot locations for the Silver Fir/Rhododendron-Alaska Huckleberry Association.

Timber Productivity

Timber productivity of this type is moderate to low (Site IV). This is due to the dryness of the site and cold soils. Site index of measured stands averaged 120 (base 100) for Douglas-fir, 64 (base 50) for western hemlock, and 96 (base 100) for silver fir. The productivity potential using the site index-yield table approach was 113 cu ft/ac/yr for Douglas-fir and an average of 117 for western hemlock and silver fir (Table 66). The empirical yield estimate for this association was 109 cu ft/ac/yr. The stockability of these sites is apparently low but the stocking in wild stands tends to be high.

Management Considerations

Management considerations for this type include regulation of stocking and enhancement of soil nutrients and organic matter. Advance regeneration, soil organic matter and nitrogen should be preserved. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Silver fir, western hemlock and Douglas-fir are preferred species.

Root disease problems can include all three major diseases; laminated root rot, on Douglas-fir, Armillaria root disease on Douglas-fir, silver fir, and western hemlock, and annosus root disease on western hemlock and silver fir. Armillaria may pose the most serious threat to Douglas-fir regeneration on this type. Laminated root rot may be damaging to Douglas-fir and may moderately damage silver fir and western hemlock on this type. Heart and butt rots may include red ring rot damaging Douglas-fir and western hemlock, brown trunk rot and brown cubical butt rot may be present on old-growth Douglas-fir.

Insect problems may include balsam woolly aphid on silver fir, western blackheaded budworm on Douglas-fir, silver fir and western hemlock, hemlock looper on western hemlock. Silver fir beetle may be on suppressed or diseased silver fir, and Douglas-fir beetle on diseased, stressed, or windthrown Douglas-fir.

Table 66. Timber productivity values for the Silver Fir/Rhododendron-Alaska Huckleberry Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA [6]	SIGBA [7]	EMAI [8]
Douglas-fir (McArdle[1])	2	2	120	4	113					
Western Hemlock (Wiley[2])	3	6	64	5	153	489	5	394		109
Silver Fir (Hoyer[3])	3	14	96	8	82	489	9	356	98	109

[1] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[3] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[7] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[8] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include the Silver Fir/Rhododendron Association on drier sites and the Western Hemlock/Rhododendron and Western Hemlock/Rhododendron/Swordfern Associations at lower elevations. The Silver Fir/Rhododendron-Alaska Huckleberry Association has a limited distribution in the Olympics. The closely related Silver Fir/Rhododendron-Alaska Huckleberry/Bunchberry type is recognized on the Willamette National Forest in Oregon. It is discussed by Hemstrom *et al.* (1982) as having greatest similarity to the Silver Fir/Alaska Huckleberry Associations. In the Olympics it is not much like our Silver Fir/Alaska Huckleberry types. In contrast to the Silver Fir/Rhododendron-Alaska Huckleberry/Bunchberry type in Oregon, our Silver Fir/Rhododendron-Alaska Huckleberry type has little bunchberry and few of the herbs which appear to characterize this type there.

Figure 89. Photo of the Silver Fir/Rhododendron-Alaska Huckleberry Association, Bon Jon Pass, Quilcene District.

SILVER FIR/SALAL

Abies amabilis/Gaultheria shallon
ABAM/GASH CFS1 54 (OLY)

The Silver Fir/Salal Association is a variable type of mesic areas, moderate soil temperatures and moderate timber productivity. It is found throughout the Forest, often at the lower boundary of the Silver Fir Zone on southerly aspects (Figure 90). Soils are shallow to deep, derived from colluvium, and often appear to be well drained. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites. Silver fir often occurs as individuals less than 200 years old, suggesting that the boundary of this type has shifted down in elevation since the end of the Little Ice Age.

Floristic Composition

The dominant understory species (Table 67) is salal (GASH). Other shrubs include red huckleberry (VAPA), Oregongrape (BENE) and Alaska huckleberry (VAAL). Herbs may include swordfern (POMU), prince's pine (CHUM) and twinflower (LIBO2). Many stands begin with a moderate component of fireweed (EPAN) and pearly everlasting (ANMA) following fire, which may impede restocking. In some cases salal can reestablish very quickly. The tree layer is dominated by silver fir and western hemlock with smaller amounts of western redcedar and Douglas-fir (Figure 91). Old-growth stands in this type are often about 300 years old, having originated from fires about 280 and 320 years ago.

There are limited data available for cryptogams on this type. From two sample plots, ground mosses are sparse with an average of 8% cover, probably due to dense salal cover. There are no data available regarding species presence, or epiphytic mosses and lichens.

Successional Relationships

There are two probable successional pathways for this type, one dominated by silver fir and western hemlock, the other including Douglas-fir. Silver fir, western hemlock and western redcedar dominate the climax stand. Silver fir trees in old-growth plots were younger than 215 years, even though many stands approached 700 years. It appears that areas where this Association occurs may have been Western Hemlock/Salal association prior to 220 years ago (*i.e.* during the Little Ice Age).

Other Biota

There are no wildlife or bird observations recorded for this type.

Table 67. Common plants in the ABAM/GASH Association, based on stands >150 years (n=8).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	46.9	46.9	100	10-86
silver fir	ABAM	30.7	30.7	100	10-70
western redcedar	THPL	15.6	17.9	87	0-45
Douglas-fir	PSME	14.4	23.0	62	0-40
Pacific yew	TABR	3.1	12.5	25	0-15
GROUND VEGETATION					
salal	GASH	46.9	46.9	100	15-90
red huckleberry	VAPA	9.1	9.1	100	1-40
Oregongrape	BENE	4.8	5.4	87	0-15
Alaska huckleberry	VAAL	2.1	2.8	75	0-5
swordfern	POMU	1.3	2.0	62	0-3
prince's pine	CHUM	0.8	1.2	62	0-2

Environment and Soils

This type occurs on gentle to steep, generally straight slopes. It occurs on nearly any slope position except toe-slopes and bottoms, but favors mid-slopes. The slope ranged from 10 to 90% and averaged 55%. The regolith is usually colluvial of basaltic origin, but is sometimes glacial or sedimentary colluvium.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils will fall into one of two very different groups. The larger group is colluvial, shallow, well-drained soils that are rapidly permeable in the surface layer. The smaller group is deep, moderately well-drained and permeable glacial soils. Textures are sandy loams to loams. Coarse fragments ranged from 5% to 65% near the surface to 10% to 100% in the subsoils.

The mean summer soil temperature was 11.9 deg C (53.4 deg F), which is one of the warmest soils for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is on the dry end of udic.

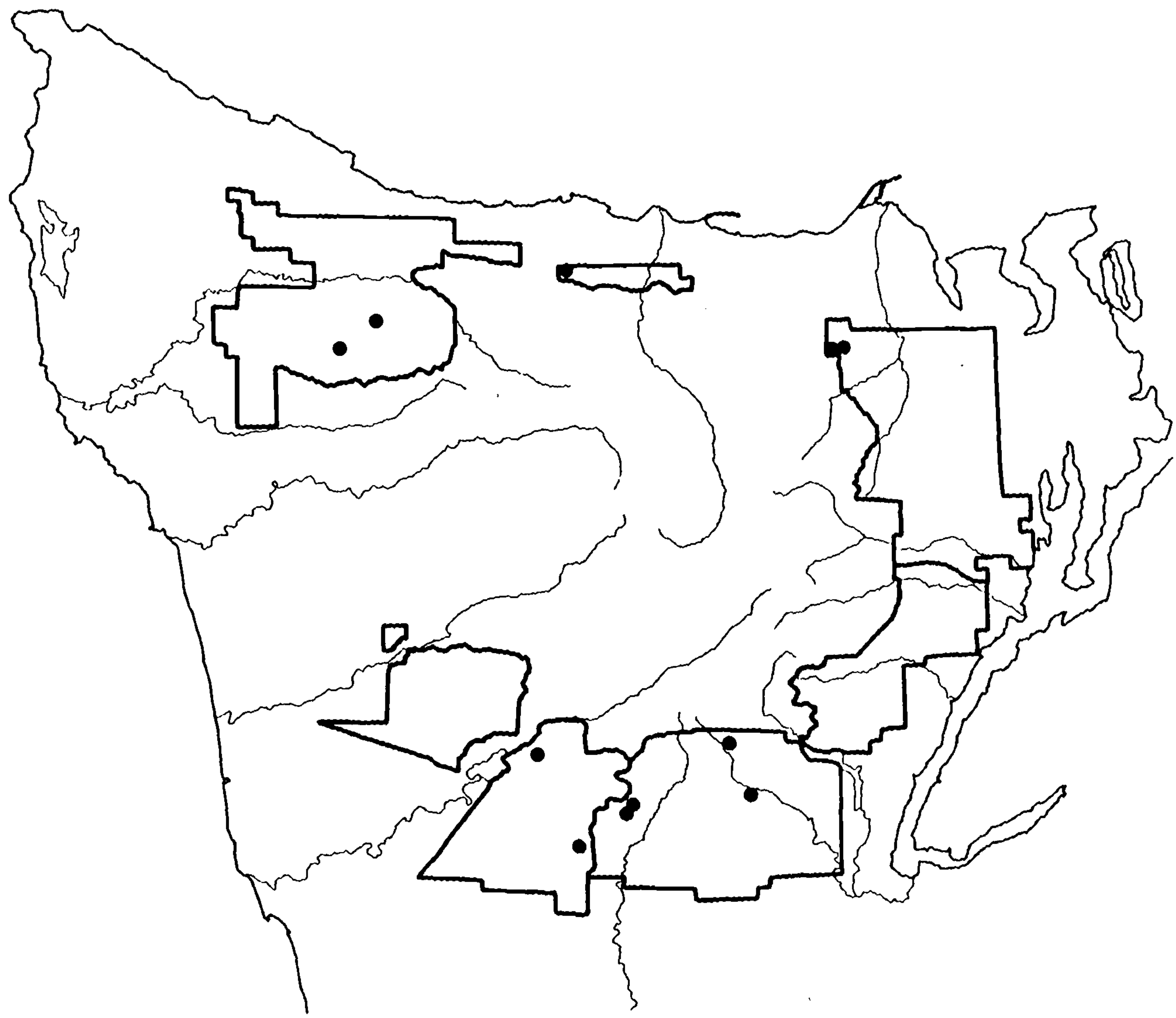


Figure 90. Map of plot locations for the Silver Fir/Salal Association.

Timber Productivity

Timber productivity of this type appears to be moderate (Site III). Site index of Douglas-fir was 137 (base 100) (based on one tree), while western hemlock averaged 89. There were not enough plots in this association to estimate potential yield in terms of cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type include ensuring rapid initial stocking and enhancement of soil nutrients and organic matter while controlling brush competition. Accumulated soil organic matter and nitrogen should be preserved, however salal competition can be severe and burning for brush control may be needed. Because of the warm, exposed site conditions where this type occurs and the dense salal dominated ground vegetation, it offers low to moderate wildlife values in young and old-growth stands. Young-growth stands often offer some browse for deer, particularly from red huckleberry. Game trails and scat are uncommon in this type, indicating that it gets only irregular use.

Root disease problems can include all three major diseases, laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir, silver fir and western hemlock, and annosus root disease on western hemlock and silver fir. Armillaria may pose the most serious threat to Douglas-fir regeneration on this type. Laminated root rot may be damaging to Douglas-fir and may moderately damage silver fir and western hemlock on this type. Heart and butt rots may include red ring rot damaging Douglas-fir and western hemlock, brown trunk rot and brown cubical butt rot may be present on old-growth Douglas-fir.

Insect problems may include balsam woolly aphid on silver fir, western blackheaded budworm on Douglas-fir, silver fir and western hemlock, hemlock looper on western hemlock. Silver fir beetle may be on suppressed or diseased silver fir, and Douglas-fir beetle on diseased, stressed, or windthrown Douglas-fir.

Comparison with Similar Types

Similar types include Silver Fir/Salal/Deerfern which occurs on slightly wetter sites at lower elevations, and the Western Hemlock/Salal-Oregongrape type which occurs in drier areas and at lower elevations. The Silver Fir/Salal Association is widely recognized in the Olympics and Cascades of Washington. It is recognized on the Gifford Pinchot National Forest (Brockway *et al.* 1983, Franklin 1966), in Mt. Rainier National Park (Franklin *et al.* 1988), on the Mt. Baker-Snoqualmie National Forest (Henderson and Peter (1981c, 1982b) and in the Olympics (Henderson and Peter 1981a,b, 1982a).

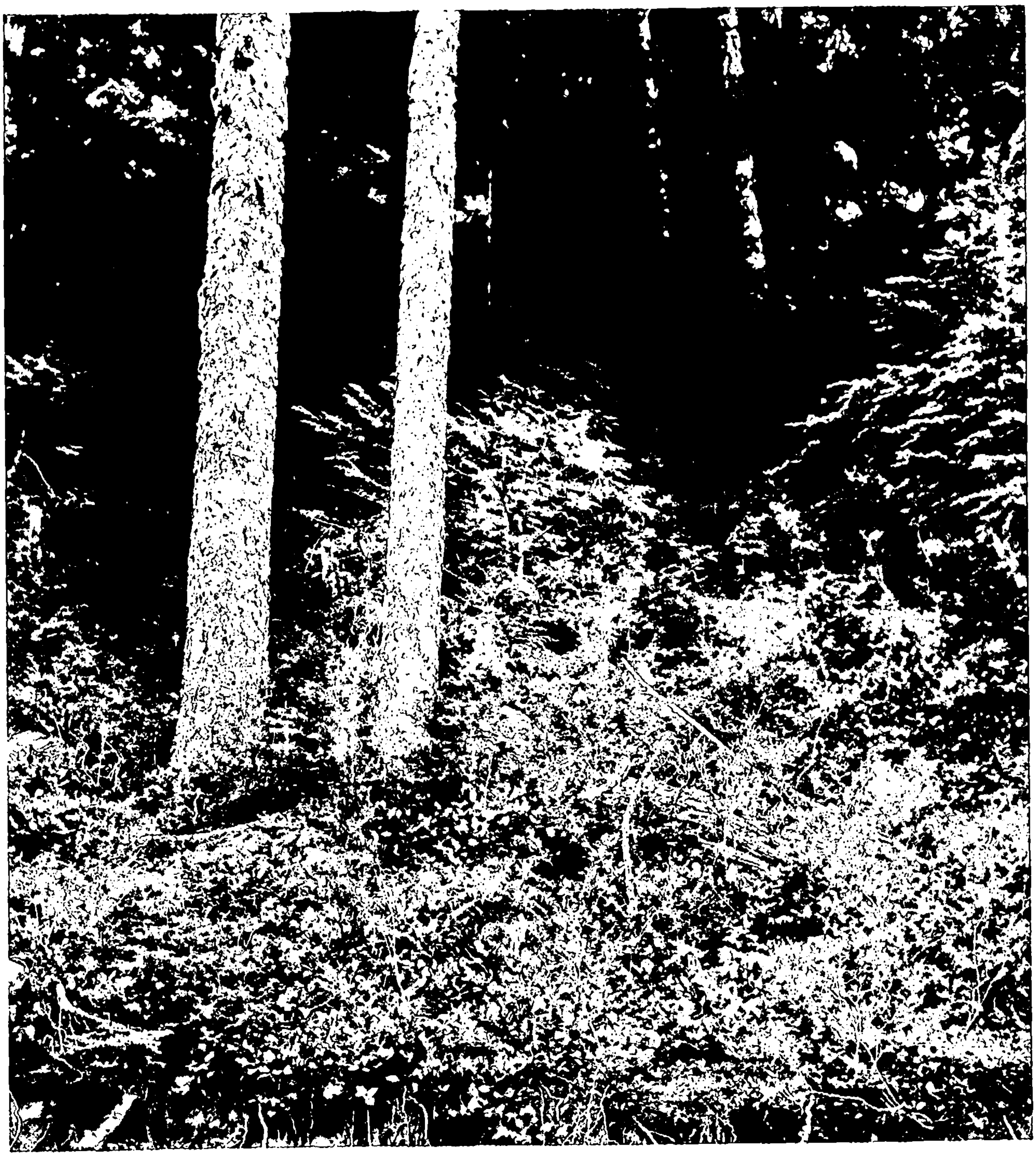


Figure 91. Photo of the Silver Fir/Salal Association, Four Stream, Hood Canal District.

SILVER FIR/SALAL/DEERFERN

Abies amabilis/Gaultheria shallon/Blechnum spicant
ABAM/GASH/BLSP CFS1 55

The Silver Fir/Salal/Deerfern Association is a common type of drier sites in wet areas, and moderate to good timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault and Soleduck Districts (Figure 92), and at low elevations for the Silver Fir Zone. Soils are mostly deep, derived from colluvium or glacial till. Soils appear to be moderately high in organic matter and nitrogen, but low in calcium and phosphorus. The typical area of this type has burned rarely, if at all, in the last 1000 years.

Floristic Composition

Dominant understory species (Table 68) are salal (GASH), red huckleberry (VAPA) and Alaska huckleberry (VAAL), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Salal, salmonberry (RUSP) and Alaska huckleberry may become established quickly after clearcut or fire. Other shrubs may include Oregongrape (BENE). False lily-of-the-valley (MADI2), deerfern (BLSP) and swordfern (POMU) may also occur. The tree layer may be dominated by silver fir or western hemlock and western redcedar may also occur (Figure 93). Most areas of this type have not been cut over. Therefore, much of the type is still in old-growth, and many stands are over 300 years old.

Information on cryptogams is limited for this type. However from the three plots sampled, ground moss cover was fairly abundant, averaging 42%, with a range from 10% to 80%. The most common species was *Rhytidiadelphus loreus*. Other species which were present but with low coverage were *Plagiothecium undulatum*, *Eurhynchium oreganum*, and *Hypnum circinale* on rotting wood. Data are limited for epiphytes to one plot where *Hypnum circinale* and *Isothecium stoloniferum* were the dominant and conspicuous epiphytic mosses.

Successional Relationships

The major successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock.

Other Biota

Wildlife observations are limited to two plots for this type. Heavy mountain beaver activity and browse on Alaska huckleberry were recorded on one plot. Elk sign and bear damage to silver fir were also observed. There are no bird observations for this type.

Environment and Soils

This type occurs on gentle to steep, convex or straight, lower slopes to ridgetops. It shows little preference for landforms in terms of macrotopography, but strongly prefers upper slopes, and to a lesser degree, mid-slopes in terms of microtopography. It was never found on a concave landform in our sample. The slope varied from 3% to 80% and averaged 46%. The regolith is usually colluvium but may also be alpine glacial. Bedrock is usually metabasalt or sandstone.

Table 68. Common plants in the ABAM/GASH/BLSP Association, based on stands >150 years (n=15).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	60.0	59.0	100	15-99
silver fir	ABAM	54.2	50.4	93	1-90
western redcedar	THPL	5.8	9.6	53	1-20
GROUND VEGETATION					
salal	GASH	22.8	22.1	100	1-65
red huckleberry	VAPA	10.6	9.3	100	1-35
deerfern	BLSP	4.2	3.7	100	1-15
Alaska huckleberry	VAAL	19.3	19.5	86	2-65
swordfern	POMU	0.9	1.4	66	1-3
false lily-of-the valley	MADI2	2.2	3.3	60	1-20

Two soil pits dug in this type show weak to moderate soil development. Texture varied from sandy loam to clay and the coarse fragments averaged 11%, which is considerably lower than average. The O1 layer was thin at l.0 cm and the O2 about average at 5.0 cm. The rooting depth was 54 cm, which is slightly less than average, but also extends up 5 cm into the O2. The water holding capacity of these soils is much higher than average owing to the fine texture and low coarse fragment fraction. The moist climate further enhances soil moisture, however, the typical topographic position of this type tends to keep the soil drier.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils are either shallow, well-drained, rapidly permeable, colluvial soils or deep, often imperfectly drained glacial soils with subsoil compaction. Textures are typically silt loams and silty clay loams or clay loams, or less commonly sandy loams. The coarse fragment fraction ranges from 15% to 65% near the surface, to 35% to 80% in the subsoil.

The mean summer soil temperature was 11.1 deg C (51.9 deg F), which is warmer than average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

The mean of two nutrient analyses indicate lower phosphorus, calcium, and copper, and higher boron and nitrogen than other types. The pH was 4.8, which is fairly low for the Silver Fir Zone.

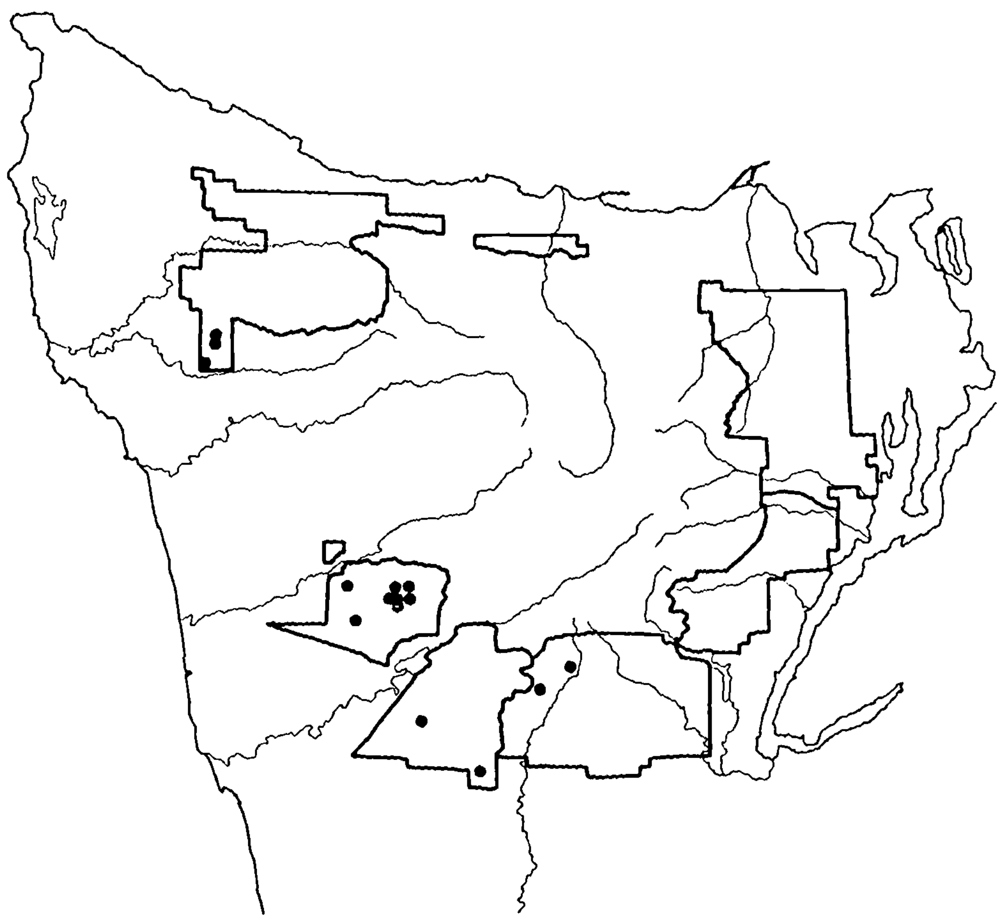


Figure 92. Map of plot locations for the Silver Fir/Salal/Deerfern Association.

Timber Productivity

Timber productivity of this type is apparently moderate (Site III). Site index for western hemlock on one plot was 123 (base 100). Since most of the stands sampled were either too young or too old to reliably estimate either site index or potential yield, these values are not yet available for this association.

Management Considerations

Management considerations for this type include elk habitat, management of soil nutrients and organic matter also appear to be very important. Response to fertilizer in this type is still unknown, but application of calcium and phosphorus is strongly indicated. This type occurs in areas where elk winter range is important. Douglas-fir apparently does not occur on this type. Silver fir or western hemlock are the preferred species. Salal and/or Alaska huckleberry can pose brush problems.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots include red ring rot on western hemlock, rusty red stringy rot and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe is usually common in old-growth hemlock stands.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock, and balsam woolly aphid on silver fir, especially at lower elevations.

Comparison with Similar Types

Similar types include the Silver Fir/Salal/Oxalis Association which occurs on moister microsites and the Western Hemlock/Alaska Huckleberry-Salal type which occurs on warmer sites at lower elevations. The Silver Fir/Alaska Huckleberry-Oregongrape type occurs at higher elevations and in drier environmental zones. The Silver Fir/Alaska Huckleberry/Queen's Cup type occurs on topographically cooler and wetter sites and at higher elevations. This association is not recognized in other areas.

Figure 93. Photo of the Silver Fir/Salal/Deerfern Association, Salmon River, Quinault District.

SILVER FIR/SALAL/OXALIS

Abies amabilis/Gaultheria shallon/Oxalis oregana
ABAM/GASH/OXOR CFS1 56

The Silver Fir/Salal/Oxalis Association is a major type of moist sites at low elevations, and moderately high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault and Soleduck Districts (Figure 94). Soils are mostly deep and moderately fine textured, and derived from colluvium or glacial till. They tend to be well drained and occur on gentle lowland slopes, in areas of high precipitation, high humidity, or fog. Soils appear to be moderately high in organic matter and nitrogen, but low in calcium and phosphorus. Little snow accumulates in this type during the winter. The typical area of this type has burned very seldom in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

Dominant understory species (Table 69) are salal (GASH) and oxalis (OXOR), which are usually present in all ages of stands. Oxalis may be rare in young second growth and salal may be inconspicuous or absent in densely stocked second growth. Oregongrape (BENE), red huckleberry (VAPA) and Alaska huckleberry (VAAL) are often present. Deerfern (BLSP), false lily-of-the-valley (MADI2), cutleaf goldthread (COLA) and swordfern (POMU) may also occur. Early seral species include salal, salmonberry (RUSP), and trailing blackberry (RUUR). The tree layer may be dominated by silver fir, western hemlock or western redcedar (Figure 95).

Ground mosses often have a moderate cover in this type, with an average of 26%. Mostly young stands were sampled for cryptogams, where *Eurhynchium oreganum* and *Plagiothecium undulatum* were most frequent. Other species may include *Hylocomium splendens*, *Rhytidiadelphus loreus* and *Polytrichum*. Data for epiphytes were only available for one plot, where *Isothecium stoloniferum* was most abundant, and the nitrogen-fixer *Lobaria oregana*, *Hypogymnia* spp. and *Platismatia* sp. also occurred.

Successional Relationships

There are successional pathways dominated by silver fir and western hemlock, with the hemlock sere being more common. Climax stages are dominated by both western hemlock and silver fir. Sampled stands of this type are not very old. In younger stands, a few planted Douglas-firs can persist, but there is some doubt whether they will be able to successfully compete with western hemlock and silver fir. There is no evidence that Douglas-fir ever occurred naturally in this type in old-growth stands.

Other Biota

Wildlife observations for this type indicate heavy use by mountain beaver and elk. Red huckleberry, Alaska huckleberry, salmonberry and western redcedar showed evidence of browse by mountain beaver and elk. Bear damage was observed on silver fir, and porcupine damage noted on Douglas-fir. Douglas squirrel were also recorded. Bird observations are limited to two plots where dark-eyed junco and winter wren were recorded.

Table 69.Common plants in the ABAM/GASH/OXOR Association, based on stands >150 years (n=7).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	84.7	84.7	100	55-98
silver fir	ABAM	22.1	22.1	100	10-43
western redcedar	THPL	19.3	33.7	57	0-88
GROUND VEGETATION					
oxalis	OXOR	36.0	36.0	100	7-85
salal	GASH	19.4	19.4	100	8-40
red huckleberry	VAPA	12.3	12.3	100	2-30
deerfern	BLSP	4.9	4.9	100	1-10
Oregongrape	BENE	10.0	11.7	85	0-25
Alaska huckleberry	VAAL	6.6	7.7	85	0-20
swordfern	POMU	4.6	5.3	85	0-8
cutleaf goldthread	COLA	2.0	2.3	85	0-3
false lily-of-the-valley	MADI2	5.4	9.5	57	0-35
salmonberry	RUSP	1.3	2.3	57	0-3

Environment and Soils

This type occurs on flat to steep, straight benches, flats, and lower to upper slopes, but rarely in bottoms or on ridgetops. The slope varied from 9% to 75% and averaged 44%. The regolith is usually colluvium derived from metabasalt, but may also be glacial deposits.

Three pits dug in this type show moderate soil development. Textures ranged from clay to more commonly sandy loam. The coarse fragment fraction averaged 41%, which is about average for the Silver Fir Zone. The O1 layer was thin at 1.3 cm and the O2 near average at 4.8 cm. This soil has a slightly below average water holding capacity, although the type is restricted to fairly moist environmental zones. Two of the pits were classified as haplumbrepts and one a haplorthod.

According to the Olympic Soil Resource Inventory (Snyder et al., 1969), these are usually shallow, well-drained, rapidly permeable colluvial soils. Where this type occurs on deep glacial soils, the subsoils are generally compacted rendering them effectively shallow. Textures tend to be silt loam and clay loam. The coarse fragments range from 5% to 65% near the surface, and 10% to 80% in the subsoils.

The mean soil temperature was 13.4 deg C (56.1 deg F), which is one of the warmest temperatures in the Silver Fir Zone. The temperature regime is lower frigid and the moisture regime is udic.

The mean of three nutrient analyses indicate relatively low phosphorus and calcium, and high nitrogen, organic matter and boron compared to other types. The pH was 4.8, which is lower than average for the series.

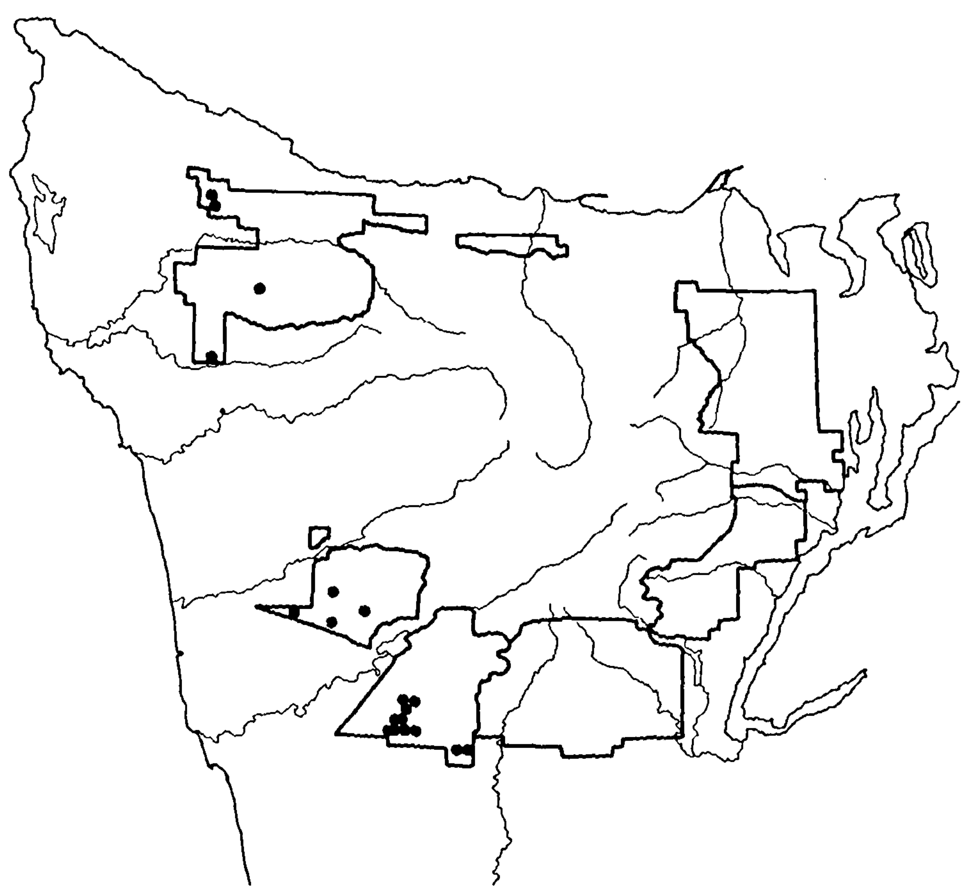


Figure 94. Map of plot locations for the Silver Fir/Salal/Oxalis Association.

Timber Productivity

Timber productivity of this type is moderate to high (Site III). This is due to the moistness of the site and relatively long growing season. Site index for Douglas-fir was 147, although this species was rare in this type. Site index for western hemlock averaged 116 (base 100) and 149 for silver fir (Table 70). The productivity potential using the site index-yield table approach averaged 172 cu ft/ac/yr. The empirical estimate of yield was 183 cu ft/ac/yr. The stockability of these sites is high. Productivity potential for western hemlock is higher than for Douglas-fir (which does not do well) on these sites. Western hemlock is probably the preferred species.

Management Considerations

Management considerations for this type include manipulation of species composition, regulation of stocking and regulation of nutrient balance. The available data indicate that stocking levels could be maintained at fairly high levels to maximize production, especially in mixed stands of silver fir and western hemlock. Accumulated soil organic matter and nitrogen should be preserved by reducing burning sites in this type, and by maintaining a component of alder in the ecosystem. However, in some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Response to fertilizer in this type is still unknown. However this type is often very low in calcium and phosphorus. This may be limiting growth or affecting tree development on these sites. We recommend that any fertilizer applications on this type include calcium and phosphorus. Wildlife values can be moderately high, especially for elk.

Root disease problems can include annosus root disease and Armillaria root disease on silver fir and western hemlock. Armillaria may be damaging to young-growth Douglas-fir planted on this type, but impact should be minimal after 30 years. Laminated root rot may occur on silver fir and western hemlock. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and western hemlock. Annosus root disease is probably the most important heart and butt rot of older stands on this type. Hemlock dwarf mistletoe is usually present on older western hemlock on this type, especially in Environmental Zones 0-5.

Insect problems may include silver fir beetle on windthrown, suppressed or diseased silver fir, western blackheaded budworm on western hemlock and silver fir buds, hemlock looper on western hemlock, and balsam woolly aphid on silver fir, especially at lower elevations.

Table 70. Timber productivity values for the Silver Fir/Salal/Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle[1])	2	4	147	50	149	250				183
Douglas-fir (Curtis[2])	2	4	151	33		250				
Western Hemlock (Barnes[3])	6	6	116	17	172			411	143	
Western Hemlock (Wiley[4])	3	12	109	4	216	479	13	411		183
Silver Fir (Hoyer[5])	4	10	149	29	154	539	10	577	261	183

1 Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

2 Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

3 Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

4 Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

5 Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

6 Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

7 Stand Density Index (Reinecke 1933).

8 Growth Basal Area (Hall 1987) (see Table 174 p. 494).

9 Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

10 Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Alaska Huckleberry/ Oxalis which occurs at higher elevations and Western Hemlock/Salal/Oxalis at lower elevations. The Silver Fir/Salal/Oxalis Association is only recognized in the Olympic Mountains. In previous classifications (Henderson and Peter 1981b, 1982a) it was included in the Silver Fir/Salal or Silver Fir/Oxalis types.

Figure 95. Photo of the Silver Fir/Salal/Oxalis Association, Salmon River, Quinault District.

SILVER FIR/SKUNKCABBAGE
Abies amabilis/Lysichitum americanum
ABAM/LYAM CFM1 11

The Silver Fir/Skunkcabbage Association is a minor type of wet sites with organic soils, at low to middle elevations, and moderate to low timber productivity. It is found sporadically in wet areas of the Forest. It was only sampled on the Quinault District (Figure 96). Soils are mostly deep with very high organic matter and are derived from alluvium or colluvium, or occur in filled-in ponds in areas of outwash or glacial till. They are very wet from subirrigation and occur in flat areas, sometimes on river terraces or broad stream bottoms. Moderate depths of snow accumulate in this type during the winter. The typical area of this type has burned very seldom in the last 1000 years, and most old-growth is very old. Some younger stands have originated from windstorms or cutting.

Floristic Composition

Dominant understory species (Table 71) are skunk cabbage (LYAM), Alaska huckleberry (VAAL) and salal (GASH) (mainly on logs). Other shrubs may include oval-leaf huckleberry (VAOV) and fool's huckleberry (MEFE). Common herbs may include five-leaved bramble (RUPE), cutleaf goldthread (COLA), deerfern (BLSP) and false lily-of-the-valley (MADI2). The tree layer may be dominated by silver fir, western hemlock, western redcedar, or any combination of these trees (Figure 97). Stands in this type are often understocked.

Ground mosses were only sampled on one plot in a 400 year old stand. Moss cover was abundant at 60%. *Rhytidiadelphus loreus* was the dominant species, other common mosses were *Eurhynchium oreganum, Hylccomium splendens.* No data are available on epiphytic mosses and lichens.

Successional Relationships

Red alder can dominate early seral stages in this association, which is unusual for the Silver Fir Zone. It dies out by about 80 years, often leaving an understocked stand of silver fir, hemlock or redcedar. Later, as the stand matures, openings may again be colonized by red alder. Besides this red alder dominated sere, there are successional pathways dominated by silver fir or western hemlock, with the hemlock sere being more common. Climax stages are dominated by silver fir, western hemlock and western redcedar.

Other Biota

Wildlife observations are limited to two plots for this type. Elk use was common. Heavily browsed species were skunkcabbage and swordfern. Oval-leaf huckleberry, salmonberry and beargrass were also browsed. Bird observations for two plots include varied thrush and brown creeper.

Table 71. Common plants in the ABAM/LYAM. Association, based on stands >150 years (n=2).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	51.0	51.0	100	50-52
western redcedar	THPL	48.5	48.5	100	40-57
silver fir	ABAM	20.5	20.5	100	20-21
red alder	ALRU	11.5	11.5	100	3-20
GROUND VEGETATION					
Alaska huckleberry	VAAL	17.5	17.5	100	15-20
salal	GASH	14.5	14.5	100	4-25
skunkcabbage	LYAM	10.5	10.5	100	6-15
oval-leaf huckleberry	VAOV	5.0	5.0	100	5-5
fool's huckleberry	MEFE	4.5	4.5	100	4-5
cutleaf goldthread	COLA	3.0	3.0	100	2-4
deerfern	BLSP	2.5	2.5	100	2-3
false lily-of-the-valley	MADI2	2.5	2.5	100	1-4
five-leaved bramble	RUPE	2.5	2.5	100	1-4
bunchberry	COCA	1.5	1.5	100	1-2
rosy twisted-stalk	STRO	1.5	1.5	100	1-2
queen's cup	CLUN	1.0	1.0	100	1-1
twinflower	LIBO2	1.0	1.0	100	1-1
licorice fern	POGL4	1.0	1.0	100	1-1
Oregon selaginella	SEOR	1.0	1.0	100	1-1
clasping-leaved twisted-stalk	STAM	1.0	1.0	100	1-1

Environment and Soils

This type occurs on flat to gently sloped, concave to straight, lower slopes and bottoms. The two plots sampled had slopes of 3% and 10%. Regolith and bedrock probably vary considerably as the overriding characteristic for this type is saturated soil. In most cases it appears that there is relatively little water movement associated with the wet soil and therefore the moisture regime is probably aquic. The temperature regime is probably frigid.

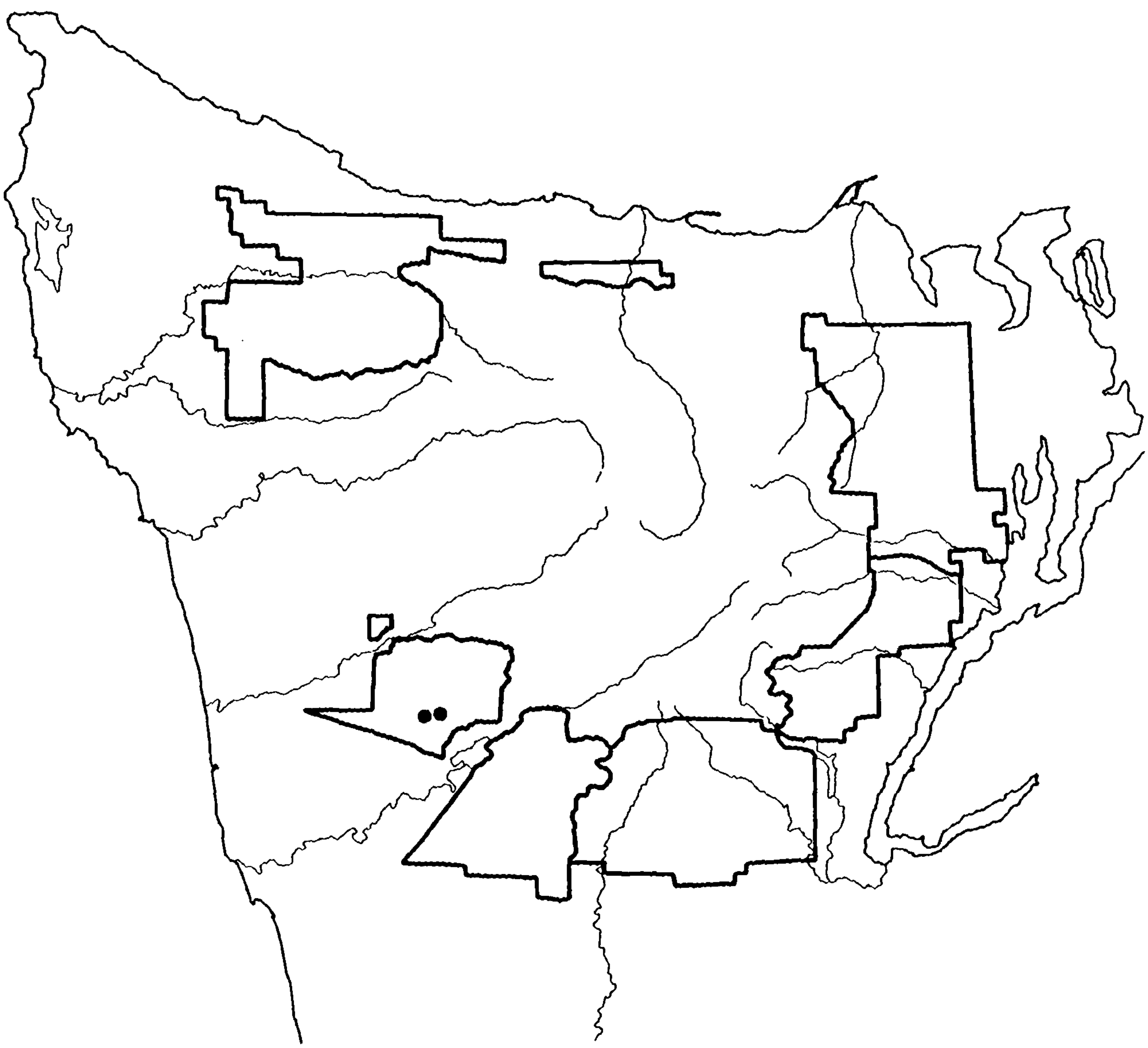


Figure 96. Map of plot locations for the Silver Fir/Skunkcabbage Association.

Timber Productivity

Timber productivity of this type is unknown, but is probably moderately low (Site V). The productivity potential for unmanaged stands is probably less than 100 cu ft/ac/yr. The stockability of these sites is low. Western hemlock or western redcedar are probably the preferred species on this type.

Management Considerations

Management considerations for this type include protection of fragile organic soils, wildlife habitat, and manipulation of species composition. Because of the wetness of these sites it may not be possible to burn in this type. Response to fertilizer in this type is still unknown. Wildlife values can be moderately high, especially for elk winter range.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe may be present in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Comparison with Similar Types

Similar types include Western Hemlock/ Skunkcabbage which occurs at lower elevations, and Silver Fir/Devil's Club which occurs on drier sites, generally in drier environmental zones and on sites with less organic soil. The Silver Fir/ Skunkcabbage Association is not previously recognized. It is known to occur in the Cascades north of Mt. Rainier, but it is not yet formally recognized there.

Figure 97. Photo of the Silver Fir/Skunkcabbage Association, Salmon River, Quinault District. The skunkcabbage in the foreground is heavily browsed by elk.

SILVER FIR/SWORDFERN
Abies amabilis/Polystichum munitum
ABAM/POMU CFF6 11

The Silver Fir/Swordfern Association is a minor type of moist sites and moderately high timber productivity. It is found throughout the Forest but mainly in the Humptulips and Wynoochee drainages (Figure 98). Soils may be shallow to deep and moderately coarse textured. They are derived from colluvium or glacial till and are often subirrigated. A shallow snowpack accumulates in this type, but it melts early in the spring. The typical area of this type has burned once or twice in the last 500 years.

Floristic Composition

Dominant understory species (Table 72) are swordfern (POMU), foamflower (TITR) and deerfern (BLSP), which may be inconspicuous or absent in very young stands or densely stocked second growth. Pearly everlasting (ANMA), fireweed (EPAN) and salmonberry (RUSP) tend to become established quickly after clearcut or fire. Shrubs may include red huckleberry (VAPA) and Oregongrape (BENE); vine maple (ACCI) and Alaska huckleberry (VAAL) may occur in small amounts. Vanillaleaf (ACTR) and queen's cup (CLUN) may also occur. The tree layer may be dominated by silver fir, western hemlock, western redcedar, or any combination of these trees (Figure 99). Douglas-fir occurs rarely, mostly in stands older than 300 years.

Ground moss cover is generally abundant on this type, ranging from 1% to 90% with an average cover of 31%. The most common and abundant species are *Hylocomium splendens* and *Plagiothecium undulatum*. Data for epiphytic mosses and lichens are only available for one 340 year old stand. *Sphaerophorus globosus* and crustose species were the most abundant lichens, other epiphytes present include *Isothecium stoloniferum*, the nitrogen-fixer *Lobaria oregana*, *Platismatia glauca*, *Hypnum circinale*, and species of *Hypogymnia*, *Dicranum* and *Cladonia*.

Successional Relationships

The common successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock. Douglas-fir was apparently a component of these stands sometime ago. In such stands where Douglas-fir is older than 300 years, silver fir is mostly younger than 200 years. This suggests that, at least for part of the area where this type occurs, it was Western Hemlock Zone 200 years ago (probably Western Hemlock/Swordfern-Foamflower Association).

Other Biota

Elk and mountain beaver activity were recorded for this type. Red huckleberry was heavily browsed, other browse species include Alaska huckleberry, salmonberry and vine maple. Douglas squirrel and shrew were also observed.

Birds observed on this type include woodpecker, chickadee, winter wren, golden-crowned kinglet, nighthawk, rufous hummingbird, varied thrush, dark-eyed junco and mountain chickadee.

Table 72. Common plants in the ABAM/POMU Association, based on stands >150 years (n=8).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	62.1	62.1	100	12-95
silver fir	ABAM	36.7	36.7	100	14-60
western redcedar	THPL	22.1	25.3	87	0-72
Douglas-fir	PSME	10.5	16.8	62	0-30
Pacific yew	TABR	1.4	3.7	37	0-6
GROUND VEGETATION					
swordfern	POMU	13.0	13.0	100	2-50
red huckleberry	VAPA	3.0	3.0	100	1-7
deerfern	BLSP	4.0	4.6	87	0-10
three-leaved foamflower	TITR	2.3	2.6	87	0-10
vanillaleaf	ACTR	6.3	10.0	62	0-25
Oregongrape	BENE	2.3	3.6	62	0-5
queen's cup	CLUN	1.3	2.0	62	0-3
rosy twisted-stalk	STRO	0.9	1.4	62	0-2
evergreen violet	VISE	0.9	1.4	62	0-2
salal	GASH	1.5	3.0	50	0-6
Alaska huckleberry	VAAL	1.3	2.5	50	0-3

Environment and Soils

This type occurs on gentle to steep, straight to concave, lower to upper slopes and toe-slopes. The slope varied from 11% to 110% and averaged 59%. The regolith is usually colluvial material derived from metabasalt, but may also be of glacial origin.

Two soil pits showed weak to moderate soil devlopment. Textures ranged from sandy loam to clay loam and coarse fragments averaged 67%, which is well above average. The O1 layer was slightly thicker than average at 3.0 cm and the O2 also thicker than average at 7.0 cm. The rooting depth went to 75 cm, which is deeper than average and also extended 7 cm into the O2. Bedrock was encountered in the two pits at 54 cm and 96 cm. The water holding capacity is low due to the high coarse fragment fraction, but these sites are probably subirrigated. One pit was classified a haplorthod and the other a dystrochrept.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils are usually shallow, well-drained, rapidly permeable colluvial soils but may also be deep glacial soils with compacted or cemented subsoils rendering them effectively shallow. Textures range from sandy loam to clay loam. The coarse fragments range from 15% to 70% near the surface to 35% to 85% in the subsoils.

The mean soil temperature was 11.3 deg C (52.4 deg F), which is warm for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

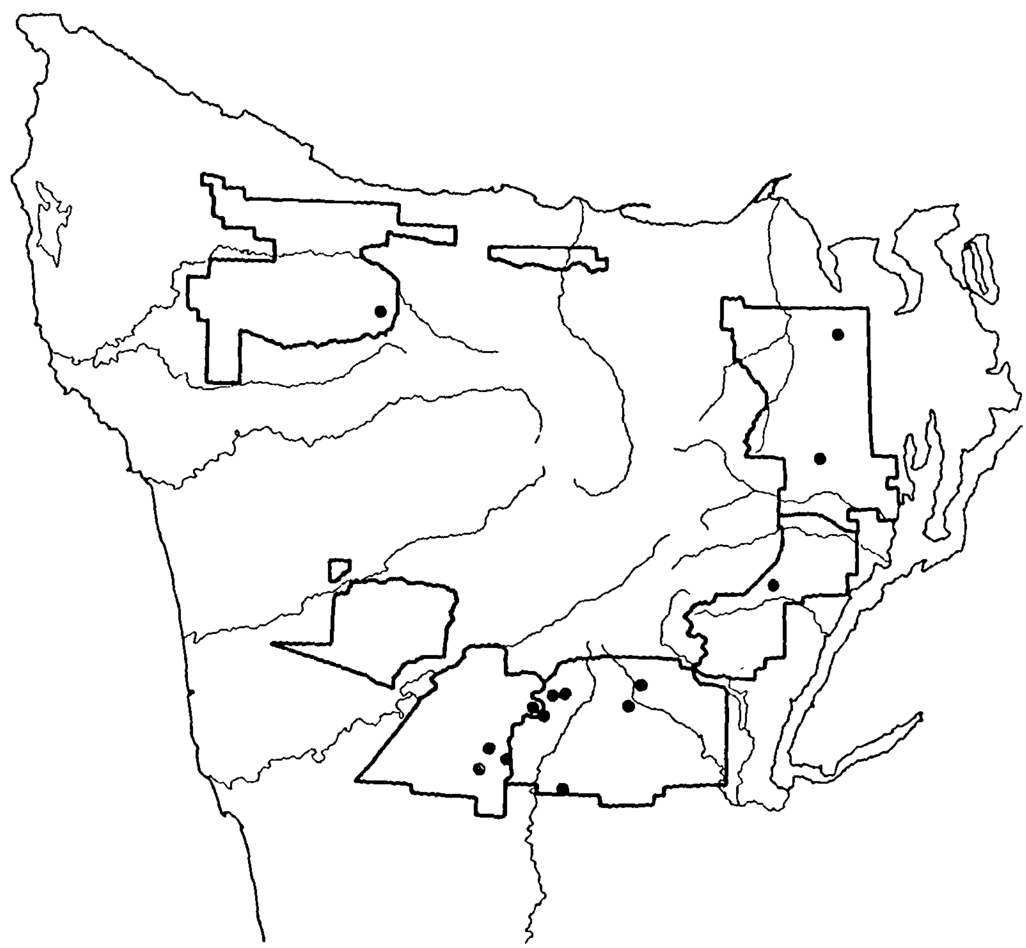


Figure 98. Map of plot locations for the Silver Fir/Swordfern Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index averaged 155 (base 100) for Douglas-fir, 145 for silver fir and 92 for western hemlock (base 50) (Table 73). The productivity potential using the site index-yield table approach averaged 170 cu ft/ac/yr for western hemlock and silver fir. The empirical yield estimate was 183 cu ft/ac/yr. The stockability of these sites is high. This is one of the more productive Silver Fir types. In many ways this type is more like Western Hemlock Zone types than the Silver Fir Zone.

Management Considerations

Management considerations for this type include manipulation of species composition and regulation of stocking. It is also important to maintain soil nutrients and organic matter. The available data (GBA=550-660) indicate that relatively high stocking levels could be maintained. Accumulation of soil organic matter and nitrogen should be preserved by reducing burning sites in this type. Response to fertilizer in this type is still unknown.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot on silver fir and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe may be present in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Table 73. Timber productivity values for the Silver Fir/Swordfern Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA [10]	EMAI [11]
Douglas-fir (McArdle[1])	2	10	155	1	164	508				183
Douglas-fir (McArdle[2])	2	2	176	57						
Douglas-fir (Curtis[3])	2	10	143	27		508				
Douglas-fir (King[4])	1	5	113		164					
Western Hemlock (Wiley[5])	3	11	92	4	189	417	9	550		183
Silver Fir (Hoyer[6])	4	12	145	10	151	477	10	660	291	183

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.

[3] Base age 100. Breast height age (Curtis et al. 1974). ages 25 to 400 years.

[4] Base age 50. Breast height age (King 1966). ages 25 to 120 years.

[5] Base age 50. Breast height age (Wiley 1978a,b). ages 25 to 120 years.

[6] Base age 100. Breast height age (Hoyer and Herman. in press). ages 25 to 400 years.

[7] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[8] Stand Density Index (Reinecke 1933).

[9] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[10] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[11] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Silver Fir/Vanillaleaf-Foamflower on somewhat drier sites at higher elevations, and Western Hemlock/Swordfern-Foamflower at lower elevatons and in drier environmental zones. The Silver Fir/Swordfern Association is previously recognized only on the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1984, 1985) and Olympic National Forest (Henderson and Peter 1981b). It is closely related to the upper elevational examples of the widespread Western Hemlock/ Swordfern types.

Figure 99. Photo of the Silver Fir/Swordfern Association, young-growth silver fir, Salmon Creek, Quilcene District.

SILVER FIR/SWORDFERN-OXALIS

Abies amabilis/Polystichum munitum-Oxalis oregana
ABAM/POMU-OXOR CFF6 12

The Silver Fir/Swordfern-Oxalis Association is a major type of moist sites at low elevations, and moderately high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault District (Figure 100). Soils tend to be moderately deep and moist. They are derived from colluvium, outwash or glacial till, and often occur along toe-slopes, and in areas of high precipitation, high humidity or fog. Little snow accumulates in this type during the winter. The typical area of this type has burned very seldom in the last 500 years, and most old-growth stands are very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

Dominant understory species (Table 74) are swordfern (POMU) and oxalis (OXOR). Swordfern is usually present even in young stands. Shrubs may include red huckleberry (VAPA), Alaska huckleberry (VAAL) and salmonberry (RUSP) in small amounts. Deerfern (BLSP) and foamflower (TITR) may also occur. The tree layer is dominated by silver fir and western hemlock, with small amounts of western redcedar (Figure 101).

Ground mosses are moderate to abundant on this type, with an average of 30% cover. The common species are *Plagiothecium undulatum*, *Hylocomium splendens* and *Eurhynchium oreganum*. Other species which may occur are the ground lichen *Peltigera*, and *Hypnum circinale* on rotting wood. Data for epiphytic mosses and lichens are limited to one 280 year old stand, where *Isothecium stoloniferum* was the most abundant epiphytic moss. Other species present include crustose lichens, *Sphaerophorus globosus*, and the nitrogen-fixer, *Lobaria oregana*.

Successional Relationships

The common successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by western hemlock and silver fir. Douglas-fir is rare in this type even in old stands. Silver fir trees are mostly less than 220 years old, but may be up to 290 years.

Other Biota

Wildlife observations for this type show frequent use by deer and elk. Red huckleberry, salmonberry, swordfern and Alaska huckleberry were frequently browsed; other browse species include Oregongrape, western hemlock, devil's club, bracken fern, woodrush and elderberry. Deer and mountain beaver had sign of recent activity in late June. Porcupine damage was observed on silver fir and Douglas-fir. Douglas squirrel and chipmunk were also recorded.

Bird observations were frequent for varied thrush, winter wren, red-breasted nuthatch and western flycatcher. A varied thrush nest was observed in western hemlock. Other birds include American robin, solitary vireo, hairy woodpecker, pileated woodpecker, chestnut-backed and black-capped chickadee, red crossbill and Steller's jay.

Table 74.Common plants in the ABAM/POMU-OXOR Association, based on stands >150 years (n=24).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	74.7	74.7	100	42-99
silver fir	ABAM	26.2	26.2	100	8-56
western redcedar	THPL	3.2	5.8	54	0-20
Douglas-fir	PSME	1.0	8.0	12	0-11
GROUND VEGETATION					
oxalis	OXOR	38.7	38.7	100	2-95
swordfern	POMU	18.2	18.2	100	2-75
three-leaved foamflower	TITR	1.3	1.3	95	0-3
red huckleberry	VAPA	2.5	2.8	91	0-8
deerfern	BLSP	2.0	2.2	91	0-6
Alaska huckleberry	VAAL	2.7	3.8	70	0-15
ladyfern	ATFI	0.7	1.1	66	0-2
trillium	TROV	0.6	1.0	58	0-1
salmonberry	RUSP	1.0	1.8	54	0-5
cutleaf goldthread	COLA	0.6	1.1	54	0-2
evergreen violet	VISE	0.6	1.3	50	0-3
small-flowered woodrush	LUPA	0.5	1.0	50	0-1

Environment and Soils

This type occurs on moderate to steep, straight to concave, lower to upper slopes and benches. The slope varied from 32% to 85% and averaged 54%. The regolith is usually colluvium of metabasaltic or sandstone origin, but may also be of alpine or continental glacial origin.

Two soil pits showed weak soil development. Textures ranged from sandy loam to clay, and coarse fragments averaged 45%, which is more than average. The O1 layer was 2.5 cm, which is average, and the O2 was 1.5 cm, which is much less than average. The rooting depth was 76.5 cm, which is a little deeper than average, but also went 1.5 cm up into the O2. This is one of the few types in which earthworms were found in a pit. The water holding capacity of the soil is average indicating that the type is moist due to climate more than soil. One of the pits was classified as a haplumbrept and the other as a dystrochrept.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), these soils tend to be shallow, well-drained, rapidly permeable colluvial soils. Deep glacial soils with compacted subsoils (rendering them effectively shallow) are also possible. Textures vary from sandy loam to silt loam. The coarse fragments range from 5% to 65% near the surface, and 10% to 85% in the subsoil.

The mean summer soil temperature was 11.9 deg C (53.4 deg F), which is warm for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

One soil nutrient analysis indicated relatively low sulfate and copper, relatively high potassium, total nitrogen, sodium, calcium and boron. The pH was 5.0, which is about average for the series.

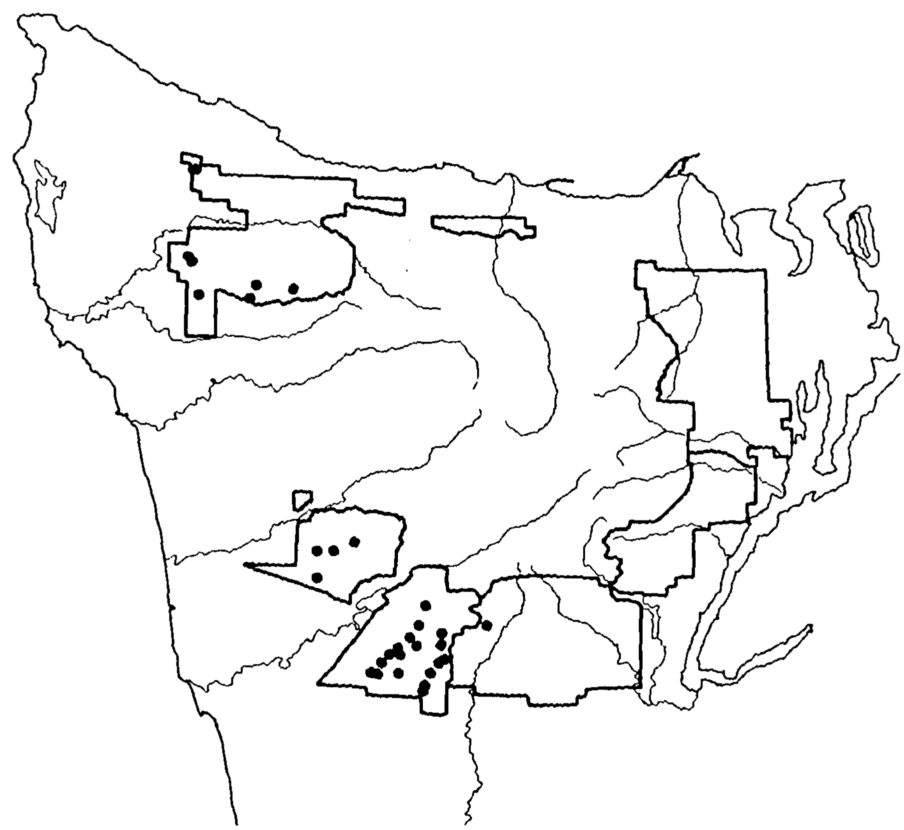


Figure 100. Map of plot locations for the Silver Fir/Swordfern-Oxalis Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index for western hemlock averaged 129 (base 100) and 154 for silver fir (Table 75). Douglas-fir site index was 203 based on its occurrence on only one plot. The productivity potential using the site index-yield table approach averaged 176 cu ft/ac/yr for silver fir and western hemlock. The empirical yield estimate was 183 cu ft/ac/yr. The stockability of these sites is moderate to high.

Management Considerations

Management considerations for this type include manipulation of species composition and regulation of stocking. Preferred species are silver fir and western hemlock. In some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Many oxalis types show very low amounts of calcium and phosphorus. Wildlife values can be moderately high, especially for elk winter range and deer.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe is usually present in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Table 75. Timber productivity values for the Silver Fir/Swordfern-Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle[1])	1	5	203		211	336				183
Douglas-fir (Curtis[2])	1	5	177			336				
Western Hemlock (Barnes[3])	12	12	129	23	195				148	
Silver Fir (Hoyer[4])	4	13	154	42	157	441	11	383	180	183

[1] Base age 100, Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.

[2] Base age 100. Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[3] Base age 100. Total age (Barnes 1962). Reconnaissance plots only, ages 25 to 400 years.

[4] Base age 100. Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[6] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 191 p. 498).

Comparison with Similar Types

Similar types include Western Hemlock/Swordfern-Oxalis at lower elevations, Silver Fir/Oxalis in more humid areas, and Silver Fir/Salal/Oxalis on poorer and drier sites. The Silver Fir/Swordfern-Oxalis Association is not recognized elsewhere. It is similar to the Silver Fir/Oxalis type found on the Mt. Hood and Willamette National Forest (Hemstrom *et al.* 1982). It is similar to the Silver Fir-Western Hemlock/Oxalis type of Fonda and Bliss (1969) and is represented within the Silver Fir-Western Hemlock/Oxalis type of Smith and Henderson (1986).

Figure 101. Photo of the Silver Fir/Swordfern-Oxalis Association, young-growth stand, Matheny Creek, Quinault District.

SILVER FIR/VANILLALEAF-FOAMFLOWER
Abies amabilis/Achlys triphylla-Tiarella unifoliata
ABAM/ACTR-TIUN CFF2 11

The Silver Fir/Vanillaleaf-Foamflower Association is a minor type of moist sites and moderate timber productivity. It is found throughout much of the Olympics (Figure 102), mostly on cove-like microsites. Soils are derived from colluvium or glacial till. They are often subirrigated, and often occur on benches or in gentle draws. The typical area of this type has burned once or twice in the last 700 years.

Floristic Composition

The dominant understory species (Table 76) are vanillaleaf (ACTR), queen's cup (CLUN), foamflower (TIUN and TITR), twinflower (LIBO2), rosy twisted-stalk (STRO) and five-leaved bramble (RUPE), which are often absent in young stands, and may be inconspicuous or absent in densely stocked second growth. Shrubs are usually very sparse. The tree layer is usually dominated by silver fir and western hemlock; western redcedar and Douglas-fir may also occur (Figure 103). Few areas of this type have been cut over. Most stands are greater than 500 years old.

Ground mosses are relatively sparse on this type, with an average cover of 8%. The common mosses include *Rhytidiopsis robusta*, *Dicranum* sp., and *Hypnum circinale* and *Scapania bolanderi* on rotting wood or lower tree boles. Occasionally, *Rhytidiadelphus triquestrus*, *Rhizomnium glabresens* and *Peltigera* sp. may occur. The common epiphytic lichens are *Alectoria sarmentosa*, *Platismatia glauca*, *Parmeliopsis hyperopta*, crustose species and *Bryoria* spp.

Successional Relationships

The common successional pathway is dominated by silver fir and western hemlock. Climax stages are dominated by both silver fir and western hemlock, with small amounts of western redcedar. There are limited old-growth examples of this association, and some stands contain Douglas-fir more than 300 years old. Older examples of this type include silver fir trees up to 530 years old.

Other Biota

Bear damage to silver fir or western hemlock occurred on all three plots in this type where wildlife observations were recorded. Deer sign and Douglas squirrel were also observed.

Birds frequently observed were red-shafted flicker, chesnut-backed chickadee and golden-crowned kinglet. Other birds recorded include woodpeckers, common raven, red-breasted nuthatch and winter wren.

Table 76. Common plants in the ABAM/ACTR-TIUN Association, based on stands >150 years (n=7).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
silver fir	ABAM	47.6	47.6	100	30-70
western hemlock	TSHE	39.6	39.6	100	25-60
Douglas-fir	PSME	12.7	17.8	71	0-40
western redcedar	THPL	3.6	8.3	42	0-10
GROUND VEGETATION					
vanillaleaf	ACTR	12.3	12.3	100	2-30
queen's cup	CLUN	5.1	5.1	100	1-20
three-leaved foamflower	TITR	3.7	4.3	85	0-12
five-leaved bramble	RUPE	3.7	5.2	71	0-15
rosy twisted-stalk	STRO	2.7	3.8	71	0-8
swordfern	POMU	1.0	1.4	71	0-2
evergreen violet	VISE	1.0	1.4	71	0-2
trillium	TROV	0.7	1.0	71	0-1
red huckleberry	VAPA	0.7	1.0	71	0-1
twinflower	LIBO2	4.1	7.3	57	0-20
ladyfern	ATFI	1.4	2.5	57	0-5
devil's club	OPHO	1.0	1.8	57	0-3

Environment and Soils

This type occurs on flat to steep, concave or straight, lower to upper slopes and benches. The slope ranges from 0% to 78% and averages 45%. The regolith is usually basaltic colluvium, but may also be continental glacial in origin.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969) these soils are usually shallow, well-drained, rapidly permeable colluvial soils, but may also be deep, glacial soils with compacted or cemented subsoils rendering them effectively shallow. The textures vary from silt loams to sandy loams. The coarse fragments range from 15% to 70% near the surface and 35% to 80% in the subsoils.

The mean soil temperature was 10.2 deg C (50.3 deg F) which is slightly cooler than average for the Silver Fir Zone. The temperature regime is frigid and the moisture regime is udic.

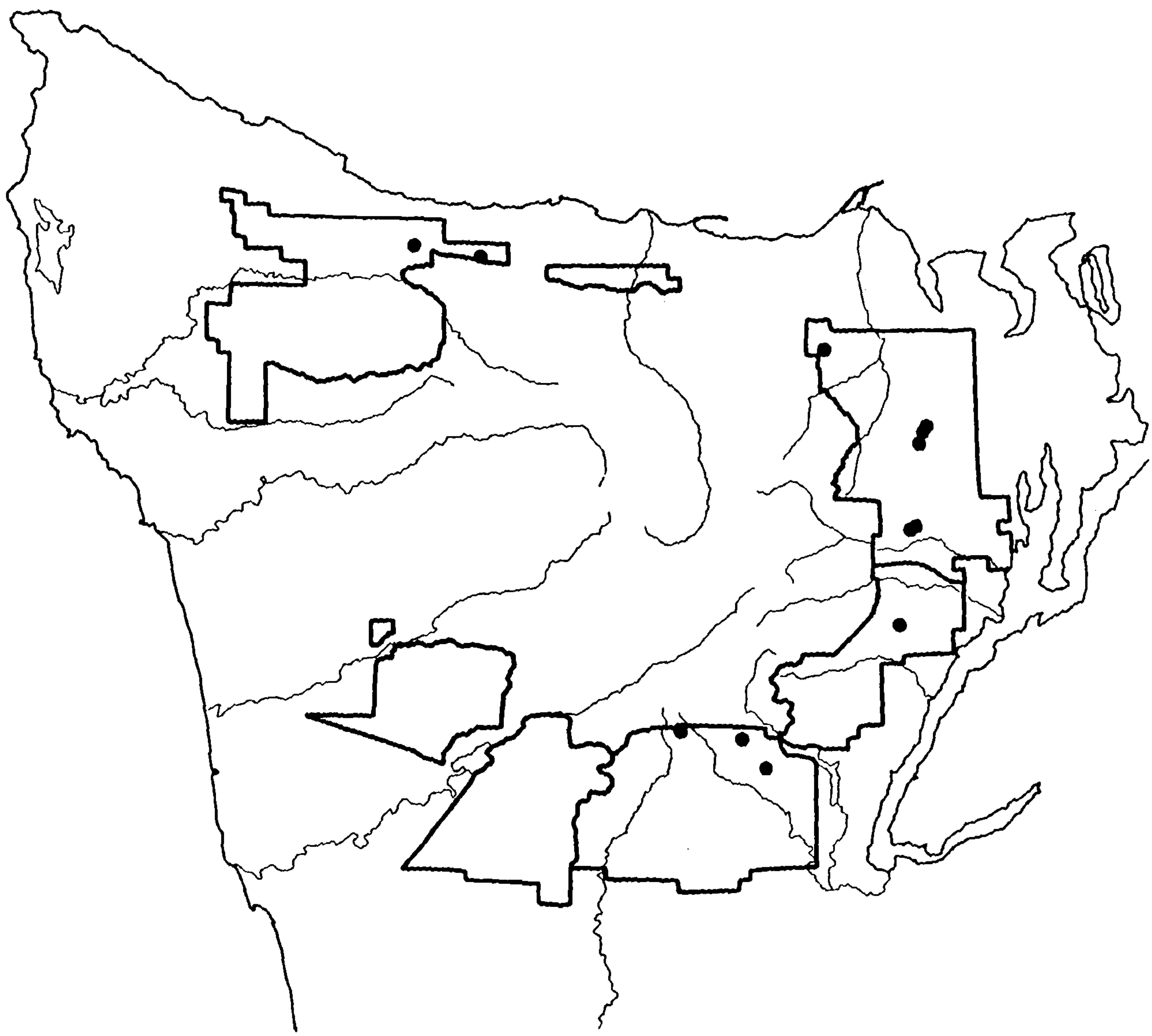


Figure 102. Map of plot locations for the Silver Fir/Vanillaleaf-Foamflower Association.

Timber Productivity

Timber productivity is moderate (Site IV). This is due to the moistness of the site and favorable soils. Site index (base 100) averaged 113 for Douglas-fir, 103 for silver fir and 63 (base 50) for western hemlock (Table 79). The productivity potential using the site index-yield table approach averaged 122 cu ft/ac/yr for western hemlock and silver fir. Douglas-fir occurs sporadically in old-growth stands and exhibits a high site index. However, as on most Silver Fir Zone types, Douglas-fir is not doing well in young-growth stands. Productivity potential for western hemlock and silver fir is probably higher than for Douglas-fir. Stockability appears to be moderately high.

Management Considerations

Management considerations for this type include manipulation of species composition and ensuring rapid initial stocking. It is also important to maintain soil nutrients and organic matter. Advance regeneration of silver fir and western hemlock should be preserved by reducing burning sites in this type. Response to fertilizer in this type is still unknown. Western hemlock and silver fir are the preferred species. Wildlife values are moderate.

Root disease problems can include annosus root disease on western hemlock and silver fir, Armillaria root disease on suppressed or stressed trees of all species, and possibly laminated root rot on western hemlock and silver fir. The most serious disease may be annosus root disease in thinned plantations and old-growth stands. Heart and butt rots may include red ring rot on western hemlock, rusty red stringy rot and annosus root disease on western hemlock and silver fir. Hemlock dwarf mistletoe may be present in old-growth western hemlock stands.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and silver fir, balsam woolly aphid on silver fir and silver fir beetle on windthrown, diseased or stressed silver fir.

Table 77. Timber productivity values for the Silver Fir/Vanillaleaf-Foamflower Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA [10]	EMAI
Douglas-fir (McArdle[1])	1	4	113		107	734	3	708	240	
Douglas-fir (McArdle[2])	3	3	118	5						
Douglas-fir (Curtis[3])	1	4	126			734	3	708	240	
Douglas-fir (King[4])	1	4	84		98					
Western Hemlock (Wiley[5])	2	7	63	8	152	714	9	364		
Silver Fir (Hoyer[6])	2	9	103	6	92	714				

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.

[3] Base age 100. Breast height age (Curtis et al. 1974). ages 25 to 400 years.

[4] Base age 50. Breast height age (King 1966). ages 25 to 120 years.

[5] Base age 50. Breast height age (Wiley 1978a.b). ages 25 to 120 years.

[6] Base age 100. Breast height age (Hoyer and Herman. in press). ages 25 to 400 years.

[7] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[8] Stand Density Index (Reinecke 1933).

[9] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[10] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include Silver Fir/Swordfern in wetter environmental zones or at lower elevations. The Silver Fir/Alaska Huckleberry/Queen's Cup type occurs on somewhat drier and less productive sites. The Silver Fir/Vanillaleaf-Foamflower Association is similar to types recognized throughout much of Washington and Oregon as Silver Fir/Vanillaleaf or Silver Fir/Rosy Twisted-stalk. The Silver Fir/Foamflower Association is recognized as far south as the H.J. Andrews Experimental Forest (Dyrness *et al.* 1976). It was also recognized on the Willamette and Mt. Hood National Forest (Hemstrom *et al.* 1982). The Silver Fir/Vanillaleaf-Queen's Cup Association is recognized on the Gifford Pinchot National Forest by Brockway *et al.* (1983), while Franklin (1966) for the same area recognized Silver Fir/Foamflower, Silver Fir/Rosy Twisted-stalk and Silver Fir/Vanillaleaf. These types have more of a shrub component and are apparently less productive than the herb-rich Silver Fir/Vanillaleaf-Foamflower Association from the Olympics. In Mt. Rainier National Park (Franklin *et al.* 1988) the Silver Fir/Foamflower type is also similar but contains a larger shrub component than ours. It appears to have some similarities to the Douglas-fir-Western Hemlock/Alaska Huckleberry-Twinflower type of del Moral *et al.* (1976) in the Snoqualmie River drainage. In the Cascades it was referred to as Silver Fir/Rosy Twisted-stalk (Henderson and Peter 1981c) and Silver Fir/Foamflower (Henderson and Peter 1982b, 1984). In the Olympics we also recognized the Silver Fir/Rosy Twisted-stalk (Henderson and Peter 1981a) and Silver Fir/Foamflower (Henderson and Peter 1982a, 1983a). In Olympic National Park it is represented by the Silver Fir-Alaska Yellowcedar/Foamflower Association (Smith and Henderson 1986). It is not formally recognized in British Columbia but is similar in some respects to the Silver Fir/*Rhytidiopsis robusta* Association of Haeussler *et al.* (1982).

Figure 103. Photo of the Silver Fir/Vanillaleaf-Foamflower Association, Four Stream, Hood Canal District.

SITKA SPRUCE SERIES

SITKA SPRUCE SERIES

Picea sitchensis

PISI

The Sitka Spruce Series (Zone) covers about 18,000 acres (3%) of the Olympic National Forest (Figure 104). It occurs in lowland areas in the wetter parts of the Forest, up to about 600 feet elevation. At higher elevations or out of the summer fog belt it is replaced by the Silver Fir Zone or Western Hemlock Zone. The Sitka Spruce Zone includes some of the most productive lands on the Forest due to the warm, moist soils and low atmospheric drought where it occurs.

The climate of the Sitka Spruce Zone is characterized as wet maritime. Winter and summer temperatures are moderate. Average January temperature is about 4 deg C (40 deg F), which is very close to the winter soil temperature at 8 inches (20 cm). Summer temperature averages about 16 deg C (60 deg F) which is close to mid-summer soil temperature readings at 8 inches (20 cm). Precipitation averages about 150 inches annually. In addition, fog and clouds can contribute a significant amount of "precipitation" in the form of tree drip during the summer. Snow accumulations are low. Winds are significant.

Soils are typically warm and moist with a well developed O horizon. They may sometimes be cool but not dry. The texture may vary from fine to coarse with many coarse fragments. They occupy primarily gentle valley bottoms, lower slopes and toe-slopes on the west and southwest sides of the Olympic Mountains. The most common regolith is deep alpine and continental glacial drift and alluvium. On toe-slopes and lower slopes deep colluvium is common.

The soil moisture regime is nearly always udic which indicates the rooting zone is usually moist throughout the summer. A few types may be aquic (saturated for extended periods). The Sitka Spruce Zone straddles the soil temperature regime boundary between mesic (average annual temperature higher than 8 deg C) and frigid (average annual temperature less than 8 C, but with a greater than 5 deg C summer-winter fluctuation).

Organic layers do not tend to be very thick (2-7 cm) in this series which is probably a reflection of favorable conditions for decomposition.

Only inceptisols and entisols were sampled, but it is probable that spodosols are also present.

The dominant tree species are Sitka spruce, western hemlock and western redcedar. Douglas-fir is uncommon. Western hemlock, western redcedar and Sitka spruce dominate the climax stage of succession. Red alder is a major early seral species in the wetter parts of the Sitka Spruce Zone as it is in the Western Hemlock Zone.

Root disease problems can include annosus root disease in western hemlock, and Armillaria root disease in stressed western hemlock and Sitka spruce. Annosus root disease represents the most serious potential threat to western hemlock productivity on this type, especially after 120 years of age or in repeatedly thinned stands (see discussion of annosus root disease p. 68). Armillaria root disease can be a problem to Douglas-fir in plantations, but by age 30 impacts should be minimal. Heart and butt rots of concern are annosus root disease and red ring rot in western hemlock. Hemlock dwarf mistletoe is common in old-growth western hemlock.

The most damaging insect is the spruce weevil which attacks terminal leaders of Sitka spruce in plantations. Hemlock looper may be present in western hemlock, western blackheaded budworm may be present on western hemlock and Sitka spruce growing tips.

Potential yield for the Sitka Spruce Series was estimated using three methods. The first method was the site index curve and yield table method. For Sitka spruce we used the site index curve of Hegyi *et al*. (1979) and the yield table of Meyer (1937). For Western hemlock and Douglas-fir we used the same curves as for the Western Hemlock Series. The second method used an empirical volume curve which was generated from the plot data. The third method used the SI-GBA method of Hall (1983, 1987). The empirical curve was for stands as they existed on the Forest and is therefore not species specific.

Therefore the empirical mean annual increment "EMAI" is the same for Douglas-fir, western hemlock or Sitka spruce. The yield table estimate for stands of Douglas-fir is less than the empirical yield estimate (Table 81), while the yield table estimates for western hemlock and Sitka spruce are greater. The yield estimates using Hall's SI-GBA were close to the empirical and yield table values for western hemlock, but were much greater for Douglas-fir and Sitka spruce. The four most reliable estimates for the Sitka Spruce/Swordfern-Oxalis Association range from 189 to 244 cubic feet per acre per year.

One plant association is recognized in the Sitka Spruce Series on the Olympic National Forest. It is described by 63 Reconnaissance and Intensive plots taken from 1979 to 1985. Environmental values and relative species coverages for this association are summarized in Tables 78 and 79 (p. 247). There are a few plots which do not fit the Sitka Spruce/Swordfern-Oxalis Association description and may properly belong to one or more additional Sitka Spruce Associations. These may be recognized at a later date. Of these, the most likely to be identified would be a devil's club dominated type.

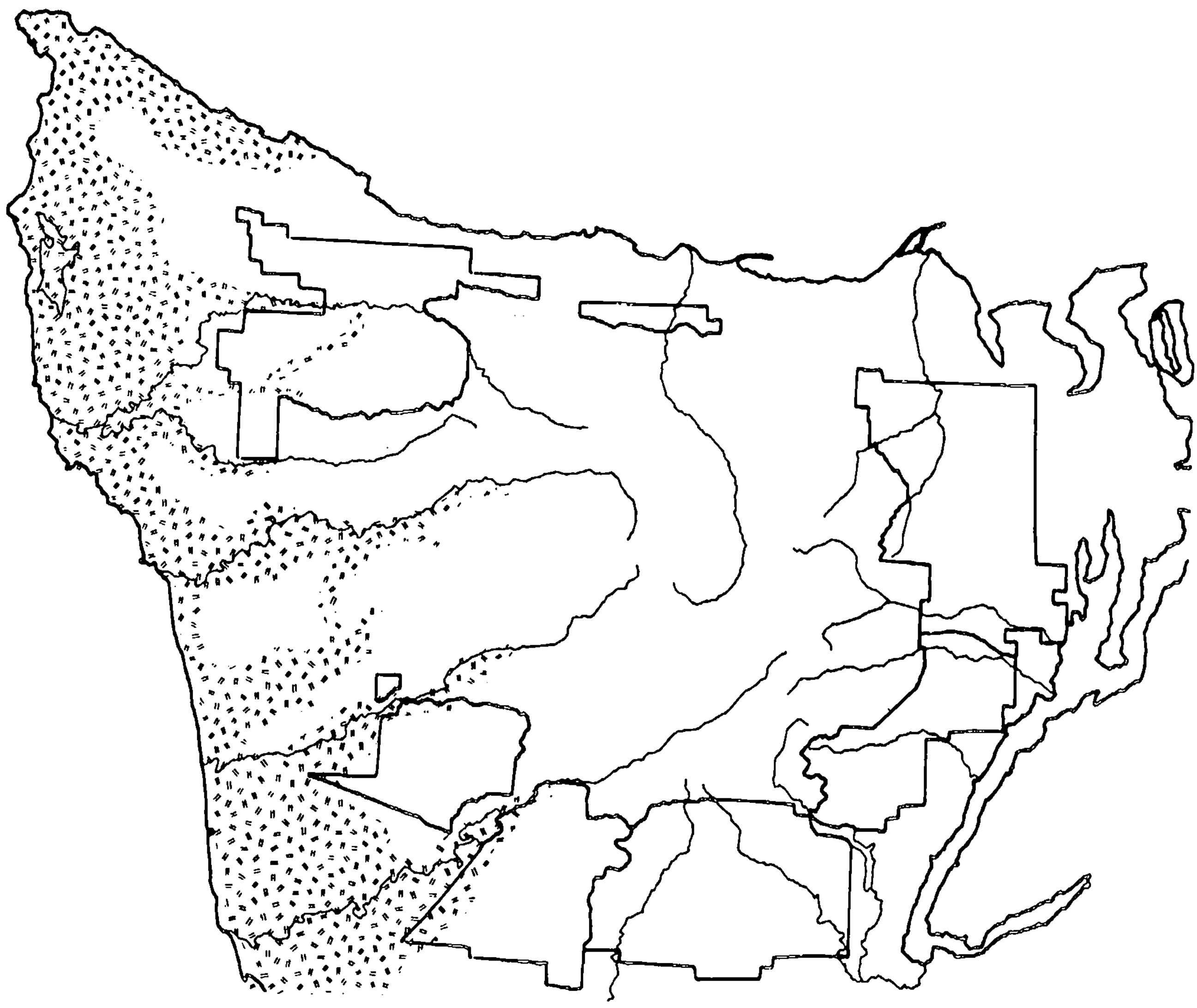


Figure 104. Map of the Sitka Spruce Zone on the Olympic Peninsula. The mapped area depicts a mosaic of both Western Hemlock and Sitka Spruce Zones.

Table 78. Environmental values for Sitka Spruce/ Swordfern-Oxalis Association. Slope, elevation and topographic moisture are mean values for the sample.

ECOCLASS Code[1]	CSF1 11
Number of plots[2]	63
Aspect	Flat, S-NE
Slope (%)	8
Elevation (ft.)	645
Environmental Zone[3]	2-6 (0-8)
Topographic Moisture[4]	5.7
Soil Moisture Regime[5]	udic
Soil Temperature (deg C)[6]	12.8 (28)
Soil Temperature Regime[7]	frigid, mesic

[1] See Table 161 p. 443

[2] Number of plots includes all successional stages sampled.

[3] See Figure 24 p. 40, and discussion p. 38.

[4] See discussion p. 84. Table 146 p. 417.

[5] See discussion p. 44.

[6] Summer soil temperature at 20 cm for mature and old-growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.

[7] See discussion p. 44-45.

Table 79. Mean relative cover values[1] and constancy[2] of trees, shrubs and herbs for the Spruce/Swordfern-Oxalis Association. Cover values based on stands 150 years and older.

ECOCLASS Code		CSF1 11
Number of plots		26
TREES		
ABAM	Silver fir	6 (7)
ACMA	Bigleaf maple	19 (7)
ALRU	Red alder	26 (15)
PISI	Sitka spruce	29(100)
PSME	Douglas-fir	4 (11)
RHPU	Cascara	2 (50)
THPL	Western redcedar	4 (30)
TSHE	Western hemlock	61(100)
SHRUBS AND HERBS		
ACCI	Vine maple	18 (46)
ARCA6	Dwarf mistletoe	2 (19)
ATFI	Ladyfern	2 (80)
BLSP	Deerfern	4 (96)
CADE	Dewey's sedge	2 (11)
CIAL	Enchanter's nightshade	5 (38)
CHGL	Western golden-carpet	2 (7)
CLUN	Queen's cup	10 (3)
COLA	Cutleaf goldthread	1 (3)
DIHO	Hooker's fairybell	1 (7)
DRAU2	Woodfern	2 (46)
GASH	Salal	2 (46)
GATR	Fragrant bedstraw	2 (42)
GYDR	Oakfern	1 (15)
HYTE	Pacific waterleaf	4 (11)
LICO3	Heartleaf twayblade	2 (7)
LUPA	Small-flowered woodrush	1 (57)
LYAM	Skunkcabbage	3 (3)
MADI2	False lily-of-the-valley	4 (38)
MEFE	Fool's huckleberry	3 (42)
MOSI	Candyflower	2 (26)
OPHO	Devil's club	3 (11)
OSCH	Sweet cicely	1 (11)
OXOR	Oxalis	45(100)
POGL4	Licorice fern	1 (19)
POMU	Swordfern	18(100)
PYSE	Sidebells pyrola	1 (7)
PYUN	Woodnymph	1 (15)
RIBR	Stink currant	2 (7)
RUPE	Five-leaved bramble	10 (53)
RUSP	Salmonberry	15 (96)
RUUR	Trailing blackberry	2 (11)
SARA	Red elderberry	3 (11)
SEOR	Oregon selaginella	7 (19)
SMST	Star-flowered solomon's seal	1 (7)
STME2	Mexican betony	1 (23)
TITR	Three-leaved foamflower	8 (88)
TOME	Piggyback, Youth-on-age	5 (30)
TRCA	Big trisetum	2 (15)
TRCE	Nodding trisetum	1 (11)
TROV	Trillium	1 (23)
VAAL	Alaska huckleberry	10 (76)
VAOV	Oval-leaf huckleberry	9 (15)
VAPA	Red huckleberry	4 (80)
VIGL	Pioneer violet	1 (15)
VISE	Evergreen violet	2 (7)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 168 p. 464 for mean absolute cover values.

[2] Constancy is the percentage of plots for that association where the species occurred.

SITKA SPRUCE/SWORDFERN-OXALIS

Picea sitchensis/Polystichum munitum-Oxalis oregana
PISI/POMU-OXOR CSF1 11

The Sitka Spruce/Swordfern-Oxalis Association is a type of moist sites at low elevations and high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Soleduck and Quinault Districts (Figure 105), in Environmental Zones 0-6. Soils are mostly deep, moist and highly weathered. They are derived from colluvium, outwash or glacial till and occur along toe-slopes, or in areas of high precipitation, high humidity or fog. Soils appear to be low in calcium and phosphorus. Little snow falls in this type during the winter. The typical area of this type has burned very seldom in the last 500 years.

Floristic Composition

Dominant understory species (Table 80) are oxalis (OXOR) and swordfern (POMU). Vine maple (ACCI) and salmonberry (RUSP) often resprout rapidly after clearcut or fire, and swordfern is usually present even in young stands. Other shrubs may include Alaska huckleberry (VAAL), red huckleberry (VAPA) and fool's huckleberry (MEFE). Deerfern (BLSP), foamflower (TITR), ladyfern (ATFI), five-leaved bramble (RUPE) may also occur. The tree layer is usually dominated by western hemlock and Sitka spruce (Figure 106). Red alder, bigleaf maple, western redcedar, or cascara may also occur. Douglas-fir is rare.

Ground mosses are an important component of this association in both young and old-growth stands, ranging from 3% to 95% cover with the average of 48%. Ground mosses which are most common and abundant are *Eurhynchium oreganum*, *Hylocomium splendens* and *Rhytidiadelphus loreus*. Other species which may occur include *Leucolepis menziesii*, *Plagiomnium insigne*, *Eurhynchium praelongum*, *Rhizomnium glabrescens*, and occasionally *Peltigera* and *Sphagnum* species.

Data for epiphytic mosses and lichens are limited to one old-growth stand and two young-growth stands. *Isothecium stoloniferum* was the common epiphytic moss in these three stands, but was particularly abundant in the old-growth stand, where *Lobaria oregana* was also observed. Epiphytic lichens are uncommon.

Successional Relationships

Red alder often dominates or codominates early seral stages in this association. It dies out by about 80 years, often leaving an understocked stand of spruce and hemlock. Red alder may reappear in some older stands which have been partially opened up by windthrow. Besides this alder dominated sere, there are early successional stages dominated by Sitka spruce and western hemlock, and some young plantations which are dominated by Douglas-fir. However, Douglas-fir may not compete well here as it appears to die out of the system by about 50 years. This trend may reflect its inability to compete with hemlock and spruce on these wet sites or it may be related to the planting history, since few Douglas-fir had been planted on this type prior to 1950. It is clear that Douglas-fir is not present in any significant amounts in natural stands

Table 80. Common plants in the PISI/POMU-OXOR Association, based on stands >150 years (n=26).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
estern hemlock	TSHE	60.5	60.5	100	15-99
Sitka spruce	PISI	28.5	28.5	100	5-60
cascara	RHPU	0.9	1.8	50	0-3
western redcedar	THPL	1.2	3.8	30	0-9
red alder	ALRU	4.0	26.2	15	0-60
bigleaf maple	ACMA	1.5	19.0	7	0-30
silver fir	ABAM	0.5	6.0	7	0-7
GROUND VEGETATION					
oxalis	OXOR	44.8	4.8	100	15-70
swordfern	POMU	18.3	18.3	100	3-40
salmonberry	RUSP	14.5	15.1	96	0-75
deerfern	BLSP	4.1	4.2	96	0-30
three-leaved foamflower	TITR	7.2	8.1	88	0-30
red huckleberry	VAPA	3.2	4.0	80	0-15
ladyfern	ATFI	1.6	2.0	80	0-6
Alaska huckleberry	VAAL	7.5	9.8	76	0-30
small-flowered woodrush	LUPA	0.7	1.2	57	0-3
five-leaved bramble	RUPE	5.6	10.4	53	0-40
vine maple	ACCI	8.1	17.6	47	0-40
woodfern	DRAU2	0.7	1.5	46	0-3
salal	GASH	1.0	2.2	46	0-8

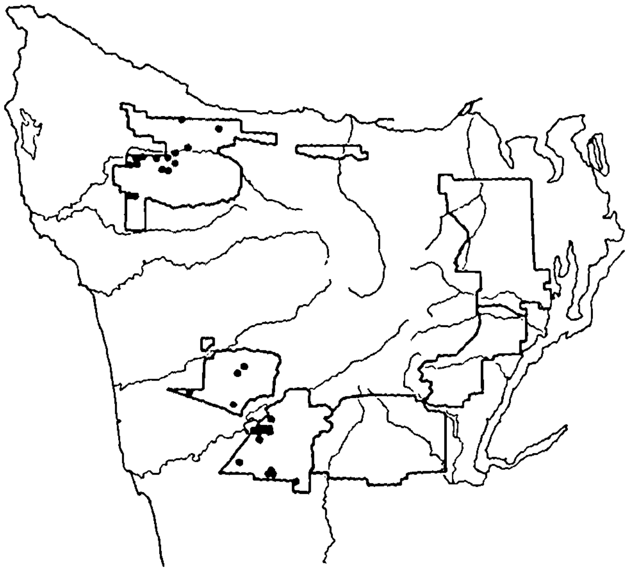


Figure 105. Map of plot locations for the Sitka Spruce/Swordfern-Oxalis Association.

in this association. We believe that the moist (i.e. drought-free) conditions and low calcium and phosphorus in soils of this association are major factors in limiting natural Douglas-fir to a few specific kinds of microsites in this type. Climax stages are dominated by western hemlock and Sitka spruce, with very little western redcedar. The absence of western redcedar in young as well as old stands in this association may be due to selective browsing by elk or may be related to the low calcium and phosphorus in the soil. Vine maple, swordfern and oxalis are often conspicuous by the time of crown closure (about 15 years). Oxalis continues to increase into old-growth stages. Vine maple, swordfern and salmonberry become relatively stable in their abundance by about 100 years.

Other Biota

Elk use was frequent and extensive on this type. Recent activity was recorded in early summer. The commonly browsed species were salmonberry, swordfern, red huckleberry, Alaska huckleberry and Columbia brome. Other browsed species were elderberry, cats-ear, bracken fern, fool's huckleberry and vine maple. Mountain beaver activity and evidence of their browse on red huckleberry, western hemlock and western redcedar was observed. Bear damage to Douglas-fir was noted and scat was found on several plots. Douglas squirrel and red-legged frog were also recorded.

Winter wren was the most common bird recorded on this type. Other birds recorded include Swainson's thrush, American robin, western flycatcher, gray jay, common crow, chickadee, golden-crowned kinglet and red-tailed hawk.

Environment and Soils

This type is found most often on glacial drift on flat to gentle slopes in valley bottoms, lower slopes and toe-slopes. It is found less commonly on a variety of other slope positions, regoliths and inclinations (up to 75%). It was never found on ridgetops and only rarely on mid- to upper slopes. Soil is fine textured. Soil structure was uniformly fine, weak subangular blocky. One pit had a clay layer on top of a fragipan which restricts drainage considerably. Coarse fragments averaged 47%, but varied from 21-73%. This effectively reduces the water holding capacity, but because of high precipitation, and in at least one instance a restrictive layer, excess water is more likely than drought. The rooting depth averaged 68 cm. It was restricted by the fragipan in one pit and at least partially restricted by a clay lens in the other. Both areas showed relatively recent disturbance--a clearcut and burn 51 years ago in one case, and deposition of sand and gravel by a flood in the other. Even so, 6 cm of O layer had accumulated of which 3.5 cm was O2. Although the plots fall on a variety of Olympic Soil Resource Inventory (Snyder *et al.* 1969) soil types, most are on deep glacial drift, till or glacio-fluvial deposits. In most cases the subsoils are weakly to moderately compacted causing them to be slowly permeable and the entire soil to be imperfectly drained. Surface layers are generally thin to thick gravelly silt loams. Some occur on deep alluvial deposits with imperfect drainage due to a high water table. The summer soil temperature averaged 12.8 deg C (55 deg F). This type is partly in the mesic and frigid temperature regime. The moisture regime is in the wet end of udic. A nutrient analysis of one pit showed one of the highest sulfate levels and among the lowest phosphorus, potassium, calcium, zinc, copper and manganese levels on the Forest. The pH was 5.2 which is about average for the Forest.

Timber Productivity

Timber productivity is high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index for Douglas-fir averaged 178 (base 100), Sitka spruce averaged 168, and western hemlock averaged 151 (Table 81). The productivity potential using the site index-yield table approach was 244 cu ft/ac/yr for Sitka spruce, 227 for western hemlock, and 189 for Douglas-fir. Empirical yield curves generated for this type from intensive plot data gave a yield of 198 cu ft/ac/yr for stands which are predominantly western hemlock and spruce. Site index (base 50) for red alder was 87 with a yield of 96 cu ft/ac/yr. Empirical curves for red alder on this type gave a yield of 131 cu ft/ac/yr.

Management Considerations

Management considerations include controlling brush competition and regulation of stocking. Ensuring prompt regeneration and full stocking is critical on this high site. Competition from salmonberry or red alder can be significant. In some stands there may be excess litter (from repeated windthrow episodes) and burning may be desirable to reduce the amount of litter and to control brush competition. This type usually has low amounts of calcium and phosphorus. Wildlife values can be high, especially for elk winter range. The abundance of elk on this type is significant in several ways. First, this type represents some of the best elk habitat on the Forest. Second, elk browsing apparently affects both the tree and ground vegetation composition. Western redcedar is a favored browse species and may be reduced to minor occurrence because of the elk. Other species, especially the shrubs, devil's club (OPHO), salmonberry, Alaska huckleberry and red huckleberry are important browse species for elk. All of these species would probably be much more abundant in this association if elk were excluded.

Root disease problems can include annosus root disease in western hemlock and Armillaria root disease in stressed western hemlock and Sitka spruce. Annosus root disease represents the most serious potential threat to western hemlock productivity on this type, especially after 120 years of age or in multiply thinned stands (see discussion of annosus root disease p. 68). Armillaria root disease can be a problem to Douglas-fir in plantations, but by age 30 impacts should be minimal. Heart and butt rots of

Table 81. Timber productivity values for the Sitka Spruce/Swordfern-Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [8]	SDI [9]	GBA TREES	GBA [10]	SIGBA [11]	EMAI [12]
Douglas-fir (McArdle[1])	4	14	178	14	189	445	5	1553	898	198
Douglas-fir (McArdle[2])	2	2	175	35						
Douglas-fir (King[3])	3	11	127	3	195					
Western Hemlock (Barnes[4])	8	8	151	48	240			536	243	
Western Hemlock (Wiley[5])	5	21	116	3	227	415	14	536		198
Sitka Spruce (Meyer[6])	8	25	168	43	244	412	16	2040	1035	198
Red Alder (Worthington[7])	4	15	87	9	96	319	5	140		131

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50. Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100. Total age (Barnes 1962). Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50. Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Base age 100, Total age (Meyer 1937).

[7] Base age 50, Total age (Worthington et al. 1962).

[8] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[9] Stand Density Index (Reinecke 1933).

[10] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[11] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[12] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

concern are annosus root disease and red ring rot in western hemlock. Hemlock dwarf mistletoe is common in old-growth western hemlock.

The most damaging insect problem is the spruce weevil which attacks terminal leaders of Sitka spruce in plantations. Hemlock looper may be present in western hemlock, western blackheaded budworm may be present on western hemlock and Sitka spruce growing tips.

Comparison with Similar Types

Similar types include other wet swordfern and oxalis types. The Western Hemlock/Swordfern-Oxalis and Western Hemlock/Swordfern-Foamflower types occur in drier environmental zones. It is also closely related to the Western Hemlock/Oxalis types which occur on slightly cooler and drier sites, but still in the wetter environmental zones. The Sitka Spruce/Swordfern-Oxalis Association is recognized as Sitka Spruce/Oxalis from the western Olympics (Henderson and Peter 1981b, 1982a) and from the Siuslaw National Forest (Hemstrom and Logan 1986). This association also includes what was called Sitka Spruce/Oxalis-Alaska Huckleberry (Henderson and Peter 1981b), and Sitka Spruce/Fool's Huckleberry-Red Huckleberry on the Siuslaw National Forest (Hemstrom and Logan 1986). Smith and Henderson (1986) recognized the Sitka Spruce-Bigleaf Maple/Oxalis and Western Hemlock-Sitka Spruce/Alaska Huckleberry/Oxalis Associations which are similar, and the Sitka Spruce-Western Hemlock/Swordfern Association which is essentially the same as our Sitka Spruce/Swordfern-Oxalis Association. Several other Sitka Spruce Associations may be represented on the Olympic National Forest. One in particular is Sitka Spruce/Devil'sClub. Because elk selectively browse key indicator species such as Alaska huckleberry and devil's club, these "types" were not readily distinguishable and were therefore aggregated into the Sitka Spruce/Swordfern-Oxalis Association as described above.

Figure 106. Photo of the Sitka Spruce/Swordfern-Oxalis Association, Quinault Research Natural Area, Quinault District.

SUBALPINE FIR SERIES

SUBALPINE FIR SERIES
Abies lasiocarpa
ABLA2

The Subalpine Fir Series (Zone) covers about 16,000 acres (2%) of the Olympic National Forest. It occurs at upper elevations in the drier environmental zones, primarily on the Quilcene District (Figure 107). It is most common in Environmental Zones 11 and 12 in the upper Dungeness River drainage. At lower elevations it is replaced by the Douglas-fir or Western Hemlock Zones. At higher elevations it gives way to subalpine meadows and krummholz. It represent a remnant of a type of vegetation which was very common in the area during the Hypsithermal Period 4000-10,000 years ago, and earlier (see Climatic History p. 32, Paleobotanical History p. 54). The dominant tree species are subalpine fir and lodgepole pine.

The climate of the Subalpine Fir Zone approaches a continental climate. Summer temperatures are warm, winter temperatures are cold. Winter soil temperatures are cold, as snow packs are light, usually accumulating to less than six feet. Summer drought is common.

Soils are typically cool and dry with a thin O horizon. The texture is usually coarse with many coarse fragments. Topographically these soils occur on steep upper slope and ridgetop positions at higher elevations on the northeastern side of the Olympic Mountains. They occupy mostly shallow, rocky colluvium and alpine till.

The soil moisture regime is xeric which means there is a pronounced summer drought. The soil temperature regime is frigid which indicates the average annual soil temperature is less than 8 deg C and the summer-winter fluctuation is greater than 5 deg C. It is likely that the soil temperature fluctuates quite widely in this zone. Stands located on south-facing slopes frequently have sparse canopies allowing the soil temperature to be quite high in the summer. The thin O layer probably reflects a frequent fire return period and low productivity.

Root diseases can include Armillaria root disease and annosus root disease, as subalpine fir is moderately susceptible to both of these (Table 13 p. 66). Lodgepole pine is thought to be moderately susceptible to Armillaria, annosus, and black stain root diseases. The impact and abundance of these diseases is unknown. Fir broom rust (*Melampsorella caryophyllacearum*) commonly causes witches brooming on subalpine fir. Potential insect problems on subalpine fir may be caused by balsam woolly aphid and western blackheaded budworm .

Potential yield for associations in the Subalpine Fir Series was estimated using three methods. The first method is the site index-yield table approach. Unfortunately there is only a yield table for Douglas-fir for this area. In this case the site index curves of McArdle and Meyer (1930), King (1966) and Curtis *et al.* (1974) were used. Also, the yield tables of McArdle and Meyer (1930) and the DFSIM model (Curtis *et al.* 1981) were used. The second method used an empirical volume curve which was generated from the plot data. The third method was the SI-GBA method of Hall (1983, 1987). Site index was also calculated for lodgepole pine and subalpine fir using the curves of Hegyi *et al.* (1979).

Four Plant Associations are recognized in the Subalpine Fir Series. They are described by 34 Reconnaissance and Intensive plots. The most common of these is Subalpine Fir/White Rhododendron (ABLA2/RHAL), which occurs on northerly aspects; Subalpine Fir/Common Juniper (ABLA2/JUCO4), Subalpine Fir/Subalpine Lupine (ABLA2/LULA) and Subalpine Fir/Big Huckleberry (ABLA2/VAME) are associations of warmer, southerly aspects. In addition, two other associations may occur. These are Subalpine Fir/Sitka Valerian (ABLA2/VASI) and Subalpine Fir/Pachistima (ABLA2/PAMY). Two plots have been taken which could be assigned to the ABLA2/VASI type. They occur in the Mt. Townsend area, on high northerly aspects. One plot near Goat Lake is best described as ABLA2/PAMY. It represented a dry, near-timberline situation.

Environmental values and relative species coverages for these four associations are summarized in Tables 82 and 83 (pp. 258-259). These associations are presented in alphabetical order by common name on pages 260-275. They can be identified using the following key. (See page 88 for explanation of how to use this abbreviated key).

Key to the Plant Associations of the Subalpine Fir Series

White Rhododendron ≥10%	ABLA2/RHAL	p. 272
Big Huckleberry ≥5%	ABLA2/VAME	p. 260
Subalpine Lupine ≥3%	ABLA2/LULA	p. 268
Common Juniper ≥3%	ABLA2/JUCO4	p. 264

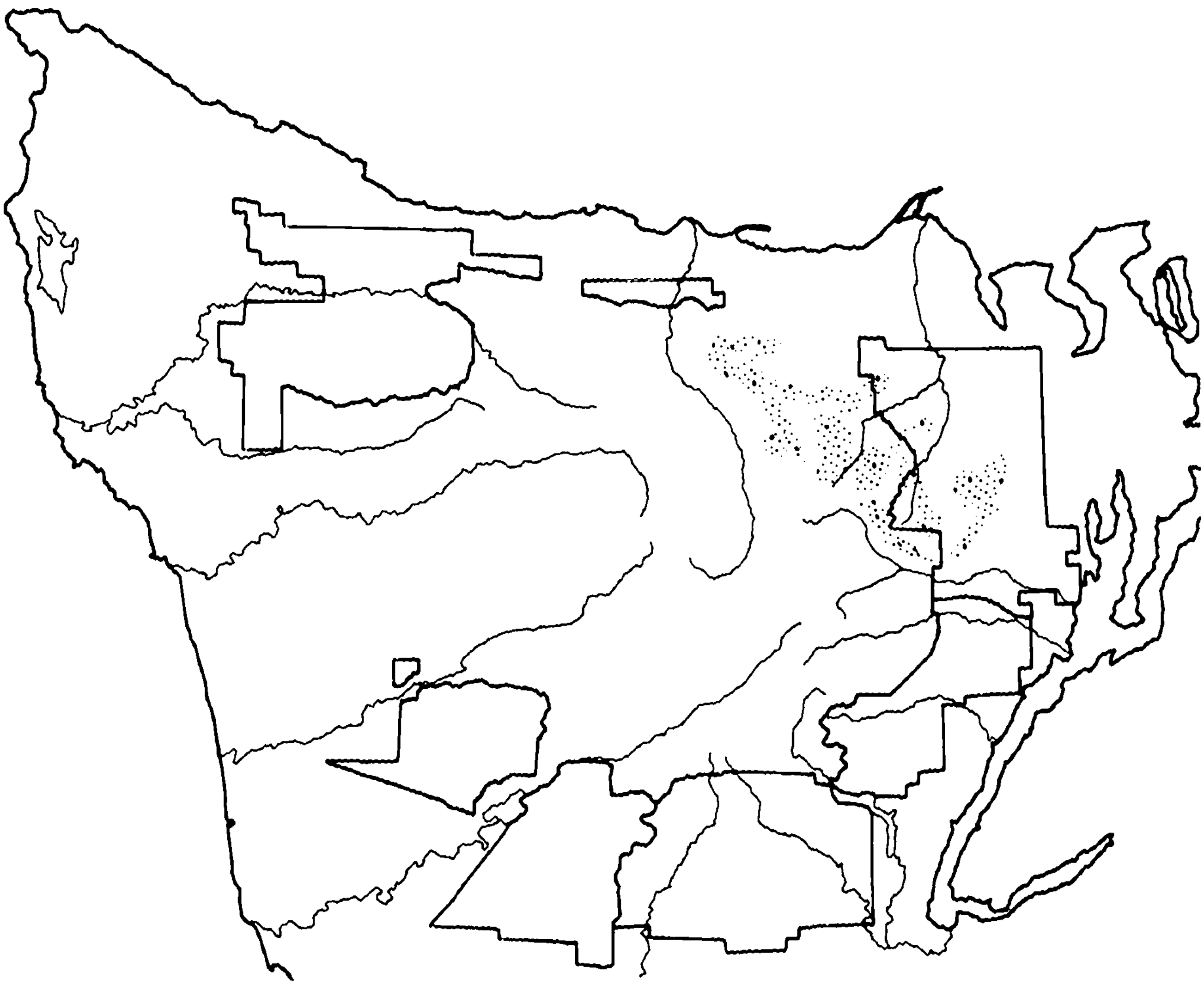


Figure 107. Map of the Subalpine Fir Zone on the Olympic Peninsula.

Table 82. Environmental values for associations in the Subalpine Fir Series. Slope, elevation and topographic moisture are mean values for the sample.

	ASSOCIATIONS			
ENVIRONMENTAL VALUES	ABLA2/VAME	ABLA2/JUCO4	ABLA2/LULA	ABLA2/RHAL
ECOCLASS Code[1]	CES3 21 (OLY)	CES6 21	CEF3 21	CES2 12 (OLY)
Number of plots[2]	6	5	8	15
Aspect	E-S	S-W	SE-W	NW-NE
Slope (%)	59	42	50	54
Elevation (ft.)	4853	5304	5187	5136
Environmental Zone[3]	8-12	11 (9,10)	11-12	10-12
Topographic Moisture[4]	4.2	3.2	3.6	3.9
Soil Moisture Regime[5]	xeric	xeric	xeric	udic
Soil Temperature (deg C)[6]	13.0 (3)	15.1 (3)	12.0 (3)	10.0 (7)
Soil Temperature Regime[7]	frigid	frigid	frigid	frigid
Lichen line (ft.)		4.5	4.0	4.5

[1] See Table 161 p. 443

[2] Number of plots includes all successional stages sampled.

[3] See Figure 24 p. 40, and discussion p. 38.

[4] See discussion p. 84, Table 146 p. 417.

[5] See discussion p. 44.

[6] Summer soil temperature at 20 cm for mature and old growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.

[7] See discussion p. 44-45.

Table 83. Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Subalpine fir Series. Cover values based on plots 80 years and older.

		ASSOCIATIONS		
		ABLA2/ JUCO4	ABLA2/ LULA	ABLA2/ RHAL
ECOCLASS Code		CES6 21	CEF3 21	CES2 12 (OLY)
Number of plots		3	8	10
TREES				
ABAM	Silver fir	5 (33)		
ABLA2	Subalpine fir	19(100)	22(100)	48(100)
CHNO	Alaska yellowcedar		5 (12)	15 (20)
PIAL	Whitebark pine		6 (12)	
PICO	Lodgepole pine	63 (66)	42 (75)	30 (60)
PIMO	Western white pine		4 (12)	1 (10)
PSME	Douglas-fir	40 (33)	20 (50)	31 (40)
TSHE	Western hemlock	1 (33)	3 (25)	8 (20)
TSME	Mountain hemlock			13 (20)
SHRUBS AND HERBS				
ACMI	Yarrow	1(100)	1 (25)	1 (30)
ACTR	Vanillaleaf		1 (25)	4 (30)
ANLY2	Lyall's anemone	1 (66)	1 (37)	1 (20)
ANRA	Raceme pussytoes	2 (33)	1 (25)	1 (30)
ARCO	Heartleaf arnica	1 (33)	5 (62)	4 (30)
ARLA	Mountain arnica		1 (37)	7 (40)
ARMA3	Bigleaf sandwort	1 (33)	1 (37)	
ARUV	Kinnikinnick	3 (33)	13 (37)	
BENE	Oregongrape		1 (25)	1 (20)
CARO	Ross sedge	1 (33)	1 (25)	1 (10)
CARO3	Bluebell	1 (33)	1 (25)	
CASC2	Scouler's harebell	1 (33)	1 (37)	1 (10)
CHUM	Prince's pine	1 (33)	4 (37)	
CLUN	Queen's cup		1 (12)	2 (20)
COCA	Bunchberry			1 (30)
FEID	Idaho fescue	1 (33)		
FEOC	Western fescue		3 (25)	1 (40)
FRVI	Broadpetal strawberry	1 (33)	1 (12)	1 (10)
GAOV	Slender wintergreen		1 (12)	2 (20)
HEOC	Western sweetvetch	2 (33)	1 (12)	1 (20)
HELA	Cow-parsnip		3 (12)	1 (20)
HIAL	White hawkweed	1 (66)	1 (62)	1 (40)
JUCO4	Common juniper	12(100)	6 (50)	1 (10)
LANE	Nuttall's peavine		20 (12)	
LIBO2	Twinflower		8 (25)	6 (30)
LOCI	Orange honeysuckle			2 (30)
LOMA2	Martindale's lomatium	1(100)	1 (62)	1 (30)
LOUT2	Utah honeysuckle	1 (33)	1 (37)	1 (30)
LULA	Subalpine lupine		15(100)	2 (60)
LUPE	Partridgefoot			2 (30)
NONE	Woodland beardtongue	1 (33)	1 (25)	1 (20)
OSCH	Sweet cicely		3 (25)	
PAMY	Pachistima	2 (66)	1 (87)	1 (80)
PERA	Leafy lousewort	1 (33)	2 (25)	1 (30)
PEPR	Small-flowered penstemon	1 (66)	1 (37)	
PHEM	Red heather			3 (30)
PHDI	Spreading phlox	2(100)	1 (37)	1 (10)
POPU	Showy polemonium		10 (12)	1 (20)
PYAS	Pink pyrola			1 (30)
PYSE	Sidebells pyrola	1(100)	1 (62)	1 (70)
RHAL	White rhododendron	1 (33)	1 (12)	42(100)
RHMA	Rhododendron			5 (20)
ROGY	Baldhip rose		2 (37)	1 (10)
RULA	Trailing bramble	1 (33)		6 (80)
RUPE	Five-leaved bramble			6 (20)
SEFL2	Flett's groundsel	2 (66)	1 (25)	2 (20)
SELU2	Black-tipped butterweed	1 (33)	1 (12)	1 (20)
SIPA	Parry's silene		1 (37)	1 (10)
SOSI	Mountain-ash			1 (30)
SYMO	Creeping snowberry	1 (66)	1 (37)	2 (20)
THFE2	Fendler's meadowrue		13 (25)	1 (20)
VAME	Big huckleberry		1 (25)	9 (70)
VASI	Sitka valerian	1 (33)	1 (50)	1 (70)
VEVI	False hellebore			1 (40)
VIOR	Round-leaved violet	1 (33)		2 (30)
VISE	Evergreen violet		1 (12)	2 (20)
XETE	Beargrass			13 (30)

1 Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 169 p. 465 for mean absolute cover values.

2 Constancy is the percentage of plots for that association where the species occurred.

SUBALPINE FIR/BIG HUCKLEBERRY

Abies lasiocarpa/Vaccinium membranaceum

ABLA2/VAME CES3 21 (OLY)

The Subalpine Fir/Big Huckleberry Association is a minor type in certain areas on the Forest. It occurs mainly on cool, dry sites, with low timber productivity. It is found primarily on Quilcene and Hood Canal Districts (Figure 108). Soils are mostly shallow and derived from colluvium. They are often well drained. The typical area of this type has burned once or twice in the last 300 years.

Floristic Composition

The dominant understory species (Table 84) is big huckleberry (VAME), which is usually present in all ages of stands, although it may be inconspicuous or absent in densely stocked second growth. Big huckleberry becomes established quickly after clearcut or fire. Other shrubs may include pachistima (PAMY), serviceberry (AMAL) and white rhododendron (RHAL). Beargrass (XETE), subalpine lupine (LULA) and phlox (PHDI) may also occur. The tree layer is dominated by subalpine fir, lodgepole pine or Douglas-fir (Figure 109).

Data for mosses and lichens are limited to one young-growth plot. Ground mosses are sparse and include *Hypnum subimponens*, *Dicranum* sp. and *Cladonia*. Epiphytic lichens are sparse in these plots as well, *Bryoria* sp. was the only species recorded.

Successional Relationships

All sampled plots in this type were less than 120 years old, which reflects its high susceptibility to burning. The common successional pathways are dominated by subalpine fir and/or Douglas-fir, while lodgepole pine may also occur in limited situations. Climax stages are presumably dominated by subalpine fir. There are insufficient data to generalize about successional trends in the ground vegetation for this type, because of the limited age range sampled.

Other Biota

Wildlife observations are limited for this type, and include deer sign with heavy browse on big huckleberry, and black bear damage to subalpine fir. Golden-crowned kinglets were recorded on one plot.

Table 84. Common plants in the ABLA2/VAME Association, based on stands >49 years (n=6).*

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
subalpine fir	ABLA2	21.5	21.5	100	4-50
Douglas-fir	PSME	14.8	22.2	66	0-65
western hemlock	TSHE	2.0	3.0	66	0-8
lodgepole pine	PICO	4.5	13.5	33	0-20
Alaska yellowcedar	CHNO	0.7	2.0	33	0-3
GROUND VEGETATION					
big huckleberry	VAME	32.2	32.2	100	3-80
pachistima	PAMY	7.7	7.7	100	1-25
subalpine lupine	LULA	6.5	6.5	100	1-20
yarrow	ACMI	1.5	2.3	66	0-5
pearly everlasting	ANMA	1.5	2.3	66	0-5
white hawkweed	HIAL	0.7	1.0	66	0-1
tigerlily	LICO4	0.7	1.0	66	0-1
beargrass	XETE	22.0	44.0	50	0-70
fireweed	EPAN	5.3	10.7	50	0-30
woodland beardtongue	NONE	2.0	4.0	50	0-10
spreading phlox	PHDI	1.3	2.7	50	0-4
serviceberry	AMAL	1.2	2.3	50	0-3
white rhododendron	RHAL	1.2	2.3	50	0-4
common juniper	JUCO4	0.8	1.7	50	0-2
Columbia brome	BRVU	0.7	1.3	50	0-2
Scouler's harebell	CASC2	0.7	1.3	50	0-2
spreading stonecrop	SEDI	0.7	1.3	50	0-2

*Stand ages range from 49 to 105 years.

Environment and Soils

This association occurs mainly on southeastern aspects between 4300 and 5700 feet elevation. It was sampled from Mt. Townsend and Mt. Jupiter south to the vicinity of Mt. Cruiser and Mt. Stone. Over this range it occurred in Environmental Zones 8 to 12 (Table 82). Topographic moisture averaged 4.2 which is dry for the Forest as a whole, but relatively moist for the Subalpine Fir Zone. Climate is generally dry with annual precipitation ranging from below 50 inches to over 100 inches. Plot data are insufficient to estimate winter snow depth.

This type is found on steep, mid- to upper slopes on colluvial metabasalt and sandstone soils. Generally these soils are shallow, coarse-textured and rocky, with a high permeability and low water holding capacity. The O layer is thin reflecting the frequency of fire. All plots occurred in areas of extensive rock outcrops with thin loam and gravelly loam inclusions (Snyder *et al.* 1969). The mean August soil temperature was 13.0 deg C (55.4 deg F). The soil temperature regime is frigid. The soil moisture regime is probably xeric.

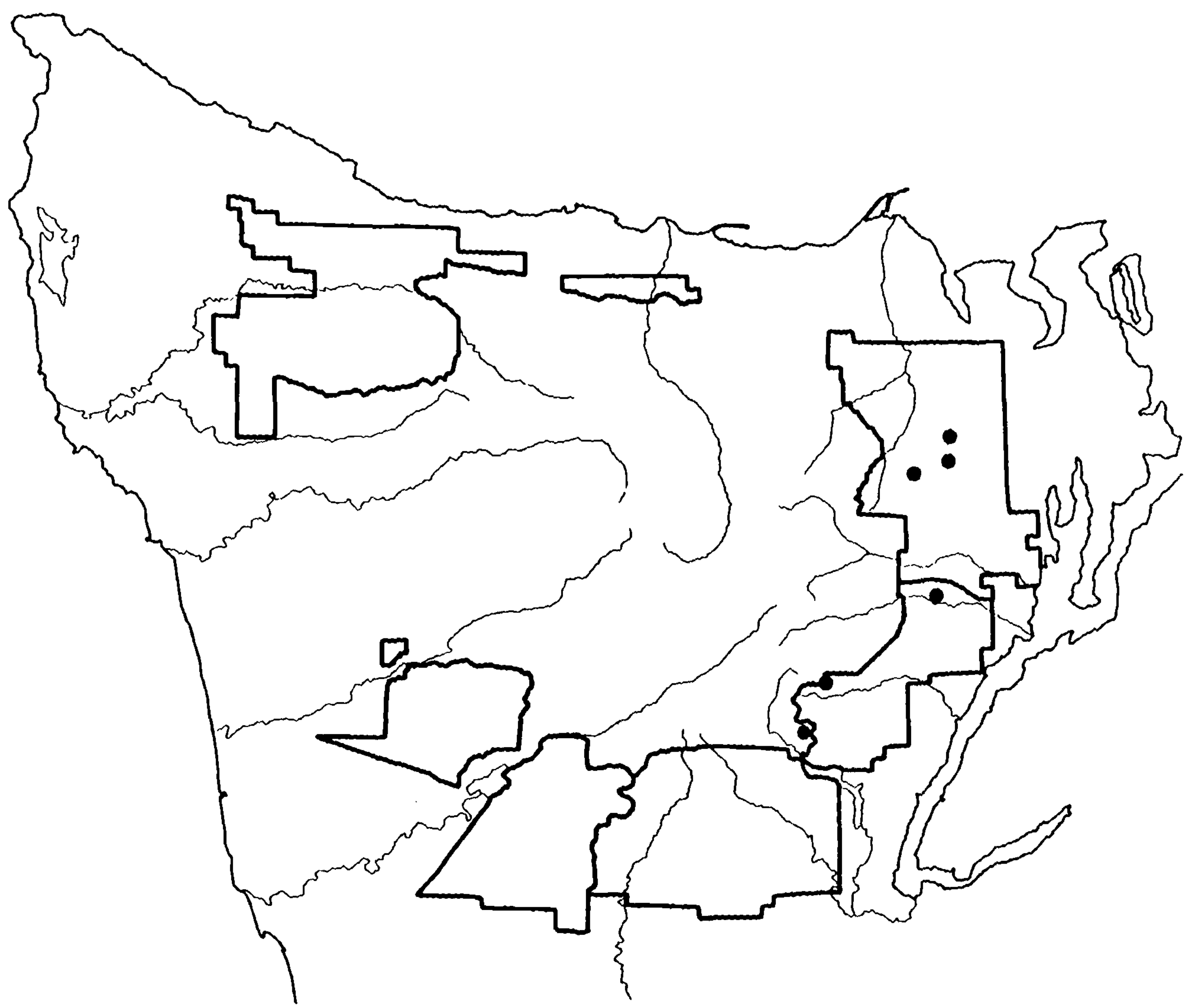


Figure 108. Map of plot locations for the Subalpine Fir/Big Huckleberry Association.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the dryness of the site, cold soils, and relatively short growing season. Site index of measured stands averaged 84 (base 100) for Douglas-fir and 81 for subalpine fir. The productivity potential using the site index-yield table approach was 63 cu ft/ac/yr for Douglas-fir and 60 cu ft/ac/yr for subalpine fir (Table 85). The empirical yield estimate for this type was 51 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations for this type include consideration of many non-timber values. Maintenance of soil nutrients and organic matter is critical on this type. Response to fertilizer in this type is unknown. Deer and bear use this type in summer. Subalpine fir and Douglas-fir are the preferred species if timber management objectives are sought. However, this type represents harsh site conditions and low growth potential. Big huckleberry can pose brush problems.

Root diseases on this series can include laminated root rot, Armillaria root disease and annosus root disease because subalpine fir is moderately susceptible to *all* these (Table 13 p. 66). Lodgepole pine is moderately susceptible to Armillaria, annosus, and black stain root diseases. The impact and abundance of these diseases on this type is unknown. Fir broom rust (*Melampsorella caryophyllacearum*) commonly causes witches brooming on subalpine fir on this type.

Insect problems can include balsam woolly aphid and western blackheaded budworm on subalpine fir.

Table 85. Timber productivity values for the Subalpine Fir/Big Huckleberry Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	1	5	84		63	371	5	432	109	51
Douglas-fir (McArdle [2])	2	2	75	4						
Douglas-fir (Curtis [3])	1	5	111			371	5	432	109	
Douglas-fir (King [4])	1	5	65		56					
Subalpine Fir (Hegyi [5])	1	3	81		60	371	3	346	84	

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[4] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[5] Base age 100, Total age (Hegyi et al. 1979).

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Comparison with Similar Types

Similar types include Subalpine Fir/White Rhododendron which occurs on cooler and moister sites, and the Subalpine Fir/Subalpine Lupine type which occurs on drier and less productive sites. The Subalpine Fir/Big Huckleberry Association is previously recognized in the Olympics (Henderson and Peter 1983a, Smith and Henderson 1986). It is related to the Subalpine Fir/Vaccinium type on the Okanogan National Forest (Williams and Lillybridge 1983). It may occur in the rainshadow of Mt. Rainier, but is not formally recognized there.

Figure 109. Photo of the Subalpine Fir/Big Huckleberry Association, Little River Summit, Quilcene District.

SUBALPINE FIR/COMMON JUNIPER
Abies lasiocarpa/Juniperus communis
ABLA2/JUCO4 CES6 21

The Subalpine Fir/Common Juniper Association is an uncommon type of high elevations in areas of low precipitation (Environmental Zones 10, 11, 12) (Figure 110) and dry topographic positions (Table 82). Soils are cold in winter, warm in summer and timber productivity is low. It is found mainly on the Quilcene and Soleduck Districts on ridgetops and southwest aspects. Soils are shallow, derived from very stony colluvium, and appear to be low in organic matter and nitrogen. Stands in this type have burned frequently in the past.

Floristic Composition

The dominant understory species (Table 86) is common juniper (JUCO4). Other shrubs may include pachistima (PAMY) and creeping snowberry (SYMO). Herbs may include spreading phlox (PHDI), yarrow (ACMI), anemone (ANLY2), Martindale's lomatium (LOMA2) and sidebells pyrola (PYSE). The tree layer is dominated by lodgepole pine, subalpine fir and/or Douglas-fir (Figure 111). Old-growth stands in this type are rare.

Observations for mosses and lichens are limited to one plot for this type. Ground mosses are sparse, but epiphytic lichens are abundant. *Bryoria* and *Hypogymnia* spp. are the most common; *Cetraria* sp., *Platismatia glauca* and *Alectoria sarmentosa* may also occur.

Successional Relationships

There are three possible successional pathways for this type. Major early successional stages may be dominated by Douglas-fir, subalpine fir, or lodgepole pine. Later seral stages are often dominated by both Douglas-fir and subalpine fir. The composition of the climax stand is unknown, but believed to be a mixture of Douglas-fir and subalpine fir. There are no clear successional trends in the ground vegetation layers. Common juniper (JUCO4) is common in all successional stages sampled. However, subalpine lupine (LULA), Idaho fescue (FEID), Ross sedge (CARO), and mountain death camas (ZIEL) are more common in younger stands. Vegetation cover decreases with age of the stand. Older successional stages tend to be somewhat sparse. Ground species which tend to characterize these later successional stages include phlox (PHDI), sidebells pyrola (PYSE) and Martindale's lomatium (LOMA2).

Other Biota

Wildlife observations are limited for this type. Chipmunk, Douglas squirrel, hare and mountain goat were recorded. Idaho fescue, creeping snowberry and white rhododendron had evidence of browse. Bird observations are limited to one plot and include red-breasted nuthatch and chestnut-backed chickadee.

Table 86. Common plants in the ABLA2/JUCO4 Association, based on stands >80 years (n=3).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
subalpine fir	ABLA2	18.7	18.7	100	1-35
lodgepole pine	PICO	41.7	62.5	66	0-65
Douglas-fir	PSME	13.3	40.0	33	0-40
silver fir	ABAM	1.7	5.0	33	0-5
western hemlock	TSHE	0.3	1.0	33	0-1
GROUND VEGETATION					
common juniper	JUCO4	11.7	11.7	100	5-15
spreading phlox	PHDI	1.7	1.7	100	1-2
Martindale's lomatium	LOMA2	1.0	1.0	100	1-1
sidebells pyrola	PYSE	1.0	1.0	100	1-1
yarrow	ACMI	1.0	1.0	100	1-1
pachistima	PAMY	1.3	2.0	66	0-3
Flett's groundsel	SEFL2	1.0	1.5	66	0-2
Lyall's anemone	ANLY2	0.7	1.0	66	0-1
white hawkweed	HIAL	0.7	1.0	66	0-1
small-flowered penstemon	PEPR	0.7	1.0	66	0-1
creeping snowberry	SYMO	0.7	1.0	66	0-1

Environment and Soils

This association occurs mainly on southern and western aspects between 4200 and 5900 feet elevation. It is most common in the Mt. Townsend area in Environmental Zones 10 and 11. Topographic moisture averaged a dry 3.2 (Table 82). A value this low is on the verge of being too dry for trees to survive. The climate is dry and somewhat continental with annual precipitation less than 50 inches. Winter snow depth (lichen line) averaged about 4 feet. The snowpack melts off early in this type, even for the Subalpine Fir Zone.

This type is found on moderately steep, upper slopes and ridgetops in colluvial metabasalt and sandstone soils. Generally these soils are very shallow, coarse-textured and rocky, with a high permeability and very low water holding capacity. All of our plots occur in areas of rock outcrops with thin loam and gravelly loam inclusions (Snyder *et al.* 1969). The O layer tends to be thin, probably reflecting both low productivity and frequency of fire. The summer soil temperature was warmest for the Series with a July-August mean of 15.1 deg C (59.2 deg F). Winter soil temperatures are relatively cold because of a low snowpack. Frozen soils and frost heaving probably occur. The soil temperature regime is frigid and the moisture regime is xeric.

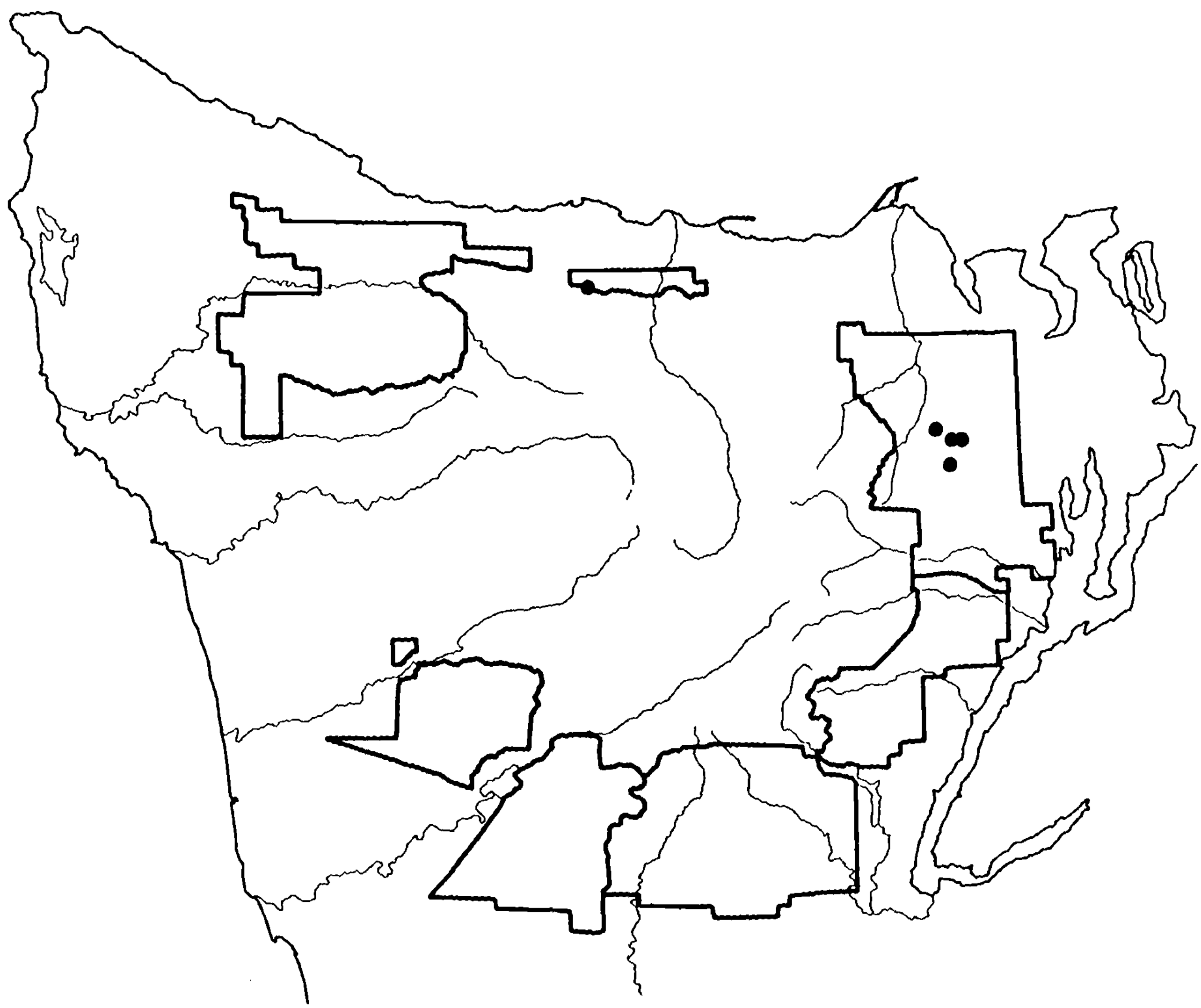


Figure 110. Map of plot locations for the Subalpine Fir/Common Juniper Association.

Timber Productivity

Timber productivity is low (Site VII). This is related to the dryness of the site and cold soils. Site index of subalpine fir averaged 28 and lodgepole pine averaged 31 (base 100) (Table 87). The productivity potential using the site index-yield table approach was 7 cu ft/ac/yr for subalpine fir and 5 cu ft/ac/yr for lodgepole pine. Values this low represent extreme extrapolations of these yield tables and are estimates only. The stockability of these sites is low. The empirical yield estimate for this type showed a growth potential of 13 cu ft/ac/yr.

Management Considerations

Management considerations are primarily related to its very low productivity and long regeneration period. Any treatments in this type should be especially sensitive to preservation of the shallow unstable soil. Because of the ridgetop positions where this type usually occurs, there is an increased susceptibility to snow and wind damage which often limits the growth and survival of Douglas-fir. This type cannot be easily regenerated by using advance regeneration. It occurs on sites which are too exposed to use shelterwood successfully. This type represents harsh growing conditions.

Root diseases can include laminated root rot, Armillaria root disease and annosus root disease because subalpine fir is moderately susceptible to all of these (Table 13 p. 66). Lodgepole pine is moderately susceptible to Armillaria, annosus, and black stain root diseases. The impact and abundance of these diseases on this type is unknown. Fir broom rust (*Melampsorella caryophyllacearum*) commonly causes witches brooming on subalpine fir on this type.

Insect problems can include balsam woolly aphid and western blackheaded budworm on subalpine fir.

Table 87. Timber productivity values for the Subalpine Fir/Common Juniper Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [2]	SDI [3]	GBA TREES	GBA [4]	SIGBA [5]	EMAI [6]
Lodgepole Pine (Hegyi [1])	2	10	31	10	7	453	10	177	17	13
Subalpine Fir (Hegyi [1])	1	2	28		5	471	2	167	14	13

[1] Base age 100. Total age (Hegyi et al. 1979).

[2] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[3] Stand Density Index (Reinecke 1933).

[4] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[5] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[6] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Comparison with Similar Types

Similar types include Subalpine Fir/Subalpine Lupine which occurs on slightly moister sites and on colder soils, and the Douglas-fir/Kinnikinnick type at lower elevations with less snow and warmer soil temperatures. The Subalpine Fir/Common Juniper Association is previously described only from the Olympics (Henderson and Peter 1983a).

Figure 111. Photo of the Subalpine Fir/Common Juniper Association, near Tyler Peak, Quilcene District.

SUBALPINE FIR/SUBALPINE LUPINE
Abies lasiocarpa/Lupinus latifolius
ABLA2/LULA CEF3 21

The Subalpine Fir/Subalpine Lupine Association is an uncommon type of high elevations in areas of low precipitation (Environmental Zones 11 and 12, Figure 112). Soils are cold in winter and warm in summer; timber productivity is low. This type occurs mainly on the Quilcene District on southwest aspects. Soils are shallow and derived from very stony colluvium. Stands in this type have burned frequently in the past, which has contributed partially to the apparently low fertility of these sites.

Floristic Composition

The dominant understory species (Table 88) are subalpine lupine (LULA), heartleaf arnica (ARCO) and common juniper (JUCO4). Pachistima (PAMY) may also occur. Herbs are sparse but may include Martindale's lomatium (LOMA2), Sitka valerian (VASI) and sidebells pyrola (PYSE). The tree layer is dominated by subalpine fir and lodgepole pine (Figure 113). Douglas-fir may sometimes occur. Many stands begin with a moderate component of lupine following fire, which may impede restocking.

Data on mosses and lichens are limited to three plots for this type. Ground cryptogams are sparse. The common ground lichens include *Peltigera* spp., *Peltigera aphthosa* and *Cladonia* spp.; the common ground mosses are *Dicranum* spp. and *Rhytidiadelphus triquetrus*. Epiphytic lichens are moderate in abundance. *Bryoria* spp. are the most common and abundant; *Hypogymnia enteromorpha*, *H. imshaugii*, *Platismatia glauca* and *Alectoria sarmentosa* also occur.

Successional Relationships

There are two probable successional pathways for this type. One dominated by subalpine fir, the other by lodgepole pine, although Douglas-fir can sometimes be a significant component. Later seral stages are presumed to be dominated by subalpine fir. There are no clear successional trends in the ground vegetation layers. Subalpine lupine is a dominant species in seral as well as old-growth stands.

Other Biota

Deer sign are frequently encountered in this type; porcupine damage is occasionally observed on lodgepole pine. Snowshoe hare and Douglas squirrel may also occur. Birds frequently observed were gray jays and chestnut-backed chickadees.

Table 88. Common plants in the ABLA2/LULA Association, based on stands >80 years (n=8).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Subalpine fir	ABLA2	22.1	22.1	100	4-60
lodgepole pine	PICO	31.4	41.8	75	0-65
Douglas-fir	PSME	9.8	19.5	50	0-45
western hemlock	TSHE	0.8	3.0	25	0-5
GROUND VEGETATION					
subalpine lupine	LULA	14.9	14.9	100	2-30
pachistima	PAMY	0.9	1.0	87	0-1
heartleaf arnica	ARCO	3.1	5.0	62	0-20
Martindale's lomatium	LOMA2	0.8	1.2	62	0-2
sidebells pyrola	PYSE	0.8	1.2	62	0-2
white hawkweed	HIAL	0.6	1.0	62	0-1
common juniper	JUCO4	2.9	5.8	50	0-15
Sitka valerian	VASI	0.5	1.0	50	0-1

Environment and Soils

This association occurs mainly on southwestern aspects between 4800 and 5900 feet elevation. It is most common in the upper Dungeness and Mt. Townsend area in Environmental Zones 11 and 12. Topographic moisture averaged a dry 3.6 (Table 82). The climate is dry and somewhat continental with annual precipitation less than 50 inches. Winter snow depth (lichen line) averaged about 4 feet. The snowpack melts off early in this type relative to comparable elevations elsewhere on the Forest.

This type is found mostly on steep upper slopes and ridgetops, on colluvial metabasalt and sandstone soils. Generally the soils are shallow, coarse-textured and very rocky, with a high permeability and low water holding capacity. These soils are thin gravelly and very gravelly loam inclusions in areas of extensive bedrock outcrop (Snyder *et al.* 1969). The O layer is thin, reflecting the fire frequency. The mean soil temperature for August was 12.0 deg C (53.6 deg F), which falls in the mid-range for the Subalpine Fir Zone. The soil temperature regime is frigid and the soil moisture regime is xeric.

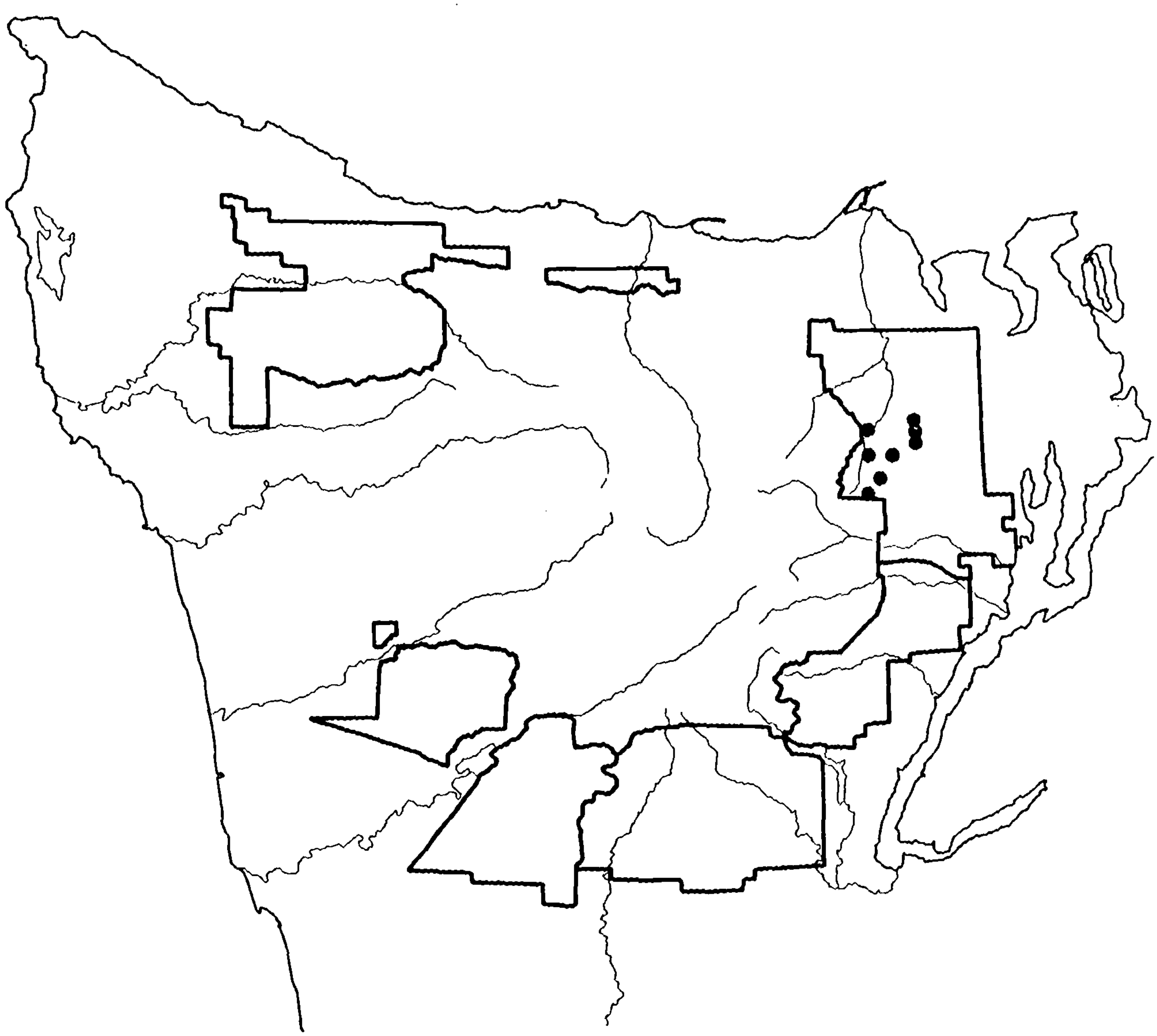


Figure 112. Map of plot locations for the Subalpine Fir/Subalpine Lupine Association.

Timber Productivity

Timber productivity is low (Site VI). This is due to the dryness of the site and extreme soil conditions. Site index of Douglas-fir averaged 50 (base 100), while lodgepole pine averaged 49 and subalpine fir averaged 42 (Table 89). The productivity potential using the site index-yield table approach was 21 cu ft/ac/yr for Douglas-fir and 21 cu ft/ac/yr for lodgepole pine. The stockability of these sites is low. An empirical estimate of yield for this type is not available.

Management Considerations

Management considerations are primarily related to its low productivity and long regeneration period. If treatments are to be done in this type at all, particular attention should be given to maintaining soil nutrients and organic matter, and preserving the shallow, unstable soil. Because of the ridgetop positions where this type usually occurs, there is an increased susceptibility to snow and wind damage which often limits the growth and survival of Douglas-fir. Natural regeneration rates are very slow. Natural stands appear to have taken 50-150 years to regenerate following wildfire. This type represents very harsh growing conditions.

Root diseases can include laminated root rot, Armillaria root disease and annosus root disease, because subalpine fir is moderately susceptible to all of these (Table 13 p. 66). Lodgepole pine is moderately susceptible to Armillaria, annosus, and black stain root diseases. The impact and abundance of these diseases on this type is unknown. Fir broom rust (*Melampsorella caryophyllacearum*) commonly causes witches brooming on subalpine fir.

Insect problems can include balsam woolly aphid and western blackheaded budworm on subalpine fir.

Table 89. Timber productivity values for the Subalpine Fir/Subalpine Lupine Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI
Douglas-fir (McArdle [1])	2	4	50	15	21	366	4	187	30	
Douglas-fir (Curtis [2])	2	4	56	24		366	4	187	30	
Douglas-fir (King [3])	2	4	38	12	28					
Lodgepole Pine (Hegyi [4])	3	14	49	13	21	400	14	155	24	
Subalpine Fir (Hegyi [4])	1	2	42		13	321	2	133	17	

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Breast height age (Curtis et al. 1974), ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100, Total age (Hegyi et al. 1979).

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[6] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include Subalpine Fir/Common Juniper which occurs on slightly drier sites at higher elevations and on warmer or more exposed soils; the Subalpine Fir/White Rhododendron type on moister and more northerly aspects; and the Western Hemlock/Beargrass type in wetter precipitation areas. It is also related to the Western Hemlock/Rhododendron/Beargrass type which occurs on similar sites but at much lower elevations. The Subalpine Fir/Subalpine Lupine Association is recognized only in the Olympic Mountains (Henderson and Peter 1983a, Smith and Henderson 1986).

Figure 113. Photo of the Subalpine Fir/Subalpine Lupine Association, Mt. Townsend Trail, Quilcene District.

SUBALPINE FIR/WHITE RHODODENDRON
Abies lasiocarpa/Rhododendron albiflorum
ABLA2/RHAL CES2 12 (OLY)

The Subalpine Fir/White Rhododendron Association is a minor type on the Forest, although it is locally common. It occurs primarily on cold, dry sites, with low timber productivity, mainly on the Quilcene District (Figure 114). Soils are mostly shallow or stony, and derived from colluvium. They are often well-drained. The typical area of this type has burned at least twice in the last 300 years.

Floristic Composition

The dominant understory species (Table 90) are white rhododendron (RHAL) and big huckleberry (VAME), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Big huckleberry can become established quickly after clearcut or fire. Other shrubs may include pachistima (PAMY) and mountain-ash (SOSI). Dwarf bramble (RULA), Sitka valerian (VASI), sidebells pyrola (PYSE), subalpine lupine (LULA) and arnica (ARLA and ARCO) may also occur. The tree layer is usually dominated by subalpine fir, lodgepole pine, and/or Douglas-fir (Figure 115). Alaska yellowcedar or mountain hemlock can sometimes occur. When stands in this type are understocked, a thick understory may develop.

Ground mosses can be sparse or rather abundant in this type. *Rhytidiopsis robusta* frequently occurs and is the most common ground moss. *Peltigera* spp. occurred on 70% of the sampled plots but had low coverage, *Dicranum* sp. may also occur. Epiphytic lichens are abundant, the common species include *Hypogymnia* spp., *Bryoria* spp., *Alectoria sarmentosa*, *Plastimatia glauca*, *P. herrei* and *Cetraria* sp.

Successional Relationships

Most stands sampled were under 120 years old which reflects a high fire frequency. The common successional pathways are dominated by subalpine fir, lodgepole pine or occasionally by Douglas-fir. The climax stage is presumably dominated by subalpine fir. Ground vegetation trends are not clear. White rhododendron dominates all stages sampled. Early successional stages often contain subalpine lupine, trailing bramble, pachistima, beardtongue (NONE), partridgefoot (LUPE) and yarrow (ACMI).

Other Biota

Deer and snowshoe hare signs are frequently observed on this type, with recent activity of deer noted in early August. Big huckleberry is the most commonly browsed species; trailing snowberry (SYMO) and beargrass (XETE) may also be browsed when they are present. Black bear, Douglas squirrel, marmot and mountain goat may also occur. Birds commonly encountered were golden-crowned kinglet, red-breasted nuthatch and chestnut-backed chickadee. Rufous hummingbirds may also be seen.

Table 90. Common plants in the ABLA2/RHAL Association, based on stands >80 years (n=10).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
subalpine fir	ABLA2	47.9	47.9	100	1-70
lodgepole pine	PICO	18.1	30.2	60	0-85
Douglas-fir	PSME	12.3	30.7	40	0-65
Alaska yellowcedar	CHNO	3.0	15.0	20	0-20
mountain hemlock	TSME	2.5	12.5	20	0-20
western hemlock	TSHE	1.6	8.0	20	0-15
GROUND VEGETATION					
white rhododendron	RHAL	41.5	41.5	100	15-80
dwarf bramble	RULA	4.8	6.0	80	0-35
pachistima	PAMY	1.0	1.3	80	0-2
big huckleberry	VAME	6.6	9.4	70	0-30
sidebells pyrola	PYSE	0.9	1.3	70	0-2
Sitka valerian	VASI	0.9	1.3	70	0-3
subalpine lupine	LULA	0.9	1.5	60	0-2

Environment and Soils

This association occurs mostly on northwest and eastern aspects between 4400 and 5800 feet elevation. It is most common in the Mt. Townsend and upper Dungeness area in Environmental Zones 10-12. Topographic moisture averaged 3.9. The climate is dry and somewhat continental, with annual precipitation less than 50 inches. Winter snow depth (lichen line) is about 4 feet. The snowpack melts off early allowing the soil to begin warming before comparable sites in the Silver Fir Zone.

This type is found mostly on steep, mid- to upper slope, colluvial metabasalt and sandstone soils. Generally these soils tend to be shallow, coarse textured and very rocky. As such they probably have a high permeability and low water holding capacity. All plots occurred in thin gravelly loam (Snyder *et al.* 1969). The O layer tends to be thin which is probably a reflection of the high frequency of fire. This is the coldest type in the Subalpine Fir Series and among the coolest types overall. The August soil temperature averaged 10.0 deg C (50.0 deg F). We believe this soil falls into the cooler end of the frigid soil temperature regime. The soil moisture regime is probably udic or drier.

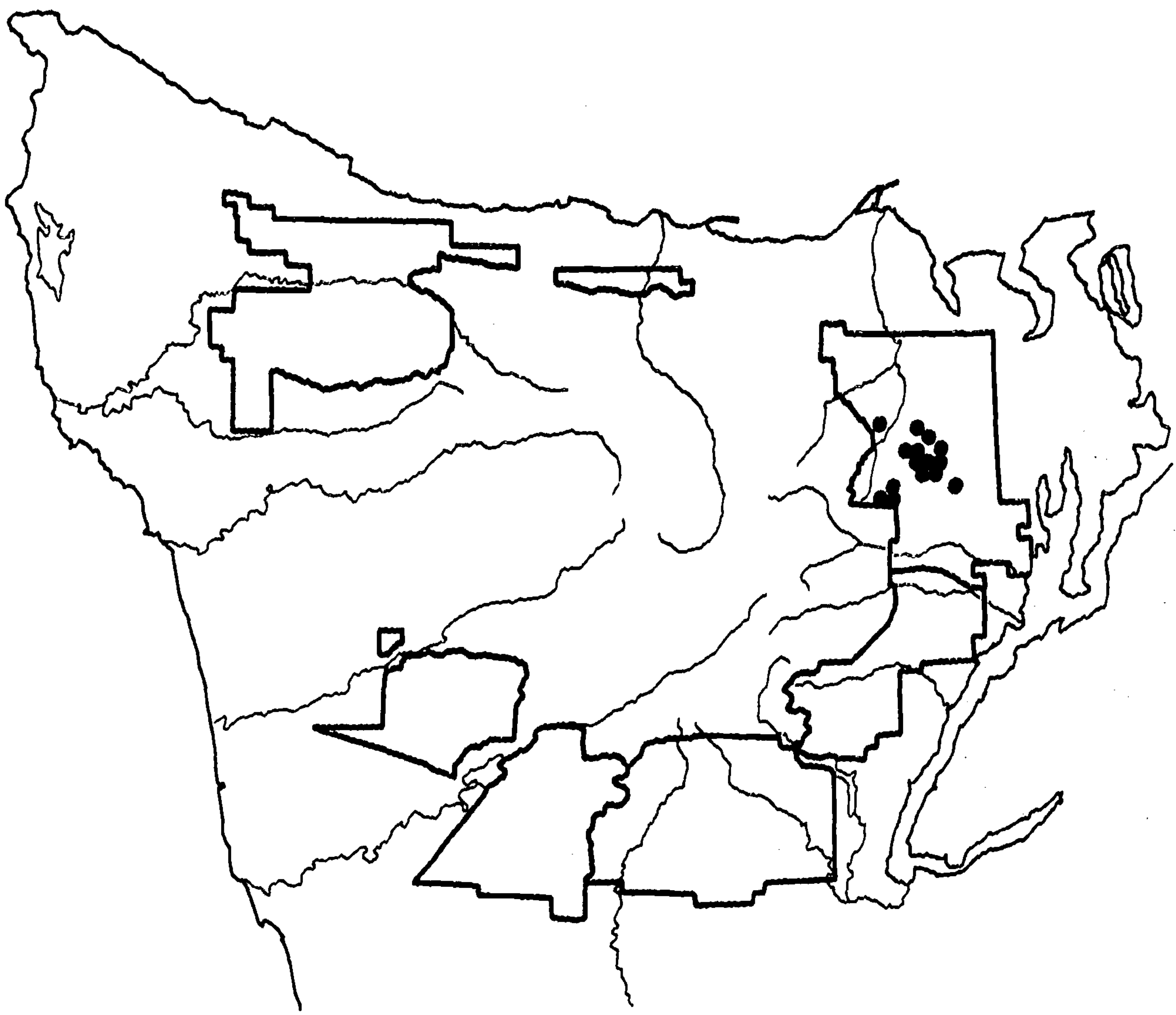


Figure 114. Map of plot locations for the Subalpine Fir/White Rhododendron Association.

Timber Productivity

Timber productivity is low (Site VI). This is due to cold soils and a relatively short growing season. Site index of measured stands averaged 55 (base 100) for Douglas-fir and 57 for subalpine fir (Table 91). The productivity potential using the site index-yield table approach was 28 cu ft/ac/yr for Douglas-fir and 30 cu ft/ac/yr for subalpine fir. The empirical yield estimate for this association was 51 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations are mainly for resource values other than timber. Maintenance of soil nutrients and organic matter is important on this type. Deer and bear use this type in summer. Big huckleberry or white rhododendron can pose brush problems after timber harvest or wildfire. Fires have been common in this type and will probably occur again in the near future. This can pose some watershed and recreation problems since all Subalpine Fir types are slow to regenerate.

Root diseases can include laminated root rot, Armillaria root disease and annosus root disease because subalpine fir is moderately susceptible to all these (Table 13 p. 66). Lodgepole pine is moderately susceptible to Armillaria, annosus, and black stain root diseases. The impact and abundance of these diseases on this type is unknown. Fir broom rust (*Melampsorella caryophyllacearum*) commonly causes witches brooming on subalpine fir.

Insect problems can include balsam woolly aphid and western blackheaded budworm on subalpine fir.

Table 91. Timber productivity values for the Subalpine Fir/White Rhododendron Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	3	5	55	20	28	389	5	310	55	51
Douglas-fir (McArdle [2])	3	3	82	28						
Douglas-fir (Curtis [3])	3	5	68	21		389	5	310	55	
Douglas-fir (King [4])	3	5	43	15	35					
Lodgepole Pine (Hegyi [5])	4	15	40	9	12	410	15	151	18	51
Subalpine Fir (Hegyi [5])	6	29	57	18	30	457	29	194	35	51

1 Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.
2 Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.
3 Base age 100. Breast height age (Curtis et al. 1974). ages 25 to 400 years.
4 Base age 50. Breast height age (King 1966). ages 25 to 120 years.
5 Base age 100. Total age (Hegyi et al. 1979).
6 Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
7 Stand Density Index (Reinecke 1933).
8 Growth Basal Area (Hall 1987) (see Table 174 p. 494).
9 Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).
10 Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Comparison with Similar Types

Similar types in the Olympics include the Mountain Hemlock/White Rhododendron-Big Huckleberry type which occurs on cooler sites with more snowfall, and the Subalpine Fir/Big Huckleberry type on drier and less productive sites. This association is previously recognized in the Olympics (Henderson and Peter 1983a, Smith and Henderson 1986), on the White River District of the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1981c), and on the Okanogan National Forest (Williams and Lillybridge 1983).

Figure 115. Photo of the Subalpine Fir/White Rhododendron Association, young-growth, Little River Summit, Quilcene District.

WESTERN HEMLOCK SERIES

WESTERN HEMLOCK SERIES
Tsuga heterophylla
TSHE

The Western Hemlock Series (Zone) covers about 388,000 acres (60%) of the Olympic National Forest (Figure 116). It occupies the lowland areas around the Forest, up to about 1000 feet elevation in the wetter environmental zones (Matheny Creek area), and up to about 4000 feet elevation in the drier enviromental zones (Dungeness River area). At higher elevations it is replaced by the Silver Fir Zone, except in Environmental Zones 10, 11 and 12 (Quilcene District), where it is replaced by the Subalpine Fir Zone. On drier microsites at lower elevations it is replaced by the Douglas-fir Zone (mostly Hood Canal and Quilcene Districts), on moister and foggier sites along the western side of the Forest, it is replaced by the Sitka Spruce Zone. The Western Hemlock Zone includes some of the most productive lands on the Forest. It also includes some low site lands on shallow soils or on steep well-drained slopes. The productivity within this zone varies greatly, but mostly as a function of water and nutrient availability.

The climate of the Western Hemlock Zone is characterized as warm temperate to maritime. Winter and summer temperatures are moderate. Average January temperature is about 7 deg C (38 deg F) for Western Hemlock Zone weather stations around the Forest, which is very close to the winter soil temperature at 8 inches (20 cm). Summer temperature averages about 17 deg C (62 deg F) which is close to mid-summer soil temperature readings at 8 inches (20 cm) in open sites. Soil temperatures at 8 inch depth under a forest canopy average about 5-10 deg F lower than those in open sunny locations. Precipitation varies from over 150 inches annually in the wetter areas of the Forest (Quinault District) to about 30 inches in the rainshadow area (Dungeness River drainage, Quilcene District). In addition, fog and clouds can contribute a significant amount of "precipitation" in the form of tree drip during the summer. Snow accumulations are low. Winds are significant, especially on the southern and western part of the Forest.

Soils are typically warm and moist with a fairly well developed O horizon. There are, however, some dry sites and some cool sites. The A horizon is often relatively low in organic matter and nitrogen, but may be high in phosphorus, sulphur, calcium and magnesium compared to the other zones. The average pH (5.3) is higher than any other zone except for the Douglas-fir Zone. Textures of these soils are fine to coarse but most commonly have many coarse fragments. Topographically they occur on a wide range of slope positions spanning low to mid-elevations across the Olympic Peninsula. They occupy nearly all types of regolith and bedrock, and the entire range of slopes from flat to very steep and slope positions from bottoms to ridgetops.

The soil moisture regime may be udic, which means that the rooting zone is usually moist throughout the summer, or it may be xeric (with a prominent summer drought), or aquic (saturated for extended periods). The soil temperature regime is frigid which indicates the rooting zone is cool (average annual temperature less than 8 deg C, with a greater than 5 deg C summer-winter fluctuation) or mesic (the average annual temperature is higher than 8 deg C).

The organic layer can be mull, duff mull or mor. Duff mulls occur slightly more often than the other two which have nearly the same frequency. The O2 horizon averaged 3.6 cm in stands under 300 years and 13 cm in stands over 300 years, but the thickness in any one stand is quite variable. Causes of variation are climate, topographic configuration and stand history. Stands originating following windthrow may inherit the previous O layer and the windthrown trees. Stands originating from fire may or may not inherit a previous O layer depending on the intensity of the fire and may inherit fire killed trees as well. The fire frequency is greater in the Western Hemlock Zone than in the Silver Fir Zone and the fires tend to be hotter. In general the thickest O2 horizons occur in the wetter environmental zones where the soils are more moist and the stands are older. While some of the thickest O2 horizons occur in the Western Hemlock Zone, they tend to be less decomposed and less dense than those in the Silver Fir or Mountain Hemlock Zones. O layers in hardwood stands in the Western Hemlock Zone are mulls. In these stands there is a thin to moderate O1 horizon and little if any O2. This probably reflects the ease of decomposition of most hardwood litter.

Inceptisols comprised over half the soils sampled in this series while over a quarter were spodosols. The remainder were mostly entisols and a few were histosols. The spodosols are generally weakly developed and the inceptisols may show signs of becoming spodosols especially in the wetter environmental zones.

The dominant tree species are Douglas-fir and western hemlock. Douglas-fir, a long-lived seral species, is common except in the wettest environmental zones. Western hemlock and western redcedar dominate the climax stage of succession. In the wetter areas of the Forest, western hemlock is the most competitive tree species in young stands, where it establishes readily after a clearcut or burn. Red alder is a major early seral species in the wetter plant associations in the Western Hemlock Series. It is short-lived and is usually succeeded by western hemlock or western redcedar. Bigleaf maple, black cottonwood, grand fir, lodgepole pine and western white pine may also occur.

Root diseases of concern in this zone are laminated root rot, Armillaria root disease, and annosus root disease. Black stain root disease may be present in Douglas-fir plantations. Laminated root rot is most important on the types where older Douglas-fir was or is growing and disease centers are already present. When these sites are cut and replanted, mortality in the new Douglas-fir stand can be considerable. The types where Douglas-fir is a major successional species should be where the disease is most problematic, especially Western Hemlock/Salal and Western Hemlock/Salal-Oregongrape. Armillaria root disease is present throughout the zone. In the drier types, such as Western Hemlock/Salal, Western Hemlock/ Rhododendron-Salal, Western Hemlock/Salal-Oregongrape and Western Hemlock/Beargrass, Armillaria may be a problem in Douglas-fir plantations beyond 30 years. In the mesic and wetter types, such as Western Hemlock/Swordfern-Foamflower, Western Hemlock/Oxalis and Western Hemlock/Alaska Huckleberry, impacts should be minimal after 30 years. Annosus root disease is a root, butt and stem decay of western hemlock throughout this zone. It is common in old-growth and is present in residual root systems left from logging. In addition, it readily colonizes thinning stumps. In stands managed for western hemlock, such as Western Hemlock/Swordfern-Oxalis and Western Hemlock/Oxalis, which are the wetter types of this series, annosus root disease may be a problem in second-growth. In general the disease has limited impacts in stands until an approximate age of 120 years.

Heart and butt rots of importance are annosus root disease and red ring rot on western hemlock, red ring rot, brown cubical butt rot and brown trunk rot on Douglas-fir. These heart and butt rots are usually not a problem until trees are 120 years or older. However, any wounding caused by thinning will increase damage from these decays. Annosus root disease will be an important decay of western hemlock in old-growth stands and on intensively managed second-growth of wetter types. Red ring rot is important in western hemlock and Douglas-fir throughout the series. It was most commonly observed on the drier types, such as Western Hemlock/Rhododendron, Western Hemlock/Rhododendron-Salal, Western Hemlock/Salal-Oceanspray and Western Hemlock/Salal-Oregongrape. Brown cubical butt rot is especially common in old-growth stands of Douglas-fir on a variety of types, such as Western Hemlock/Swordfern-Foamflower, Western Hemlock/Salal/Swordfern, Western Hemlock/Salal-Oregongrape and especially Western Hemlock/Rhododen- dron-Salal.

Hemlock dwarf mistletoe causes witches brooms, deforms stems, and may cause bole cankers on western hemlock. This parasitic plant is most common on the wetter types, such as Western Hemlock/Alaska Huckleberry-Oxalis, Western Hemlock/Swordfern-Oxalis and Western Hemlock/Oxalis.

Potential insect problems may include western blackheaded budworm on Douglas-fir and western hemlock growing tips, hemlock looper on western hemlock foliage, and Douglas-fir beetle on stressed, windthrown or diseased Douglas-fir. Flare-ups of Douglas-fir beetle may occur in healthy trees adjacent to abundant windthrow, fire-killed, or root diseased Douglas-fir.

Potential yield for associations in the Western Hemlock Series can be estimated several ways. These yield values are supported by considerable mensurational research over the years, and should be more reliable than estimates for other series. Estimates of yields for different associations were made using McArdle and Meyer's (1930) site index curve and yield tables for Douglas-fir, King's (1966) site index curve, and the DFSIM yield model for

Douglas-fir (Curtis *et al.* 1981). For western hemlock, we used Barnes (1962) site index curve and yield table (Reconnaissance plots only) and Wiley's (1978a,b) site index curve and yield table. These yield estimates are given in the timber productivity tables for each association. When available, additional estimates of potential yield were made using a modification of Hall's (1983, 1987) SI-GBA method and an empirical method which generated a volume-age curve from plot data. When the various methods were compared, it was found that western hemlock yields were greater than Douglas-fir for the same type and that yields based on McArdle and Meyer's (1930) site index and yield table were not significantly different from the empirical yields from plot data or from yields estimated from King's (1966) site index curves and DFSIM model (Curtis *et al.* 1981).

Yields for western hemlock were 42 percent greater than for Douglas-fir when averaged by type. However, the yield was only 25 percent greater for those associations where western hemlock is a significant component (*i.e.* the moist to wet types).

Empirical yields for Douglas-fir were not significantly different from site index-yield table values. There did appear to be a trend however, with the empirical values averaging 6.4 percent lower than the yield table values. The differences are even less than 6.4 percent on lower sites, but are significantly lower on the highest sites where the difference was 11.2 percent.

Twenty-six Plant Associations are recognized in the Western Hemlock Series on the Olympic National Forest. They are described by 772 Reconnaissance and Intensive plots taken from 1979 to 1985. Environmental values and relative species coverages for these 26 associations are summarized in Tables 92 and 93 (pp. 284-289). These associations are presented in alphabetical order by common name on pages 290-393, and can be identified by using the following key. (See page 88 for explanation of how to use this abbreviated key).

Key to Plant Associations of the Western Hemlock Series

Skunkcabbage $\geq$5%	TSHE/LYAM	p. 378
Devil's Club $\geq$5%	TSHE/OPHO	p. 314
Rhododendron $\geq$10%		
Beargrass $\geq$5%	TSHE/RHMA/XETE	p. 334
Swordfern $\geq$5%	TSHE/RHMA/POMU	p. 346
Salal $\geq$10%	TSHE/RHMA-GASH	p. 342
Oregongrape $\geq$5%	TSHE/RHMA-BENE	p. 338
Oregongrape $\leq$5%	TSHE/RHMA	p. 330
Oxalis $\geq$10%		
Swordfern $\geq$10%	TSHE/POMU-OXOR	p. 386
Alaska Huckleberry $\geq$10%	TSHE/VAAL/OXOR	p. 298
Salal $\geq$5%	TSHE/GASH/OXOR	p. 370
Salal $\leq$5%	TSHE/OXOR	p. 326
Alaska Huckleberry $\geq$10%		
Beargrass $\geq$5%	TSHE/VAAL/XETE	p. 294
Salal $\geq$5%	TSHE/VAAL-GASH	p. 302
Salal $\leq$5%	TSHE/VAAL	p. 290
Swordfern $\geq$10%		
Salal $\geq$5%	TSHE/GASH/POMU	p. 374
Oregongrape $\geq$5%	TSHE/BENE/POMU	p. 322
Oxalis $\geq$5%	TSHE/POMU-OXOR	p. 386
Foamflower, Fragrant Bedstraw usually present	TSHE/POMU-TITR	p. 382
Salal $\geq$10%		
Rhododendron $\geq$5%	TSHE/RHMA-GASH	p. 342
Oxalis $\geq$5%	TSHE/GASH/OXOR	p. 370
Evergreen Huckleberry $\geq$4%	TSHE/GASH-VAOV2	p. 358
Oceanspray $\geq$2%	TSHE/GASH-HODI	p. 362
Beargrass $\geq$2%	TSHE/GASH/XETE	p. 354
Swordfern $\geq$3%	TSHE/GASH/POMU	p. 374
Oregongrape $\geq$2%, Red Huckleberry and/or Vine Maple present	TSHE/GASH-BENE	p. 366
Not as above	TSHE/GASH	p. 350
Vanillaleaf and Star-flowered Solomon's Seal $\geq$5% and Oregongrape often present	TSHE/ACTR	p. 390
Oregongrape $\geq$5%		
Swordfern $\geq$4%	TSHE/BENE/POMU	p. 322
Swordfern $\leq$4%	TSHE/BENE	p. 318
Beargrass $\geq$5%	TSHE/XETE	p. 306
Ground Cover $\leq$10% (except Vine Maple)	TSHE/Dep.	p. 310

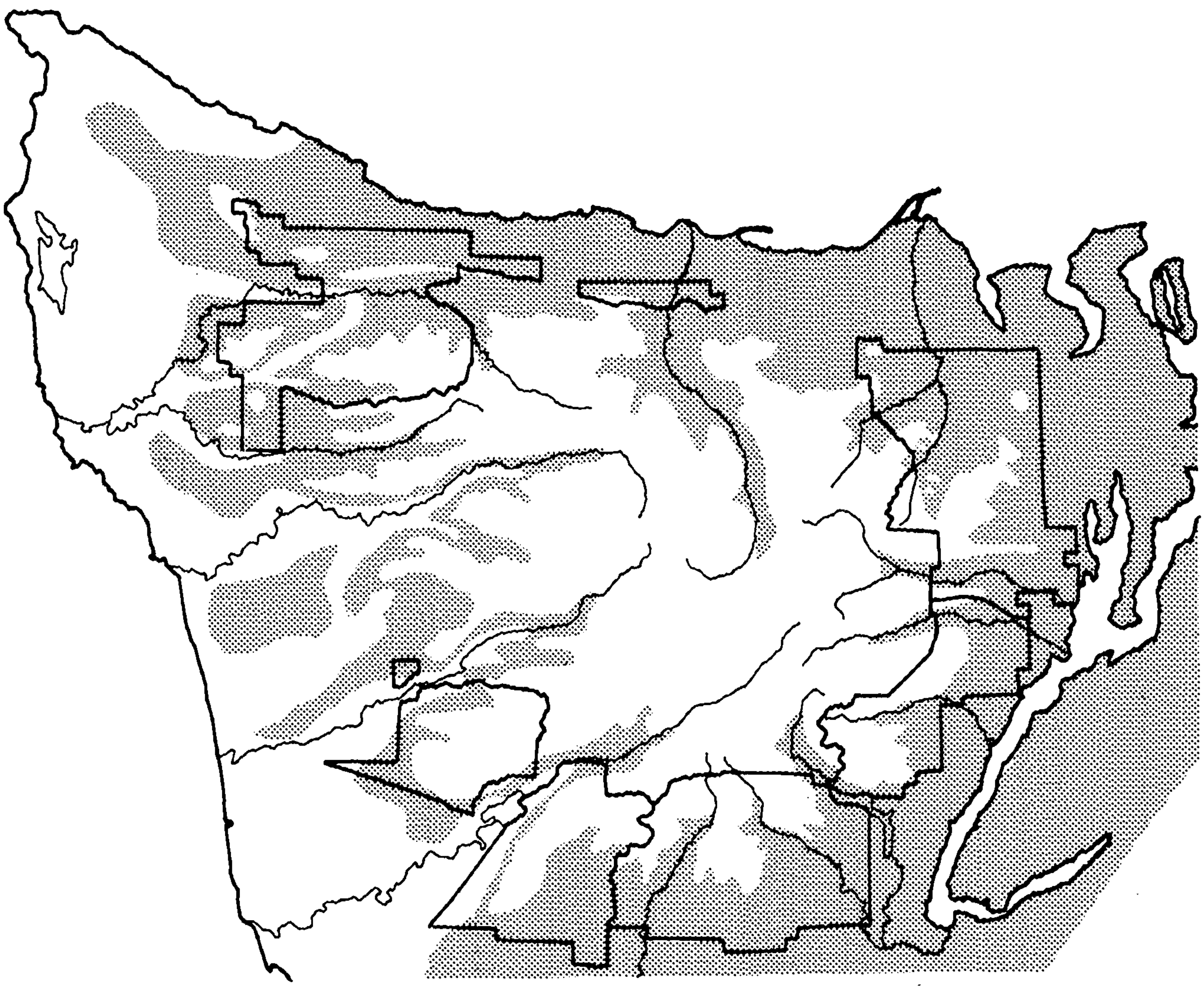


Figure 116. Map of the Western Hemlock Zone on the Olympic Peninsula.

Table 92. Environmental values for associations in the Western Hemlock Series. Slope, elevation and topographic moisture are mean values for the sample.

ENVIRONMENTAL VALUES	ASSOCIATIONS TSHE/ VAAL	TSHE/ VAAL/XETE	TSHE/ VAAL/OXOR	TSHE/ VAAL-GASH	TSHE/ XETE	TSHE/ Dep.	TSHE/ OPHO
ECOCLASS Code[1]	CHS6 21	CHS6 22	CHS6 23 (OLY)	CHS6 24 (OLY)	CHF5 11 (OLY)	CHF9 11	CHS5 12 (OLY)
Number of plots[2]	28	3	20	34	5	35	13
Aspect	FLAT, ALL	E-SW	FLAT, W-N	FLAT, SE	SE-SW	ALL	FLAT, SE-W
Slope (%)	20	48	25	23	81	40	21
Elevation (ft.)	1273	2940	892	1047	3030	1739	1526
Environmental Zone[3]	7,8 (1-9)	8,9	0-7	2,4,7 (0-9)	8	4-10 (2-12)	7-9 (4,11)
Topographic Moisture[4]	5.2	3.0	5.4	4.9	3.2	4.9	6.9
Soil Moisture Regime[5]	udic	udic	udic	udic	xeric		aquic?
Soil Temperature (deg C)[6]	10.1 (5)		12.5 (7)	12.4 (9)	10.2 (2)	11.4 (22)	11.9 (9)
Soil Temperature Regime[7]	frigid-mesic	frigid	frigid	frigid	frigid	frigid	frigid

ENVIRONMENTAL VALUES	ASSOCIATIONS TSHE/ BENE	TSHE/ BENE/POMU	TSHE/ OXOR	TSHE/ RHMA	TSHE/ RHMA/XETE	TSHE/ RHMA-BENE	TSHE/ RHMA-GASH
ECOCLASS Code[1]	CHS1 38 (OLY)	CHS1 39 (OLY)	CHF1 12 (OLY)	CHS3 31 (OLY)	CHS3 32 (OLY)	CHS3 33 (OLY)	CHS3 34 (OLY)
Number of plots[2]	15	37	44	29	6	8	70
Aspect	S, ALL	ALL	FLAT, E-W	W, ALL	SE-S	NW, NE	SE-W
Slope (%)	76	42	21	47	61	54	48
Elevation (ft.)	2424	1296	925	3261	3237	2915	2456
Environmental Zone[3]	8 (4-12)	8-10 (3-11)	3,4 (1-7)	9,10 (8-12)	9 (10)	10-12 (9)	9-11 (8)
Topographic Moisture[4]	4.1	5.5	5.4	4.3	4.0	4.1	4.5
Soil Moisture Regime[5]	udic	udic	udic	xeric	xeric	xeric	xeric
Soil Temperature (deg C)[6]	10.4 (7)	11.2 (11)	13.2 (12)	9.5 (19)	9.3 (3)	11.9 (6)	10.5 (44)
Soil Temperature Regime[7]	frigid	frigid	frigid	frigid	frigid	frigid	frigid

[1] See Table 161 p. 443
[2] Number of plots includes all successional stages sampled.
[3] See Figure 24 p. 40, and discussion p. 38.
[4] See discussion p. 84, Table 146 p. 417.
[5] See discussion p. 44.
[6] Summer soil temperature at 20 cm for mature and old-growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.
[7] See discussion p. 44-45.

Table 92 (cont.). Environmental values for associations in the Western Hemlock Series. Slope, elevation and topographic moisture are mean values for the sample.

ENVIRONMENTAL VALUES	ASSOCIATIONS TSHE/ RHMA/POMU	TSHE/ GASH	TSHE/ GASH/XETE	TSHE/ GASH-VAOV2	TSHE/ GASH-HODI	TSHE/ GASH-BENE
ECOCLASS Code[1]	CHS3 35 (OLY)	CHS1 31 (OLY)	CHS1 32	CHS1 33	CHS1 34	CHS1 35
Number of plots[2]	10	50	31	4	19	53
Aspect	S-SW, N-NE	S, ALL	SE-W, ALL	E-SE	SE-W, N	SE-SW
Slope (%)	51	38	50	17	52	36
Elevation (ft.)	1959	1562	1892	209	2288	1396
Environmental Zone[3]	9,10	8 (1-11)	8 (3-9)	10	10-12 (8,9)	8 (4-12)
Topographic Moisture[4]	5.0	4.5	4.2	5.8	4.3	4.6
Soil Moisture Regime[5]	udic	udic	xeric		xeric	udic
Soil Temperature (deg C)[6]	10.6 (6)	12.5 (25)	13.4 (3)		11.9 (8)	12.2 (15)
Soil Temperature Regime[7]	frigid	frigid	frigid	mesic	frigid	mesic

ENVIRONMENTAL VALUES	ASSOCIATIONS TSHE/ GASH/OXOR	TSHE/ GASH/POMU	TSHE/ LYAM	TSHE/ POMU-TITR	TSHE/ POMU-OXOR	TSHE/ ACTR
ECOCLASS Code[1]	CHS1 36	CHS1 37	CHM1 11 (OLY)	CHF1 32	CHF1 31 (OLY)	CHF2 11 (OLY)
Number of plots[2]	11	99	3	74	58	13
Aspect	NW,SE	SE-S, ALL	FLAT	ALL	ALL	E-S
Slope (%)	43	44	6	38	38	47
Elevation (ft.)	1055	1221	1540	1152	930	2812
Environmental Zone[3]	3-5 (1-7)	8-10 (0-7)	2,7,9	7-10 (1-6)	2-5 (0-7)	7-12
Topographic Moisture[4]	4.6	5.4	8.0	5.8	5.7	5.2
Soil Moisture Regime[5]	udic	udic	aquic	udic	udic	udic
Soil Temperature (deg C)[6]	14.3 (4)	12.3 (35)		11.5 (36)	12.2 (15)	11.6 (8)
Soil Temperature Regime[7]	frigid	mesic	frigid	mesic	frigid	frigid

[1] See Table 161 p. 443
[2] Number of plots includes all successional stages sampled.
[3] See Figure 24 p. 40, and discussion p. 38.
[4] See discussion p. 84, Table 146 p. 417.
[5] See discussion p. 44.
[6] Summer soil temperature at 20 cm for mature and old-growth stands; only June, July and August measurements included; values in ( ) are sample size for the mean. See discussion p. 83.
[7] See discussion p. 44-45.

Table 93. Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS						
		TSHE/ VAAL	TSHE/ VAAL/XETE	TSHE/ VAAL/OXOR	TSHE/ VAAL-GASH	TSHE/ XETE	TSHE/ Dep.	TSHE/ OPHO
ECOCLASS Code		CHS6 21	CHS6 22	CHS6 23 (OLY)	CHS6 24 (OLY)	CHF5 11 (OLY)	CHF9 11	CHS5 12 (OLY)
Number of plots		17	3	15	21	3	12	4
TREES								
ABAM	Silver fir	5 (70)	3(100)	8 (46)	4 (42)	1 (25)	3 (41)	2 (25)
ABGR	Grand fir	1 (5)					30 (8)	
ABLA2	Subalpine fir							
ACMA	Bigleaf maple						1 (16)	3 (50)
ALRU	Red alder				10 (4)		28 (18)	2 (50)
ARME	Madrone							
CHNO	Alaska yellowcedar	10 (5)						
CONU	Pacific dogwood							1 (25)
PICO	Lodgepole pine							
PIMO	Western white pine							
PISI	Sitka spruce	1 (5)		1 (13)	1 (9)		1 (8)	
POTR2	Black cottonwood							
PSME	Douglas-fir	30 (52)	29(100)	12 (20)	27 (57)	55(100)	32 (91)	60 (75)
PYFU	Western crabapple				15 (4)			
RHPU	Cascara	2 (17)		1 (20)	2 (23)			
TABR	Pacific yew	2 (5)			5 (19)		5 (25)	2 (25)
THPL	Western redcedar	11 (35)	7(100)	7 (33)	22 (57)		8 (41)	15 (75)
TSHE	Western hemlock	79(100)	63(100)	88(100)	70(100)	49(100)	73(100)	38(100)
TSME	Mountain hemlock					2 (33)		
SHRUBS and HERBS								
ACCI	Vine maple	14 (47)	55 (33)	6 (26)	14 (81)	17 (66)	3 (25)	28 (75)
ACGL	Douglas maple					3 (33)		
ACTR	Vanillaleaf	3 (41)	1 (66)	2 (13)	1 (23)	2(100)	1 (25)	3(100)
ARCA6	Dwarf mistletoe	4 (17)	8 (33)	4 (6)	2 (19)			
ARUV	Kinnikinnick							
ATFI	Ladyfern	1 (41)		1 (46)	1 (14)			4(100)
BENE	Oregongrape	4 (29)	4(100)		5 (42)	12(100)	2 (58)	1 (50)
BLSP	Deerfern	4 (70)	1 (33)	5(100)	7 (66)		2 (16)	3 (50)
CASC2	Scouler's harebell					1 (33)		
CHME	Little prince's pine	1 (17)	1 (66)		1 (14)	1(100)	1 (33)	
CHUM	Prince's pine	1 (17)	1 (66)		2 (19)	1 (33)	1 (8)	
CIAL	Enchanter's nightshade			1 (6)				20 (25)
CLUN	Queen's cup	2 (70)	1 (66)	1 (40)	1 (23)		2 (16)	2 (50)
COCA	Bunchberry	2 (35)	1 (66)	5 (33)	5 (38)		1 (8)	3 (25)
COCO2	Hazelnut						1 (8)	
COLA	Cutleaf goldthread	3 (35)		1 (46)	2 (14)			
DRAU2	Woodfern	1 (41)		1 (60)	1 (14)		1 (25)	1 (75)
ERMO	Avalanche lily							
FEOC	Western fescue							
GASH	Salal	2 (64)	3 (66)	2 (86)	30(100)	3(100)	1 (33)	2 (75)
GATR	Fragrant bedstraw			1 (13)				2 (75)
GOOB	Rattlesnake-plantain		1 (33)	1 (13)	1 (33)	1 (33)		
GYDR	Oakfern	2 (5)		1 (26)	1 (4)			3 (75)
HIAL	White hawkweed	1 (5)			1 (4)	1 (33)	1 (8)	1 (50)
HODI	Oceanspray							
LIBO2	Twinflower	14 (41)		8 (20)	5 (47)		1 (25)	2 (50)
LYAM	Skunkcabbage	1 (5)			1 (14)			
MADI2	False lily-of-the-valley	2 (23)		2 (66)	2 (19)		1 (8)	15 (25)
MEFE	Fool's huckleberry	2 (52)	4 (66)	3 (73)	2 (71)			
NONE	Woodland beardtongue				1 (4)		1 (8)	
OPHO	Devil's club	1 (5)		1 (6)	1 (19)			11(100)
OXOR	Oxalis	2 (5)		24(100)	1 (14)			
PAMY	Pachistima		1 (33)		1 (4)	1 (33)		
POMU	Swordfern	3 (76)		4 (93)	2 (81)	1 (33)	2 (75)	24(100)
PTAQ	Bracken fern	1 (11)			3 (14)		1 (16)	2 (25)
PYSE	Sidebells pyrola	1 (17)	1 (33)		1 (9)	1 (66)	1 (16)	
RHMA	Rhododendron	2 (11)	1 (33)				1 (8)	
ROGY	Baldhip rose	1 (5)	1 (33)		1 (14)	1 (66)	2 (8)	
RULA	Trailing bramble	1 (11)	1 (66)		1 (9)			
RUPE	Five-leaved bramble	4 (47)		2 (66)	4 (38)			1 (25)
RUSP	Salmonberry	4 (52)		4 (93)	6 (38)		1 (8)	3 (50)
RUUR	Trailing blackberry	1 (41)		1 (20)	1 (38)		1 (33)	1 (75)
SMST	Star-flowered solomon's seal	2 (23)		1 (20)	1 (23)	1 (33)	1 (8)	5 (75)
STRO	Rosy twisted-stalk	1 (41)	1 (33)	1 (20)	1 (4)			2 (50)
SYAL	Common snowberry						1 (8)	
SYMO	Creeping snowberry						1 (8)	
TITR	Three-leaved foamflower	3 (64)		2 (73)	2 (38)		1 (8)	5(100)
TIUN	Single-leaved foamflower	1 (5)					1 (8)	4 (50)
TRLA2	Starflower	1 (5)	1 (33)	1 (8)	1 (14)	1 (33)	1 (33)	1 (75)
TROV	Trillium	1 (35)	1 (33)	1 (53)	1 (28)	1 (33)	1 (25)	1 (75)
VAAL	Alaska huckleberry	22(100)	32(100)	30(100)	24(100)	1 (66)	1 (33)	4 (25)
VAME	Big huckleberry	1 (5)	1 (33)			1 (33)		
VAOV	Oval-leaf huckleberry	7 (11)	1 (33)	4 (33)	4 (33)		1 (8)	1 (50)
VAOV2	Evergreen huckleberry							
VAPA	Red huckleberry	13 (94)	12 (66)	4 (93)	10(100)	1(100)	1 (50)	3(100)
VISE	Evergreen violet	2 (17)	1 (33)	1 (20)	1 (19)	1(100)	1 (33)	1 (25)
XETE	Beargrass	1 (5)	7(100)		5 (23)	33(100)	1 (8)	

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 170 p. 467 for mean absolute cover values.

[2] Constancy is the percentage of plots for that association where the species occurred.

Table 93. (cont.) Mean relative cover values[1] and constancy[2] of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

ASSOCIATIONS

		TSHE/ BENE	TSHE/ BENE/POMU	TSHE/ OXOR	TSHE/ RHMA	TSHE/ RHMA/XETE	TSHE/ RHMA-BENE	TSHE/ RHMA-GASH
ECOCLASS Code		CHS1 38 (OLY)	CHS1 39 (OLY)	CHF1 12 (OLY)	CHS3 31 (OLY)	CHS3 32 (OLY)	CHS3 33 (OLY)	CHS3 34 (OLY)
Number of plots		3	9	8	13	5	5	34
TREES								
ABAM	Silver fir	4 (66)		5 (12)	4 (46)	2 (60)	4 (40)	2 (29)
ABGR	Grand fir		1 (11)		7 (7)			1 (8)
ABLA2	Subalpine fir	1 (33)				4 (20)		2 (2)
ACMA	Bigleaf maple		13 (22)					
ALRU	Red alder		2 (22)	5 (37)			1 (8)	
ARME	Madrone							
CHNO	Alaska yellowcedar	5 (33)			9 (15)			25 (2)
CONU	Pacific dogwood		1 (11)					
PICO	Lodgepole pine							
PIMO	Western white pine					2 (40)	1 (20)	3 (5)
PISI	Sitka spruce			8 (12)				
POTR2	Black cottonwood							
PSME	Douglas-fir	77(100)	29(100)	23 (75)	39(100)	38(100)	38(100)	47(100)
PYFU	Western crabapple							
RHPU	Cascara			2 (12)				
TABR	Pacific yew	10 (33)	1 (22)		16 (23)	3 (20)	5 (40)	4 (44)
THPL	Western redcedar	30 (33)	14 (55)	1 (12)	14 (76)	19 (80)	13 (60)	21 (91)
TSHE	Western hemlock	33(100)	62(100)	92(100)	71(100)	63(100)	68(100)	49 (94)
TSME	Mountain hemlock							
SHRUBS and HERBS								
ACCI	Vine maple	43 (66)	20 (68)	13 (37)	2 (15)	2 (20)	35 (20)	10 (35)
ACGL	Douglas maple							2 (5)
ACTR	Vanillaleaf	1 (33)	5 (77)	10 (12)	1 (38)		1 (60)	1 (17)
ARCA6	Dwarf mistletoe			4 (25)				1 (5)
ARUV	Kinnikinnick					1 (20)	1 (8)	
ATFI	Ladyfern			1 (50)				
BENE	Oregongrape	17(100)	17(100)	2 (25)	2 (84)	4(100)	13(100)	5 (97)
BLSP	Deerfern		1 (11)	3 (62)			1 (20)	
CASC2	Scouler's harebell				1 (15)			1 (5)
CHME	Little prince's pine	1 (66)	1 (22)		1 (38)	1 (20)		1 (26)
CHUM	Prince's pine	1 (66)	1 (11)		1 (46)	1 (60)	2(100)	1 (76)
CIAL	Enchanter's nightshade		3 (11)					1 (2)
CLUN	Queen's cup	1 (33)	1 (22)	1 (25)	1 (30)		1 (40)	1 (5)
COCA	Bunchberry		1 (11)	3 (12)	1 (23)	1 (20)	2 (40)	4 (11)
COCO2	Hazelnut							
COLA	Cutleaf goldthread			2 (50)				
DRAU2	Woodfern		1 (11)	1 (12)				
ERMO	Avalanche lily							
FEOC	Western fescue	1 (33)			1 (7)			2 (8)
GASH	Salal	2 (33)	3 (66)	1 (75)	1 (30)	26(100)	2 (60)	45(100)
GATR	Fragrant bedstraw	1 (33)	2 (44)	1 (12)	1 (7)			
GOOB	Rattlesnake-plantain	1 (66)	1 (33)		1 (15)	1 (20)		1 (32)
GYDR	Oakfern		1 (11)	1 (37)				
HIAL	White hawkweed	1 (33)			1 (15)	1 (20)		1 (26)
HODI	Oceanspray	1 (33)						9 (11)
LIBO2	Twinflower	6 (33)	2 (55)	11 (25)	1 (84)	1 (60)	3(100)	5 (82)
LYAM	Skunkcabbage							
MADI2	False lily-of-the-valley			3 (50)				
MEFE	Fool's huckleberry			2 (37)	2 (7)	1 (20)	1 (20)	1 (5)
NONE	Woodland beardtongue	1 (33)			1 (23)			1 (8)
OPHO	Devil's club			1 (12)				
OXOR	Oxalis			30(100)				
PAMY	Pachistima	2 (33)			1 (15)	1 (20)		1 (23)
POMU	Swordfern	2 (66)	25(100)	3 (75)	1 (61)		2 (60)	1 (52)
PTAQ	Bracken fern		1 (11)	7 (37)				
PYSE	Sidebells pyrola	1 (66)			1 (69)	1 (60)	1 (40)	1 (8)
RHMA	Rhododendron	2 (66)			49(100)	45(100)	26(100)	39(100)
ROGY	Baldhip rose	[illegible] (33)	1 (22)		1 (7)	1 (20)	1 (60)	2 (29)
RULA	Trailing bramble	1 (33)			1 (30)	1 (20)		1 (2)
RUPE	Five-leaved bramble		1 (11)	4 (37)	1 (7)			
RUSP	Salmonberry			7 (75)				
RUUR	Trailing blackberry		1 (44)	10 (12)	1 (7)	1 (20)	1 (20)	1 (23)
SMST	Star-flowered solomon's seal			1 (12)	2 (7)			1 (2)
STRO	Rosy twisted-stalk				1 (7)			1 (2)
SYAL	Common snowberry		1 (11)	1 (12)			1 (2)	
SYMO	Creeping snowberry	2 (66)			1 (15)		1 (40)	1 (8)
TITR	Three-leaved foamflower		1 (33)	2 (87)	1 (30)			1 (8)
TIUN	Single-leaved foamflower				1 (15)			1 (2)
TRLA2	Starflower	5 (33)	1 (44)	1 (12)	1 (38)			1 (32)
TROV	Trillium		1 (66)	1 (62)	1 (38)		1 (20)	1 (38)
VAAL	Alaska huckleberry		5 (11)	4 (75)	2 (15)	4 (40)	2 (20)	2 (23)
VAME	Big huckleberry	1 (33)			1 (15)	1 (40)	1 (20)	
VAOV	Oval-leaf huckleberry	2 (33)						2 (8)
VAOV2	Evergreen huckleberry			1 (12)				
VAPA	Red huckleberry	2 (66)	4 (66)	2(100)	1 (53)	4(100)	2 (80)	4 (73)
VISE	Evergreen violet		1 (33)	1 (50)	1 (38)	1 (40)	1 (60)	1 (32)
XETE	Beargrass		2 (33)		2 (15)	9(100)	1 (20)	4 (29)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 170 p. 467 for mean absolute cover values.
[2] Constancy is the percentage of plots for that association where the species occurred.

Table 93. (cont.) Mean relative cover values[1] and constancy[2] of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		TSHE/ RHMA/POMU	TSHE/ GASH	TSHE/ GASH/XETE	TSHE/ GASH-VAOV2[3]	TSHE/ GASH-HODI	TSHE/ GASH-BENE
ECOCLASS Code		CHS3 35 (OLY)	CHS1 31 (OLY)	CHS1 32	CHS1 33	CHS1 34	CHS1 35
Number of plots		3	12	21	4	5	18
TREES							
ABAM	Silver fir	2 (66)	4 (16)	4 (28)			2 (12)
ABGR	Grand fir			1 (4)	1 (25)	15 (40)	1 (6)
ABLA2	Subalpine fir						
ACMA	Bigleaf maple				6 (50)		
ALRU	Red alder				1 (25)		1 (8)
ARME	Madrone				13 (50)		
CHNO	Alaska yellowcedar						
CONU	Pacific dogwood			4 (23)			
PICO	Lodgepole pine						
PIMO	Western white pine			2 (4)		1 (20)	5 (6)
PISI	Sitka spruce						
POTR2	Black cottonwood						
PSME	Douglas-fir	40(100)	32 (83)	39(100)	70(100)	60(100)	54 (93)
PYFU	Western crabapple		2 (8)				
RHPU	Cascara			2 (9)			
TABR	Pacific yew		2 (33)	4 (47)		20 (20)	4 (25)
THPL	Western redcedar	33(100)	23 (66)	12 (57)	30(100)	10 (60)	7 (68)
TSHE	Western hemlock	53(100)	53(100)	54(100)	15(100)	24(100)	46(100)
TSME	Mountain hemlock						
SHRUBS and HERBS							
ACCI	Vine maple	1 (33)	4 (33)	20 (95)	20 (25)	2 (20)	8 (75)
ACGL	Douglas maple					2 (20)	2 (6)
ACTR	Vanillaleaf	1 (33)	1 (33)	1 (57)	1 (25)	2 (80)	3 (62)
ARCA6	Dwarf mistletoe	1 (33)					3 (6)
ATFI	Ladyfern						1 (6)
BENE	Oregongrape	11(100)	2 (66)	6(100)	3(100)	14(100)	10(100)
BLSP	Deerfern		7 (25)	1 (9)			3 (18)
CASC2	Scouler's harebell	1 (33)	1 (8)			1 (60)	
CHME	Little prince's pine	1 (66)	1 (25)	1 (57)			1 (37)
CHUM	Prince's pine	1 (33)	1 (25)	2 (66)		1(100)	1 (43)
CIAL	Enchanter's nightshade			1 (4)			
CLUN	Queen's cup	2 (33)	1 (8)			1 (40)	2 (25)
COCA	Bunchberry	1 (33)	1 (16)	4 (14)		1 (20)	4 (12)
COCO2	Hazelnut		2 (8)				
COLA	Cutleaf goldthread		2 (16)	2 (9)			3 (6)
DRAU2	Woodfern						
ERMO	Avalanche lily			1 (4)			
FEOC	Western fescue		1 (8)			1 (20)	1 (6)
GASH	Salal	55 (66)	84(100)	51(100)	68(100)	62(100)	63(100)
GATR	Fragrant bedstraw				1 (25)		1 (8)
GOOB	Rattlesnake-plantain	1 (33)	1 (25)	1 (33)	1 (25)	1 (60)	1 (56)
GYDR	Oakfern	4 (33)				2 (20)	1 (6)
HIAL	White hawkweed		1 (8)	1 (4)		1 (40)	1 (43)
HODI	Oceanspray				2(100)	3(100)	
LIBO2	Twinflower	3 (66)	3 (50)	2 (80)	3 (50)	2(100)	17 (68)
LYAM	Skunkcabbage		4 (8)				
MADI2	False lily-of-the-valley		1 (8)				1 (8)
MEFE	Fool's huckleberry	1 (33)	2 (41)	1 (33)			2 (6)
NONE	Woodland beardtongue						
OPHO	Devil's club						1 (6)
OXOR	Oxalis						
PAMY	Pachistima			1 (4)		1 (60)	
POMU	Swordfern	9(100)	2 (33)	2 (66)	4(100)	2 (60)	1 (62)
PTAQ	Bracken fern		5 (16)	1 (14)	1 (50)	2 (20)	1 (25)
PYSE	Sidebells pyrola	1 (33)		1 (14)		1 (20)	1 (6)
RHMA	Rhododendron	25(100)	2 (8)	1 (9)	4(100)		2 (6)
ROGY	Baldhip rose		2 (8)	1 (23)	1 (25)	3(100)	1 (37)
RULA	Trailing bramble		1 (33)				
RUPE	Five-leaved bramble	1 (33)	1 (8)				1 (6)
RUSP	Salmonberry		10 (8)				2 (8)
RUUR	Trailing blackberry		1 (8)	1 (9)	1 (75)	1 (40)	1 (56)
SMST	Star-flowered solomon's seal	1 (33)		1 (4)		1 (37)	
STRO	Rosy twisted-stalk	1 (33)					
SYAL	Common snowberry				1 (25)		
SYMO	Creeping snowberry					1 (80)	
TITR	Three-leaved foamflower	2 (33)				1 (20)	1 (25)
TIUN	Single-leaved foamflower	1 (33)					
TRLA2	Starflower		1 (25)	1 (33)	1 (25)	1 (60)	1 (37)
TROV	Trillium	1 (33)	1 (25)	1 (23)		1 (20)	1 (62)
VAAL	Alaska huckleberry	1 (66)	3 (58)	3 (38)			3 (37)
VAME	Big huckleberry			1 (4)		1 (20)	1 (6)
VAOV	Oval-leaf huckleberry	1 (33)	2 (25)	1 (4)			6 (5)
VAOV2	Evergreen huckleberry				9(100)		
VAPA	Red huckleberry	4(100)	5(100)	4 (95)	4 (75)	2 (60)	11(100)
VISE	Evergreen violet	1 (66)	1 (16)	1 (33)		2 (20)	3 (37)
XETE	Beargrass		1 (25)	12(100)			2 (12)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 170 p. 467 for mean absolute cover values.
[2] Constancy is the percentage of plots for that association where the species occurred.
[3] Stand ages for the TSHE/GASH/VAOV2 Association ranged between 55 and 98 years.

Table 93. (cont.) Mean relative cover[1] values and constancy[2] of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		TSHE/ GASH/OXOR	TSHE/ GASH/POMU	TSHE/ LYAM	TSHE/ POMU-TITR	TSHE/ POMU-OXOR	TSHE/ ACTR
ECOCLASS Code		CHS1 36	CHS1 37	CHM1 11 (OLY)	CHF1 32	CHF1 31 (OLY)	CHF2 11 (OLY)
Number of plots		4	34	1	17	25	10
TREES							
ABAM	Silver fir	4 (50)	1 (14)	4	4 (35)	6 (32)	1 (50)
ABGR	Grand fir		1 (2)		2 (11)		
ABLA2	Subalpine fir						
ACMA	Bigleaf maple		5 (26)		19 (17)	4 (4)	
ALRU	Red alder	25 (25)	4 (5)			3 (4)	
ARME	Madrone						
CHNO	Alaska yellowcedar						
CONU	Pacific dogwood		4 (29)		1 (11)		
PICO	Lodgepole pine						
PIMO	Western white pine		2 (5)				
PISI	Sitka spruce					2 (44)	
POTR2	Black cottonwood						
PSME	Douglas-fir		44 (94)		44 (88)	29 (24)	48(100)
PYFU	Western crabapple						
RHPU	Cascara		2 (11)		2 (11)	7 (24)	
TABR	Pacific yew		4 (44)		1 (11)	2 (7)	1 (20)
THPL	Western redcedar	8 (50)	17 (67)	21	22 (70)	14 (52)	18 (60)
TSHE	Western hemlock	90(100)	48(100)	45	53(100)	81(100)	54(100)
TSME	Mountain hemlock						
SHRUBS and HERBS							
ACCI	Vine maple	3 (50)	27 (85)	5	18 (52)	9 (40)	25 (40)
ACGL	Douglas maple						
ACTR	Vanillaleaf		2 (76)		5 (76)	2 (32)	15(100)
ARCA6	Dwarf mistletoe	3 (25)			4 (11)	1 (4)	
ATFI	Ladyfern	1 (25)	2 (17)	1	5 (47)	1 (60)	1 (20)
BENE	Oregongrape	11 (50)	13 (88)		2 (58)	2 (16)	9 (70)
BLSP	Deerfern	2(100)	3 (32)		4 (70)	6 (92)	1 (30)
CASC2	Scouler's harebell						1 (10)
CHME	Little prince's pine		1 (35)		1 (17)		1 (60)
CHUM	Prince's pine		2 (32)		1 (11)		2 (80)
CIAL	Enchanter's nightshade		1 (5)		2 (5)	2 (12)	1 (20)
CLUN	Queen's cup		1 (5)		2 (29)	1 (12)	2 (80)
COCA	Bunchberry		1 (11)		2 (5)	1 (12)	3 (60)
COCO2	Hazelnut		1 (11)		1 (5)		
COLA	Cutleaf goldthread	2 (25)	1 (2)		1 (5)	1 (20)	
DRAU2	Woodfern		1 (2)		1 (17)	1 (32)	1 (10)
ERMO	Avalanche lily						
FEOC	Western fescue		1 (2)				
GASH	Salal	18(100)	45(100)	1	2 (70)	2 (72)	2 (30)
GATR	Fragrant bedstraw		1 (26)		2 (76)	2 (32)	1 (10)
GOOB	Rattlesnake-plantain		1 (44)		1 (35)	1 (4)	1 (40)
GYDR	Oakfern		7 (2)		7 (11)	2 (32)	
HIAL	White hawkweed		1 (14)		1 (11)		1 (20)
HODI	Oceanspray		1 (5)				
LIBO2	Twinflower		5 (67)		11 (47)	10 (4)	5 (70)
LYAM	Skunkcabbage			15			
MADI2	False lily-of-the-valley	2 (50)		1	2 (17)	1 (36)	1 (10)
MEFE	Fool's huckleberry	2 (50)	2 (11)	1	3 (11)	3 (56)	1 (30)
NONE	Woodland beardtongue		1 (2)		1 (5)		1 (10)
OPHO	Devil's club		2 (8)		2 (29)	1 (24)	1 (20)
OXOR	Oxalis	16(100)				36(100)	
PAMY	Pachistima		1 (5)				1 (10)
POMU	Swordfern	4(100)	19(100)	1	33(100)	25(100)	2 (90)
PTAQ	Bracken fern		3 (11)		2 (5)		
PYSE	Sidebells pyrola					1 (4)	1 (50)
RHMA	Rhododendron		5 (5)		3 (11)		3 (40)
ROGY	Baldhip rose		1 (50)		1 (5)		1 (60)
RULA	Trailing bramble				1 (5)	1 (7)	
RUPE	Five-leaved bramble		1 (2)	1	4 (11)	4 (36)	1 (20)
RUSP	Salmonberry	4 (50)	3 (14)	45	2 (29)	7 (72)	
RUUR	Trailing blackberry		1 (58)		4 (47)	1 (40)	1 (20)
SMST	Star-flowered solomon's seal		1 (5)		1 (35)	1 (12)	12 (60)
STRO	Rosy twisted-stalk		1 (2)		1 (11)	2 (4)	3 (30)
SYAL	Common snowberry						
SYMO	Creeping snowberry		1 (5)				1 (10)
TITR	Three-leaved foamflower	1 (25)	5 (38)	3	7 (88)	2 (88)	4 (70)
TIUN	Single-leaved foamflower		1 (2)		2 (17)		1 (30)
TRLA2	Starflower		2 (47)		1 (64)	1 (24)	1 (30)
TROV	Trillium	1(100)	1 (58)		1 (76)	1 (64)	1 (60)
VAAL	Alaska huckleberry	3(100)	3 (38)	10	3 (35)	6 (84)	2 (50)
VAME	Big huckleberry						1 (40)
VAOV	Oval-leaf huckleberry		2 (5)		1 (5)	2 (7)	1 (20)
VAOV2	Evergreen huckleberry						
VAPA	Red huckleberry	7(100)	10 (91)	1	3 (94)	5 (96)	3 (80)
VISE	Evergreen violet	2 (25)	2 (47)		1 (41)	1 (32)	1(100)
XETE	Beargrass		1 (5)				6 (30)

[1] Mean relative cover are values where zeroes are not included in the calculation of the mean. See Table 170 p. 46 for mean absolute cover values.
[2] Constancy is the percentage of plots for that association where the species occurred.

WESTERN HEMLOCK/ALASKA HUCKLEBERRY
Tsuga heterophylla/Vaccinium alaskaense
TSHE/VAAL CHS6 21

The Western Hemlock/Alaska Huckleberry Association is an important type in certain areas on the Forest. It occurs mainly on warm, moist sites, with moderately high timber productivity. It is found mainly on Hood Canal and Soleduck Districts, and in the Humptulips drainage of the Quinault District (Figure 117), especially in river bottoms. Soils are mostly deep, and derived from colluvium, glacial till or glacial-fluvial deposits. They are often subirrigated. The typical area of this type has burned rarely in the last 500 years.

Floristic Composition

The dominant understory species (Table 94) are Alaska huckleberry and red huckleberry (VAPA), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry and salmonberry (RUSP) become established quickly after clearcut or fire. Other shrubs may include fool's huckleberry (MEFE), salal (GASH) and vine maple (ACCI). Queen's cup (CLUN), foamflower (TITR) and deerfern (BLSP) may also occur. The tree layer may be dominated by Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 118). As this association is transitional to the Silver Fir Zone, silver fir may occur in small amounts in some stands. When stands in this type are understocked, a thick understory may develop.

Ground mosses are abundant on this type, averaging 56% cover. The most common species are *Hylocomium splendens* and *Eurhynchium oreganum*. Other species which occasionally occur include *Plagiothecium undulatum*, *Leucolepis menziesii* and *Rhytidiadelphus loreus*. Data are limited for epiphytic lichens and mosses. Species recorded on two plots include *Isothecium stoloniferum* and *Lobaria oregana*.

Successional Relationships

Red alder sometimes dominates or codominates early seral stages in this association. It dies out by about 80 years. This can leave an understocked stand of hemlock and redcedar, with some Douglas-fir, if it was present in early stages. Besides the red alder dominated sere, there are successional pathways dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Frequent elk sign was observed on this type, including scat, trail and browse, with recent activity recorded in early summer. Browse species were Alaska huckleberry, red huckleberry, salmonberry, fool's huckleberry and deerfern. A red-legged frog was also observed.

Bird observations for this type are limited to one plot, where Swainson's thrush, American robin, Steller's jay, winter wren and pileated woodpecker were recorded.

Table 94. Common plants in the TSHE/VAAL Association, based on stands >150 years (n=17).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	79.4	79.4	100	35-99
silver fir	ABAM	3.5	4.9	70	0-9
Douglas-fir	PSME	15.9	30.1	52	0-60
western redcedar	THPL	3.9	11.0	35	0-40
cascara	RHPU	0.3	1.7	17	0-2
GROUND VEGETATION					
Alaska huckleberry	VAAL	22.3	22.3	100	3-60
red huckleberry	VAPA	12.6	13.4	94	0-45
swordfern	POMU	2.2	2.9	76	0-7
deerfern	BLSP	2.9	4.2	70	0-10
queen's cup	CLUN	1.6	2.3	70	0-10
three-leaved foamflower	TITR	1.8	2.8	64	0-10
salal	GASH	1.4	2.2	64	0-4
salmonberry	RUSP	1.9	3.7	52	0-15
fool's huckleberry	MEFE	0.9	1.7	52	0-3

Environment and Soils

This association occurs on flat to steep, straight or concave slope configurations on lower slopes, toe-slopes and benches. The slope varied from 0% to 75%, but averaged 20%. Bedrock included sedimentary types but was almost always metabasalt. Regolith was split about equally between colluvium and glacial sediments with some alluvium as well. It appears that this type occupies cool sites such as frost pockets, areas of cold air drainage and north slopes in otherwise warm areas.

Three soil pits showed weak to moderate soil development. Textures were gravelly sandy clay loams and loams. The coarse fragment fraction was high, consisting mostly of gravel but including cobbles and stones as well. Coarse fragments averaged 52%. The high coarse fragment fraction and the sandy texture combine to make a potentially drouthy soil. However, this is compensated in part by the moist topographic position. Soil compaction was noted in the lower horizons in two pits and throughout the profile in one. This is the reason for the below average rooting depth of 44.3 cm. The O1 was a little thinner than average at 1.7 cm and the O2 was about average at 5.3 cm. The O2 was occupied by a root mass. Two haplorthods and one dystrochrept were identified.

The Olympic Soil Resource Inventory (Snyder *et al.* 1969) indicates that soils in this type fall into two categories. One group consists of deep glacial sediments with compacted subsoils and rapid surface and low subsurface permeability. These soils are probably rendered effectively shallow by subsoil compaction. They tend to have silt loam to clay loam textures. The other group consists of shallow colluvial soils that are well drained and rapidly permeable. They have textures ranging from clay loams to sandy loams. Coarse fragments range from 15% to 65% near the surface and 25% to 85% in the subsoil.

Summer soil temperatures averaged 10.1 deg C (50.2 deg F) making this one of the coolest associations in the Western Hemlock Zone. Temperature regime is borderline between mesic and frigid. The moisture regime is udic.

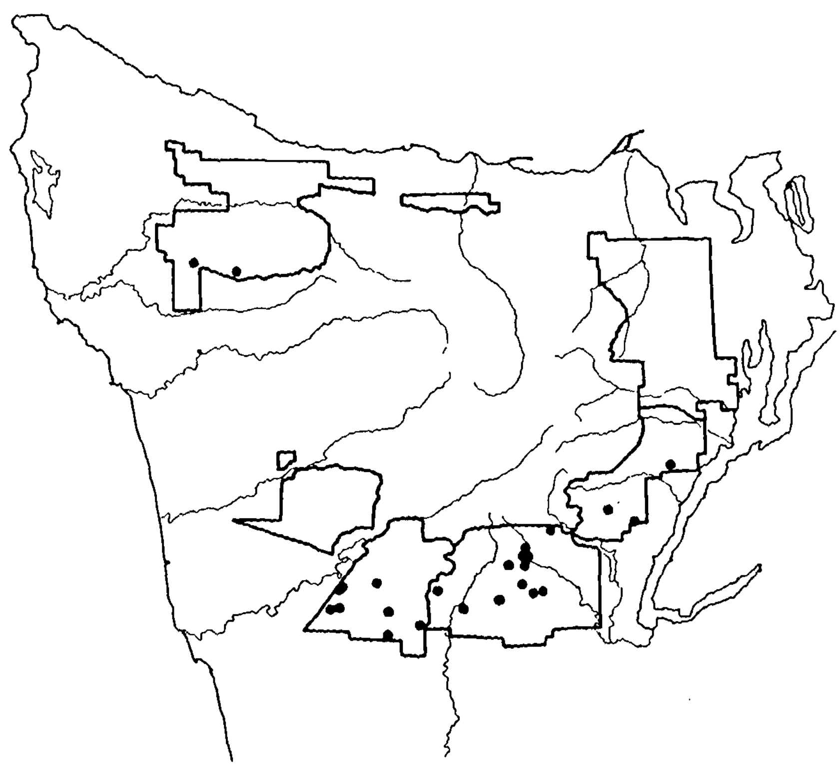


Figure 117. Map of plot locations for the Western Hemlock/Alaska Huckleberry Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index of measured stands averaged 169 (base 100) and 121 (base 50). The productivity potential for Douglas-fir using the site index-yield table approach was 179 cu ft/ac/yr and 214 cu ft/ac/yr for western hemlock (Table 95). The empirical yield estimate was 164 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations include elk habitat, riparian zone and manipulation of species composition. Response to fertilizer in this type is still unknown. This type occurs in low areas and along major stream bottoms where elk winter range and riparian management are important. Red alder can be cultivated on this type but it is not common. Salmonberry and/or Alaska huckleberry can pose brush problems. Douglas-fir and/or western hemlock are the preferred species.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock, and annosus root disease on western hemlock. When present laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can damage western hemlock after 120 years of age, and red ring rot and rusty red stringy rot may be present on western hemlock also. Hemlock dwarf mistletoe may be present, especially in Environmental Zones 0-5, on older western hemlock.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 95. Timber productivity values for the Western Hemlock/Alaska Huckleberry Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	2	4	169	6	179	507	2	485	251	164
Douglas-fir (McArdle [2])	5	5	130	15	128					
Douglas-fir (King [3])	2	4	121	2	183					
Western Hemlock (Barnes [4])	2	2	140	34	218			389	163	
Western Hemlock (Wiley [5])	3	13	108	5	214	431	9	389		

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966). ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include the Swordfern and Alaska Huckleberry types. The Western Hemlock/Alaska Huckleberry-Salal type occurs on warmer and somewhat lower elevation sites. The Western Hemlock/Swordfern-Foamflower type occurs on moister and more productive sites. The Western Hemlock/Alaska Huckleberry Association is recognized throughout the Olympic and Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1981a,b,c,d, 1982a,b, 1983a,b, 1984, 1985). In British Columbia it is recognized as the Hemlock-Vaccinium-Moss Ecosystem Association (Haeussler *et al.* 1982). A similar association, the Western Hemlock/Alaska Huckleberry/Bunchberry Dogwood, is recognized on the Gifford Pinchot National Forest (Topik *et al.* 1986), Mt. Hood National Forest (Halverson *et al.* 1986) and Willamette National Forest (Hemstrom *et al.* 1987).

Figure 118. Photo of the Western Hemlock/Alaska Huckleberry Association, Elk Creek, Hood Canal District.

WESTERN HEMLOCK/ALASKA HUCKLEBERRY/BEARGRASS

Tsuga heterophylla/Vaccinium alaskaense/Xerophyllum tenax
TSHE/VAAL/XETE CHS6 22

The Western Hemlock/Alaska Huckleberry/ Beargrass Association is a minor type of warm dry sites, and moderately low timber productivity. It occurs in a limited area on the Hood Canal District (Figure 119), where it occurs primarily along the upper slopes just below the Silver Fir Zone. Soils are mostly shallow and derived from colluvium, and are often well drained. Much of this type has burned once or twice in the last 500 years.

Floristic Composition

Dominant understory species (Table 96) are Alaska huckleberry and beargrass, which are usually present in all ages of stands, although they may be inconspicuous absent in densely stocked second growth. Beargrass, Alaska huckleberry and vine maple (ACCI) can resprout or become established quickly after clearcut or fire. Other shrubs may include Oregongrape (BENE), red huckleberry (VAPA), fool's huckleberry (MEFE) and salal (GASH). Herbs include vanillaleaf (ACTR), prince's pine (CHUM, CHME), queen's cup (CLUN) and bunchberry (COCA). The tree layer may be dominated by Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 120). Stands in this type may be slow to regenerate. Most areas of this type have not been cut over.

Cryptogam information is limited to one old-growth plot, where 40% ground moss cover was recorded. There are no data available regarding species presence, or epiphytic mosses and lichens.

Successional Relationships

The common successional pathway is dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

No observations for wildlife or birds are recorded for this type.

Table 96. Common plants in the TSHE/VAAL/XETE Association, based on stands >150 years (n=3).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	62.7	62.7	100	35-83
Douglas-fir	PSME	29.0	29.0	100	7-65
western redcedar	THPL	6.7	6.7	100	4-10
silver fir	ABAM	3.0	3.0	100	2-4
GROUND VEGETATION					
Alaska huckleberry	VAAL	31.7	31.7	100	15-45
beargrass	XETE	7.3	7.3	100	3-15
Oregongrape	BENE	3.7	3.7	100	2-5
red huckleberry	VAPA	7.7	11.5	66	0-15
fool's huckleberry	MEFE	2.3	3.5	66	0-6
salal	GASH	2.0	3.0	66	0-3
vanillaleaf	ACTR	0.7	1.0	66	0-1
little prince's pine	CHME	0.7	1.0	66	0-1
prince's pine	CHUM	0.7	1.0	66	0-1
queen's cup	CLUN	0.7	1.0	66	0-1
bunchberry	COCA	0.7	1.0	66	0-1
pinesap	HYMO	0.7	1.0	66	0-1
trailing bramble	RULA	0.7	1.0	66	0-1

Environment and Soils

This type occurs on moderately steep, convex or straight, upper slopes and ridgetops. The slope on sampled areas varied from 45% to 50% and averaged 46%. Two plots occurred on metabasalt and one on shale. All three occurred on colluvium.

All three old-growth plots in this type occurred on shallow colluvial units according to the Soil Resource Inventory (Snyder *et al.* 1969). Soil on these units was only 1 to 3 feet deep. They are well drained and rapidly permeable. Textures are loam, silt loam and sandy loam. Coarse fragments range from 15% to 50% near the surface and 35% to 75% in the subsoils.

No soil temperature data were taken for this type, but elevation and environmental zone data indicated a frigid soil temperature regime. The moisture regime is probably xeric.

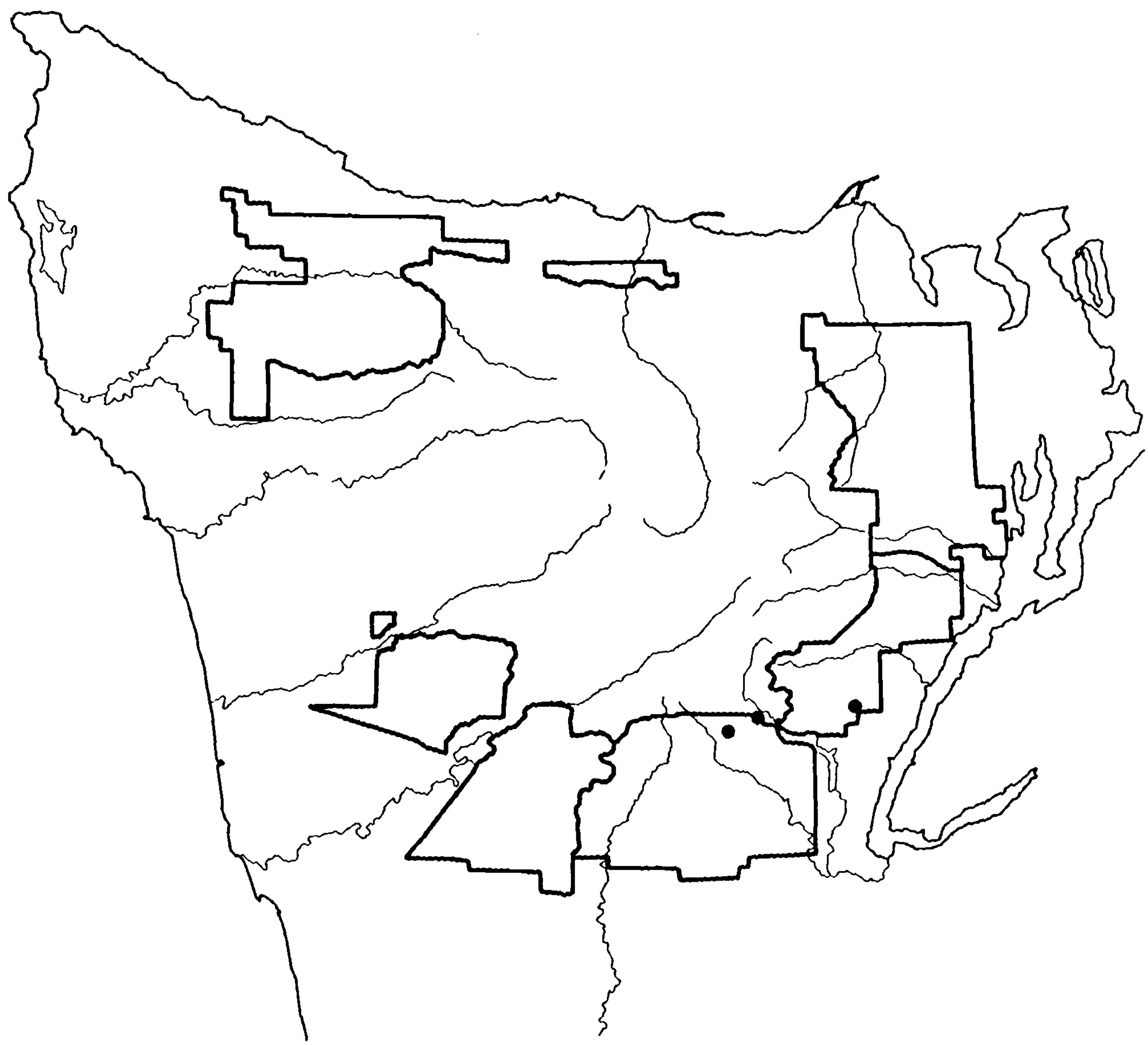


Figure 119. Map of plot locations for the Western Hemlock/Alaska Huckleberry/Beargrass Association.

Timber Productivity

Timber productivity of this type is moderately low (Site IV or V). This is due to the dryness of the site, well-drained soils, and relatively short growing season. Site index of measured stands (Reconnaissance plots only) averaged 94 (base 100). The productivity potential using the site index-yield table approach was 76 cu ft/ac/yr (Table 97). The stockability of these sites is moderate to low.

Management Considerations

Management considerations include soil maintenance and stability, and ensuring suitable regeneration. Maintenance of soil nutrients and organic matter is more critical in this type than other Western Hemlock Zone types. Response to fertilizer is unknown. This type occurs in high areas for the Western Hemlock Zone, and along upper slopes and ridgetops. Red alder cannot be easily cultivated on this type, so it is probably not a management option. Douglas-fir or western hemlock are the preferred species. Beargrass and/or Alaska huckleberry can pose brush problems.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also. Hemlock dwarf mistletoe may be present on older western hemlock.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 97. Timber productivity values for the Western Hemlock/Alaska Huckleberry/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [2]	SDI	GBA TREES	GBA	SIGBA	EMAI [3]
Douglas-fir (McArdle [1])	2	2	94	23	76					69

[1] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[2] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[3] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include the Alaska Huckleberry types. The Western Hemlock/Alaska Huckleberry type occurs on warmer and lower elevation sites. The Silver Fir/Alaska Huckleberry/Beargrass type occurs at higher elevations with more snow. The Western Hemlock/Alaska Huckleberry-Salal type occurs on topographically wetter sites and at lower elevations. The Western Hemlock/Alaska Huckleberry/Beargrass Association is not previously recognized and may be limited to the Olympic Mountains.

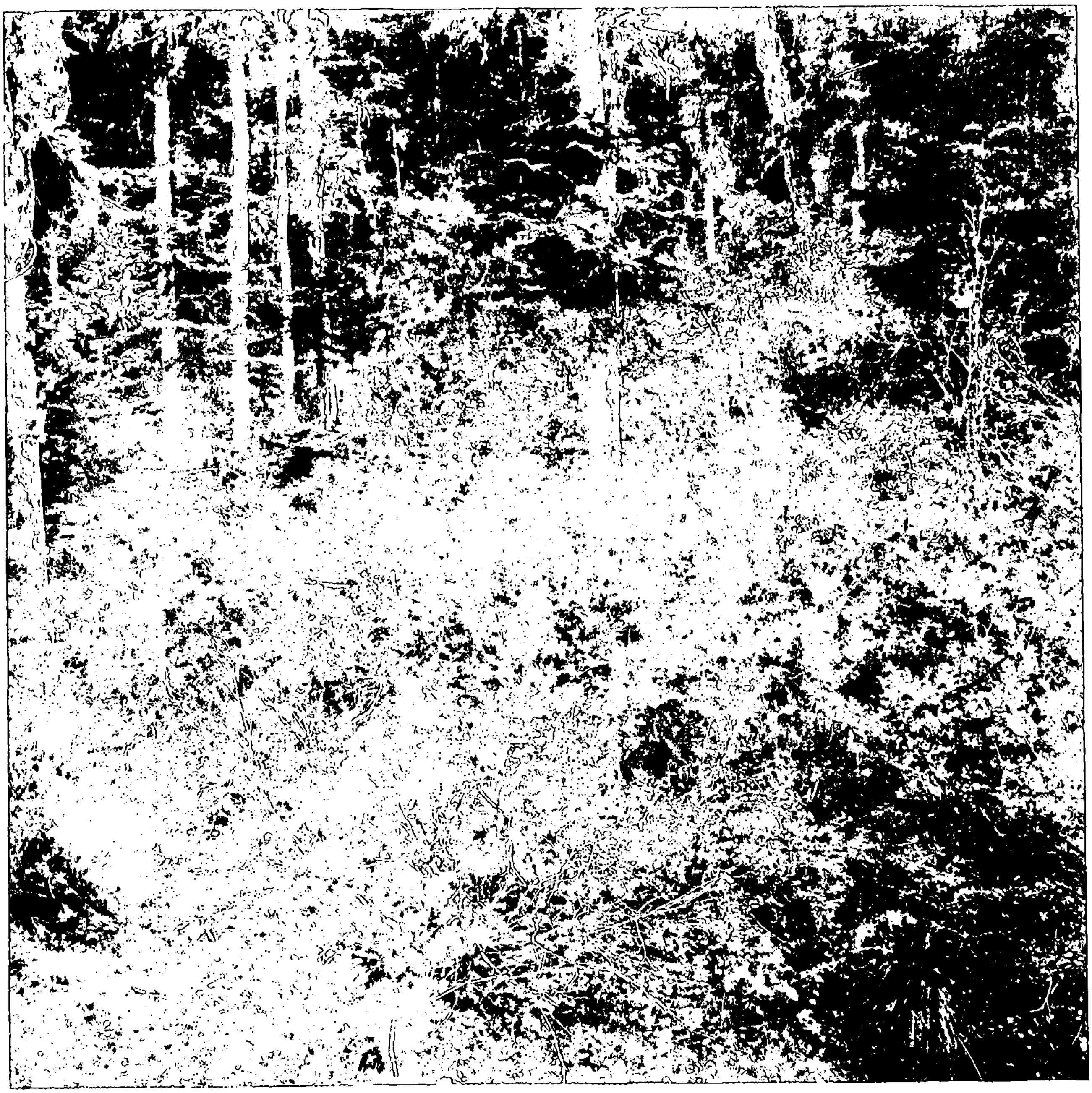


Figure 120. Photo of the Western Hemlock/Alaska Huckleberry/Beargrass Association, Four Stream, Hood Canal District.

WESTERN HEMLOCK/ALASKA HUCKLEBERRY/OXALIS

Tsuga heterophylla/Vaccinium alaskaense/Oxalis oregana
TSHE/VAAL/OXOR CHS6 23 (OLY)

The Western Hemlock/Alaska Huckleberry/Oxalis Association is a type of moist sites at low elevations and moderately high timber productivity. It is found mostly in the wetter climatic areas of the Olympics, particularly on the Quinault District (Figure 121). Soils are mostly deep, moderately fine textured, and derived from colluvium, outwash or glacial till. They are often subirrigated and occur along toe-slopes, or in areas of high precipitation, high humidity or fog. Little snow accumulates in this type during the winter. The typical area of this type has burned very seldom in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

Dominant understory species (Table 98) are Alaska huckleberry and oxalis, which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Alaska huckleberry and salmonberry (RUSP) often resprout rapidly after clearcut or fire, and swordfern and deerfern are usually present in small amounts. Other shrubs may include fool's huckleberry (MEFE) and red huckleberry (VAPA). False lily-of-the-valley (MADI2) and foamflower (TITR) may also occur. The tree layer may be dominated by red alder, Douglas-fir, western hemlock, western redcedar, or any combination of these trees, although Douglas-fir is not common (Figure 122).

Ground mosses are abundant on this type, ranging from 2 to 95% cover, with an average cover of 53%. The most common species are *Hylocomium splendens* and *Eurhynchium oreganum*. Other species which may occur include *Plagiothecium undulatum* and *Rhytidiadelphus loreus*. Data on epiphytic mosses and lichens are limited to one plot, where *Isothecium stoloniferum* was recorded.

Successional Relationships

There are successional pathways dominated by Douglas-fir, red alder and western hemlock, with the hemlock sere being most common. Climax stages are dominated by western hemlock, or by both western redcedar and western hemlock.

Other Biota

Elk sign was frequently observed on this type, including scat, trails and browse. Moderate browsing was noted on red huckleberry; other browse species were Alaska huckleberry, salmonberry, swordfern, fool's huckleberry and vine maple.

Bird observations were recorded for winter wren, varied thrush, Swainson's thrush, pine siskin, red-tailed hawk, Steller's jay and woodpecker.

Table 98. Common plants in the TSHE/VAAL/OXOR Association, based on stands >150 years (n=15).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	88.0	88.0	100	40-99
silver fir	ABAM	2.7	5.9	46	0-9
western redcedar	THPL	2.4	7.2	33	0-20
Douglas-fir	PSME	2.3	11.7	20	0-15
cascara	RHPU	0.3	1.3	20	0-2
Sitka spruce	PISI	0.1	1.0	13	0-1
GROUND VEGETATION					
Alaska huckleberry	VAAL	29.8	29.8	100	2-65
oxalis	OXOR	24.1	24.1	100	1-65
deerfern	BLSP	5.0	5.0	100	1-15
red huckleberry	VAPA	4.0	4.3	93	0-15
swordfern	POMU	3.6	3.9	93	0-8
salmonberry	RUSP	3.4	3.6	93	0-20
salal	GASH	1.4	1.6	86	0-3
fool's huckleberry	MEFE	2.3	3.2	73	0-15
three-leaved foamflower	TITR	1.1	1.5	73	0-3
false lily-of-the-valley	MADI2	1.5	2.2	66	0-8
five-leaved bramble	RUPE	1.1	1.7	66	0-3
woodfern	DRAU2	0.6	1.0	60	0-1
trillium	TROV	0.5	1.0	53	0-1

Environment and Soils

This type occurs on flat to steep, but usually gentle, straight to concave slopes. It usually occurs on lower slopes, toe-slopes and benches. Bedrock is usually metabasalt, regolith can be colluvium or glacial till. Slopes ranged from 1% to 80% and averaged 25%.

Two soil pits were dug, one showed poor soil development, the other showed a well-developed profile. A definite albic horizon was present in one old-growth stand. Texture varied from gravelly sandy clay to cobbly silt loam. Coarse fragments averaged 55% which is considerably higher than average. The O1 averaged 1 cm and the O2 was 12.9 cm. This is thin for an O1 and very thick for an O2. The rooting depth averaged 55 cm which is not quite average but roots also occupied the entire O2 horizon. Water holding capacity of the mineral soil is about average but is above average if the O layer is included. These two soils were classified as a haplorthod and a dystrochrept.

According to the Olympic Soil Resource Inventory (Snyder *et al.* 1969), most soils are well drained with rapid surface permeability and moderate to slow subsurface permeability. Textures vary from silty clay loams to sandy loams. Coarse fragments range from 5% to 65% near the surface and 15% to 85% in the subsoil. There is a strong tendency for subsoil compaction in these glacial and deep colluvial soils.

The summer soil temperature averaged 12.5 deg C (54.5 deg F) which is warm for the Western Hemlock Zone. The temperature regime is at the warm end of frigid. The moisture regime is udic.

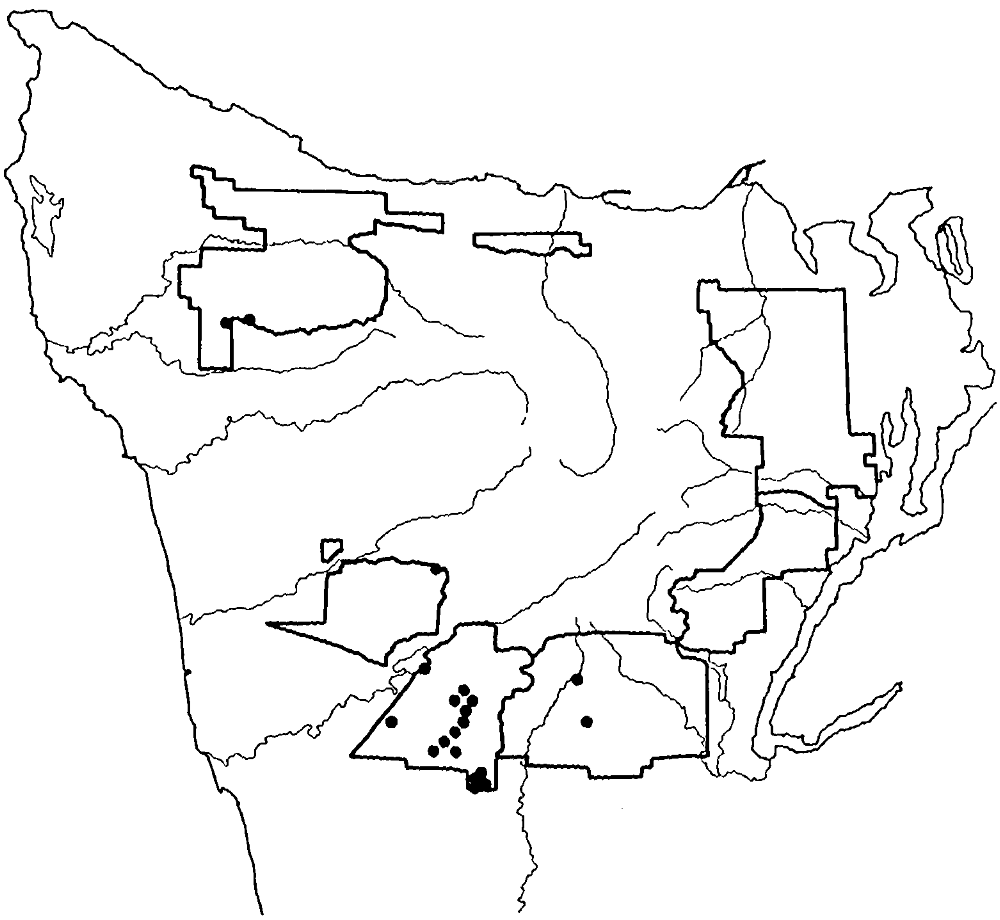


Figure 121. Map of plot locations for the Western Hemlock/Alaska Huckleberry/Oxalis Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils and relatively long growing season. Site index for Douglas-fir on one plot was 173 (base 100). Site index for western hemlock was 135, and 127 for silver fir (Table 99). The productivity potential for western hemlock using the site index-yield table approach was 206 cu ft/ac/yr. The stockability of these sites is high.

Management Considerations

Management considerations include manipulation of species composition and maintenance of nutrient balance. Accumulated soil organic matter and nitrogen could be preserved by reducing burning sites in this type and by maintaining a component of red alder in the ecosystem. However, in some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Many oxalis types show very low amounts of calcium and phosphorus. This may be limiting growth or affecting tree development on these sites. We recommend that any fertilizer applications on this type include calcium and phosphorus. Wildlife values can be moderately high, especially for elk winter range. Douglas-fir is uncommon on this type. Western hemlock and western redcedar are the preferred species.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Armillaria may also be important in young-growth western hemlock and Douglas-fir plantations, but by age 30 impacts should be minimal. Annosus root disease appears to represent the most serious potential problem on this type to thinned western hemlock, reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot, rusty red stringy rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe can be abundant in old-growth stands of this type.

Potential insect pests which may occur on this type include the hemlock looper which may be present on western hemlock, and the western blackheaded budworm which can occur on buds of western hemlock or Douglas-fir.

Table 99. Timber productivity values for the Western Hemlock/Alaska Huckleberry/Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA	SIGBA	EMAI [6]
Western Hemlock (Barnes [1])	8	8	135	36	209					189
Western Hemlock (Wiley [2])	2	5	99	20	201	348				
Silver Fir (Hoyer [3])	2	2	122	14	120	335				

[1] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[2] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[3] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include other Alaska Huckleberry and Oxalis types. The Western Hemlock/Alaska Huckleberry-Salal type occurs on drier sites. The Western Hemlock/Swordfern-Oxalis type occurs on similar sites in slightly drier areas. It is also closely related to the Silver Fir/Alaska Huckleberry/Oxalis and Silver Fir/Oxalis types which occur at higher elevations, but still in the wetter environmental zones. The Western Hemlock/Alaska Huckleberry/Oxalis Association is not previously recognized in Oregon or Washington. On the Olympic National Forest it was included in the Western Hemlock/Oxalis type (Henderson and Peter 1981b) or the Western Hemlock/Alaska Huckleberry type (Henderson and Peter 1982a).

Figure 122. Photo of the Western Hemlock/Alaska Huckleberry/Oxalis Association, lower Wynoochee Valley, Hood Canal District.

WESTERN HEMLOCK/ALASKA HUCKLEBERRY-SALAL

Tsuga heterophylla/Vaccinium alaskaense-Gaultheria shallon

TSHE/VAAL-GASH CHS6 24 (OLY)

The Western Hemlock/Alaska Huckleberry-Salal Association is a major type of warm, moist sites and moderately high timber productivity. It occurs mostly in the wetter climatic areas of the Olympics, particularly on the Quinault and Soleduck Districts (Figure 123). Soils are mostly deep, and derived from colluvium, glacial till or glacial-fluvial deposits. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned rarely in the last 500 years.

Floristic Composition

Dominant understory species (Table 100) are Alaska huckleberry, red huckleberry (VAPA) and salal, which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Salal, Alaska huckleberry, salmonberry (RUSP) and red huckleberry become established quickly after clearcut or fire. Other shrubs may include vine maple (ACCI), Oregongrape (BENE) and fool's huckleberry (MEFE). Swordfern (POMU), deerfern (BLSP) and occasionally twinflower (LIBO2) may occur. The tree layer may be dominated by red alder, Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 124).

Ground mosses are abundant on this type, with cover values ranging from 2% to 95%, and averaging 63%. The most common species are *Hylocomium splendens* and *Eurhynchium oreganum*. Other species which may occur include *Rhytidiadelphus loreus*, *Sphagnum* sp. and *Plagiothecium undulatum*. Information on epiphytic mosses and lichens is limited; *Isothecium stoloniferum* was often abundant, the nitrogen-fixer *Lobaria oregana* occurred occasionally. Other epiphytes may include *Dicranum* and *Cladonia* spp. on lower tree boles.

Successional Relationships

Red alder sometimes dominates early seral stages in this association. It dies out by about 80 years, leaving an understocked stand of western hemlock and redcedar, with some Douglas-fir, if it was present in early stages. Besides the red alder dominated sere, there are successional pathways dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Frequent elk and mountain beaver activity were observed on this type, with recent activity recorded in early summer. Evidence of browsing was observed on red huckleberry, Alaska huckleberry, vine maple and swordfern. Mountain beaver appear to prefer Alaska huckleberry as a browse species. Other wildlife observations include deer, mole, bear scat and Douglas squirrel.

Bird observations include Steller's jay, rufous hummingbird, red-shafted flicker, western flycatcher, chestnut-backed chickadee, winter wren, American robin, pine siskin, red crossbill, brown creeper, golden-crowned kinglet, varied thrush, olive-sided flycatcher and common raven.

Table 100.Common plants in the TSHE/VAAL-GASH Association, based on stands >150 years (n=21).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	70.0	70.0	100	30-99
Douglas-fir	PSME	15.3	26.8	57	0-68
western redcedar	THPL	12.6	22.0	57	0-45
silver fir	ABAM	1.7	3.9	42	0-7
cascara	RHPU	0.5	2.2	23	0-3
Pacific yew	TABR	0.9	4.8	19	0-11
Sitka spruce	PISI	0.1	1.0	9	0-1
GROUND VEGETATION					
salal	GASH	30.0	30.0	100	4-99
Alaska huckleberry	VAAL	24.0	24.0	100	2-55
red huckleberry	VAPA	9.7	9.7	100	1-30
fool's huckleberry	MEFE	1.3	1.9	71	0-10
deerfern	BLSP	4.5	6.8	66	0-20
vine maple	ACCI	8.8	14.2	61	0-55
swordfern	POMU	1.4	2.2	61	0-15

Envlronment and Solls

This type occurs on flat to steep, straight or convex slopes mainly on lower slopes and bottoms. In terms of microtopography however, it rarely occurs in a low spot. The slope ranged from 0% to 85% and averaged 23%. Bedrock is either metabasalt or sedimentary rocks. Regolith is either glacial or colluvial.

Two very different soil pits were described in this type. One was a medihemist with a water table at 23 cm, and the other was a well-drained haplumbrept. Both were in high rainfall areas of the Quinault District. Horizonation was clear in the medihemist, but poor due to windthrow mixing in the haplumbrept. The haplumbrept showed some indication of an albic horizon which had been destroyed by windthrow. This soil was deep and the rooting depth was 80 cm. The roots also occupied the O2 which was 6 cm thick (about average). The medihemist was gleyed below 23 cm. In this soil there were very few roots in the mineral soil. Almost all of the roots were in the O2 which was 17 cm thick. Compared to other soils this is a very thick O layer. The mineral soil in the medihemist was clay and loam to very sandy loam in the haplumbrept. Both had a low coarse fragment component. This resulted in a relatively high water holding capacity.

Our plots occurred on colluvial or glacial soils as described by the Olympic Soil Resource Inventory (Snyder *et al*. 1969). All of the glacial and some of the colluvial soils show subsoil compaction but no cementation. Half of the colluvial soils are shallow. Between compaction and shallow bedrock almost all of these soils may be rendered effectively shallow. Since the type generally occurs in high precipitation areas, the result of this would be to retard drainage and perch the water table. Nevertheless, most of these soils were considered well drained with rapid surface permeability and generally moderate or slow subsoil permeability. Soil texture varied from sandy loam to clay loam. Coarse fragments ranged from 5% to 65% near the surface and 15% to 85% in the subsoil.

The summer soil temperature for the type averaged 12.4 deg C (54.3 deg F) which is warm for the Western Hemlock Zone. This type is borderline between mesic and frigid temperature regimes. The moisture regime is udic, or in rare cases, aquic.

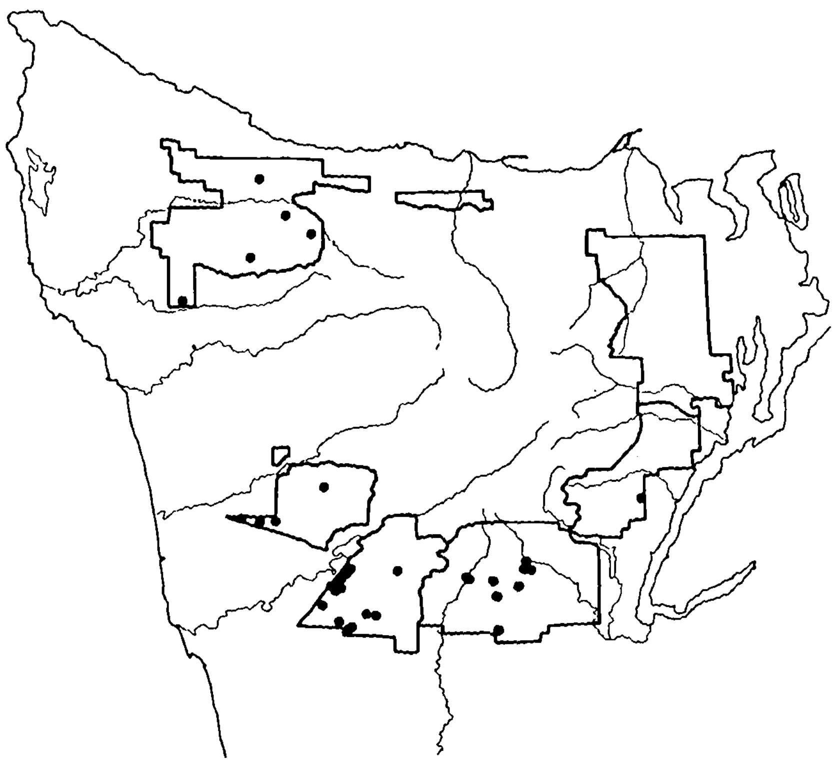


Figure 123. Map of plot locations for the Western Hemlock/Alaska Huckleberry-Salal Association.

Nutrient analysis from one pit showed high potassium, total nitrogen, organic matter, sulfate, boron, zinc, copper, manganese and sodium compared to other types. The pH was 4.7 which is low compared to other types. This one sample came from a colluvial soil derived from basalt bedrock.

Timber Productivity

Timber productivity of this type is moderately high (Site III). Site index of Douglas-fir averaged 153 (base 100), and 117 for western hemlock (Table 101). The productivity potential for Douglas-fir using the site index-yield table approach and unmanaged stands was 158 cu ft/ac/yr, and for western hemlock was 205 cu ft/ac/yr. The empirical yield estimate was 164 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations include elk habitat, riparian zone and manipulation of species composition. Response to fertilizer in this type is still unknown. This type occurs in low areas and along major stream bottoms where elk winter range and riparian management are important. Red alder can be cultivated on this type, or it may be a management problem if Douglas-fir or western hemlock are the preferred species. Salmonberry and/or Alaska huckleberry can pose brush problems.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock, and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also. Hemlock dwarf mistletoe may be present, especially in Environmental Zones 0-5, on older western hemlock.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 101. Timber productivity values for the Western Hemlock/Alaska Huckleberry-Salal Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	3	10	153	35	158	263	4	243	112	164
Douglas-fir (McArdle [2])	6	6	135	24	144					
Western Hemlock (Barnes [3])	5	5	117	17	174			548	192	
Western Hemlock (Wiley [4])	3	11	102	9	205	419	12	548		
Silver Fir (Hoyer [5])	1	3	184		195	484	3	329	182	

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.
[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.
[3] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.
[4] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.
[5] Base age 100, Breast height age (Hoyer and Herman, in press), ages 25 to 400 years.
[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
[7] Stand Density Index (Reinecke 1933).
[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).
[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include the Swordfern and Alaska Huckleberry types. The Western Hemlock/Alaska Huckleberry type occurs on colder and somewhat higher elevation sites. The Western Hemlock/ Swordfern-Foamflower type occurs on moister and more productive sites. The Western Hemlock/ Alaska Huckleberry-Salal Association is previously recognized on the Gifford Pinchot National Forest (Topik *et al.* 1986) and Mt. Hood National Forest (Halverson *et al.* 1986). It is essentially the same as the Western Hemlock/Alaska Huckleberry Association, Salal phase as used by Smith and Henderson (1986). In earlier work on the Olympic National Forest it was included with the Western Hemlock/ Alaska Huckleberry Association.

Figure 124. Photo of the Western Hemlock/Alaska Huckleberry-Salal Association, West Fork Humptulips River, Quinault District.

WESTERN HEMLOCK/BEARGRASS

Tsuga heterophylla/Xerophyllum tenax

TSHE/XETE CHF5 11 (OLY)

The Western Hemlock/Beargrass Association is an uncommon type of topographically dry areas, cold soils and low timber productivity. It is found in the Prospect Ridge and Big Creek areas on the Hood Canal District (Figure 125). Soils are shallow, derived from very stony colluvium, and appear to be low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 102) is beargrass. Shrubs may include Oregongrape (BENE), red huckleberry (VAPA), salal (GASH) and occasionally vine maple (ACCI). Herbs may include vanillaleaf (ACTR), little prince's pine (CHME) and evergreen violet (VISE). The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 126). Old-growth stands in this type are all about 300 years old, having originated from a fire about 320 years ago. Many stands begin with a moderate component of beargrass following fire, which may impede restocking.

Ground mosses and lichens are relatively sparse in this type, averaging only 10% cover. Data are limited for species presence and abundance, but species which may occur include *Eurhynchium oreganum*, *Rhytidiopsis robusta*, *Dicranum* sp., *Plagiothecium undulatum* and *Cladonia* spp. Epiphytes were only recorded on one plot, where they were sparse in abundance. Lichens present included *Hypogymnia enteromorpha*, *Platismatia glauca* and crustose species on tree bark, with a small amount of *Alectoria sarmentosa*.

Successional Relationships

There are two probable successional pathways for this type. One dominated by Douglas-fir, the other by western hemlock. Later seral stages are often dominated by both Douglas-fir and western hemlock, and presumably western hemlock and western redcedar dominate the climax stand.

Other Biota

Wildlife observations are limited to one plot for this type, where deer and snowshoe hare were recorded. Bird observations from one plot noted golden-crowned kinglet and hermit thrush.

Table 102. Common plants in the TSHE/XETE Association, based on stands >150 years (n=3).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	55.0	55.0	100	45-75
western hemlock	TSHE	49.0	49.0	100	40-60
GROUND VEGETATION					
beargrass	XETE	33.3	33.3	100	20-55
Oregongrape	BENE	12.0	12.0	100	3-30
salal	GASH	2.7	2.7	100	2-4
vanillaleaf	ACTR	1.7	1.7	100	1-3
red huckleberry	VAPA	1.3	1.3	100	1-2
evergreen violet	VISE	1.3	1.3	100	1-2
little prince's pine	CHME	1.0	1.0	100	1-1
vine maple	ACCI	11.3	17.0	66	0-25
pinesap	HYMO	0.7	1.0	66	0-1
sidebells pyrola	PYSE	0.7	1.0	66	0-1
baldhip rose	ROGY	0.7	1.0	66	0-1
Alaska huckleberry	VAAL	0.7	1.0	66	0-1

Environment and Soils

This type occurs on steep, straight, mid- to upper slopes. Slopes ranged from 66% to 120% and averaged 81%. All examples have thus far occurred on gravelly metabasaltic colluvium.

One soil pit was described for this type and classified as a xerorthent. The course fragments fraction of the soil was 63% and consisted mostly of gravel. Soil textures were loamy sand and sandy loam. O layers are thin in this type. The O1 measured 1 cm and the O2 measured 2 cm. Horizons and structure were very weakly expressed. Rooting depth was deep (105 cm) and roots also occupied the O2 layer. The high coarse fragment fraction, coarse texture, steep slope and shallowness combine to make this soil one of the drouthiest in the Western Hemlock Zone. The depth of the rooting zone probably reflects the need to maintain a large root volume as deep as possible to survive drouth.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as gravelly loams, gravelly silt loams and gravelly sandy loams. Although no bedrock was encountered in the pit, Snyder *et al.* (1969) indicates that bedrock is usually 3 feet deep and rock outcrops are common. Soils are well drained and highly permeable, and coarse fragments range from 15% to 50% near the surface and 35% to 75% in the subsoils (Snyder *et al.* 1969).

The mean summer soil temperature is 10.2 deg C (50.3 deg F) which is cool for the Western Hemlock Zone. The elevation and environmental zone data indicate that this association is in the frigid temperature regime. The moisture regime is probably xeric.

Nutrient analysis from one pit indicated low calcium, magnesium and nitrogen, but high organic matter (Table 153 p.434). The pH was 5.1 which is about average for the series.

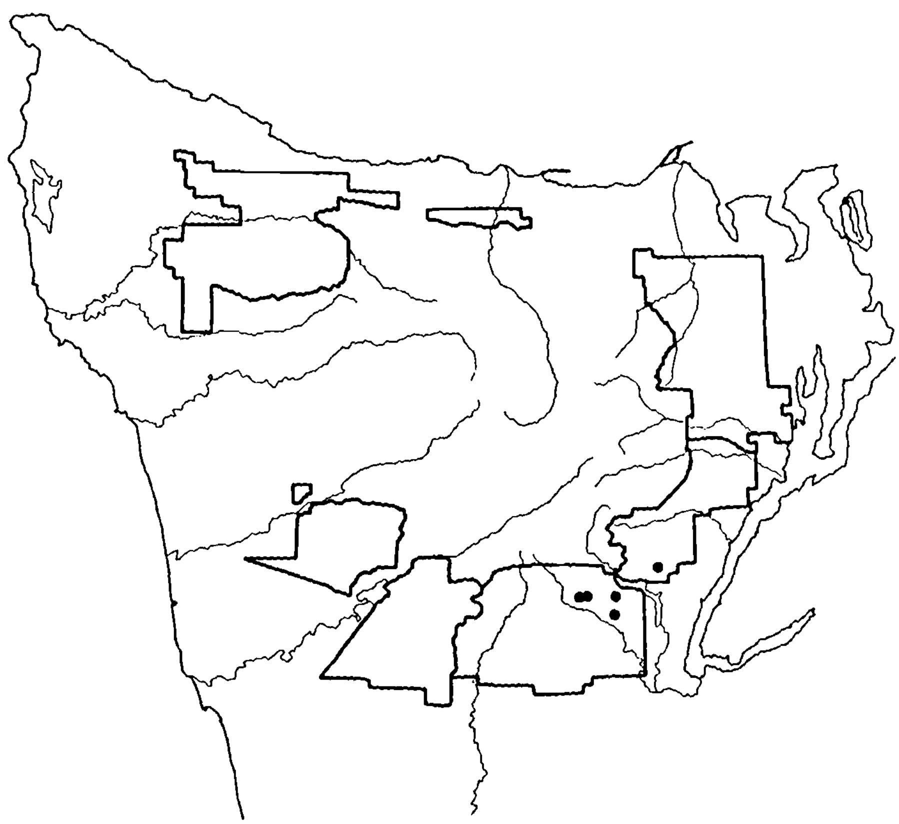


Figure 125. Map of plot locations for the Western Hemlock/Beargrass Association.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the dryness of the site and poor soils. Site index for Douglas-fir averaged 78 (base 100) for both Intensive and Reconnaissance plots, and 51 (base 50). The productivity potential using the site index-yield table approach 55 cu ft/ac/yr (Table 103). The empirical yield estimate was 69 cu ft/ac/yr. The stockability of these sites is apparently low.

Management Considerations

Management considerations include ensuring rapid initial stocking, enhancement of soil nutrients, maintaining organic matter and preservation of the stony, unstable soil. Because of the ridgetop positions where this type usually occurs, there is an increased susceptibility to snow and wind damage. Soil nitrogen should be preserved in this type, and the litter layer should be kept intact to help keep the shallow, unstable soil in place. Fertilizing with nitrogen should enhance the productivity of this type, however maintaining the organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Soil water limitation should be addressed by regulating stocking and maintaining suitably low number of trees per acre. This type represents harsh growing conditions for the Western Hemlock Zone.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are important in Douglas-fir. Red ring rot and rusty red stringy rot can also be expected on western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock.

Table 103. Timber productivity values for the Western Hemlock/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle [1])	1	3	67		41	520	3	205	41	69
Douglas-fir (McArdle [2])	4	4	86	26	68					
Douglas-fir (King [3])	1	3	51		46					
Western Hemlock (Wiley [4])	1	3	48		135	520	3	252		

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.
[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.
[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.
[4] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.
[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496)
[6] Stand Density Index (Reinecke 1933).
[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[8] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).
[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/Alaska Huckleberry/Beargrass which occurs on slightly moister sites at higher elevations and on colder soils, Western Hemlock/Oregongrape which occurs on slightly moister sites with deeper soils, and Silver Fir/Alaska Huckleberry/Beargrass at higher elevations with more snow and colder soil temperatures. It is also related to the Western Hemlock/ Rhododendron/Beargrass type which occurs on similar sites but farther north along the eastern front of the Olympic Mountains. The Western Hemlock/ Beargrass Association is not recognized elsewhere and may be limited to the Olympic Mountains.

Figure 126. Photo of the Western Hemlock/Beargrass Association, Big Creek, Hood Canal District.

WESTERN HEMLOCK/DEPAUPERATE
Tsuga heterophylla/Depauperate
TSHE/Dep. CHF9 11

The Western Hemlock/Depauperate Association is a rare and somewhat artificial type. It is easily confused with depauperate stand conditions which may occur in many other associations. A sparse ground vegetation can be due to 1) excessive shading from a dense overstory, 2) a deep litter layer, or 3) an unusual combination of site factors which are too limiting for most shrubs and herbs. Only the last of these three conditions represents this type. For other stands which represent either of the first two cases, one should either return to the association key and use relative cover instead of absolute cover, or determine what the absolute covers might be given more normal stand conditions. Alternatively, one can either find a more sparsely stocked overstory in the stand and determine the type from those "holes" in the canopy, or use local knowledge of the site factors to predict which combination of shrubs and herbs might have developed under more normal conditions. Only in the third case, where the depauperate condition is due to site factors does the stand truely belong to the Depauperate type. The Tshe/Depauperate Association in this latter sense is a type usually of dry microsites in moderately dry areas throughout the Forest (Figure 127). It often occurs near the tops of ridges or along upper slopes. In these cases there is ample light passing through the tree canopy and there is a thin enough litter layer to not impede development of a ground vegetation (Table 104).

Floristic Composition

Western hemlock and Douglas-fir dominate the tree layer, with minor amounts of western redcedar, silver fir or Pacific yew. Understory shrubs and herbs are sparse (Figure 128). The most common species encountered were swordfern (POMU), Oregongrape (BENE) and red huckleberry (VAPA). Salal (GASH), trailing blackberry (RUUR), starflower (TRLA2), Alaska huckleberry (VAAL) and evergreen violet (VISE) may sometimes occur (Table 104).

Ground mosses were sampled mostly on young stands from 30 to 60 years, with data from one old-growth plot. Cover of ground mosses varied from sparse (1%) to moderate (35%), with an average cover of 12%. The most common and abundant species were *Hylocomium splendens* and *Eurhynchium oreganum*. Other species present included *Plagiothecium undulatum*, *Eurhynchium praelongum*, *Rhytidiadelphus loreus*, and *Hypnum circinale* on rotting wood. Data for epiphytic lichens and mosses are limited to three plots where the epiphytes were sparse. Species included *Sphaerophorus globosus*, *Platismatia glauca*, *Hypogymnia enteromorpha* and *Isothecium stoloniferum*. *Lobaria oregana* occurred on the old-growth plot.

Successional Relationships

Douglas-fir and western hemlock dominate seral stages; western redcedar and western hemlock dominate the climax stage.

Table 104. Common plants in the TSHE/Depauperate Association, based on stands >150 years (n=12).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	72.8	72.8	100	1-99
Douglas-fir	PSME	28.8	31.5	91	0-70
western redcedar	THPL	3.2	7.6	41	0-20
silver fir	ABAM	1.3	3.0	41	0-8
Pacific yew	TABR	1.2	4.7	25	0-10
red alder	ALRU	4.7	28.0	16	0-55
bigleaf maple	ACMA	0.2	1.0	16	0-1
GROUND VEGETATION					
swordfern	POMU	1.2	1.6	75	0-4
Oregongrape	BENE	1.2	2.0	58	0-4
red huckleberry	VAPA	0.6	1.2	50	0-2
salal	GASH	0.3	1.0	33	0-1
trailing blackberry	RUUR	0.3	1.0	33	0-1
starflower	TRLA2	0.3	1.0	33	0-1
Alaska huckleberry	VAAL	0.3	1.0	33	0-1
evergreen violet	VISE	0.3	1.0	33	0-1

Other Biota

Wildlife observations for this type include deer and elk sign, with browse noted on Alaska huckleberry, red huckleberry and fireweed. Bear and porcupine damage was observed on Douglas-fir. One plot had evidence of heavy browse which killed western hemlock and western redcedar seedlings and saplings. This was thought to be from mountain beaver or snowshoe hare. Signs of Douglas squirrel and showshoe hare were also recorded.

Common birds included Steller's jay, chestnut-backed chickadee, American robin and dark-eyed junco. Other birds recorded were red-breasted sapsucker, brown creeper, winter wren, golden-crowned kinglet, ruby-crowned kinglet, Swainson's thrush, red-breasted nuthatch, common raven, western flycatcher, northern harrier, band-tailed pigeon and woodpecker activity on snags.

Environment and Soils

This type occurred on a variety of soils. It was found on slopes from 1-82% (mean=40%), on colluvium derived from metabasalt and sedimentary rocks, and on a variety of glacial deposits. Our plots occurred on about half of the Olympic Soil Resource Inventory (Snyder *et al.* 1969) soil types and over their full range. It occurs on shallow or deep, glacial or colluvial, fine or coarse, rocky or rock free, and well-drained or sometimes not well-drained soils. One soil pit was analyzed for nutrients. It was very low in phosphorus, but apparently not limiting in any other nutrient.

The average summer soil temperature was 11.4 deg C (52.5 deg F), which is about average for the Western Hemlock Zone. The temperature regime is mostly frigid. The soil moisture regime is udic or xeric.

Figure 127. Map of plot locations for the Western Hemlock/Depauperate Association.

Timber Productivity

This type has a moderate productivity potential (Site III) (Table 105). Site index for Douglas-fir on Intensive plots was 153, but on Reconnaissance plots was 128. Western hemlock site index was 107. The yield potential based on site index-yield table approach was 122-159 cu ft/ac/yr for Douglas-fir and 214 cu ft/ac/yr for western hemlock.

Management Considerations

This type often has a moderate stockability and low wildlife values, due to the sparse understory. However, brush competition is not a problem. Since different site factors can combine to give depauperate conditions, it is difficult to generalize about this type.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 105. Timber productivity values for the Western Hemlock/Depauperate Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	8	32	153	21	159	438	14	295	133	122
Douglas-fir (McArdle [2])	18	18	128	44	122					
Douglas-fir (King [3])	7	27	111	16	160					
Western Hemlock (Barnes [4])	4	4	83	45						
Western Hemlock (Wiley [5])	9	36	107	14	214	445	20	422		

[1] Base age 100. Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50. Breast height age (King 1966). ages 25 to 120 years.

[4] Base age 100. Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50. Breast height age (Wiley 1978a,b). ages 25 to 120 years.

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Western Hemlock/Depauperate is closely related to Western Hemlock/Rhododendron-Salal, Western Hemlock/Oregongrape and Silver Fir/Depauperate associations. It was recognized by Henderson and Peter on the Olympic and Mt. Baker-Snoqualmie National Forests (1981a,b,c,d, 1982a,b, 1983a,b 1984, 1985), but is not recognized elsewhere.

Figure 128. Photo of the Western Hemlock/Depauperate Association, Le Bar Pass, Hood Canal District.

WESTERN HEMLOCK/DEVIL'S CLUB
Tsuga heterophylla/Oplopanax horridum
TSHE/OPHO CHS5 12 (OLY)

The Western Hemlock/Devil's Club Association is a minor type of warm wet sites, and moderate timber productivity. It is found mainly in the drier climatic areas of the Olympics, but also throughout much of the Forest (Figure 129). Soils are mostly shallow, moderately fine textured and derived from colluvium or alluvium. They are irrigated from an adjacent stream or spring. Soils appear to be moderately high in organic matter and nitrogen. The typical area of this type has burned seldom in the last 500 years.

Floristic Composition

The dominant understory species (Table 106) are devil's club, swordfern (POMU) and vine maple (ACCI), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Salmonberry (RUSP) or vine maple often become established quickly after clearcut or fire. Common understory species include foamflower (TITR), ladyfern (ATFI), red huckleberry (VAPA), vanillaleaf (ACTR) and star-flowered solomon's seal (SMST). The tree layer may be dominated by red alder, Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 130). Stands in this type are sometimes understocked. Few areas of this type have been cut over or burned. Those that are cut over occur as small pockets in stands which are mainly other types.

There are no data for cryptogams on this type.

Successional Relationships

Early successional stages are usually dominated by Douglas-fir, red alder and/or western hemlock. Western redcedar also may occur, but in smaller amounts. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Wildlife observations are limited for this type. Mountain beaver activity and winter wren were observed. Browsing was evident on Alaska huckleberry, red huckleberry, oval-leaf huckleberry, fool's huckleberry and Hooker fairybell.

Table 106. Common plants in the TSHE/OPHO Association, based on stands >150 years (n=4).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	37.5	37.5	100	20-55
Douglas-fir	PSME	45.0	60.0	75	0-75
western redcedar	THPL	11.5	15.3	75	0-26
bigleaf maple	ACMA	1.5	3.0	50	0-4
red alder	ALRU	0.8	1.5	50	0-2
GROUND VEGETATION					
swordfern	POMU	24.2	24.2	100	2-55
devil's club	OPHO	10.7	10.7	100	6-25
three-leaved foamflower	TITR	5.0	5.0	100	1-15
ladyfern	ATFI	3.5	3.5	100	1-7
red huckleberry	VAPA	3.0	3.0	100	1-6
vanillaleaf	ACTR	2.8	2.8	100	1-5
vine maple	ACCI	21.2	28.3	75	0-60
star-flowered solomon's seal	SMST	4.0	5.3	75	0-10
oakfern	GYDR	2.0	2.7	75	0-5
fragrant bedstraw	GATR	1.8	2.3	75	0-5
salal	GASH	1.5	2.0	75	0-4
trailing blackberry	RUUR	1.0	1.3	75	0-2
woodfern	DRAU2	0.8	1.0	75	0-1
starflower	TRLA2	0.8	1.0	75	0-1
trillium	TROV	0.8	1.0	75	0-1

Environment and Soils

This type occurs on flat to moderately steep, concave and straight, lower slopes, toe-slopes, bottoms and benches. The slope ranged from 2% to 67% and averaged 21%. Bedrock varied but was usually metabasalt. Regolith was usually colluvial, but may be glacial. Only one pit was described in this type. The texture was loam to clay loam and coarse fragments were negligible. Structure was weak but horizonation was moderately well developed. The O1 was 2 cm and the O2 was 2 cm. The O2 was less than average even though this was a young old-growth stand. Rooting depth was 30 cm which is about half of average but also occupied the O2. The water holding capacity was about average. Other observations where pits were not dug indicate highly diverse soil characteristics. Texture, coarse fragment content, and O layer thickness are especially variable. This soil was classified a haplorthod, but Inceptisols are probably very common also.

Our plots occurred on glacial or colluvial soils that tend to be either shallow or compacted in the subsoil, as described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969). Our observations show these soils are saturated most of the year in all but the most extreme droughts. These sites are generally seepage areas with water moving through and not stagnating in the soil. Coarse fragments range from 5% to 70% near the surface and 5% to 100% in the subsoil.

The mean summer soil temperature was 11.9 deg C (53.4 deg F) which is about average for the Western Hemlock Zone. This type is probably borderline between mesic and frigid temperature regimes. The moisture regime is udic.

The results of one nutrient analysis showed that levels of potassium, calcium, magnesium, sulfate, zinc and copper may be a little low compared to other types. The pH was 5.1 which is a slightly below average for the series.

Figure 129. Map of plot locations for the Western Hemlock/Devil's Club Association.

Timber Productivity

Timber productivity of this type is moderate to high (Site II). Douglas-fir site index from Reconnaissance plots averaged 151 (base 100), but two Intensive plots averaged 188 (Table 107). The overall mean for these values is 172. The stockability of these sites is low due to their streamside locations. Growth of measured stands appears to be less than yield table projections due to stocking. However, because of the sample size, the potential yield of this type is not well known.

Management Considerations

The main management consideration for this type is riparian management. It is important to maintain soil and ground vegetation intact to protect stream channels. Response to fertilizer in this type is unknown. Douglas-fir, western hemlock and/or western redcedar are preferred species. This type represents more restrictive management opportunities than other Western Hemlock Zone types.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Armillaria may also be important in young-growth Douglas-fir plantations, but by age 30 impacts should be minimal. Annosus root disease appears to represent the most serious potential problem on this type to thinned western hemlock, reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe may occur in old-growth stands of this type.

Table 107. Timber productivity values for the Western Hemlock/Devil's Club Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [3]	SDI [4]	GBA TREES	GBA [5]	SIGBA [6]	EMAI
Douglas-fir (McArdle [1])	2	8	188		198	556	4	1044	586	
Douglas-fir (McArdle [2])	6	6	151	28	146					

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[3] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[4] Stand Density Index (Reinecke 1933).

[5] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[6] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include Western Hemlock/ Skunkcabbage which occurs in wet sites with deep organic soils, and Western Hemlock/Swordfern-Foamflower which occurs on somewhat drier sites with higher productivity. The Western Hemlock/ Alaska Huckleberry type occurs in somewhat drier areas that are better drained. The Western Hemlock/Devil's Club Association is widely distributed in Washington, Oregon and British Columbia. It was described in the Olympics (Henderson and Peter 1981a, 1982a, 1983, Smith and Henderson 1986), and the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1981d, 1982b, 1983b, 1984, 1985). In British Columbia it was recognized as the Devil's Club-Ladyfern-Oakfern Association by Haeussler *et al.* (1982). In Mt. Rainier National Park it was described by Franklin *et al.* (1988). On the Gifford Pinchot National Forest it was recognized as the Western Hemlock/Devil's Club/Swordfern type (Topik *et al.* 1986), while on the Mt. Hood National Forest it was recognized as the Western Hemlock/ Devil's Club/Oxalis and Western Hemlock/Devil's Club/Star-flowered Solomon's Seal types (Halverson *et al.* 1986). On the Siuslaw National Forest it was recognized by Hemstrom and Logan (1986).

Figure 130. Photo of the Western Hemlock/Devil's Club Association, young-growth red alder stand, Eagle Creek, Hood Canal District.

WESTERN HEMLOCK/OREGONGRAPE

Tsuga heterophylla/Berberis nervosa

TSHE/BENE CHS1 38 (OLY)

The Western Hemlock/Oregongrape Association is a type that occurs mostly on topographically dry areas with cold soils and moderate timber productivity. It is found mainly on the Hood Canal and Quilcene Districts (Figure 131). Soils tend to be shallow, well drained and derived from very stony colluvium. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 108) are Oregongrape and vine maple (ACCI). Other shrubs may include red huckleberry (VAPA), rhododendron (RHMA) and creeping snowberry (SYMO). Herbs are sparse but may include swordfern (POMU), sidebells pyrola (PYSE), rattlesnake plantain (GOOB), little prince's pine (CHME) and prince's pine (CHUM). The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar or silver fir (Figure 132). Old-growth stands in this type are all about 300 years old, having originated from fires about 287 or 320 years ago. Many stands begin with a moderate component of fireweed (EPAN) and pearly everlasting (ANMA) following fire, which may impede restocking.

Ground mosses varied from sparse to abundant on this type, with cover values ranging from 5% to 85% on three plots sampled where stands ages were over 80 years. The plot where moss cover was 85% had understory cover of only 20%. Generally, moss cover is moderate on this type. The common species include *Hylocomium splendens* and *Eurhynchium oreganum* and occasionally *Rhytidiadelphus triquetrus*. Epiphytic lichens are not abundant. On two plots where epiphytes were recorded, the common species were *Hypogymnia enteromorpha*, *Platismatia glauca* and *Alectoria sarmentosa*.

Successional Relationships

There are two probable successional pathways for this type. One dominated by Douglas-fir, the other by western hemlock, although the latter is less common. Later seral stages are often dominated by both Douglas-fir and western hemlock, and presumably western hemlock and western redcedar dominate the climax stand.

Other Biota

Wildlife observations for this type are limited to one plot where deer sign was recorded and trails were common. Bird observations on one plot include red-breasted nuthatch, winter wren and golden-crowned kinglet.

Table 108. Common plants in the TSHE/BENE Association, based on stands >150 years (n=3).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	76.7	76.7	100	70-85
western hemlock	TSHE	33.3	33.3	100	20-55
silver fir	ABAM	2.3	3.5	66	0-5
GROUND VEGETATION					
Oregongrape	BENE	17.0	17.0	100	1-35
vine maple	ACCI	28.3	42.5	66	0-65
rhododendron	RHMA	1.3	2.0	66	0-2
swordfern	POMU	1.0	1.5	66	0-2
creeping snowberry	SYMO	1.0	1.5	66	0-2
red huckleberry	VAPA	1.0	1.5	66	0-2
little prince's pine	CHME	0.7	1.0	66	0-1
prince's pine	CHUM	0.7	1.0	66	0-1
rattlesnake plantain	GOOB	0.7	1.0	66	0-1
sidebells pyrola	PYSE	0.7	1.0	66	0-1

Environment and Soils

This type is usually found on steep (69%), metabasaltic colluvium on mid- to upper slopes. It may occasionally be found on glacial soils or sedimentary colluvium, from ridgetops to lower slopes but never on toes or bottoms. Only one plot occurred on a slope less than 60%, where it was transitional with the Western Hemlock/Oregongrape/Swordfern Association.

Our plots occurred on soil types described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as well-drained, colluvial soils which frequently occur in areas of extensive rock outcrop. Surface and subsoils tend to be thin, gravelly or very gravelly loams (Snyder *et al.* 1969). The O layer tends to be thin which probably reflects a fairly high rate of decomposition. The mean summer soil temperature was 10.4 deg C (50.7 deg F) which is cool for the Western Hemlock Zone. The temperature regime is probably modal frigid and the moisture regime probably udic to xeric.

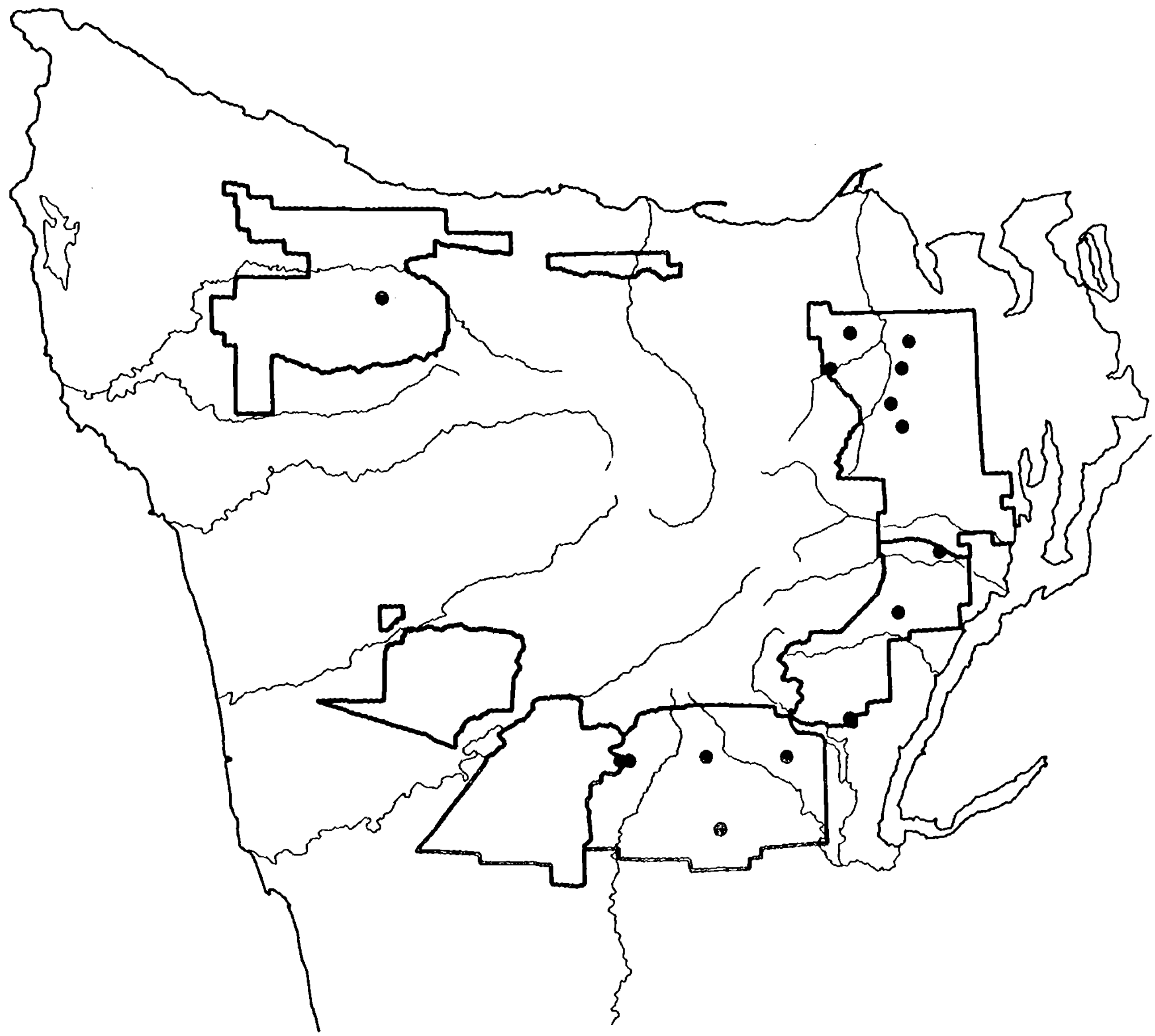


Figure 131. Map of plot locations for the Western Hemlock/Oregongrape Association.

Timber Productivity

Timber productivity of this type is moderate (Site IV). Site index of measured stands averaged 102 (base 100) (Reconnaissance and Intensive plots combined). The productivity potential using the site index-yield table approach averaged 99 cu ft/ac/yr (Table 109). The empirical yield estimate for this type is 122 cu ft/ac/yr. The stockability of these sites is moderate to low.

Management Considerations

Management considerations include ensuring rapid initial stocking and enhancement of soil nutrients, organic matter and preservation of the unstable soil. Because of the upper slope positions where this type often occurs, there is an increased susceptibility to snow and wind damage. Accumulated soil organic matter and nitrogen should be preserved by not burning sites in this type if fuel loadings permit, and the litter layer should be kept intact to help keep the shallow, unstable soil in place. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. The steepness of slope and instability of the soil may preclude commercial thinning on this type. Because of the warm exposed site conditions where this type occurs and the sparse ground vegetation, it offers low wildlife values. Game trails are common in this type however, as it is easy to travel through. This type represents moderately harsh growing conditions.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 109. Timber productivity values for the Western Hemlock/Oregongrape Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA [6]	SIGBA [7]	EMAI [8]
Douglas-fir (McArdle [1])	2	11	95	29	81	564	11	322	99	122
Douglas-fir (McArdle [2])	9	9	110	15	99					
Douglas-fir (King [3])	1	5	56		53					

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[7] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[8] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/Salal-Oregongrape which occurs on slightly moister sites at lower elevations and on warmer soils, Western Hemlock/Beargrass which occurs on slightly drier and shallower soils, and Silver Fir/Alaska Huckleberry-Oregongrape at higher elevations with more snow and colder soil temperatures. It is also related to the Western Hemlock/Rhododendron-Oregongrape type which occurs at higher elevations and mostly on the Quilcene District. The Western Hemlock/Oregongrape Association is widely recognized in Washington and Oregon. It is described as far south as the Willamette National Forest (Hemstrom *et al.* 1987) and as far north in Washington as the Mt. Baker District on the Mt.Baker-Snoqualmie National Forest (Henderson and Peter 1985). It was previously recognized in the Olympics (Henderson and Peter 1981a, 1982a, 1983a). It is similar to the Western Hemlock/Vine Maple-Oregongrape and Western Hemlock/Red Huckleberry-Oregongrape types of Smith and Henderson (1986).

Figure 132. Photo of the Western Hemlock/Oregongrape Association, Le Bar Creek, Hood Canal District.

WESTERN HEMLOCK/OREGONGRAPE/SWORDFERN

Tsuga heterophylla/Berberis nervosa/Polystichum munitum

TSHE/BENE/POMU   CHS1 39 (OLY)

The Western Hemlock/Oregongrape/Swordfern Association is a major type of moderately moist sites at low elevations and moderately high timber productivity. It is common in the drier climatic areas of the Olympics, particularly on the Hood Canal District (Figure 133). Soils are mostly deep and are derived from colluvium or glacial till. They are often subirrigated and occur along toe-slopes. Soils appear to be moderately high in organic matter, calcium and nitrogen. Little snow accumulates in this type during the winter. The typical area of this type has burned once or twice in the last 500 years, although most old-growth of this type has now been cut over. Most old-growth that remains is either about 280 or 450 years old.

Floristic Composition

Dominant understory species (Table 110) are swordfern and Oregongrape, which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Vine maple (ACCI) often resprouts rapidly after clearcut or fire, but swordfern and Oregongrape are usually present even in young stands. Other shrubs may include salal (GASH) (in small amounts), vine maple (ACCI) and red huckleberry (VAPA). Vanillaleaf (ACTR), twinflower (LIBO2) and trillium (TROV) may also occur. Early seral species include trailing blackberry (RUUR), fireweed (EPAN) and pearly everlasting (ANMA). The tree layer may be dominated by red alder, Douglas-fir, western hemlock, western redcedar or any combination of these trees (Figure 134). Stands in this type are often understocked. When this happens a thick understory can develop.

Data for ground mosses are limited for this type. Moss cover is abundant for our sampling of stands between 50 and 270 years old. *Hylocomium splendens* and *Eurhynchium oreganum* are the most common species. There are no data available for epiphytic mosses and lichens.

Successional Relationships

Red alder often dominates or codominates early seral stages in this type. It dies out by about 80 years, often leaving an understocked stand of hemlock and redcedar, with some Douglas-fir, if it was present in early stages. Besides this red alder dominated sere, there are successional pathways dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Wildlife and bird observations for this type are limited to one plot where browsing was noted on Oregongrape, red huckleberry and Alaska huckleberry, and woodpecker activity on a Douglas-fir snag was recorded.

Table110.Common plants in the TSHE/BENE/POMU Association, based on stands >150 years (n=9).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	62.4	62.4	100	1-99
Douglas-fir	PSME	29.2	29.2	100	1-75
western redcedar	THPL	8.0	14.4	55	0-40
bigleaf maple	ACMA	2.9	13.0	22	0-25
red alder	ALRU	0.4	2.0	22	0-3
Pacific yew	TABR	0.2	1.0	22	0-1
Pacific dogwood	CONU	0.1	1.0	22	0-1
grand fir	ABGR	0.1	1.0	11	0-1
GROUND VEGETATION					
swordfern	POMU	25.2	25.2	100	5-60
Oregongrape	BENE	16.9	16.9	100	5-35
vine maple	ACCI	13.3	20.0	66	0-45
vanillaleaf	ACTR	3.7	4.7	77	0-20
red huckleberry	VAPA	2.8	4.2	66	0-10
salal	GASH	2.0	3.0	66	0-5
trillium	TROV	0.7	1.0	66	0-1
twinflower	LIBO2	1.3	2.4	55	0-5

Environment and Soils

This type can occur on flat to steep, usually straight, mid- to lower slopes, toe-slopes, benches and bottoms. The slope on sampled areas ranged from 0% to 80% with a mean of 42%. Bedrock varies but is usually metabasalt. Regolith may be either colluvium or alpine glacial drift.

No soil pits were dug on this type. Our plots occur on a diversity of Olympic Soil Resource Inventory (Snyder *et al.* 1969) soil units of which colluvial soils are more common than glacial soils. About half the plots are well drained. All have rapid surface permeability but about two-thirds have moderate to slow subsoil permeability. About half the plots occur on units where subsoil compaction or strong cementation is indicated. Most of the colluvial soils are relatively shallow. Textures are clay loams to sandy loams. The coarse fragments range from 5% to 70% near the surface and 5% to 100% in the subsoils.

Nutrient analyses for samples from five plots indicate moderate to high levels of the macronutrients with especially high calcium. The pH was 5.6 which is high for the Forest.

The mean summer soil temperature was 11.2 deg C (52.2 deg F) which is about average for the Western Hemlock Zone. The soil temperature regime is probably borderline between mesic and frigid, but probably more often frigid. The moisture regime is udic.

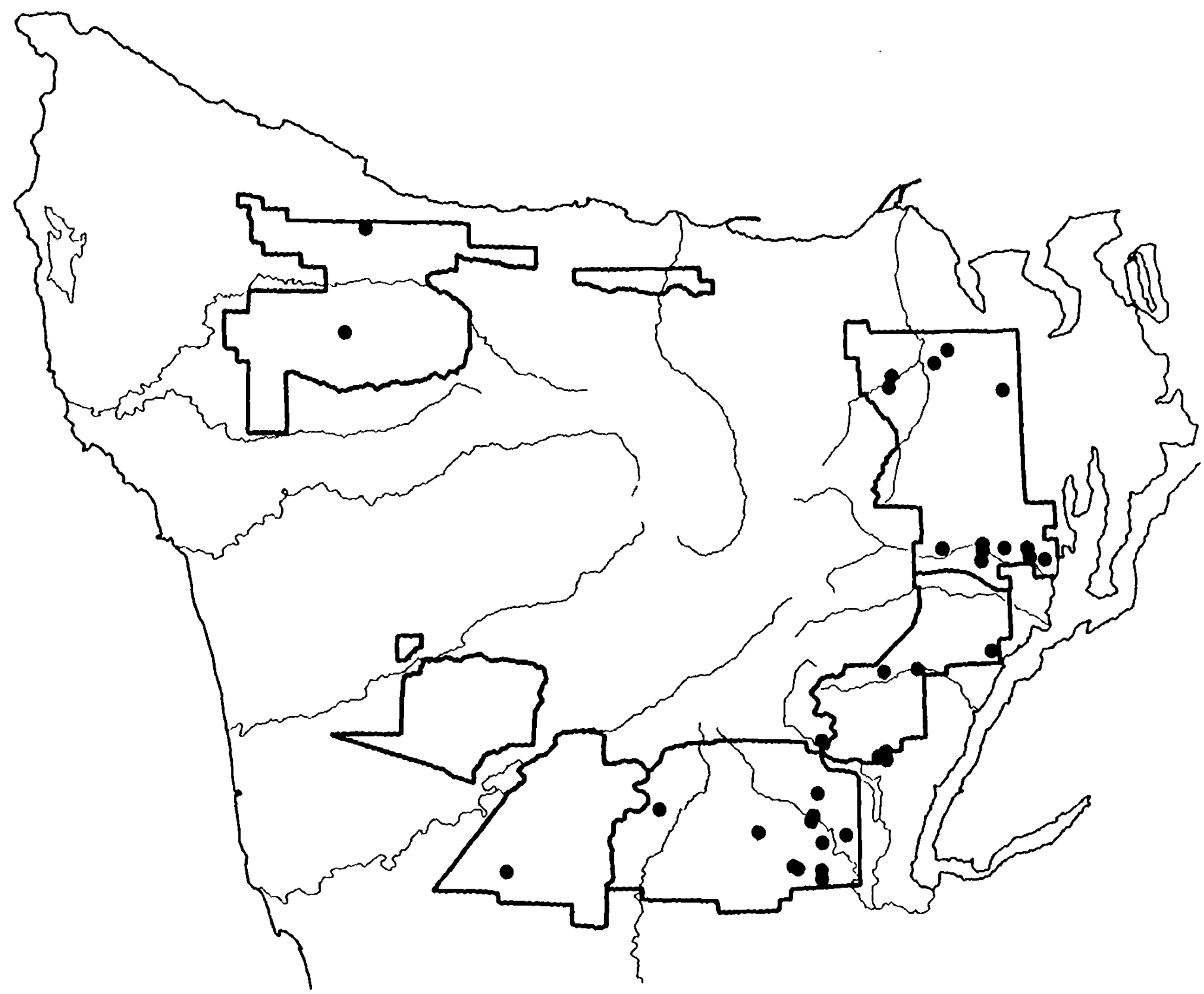


Figure 133. Map of plot locations for the Western Hemlock/Oregongrape/Swordfern Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II or III). This is due to the moistness of the site, favorable soils and relatively long growing season. Site index of Douglas-fir for stands with Intensive plots averaged 165 (base 100) and 152 for Reconnaissance plots (Table 111). The productivity potential using the site index-yield table approach was 174 cu ft/ac/yr. The stockability of these sites is high, but the stocking in wild stands can sometimes be relatively low. The empirical yield estimate was 142 cu ft/ac/yr. This value may be low due to understocking of some stands. Productivity potential for western hemlock is 200 cu ft/ac/yr and for red alder is 112 cu ft/ac/yr. Douglas-fir is probably the preferred species for this type.

Management Considerations

Management considerations for this type include manipulation of species composition and regulation of stocking. It is also important to maintain soil nutrients and organic matter. Brush competition from red alder and vine maple can be a problem. Response to fertilizer in this type is unknown. Wildlife values can be moderately high, especially for elk winter range. Douglas-fir, western hemlock and/or red alder can all be cultivated on this type.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock, and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also. Hemlock dwarf mistletoe may be present on older western hemlock.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 111. Timber productivity values for the Western Hemlock/Oregongrape/Swordfern Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	7	34	165	18	174	373	31	454	229	142
Douglas-fir (McArdle [2])	23	23	152	27	160					
Douglas-fir (King [3])	7	34	122	13	184					
Western Hemlock (Wiley [4])	1	2	99		200	409	2	414		
Red Alder (Worthington [5])	2	6	97	8	112	292	6	159		

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.
[2] Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.
[3] Base age 50, Breast height age (King 1966). ages 25 to 120 years.
[4] Base age 50. Breast height age (Wiley 1978a,b). ages 25 to 120 years.
[5] Base age 50, Total age (Worthington et al. 1962).
[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
[7] Stand Density Index (Reinecke 1933).
[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[9] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).
[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 192 p. 499).

Comparison with Similar Types

Similar types include other Swordfern types. The Western Hemlock/Salal/Swordfern type occurs on warmer and somewhat drier sites. The Western Hemlock/Swordfern-Foamflower type occurs on moister and more productive sites. The Western Hemlock/Salal-Oregongrape type occurs on drier and warmer sites of lower productivity. The Western Hemlock/Oregongrape/Swordfern Association is previously recognized on the Gifford Pinchot National Forest (Topik *et al.* 1986) and on the Mt. Hood National Forest (Halverson *et al.* 1986). It is a widespread type however, and is represented in the Western Hemlock/Swordfern Association as defined by Hemstrom *et al.* (1987), Dyrness *et al.* (1976), Smith and Henderson (1986) and Henderson and Peter (1981a,b,c,d, 1982a,b, 1983a,b, 1984, 1985).

Figure 134. Photo of the Western Hemlock/Oregongrape/Swordfern Association, young-growth Douglas-fir stand, Gold Creek, Quilcene District.

WESTERN HEMLOCK/OXALIS

Tsuga heterophylla/Oxalis oregana
TSHE/OXOR CHF1 12 (OLY)

The Western Hemlock/Oxalis Association is a major type of moist sites at low elevations and moderately high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault and Soleduck Districts (Figure 135). Soils are mostly deep, moist, and derived from colluvium, outwash or glacial till. They appear to be moderately high in organic matter and nitrogen, but low in calcium and phosphorus. Little snow accumulates in this type during the winter. The typical area of this type has burned very seldom in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

The dominant understory species (Table 112) is oxalis, which is usually present in all ages of stands, although it is rare in very young stands and may be inconspicuous or absent in densely stocked second growth. Swordfern (POMU) is usually present although in very small amounts. Shrubs may include Alaska huckleberry (VAAL) and red huckleberry (VAPA). Deerfern (BLSP), foamflower (TITR), and false lily-of-the-valley (MADI2) may also occur. The tree layer may be dominated by red alder, Douglas-fir, western hemlock, or any combination of these trees (Figure 136). Although Douglas-fir is not common, it can occur in some situations. When understocking occurs, a thick understory (particularly of salmonberry) can develop. When overstocking occurs it is usually associated with a thick duff layer and sparse ground vegetation.

Ground mosses can be moderate to fairly abundant in this type, even in young stands. The common species are *Eurhynchium oreganum* and *Hylocomium splendens*, less abundant are *Rhytidiadelphus loreus* and *Plagiothecium undulatum*. Data are limited for epiphytic mosses and lichens, but *Isothecium stoloniferum* and *Alectoria sarmentosa* are common.

Successional Relationships

Red alder often dominates or codominates early seral stages in this association. Besides this alder dominated sere, there is a successional pathway dominated by western hemlock. Old-growth and climax stages are dominated by western hemlock.

Other Biota

Frequent browse sign (presumably by elk) was observed on salmonberry, swordfern, Alaska huckleberry, oval-leaf huckleberry and red huckleberry. Mountain beaver activity and evidence of their browse on western hemlock was observed. Other animal signs include Douglas squirrel and snowshoe hare.

Bird observations are limited to one plot for this type, and include band-tailed pigeon, chickadee and winter wren.

Table 112. Common plants in the TSHE/OXOR Association, based on stands >150 years (n=8).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	92.1	92.1	100	60-99
Douglas-fir	PSME	16.9	22.5	75	0-60
red alder	ALRU	2.0	5.3	37	0-6
GROUND VEGETATION					
oxalis	OXOR	29.7	29.7	100	5-75
red huckleberry	VAPA	2.1	2.1	100	1-5
three-leaved foamflower	TITR	1.6	1.9	87	0-5
salmonberry	RUSP	5.0	6.7	75	0-20
Alaska huckleberry	VAAL	3.0	4.0	75	0-8
swordfern	POMU	2.3	3.0	75	0-8
salal	GASH	0.8	1.0	75	0-1
deerfern	BLSP	1.6	2.6	62	0-8
trillium	TROV	0.6	1.0	62	0-1
false lily-of-the-valley	MADI2	1.3	2.5	50	0-5
cutleaf goldthread	COLA	0.8	1.5	50	0-2
evergreen violet	VISE	0.6	1.3	50	0-2
ladyfern	ATFI	0.5	1.0	50	0-1

Environment and Soils

This type occurs on flat to moderate, generally straight slopes in various topographic positions, but more often on mid- to lower slopes, benches and bottoms. Slopes ranged from 0% to 64% and averaged 21%. Bedrock is usually metabasalt but can be sedimentary. The regolith can be glacial or colluvial.

The soil profile was moderately well developed in two pits. Textures varied from clay to silty clay loam with coarse fragments averaging 13%. This may indicate a preference of the type for fine-textured, rock-free soils. The O1 layer averaged 1 cm and the O2 was 3.9 cm. These values are below average, but represent early successional stages. The rooting depth was 61.5 cm which is about average, but roots also occupied the O2. These soils have higher than average water holding capacities due to their fine texture and low coarse fragment fraction . One of the pits was classified as a haplumbrept and the other a haplorthod. This is one of the few types in which earthworms were observed.

The Olympic Soil Resource Inventory (Synder *et al.* 1969) describes the glacial soils in this type as deep, gravelly and very gravelly silty clay loams to sandy loams with varying degrees of subsoil compaction. Surface permeability is rapid in the surface and moderate in subsoils. These soils tend to be moderately well drained. Subsurface compaction tends to make soils effectively shallow. The colluvial soils of this type tend to be shallow, well drained and highly permeable. They have loam to silt loam textures. Coarse fragments range from 5% to 65% near the surface and 10% to 100% in the subsoils.

The mean summer soil temperature for this type was 13.2 deg C (55.8 deg F), which is warm for the Western Hemlock Zone. The temperature regime for this type is at the warm end of frigid. The moisture regime is udic.

Two nutrient analyses for soils in this type showed low calcium, phosphorus, potassium, zinc and manganese compared to other types. Total nitrogen and sodium were high. The pH was 5.05 which is about average for the series.

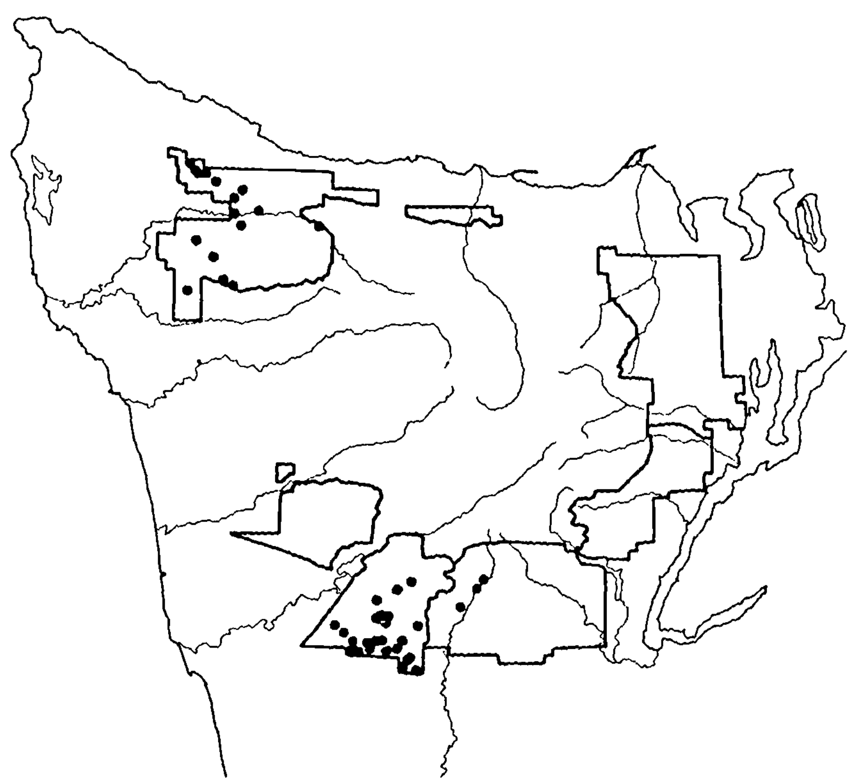


Figure 135. Map of plot locations for the Western Hemlock/Oxalis Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils and relatively long growing season. Site index for Douglas-fir in measured stands averaged 172 (base 100) and 109 (base 50). The productivity potential using the site index-yield table approach was 181 cu ft/ac/yr for Douglas-fir and 207 cu ft/ac/yr for western hemlock (Table 113). The stockability of these sites is high (GBA=793 for western hemlock). The empirical yield for this association was 183 cu ft/ac/yr.

Management Considerations

Management considerations include manipulation of species composition and regulation of stocking. Brush competition from salmonberry or red alder can be a problem. Many oxalis types show very low amounts of calcium and phosphorus. This may be limiting growth or affecting tree development on these sites. We recommend that any fertilizer applications on this oxalis type include calcium and phosphorous. Wildlife values can be moderately high, especially for elk winter range. Western hemlock is the preferred timber species. Douglas-fir can grow here, but is often affected by poor form, and in young stands is favored by bear.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Armillaria may also be important in young-growth Douglas-fir plantations, but by age 30 impacts should be minimal. Annosus root disease appears to represent the most serious potential problem to pre-commercially thinned western hemlock on this type. Reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot, rusty red stringy rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe is usually present in old-growth stands of this type.

Potential insect pests which may occur on this type include the hemlock looper which may be present on western hemlock, and the western blackheaded budworm which occur on buds of western hemlock or Douglas-fir.

Table 113. Timber productivity values for the Western Hemlock/Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA [10]	EMAI [11]
Douglas-fir (McArdle [1])	3	12	172	16	181	338				183
Douglas-fir (McArdle [2])	11	11	164	24	161					
Douglas-fir (King [3])	2	7	109	2	154					
Western Hemlock (Barnes [4])	12	12	147	27	232			793	350	183
Western Hemlock (Wiley [5])	1	5	104		207	440	4	793		
Red Alder (Worthington [6])	1	5	85		92	339				

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962). Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Base age 50, Total age (Worthington et al. 1962).

[7] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[8] Stand Density Index (Reinecke 1933).

[9] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[10] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[11] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include other Oxalis types. The Western Hemlock/Swordfern-Oxalis and Western Hemlock/Salal/Oxalis types occur on drier sites. The Western Hemlock/Swordfern-Foamflower type occurs on similar sites in slightly drier areas. The Western Hemlock/Oxalis Association occurs in the western Olympics (Henderson and Peter 1981a,b, 1982a), in the Oregon Cascades (Hemstrom *et al.* 1987) and in the Coast Range of Oregon (Hemstrom and Logan 1986).

Figure 136. Photo of the Western Hemlock/Oxalis Association, young-growth western hemlock stand, West Fork Humptulips River, Quinault District.

WESTERN HEMLOCK/RHODODENDRON

Tsuga heterophylla/Rhododendron macrophyllum
TSHE/RHMA CHS3 31 (OLY)

The Western Hemlock/Rhododendron Association is a type of dry areas, infertile soils and low timber productivity. It is common in the rainshadow area of the Olympics, particularly on the Quilcene District (Figure 137). Soils are mostly shallow, or stony colluvium, or derived from very stony glacial till and outwash, and appear to be particularly low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 114) is rhododendron, although in densely stocked stands this indicator species may be inconspicuous or absent. Oregongrape (BENE), twinflower (LIBO2), sidebells pyrola (PYSE), swordfern (POMU), red huckleberry (VAPA) and prince's pine (CHUM) may also occur in small amounts. The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 138). Silver fir and Pacific yew can also occur. Stands in this type are often densely to very densely stocked. This may make it difficult to accurately identify the type as the ground vegetation species will be sparse due to lack of light. Frequent fires have occurred in this type over the last 300 years. Many stands begin with a moderate component of rhododendron following fire. As the canopy develops during the middle stages of succession, understory vegetation decreases in response to lack of light. As old-growth develops and tree mortality opens the canopy, ground vegetation dominated by rhododendron is reestablished.

Ground mosses are sparse to abundant on this type, with cover values ranging from 1 to 99%, and averaging 28%. The common and abundant species were *Hylocomium splendens*, *Rhytidiopsis robusta* and *Eurhynchium oreganum*. Other species which can occur in less abundance are *Dicranum* sp., *Peltigera* sp., *Cladonia* spp., and *Scapania bolanderi* on rotting wood. Epiphytic lichens can be abundant in some stands, particularly *Alectoria sarmentosa*. Other common lichens that may occur are crustose species, *Hypogymnia enteromorpha*, *Parmeliopsis hyperopta* and *Bryoria* spp.

Successional Relationships

There is only one recognized successional pathway for this type. Seral stages are dominated by both Douglas-fir and western hemlock, and presumably western hemlock and western redcedar dominate the climax stand.

Other Biota

Wildlife observations were recorded for deer, snowshoe hare, elk and Douglas squirrel. Red huckleberry showed evidence of browsing.

Bird observations were recorded for golden-crowned kinglet, chickadee, common raven, gray jay and dark-eyed junco.

Table 114. Common plants in the TSHE/RHMA Association, based on stands >150 years (n=13).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	70.8	70.8	100	35-99
Douglas-fir	PSME	38.5	38.5	100	10-80
western redcedar	THPL	11.0	14.3	76	0-45
silver fir	ABAM	1.8	4.0	46	0-7
Pacific yew	TABR	3.6	15.7	23	0-25
Alaska yellowcedar	CHNO	1.3	8.5	15	0-15
GROUND VEGETATION					
rhododendron	RHMA	48.5	48.5	100	2-95
Oregongrape	BENE	1.5	1.8	84	0-5
twinflower	LIBO2	1.1	1.3	84	0-1
sidebells pyrola	PYSE	0.7	1.0	69	0-1
swordfern	POMU	0.8	1.3	61	0-3
red huckleberry	VAPA	0.5	1.0	53	0-1

Environment and Soils

This type occurs on flat to steep, straight to convex slopes, mainly on mid- to upper slopes and ridgetops. Slopes ranged from 0% to 78% and averaged 47%. Bedrock is usually metabasalt and the regolith is usually colluvium, although a few plots occurred on glacial deposits.

One soil pit dug in this type occurred in continental glacial regolith. It had a loamy texture, and weak to moderate, subangular blocky structure. There were only 3% coarse fragments. The C horizon was highly compacted which probably prevents root penetration beyond 50 cm. The rooting depth was only 37 cm. Mottles were observed in and above the C horizon. The O1 was 2 cm and the O2 was 3 cm which is relatively thin. The O2 was occupied by very fine roots. This soil has a near average water holding capacity. It was classified as a fragiochrept.

Our plots occurred on soil units with a diversity of bedrock and regolith but were most often metabasalt and colluvium as described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969). These soils are generally well-drained and very permeable although moderate drainage and slow permeability of subsoils are indicated for some of the glacial soils. Many deep glacial soils are rendered effectively shallow by compaction in the subsoil. The colluvial soils are all shallow (3 ft to 4 ft). These soil units are mostly gravelly loam and gravelly sandy loam. The coarse fragment fraction ranges from 5% to 65% near the surface and 5% to 100% in the subsoil.

The mean summer soil temperature was 9.5 deg C (49.1 deg F), which makes this types one of the coldest in the Western Hemlock Zone. This type has a frigid temperature regime and a xeric moisture region.

Nutrient analyses from four samples indicate that this type is highest in phosphorus and lowest in total nitrogen of all the types tested, while sulfate and organic matter are relatively low. The pH averaged 5.5 which is slightly higher than average for the series.

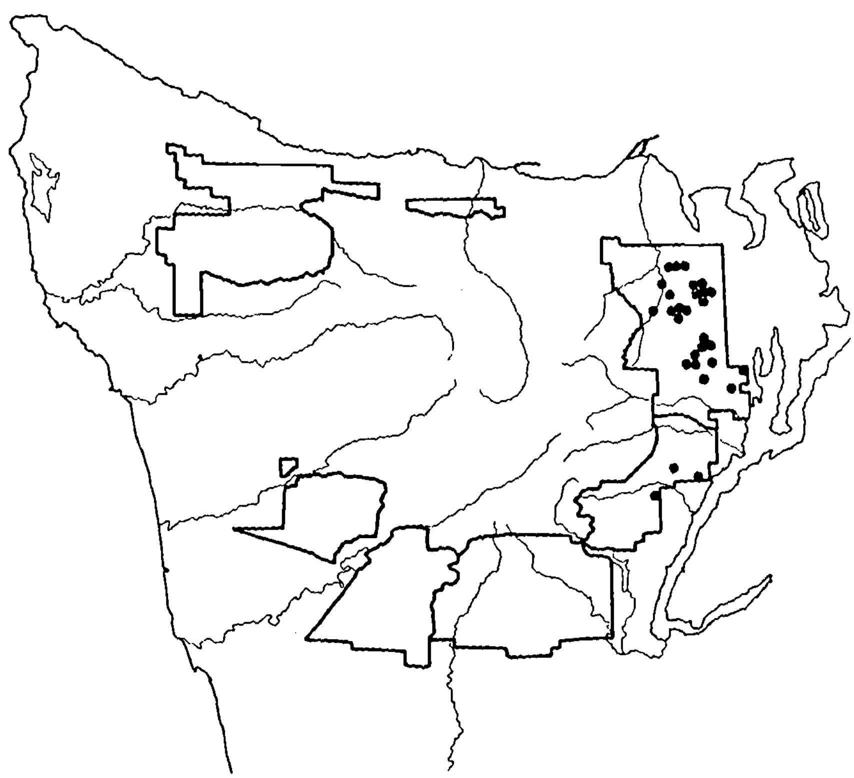


Figure 137. Map of plot locations for the Western Hemlock/Rhododendron Association.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the dryness of the site and poor soils. Site index of measured stands averaged 91 (base 100) and 74 (base 50). The productivity potential using the site index-yield table approach and unmanaged stands was 74 cu ft/ac/yr for Douglas-fir (Table 115). The stockability of these sites is low but the stocking in wild stands is sometimes very high. The empirical yield estimate for this association was 69 cu ft/ac/yr. Some existing stands are growing at less than half the expected rate for this type. This is probably due to overstocking which is common in the Rhododendron types, or to root or stem diseases, such as armillaria root disease, which is fairly common in these dry types.

Management Considerations

Management considerations include regulation of stocking and enhancement of soil nutrients and organic matter. The available data indicate that stocking levels are often too high. Soil organic matter and nitrogen should be preserved by reducing burning on sites in this type. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Soil water limitation should be addressed by regulating stocking and maintaining suitably low number of trees per acre.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock. Hemlock dwarf mistletoe may occur in older western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Table 115. Timber productivity values for the Western Hemlock/Rhododendron Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	7	33	91	20	74	610	24	315	94	69
Douglas-fir (McArdle [2])	16	16	91	23	74					
Douglas-fir (King [3])	4	18	74	16	80					
Western Hemlock (Barnes [4])	2	2	82	19				384	94	
Western Hemlock (Wiley [5])	2	6	63	26	153	741	6	384		

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50. Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100. Total age (Barnes 1962). Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50. Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include other Rhododendron types, especially Western Hemlock/Rhododendron-Salal at lower elevations, and the Western Hemlock/ Rhododendron-Oregongrape type. In many ways it is very similar to the Western Hemlock/ Rhododendron-Salal type. The Western Hemlock/ Rhododendron Association was previously recognized in the Olympics (Henderson and Peter 1983a, Smith and Henderson 1986). However, as it is used here it is more narrowly defined than before.

Figure 138. Photo of the Western Hemlock/Rhododendron Association, Upper Tunnel Creek, Quilcene District.

WESTERN HEMLOCK/RHODODENDRON/BEARGRASS

Tsuga heterophylla/Rhododendron macrophyllum/Xerophyllum tenax

TSHE/RHMA/XETE CHS3 32 (OLY)

The Western Hemlock/Rhododendron/Beargrass Association is a type of dry areas, infertile soils and low timber productivity. It has a limited distribution on the Hood Canal and Quilcene Districts (Figure 139). It occurs on moderate to steep slopes on southerly aspects. Soils are mostly shallow or stony colluvium, and appear to be low in nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

Dominant understory species (Table 116) are rhododendron (RHMA), salal (GASH) and beargrass (XETE), although in densely stocked stands these indicator species may be inconspicuous or absent. Other shrubs may include Oregongrape (BENE) and red huckleberry (VAPA). Herbs may include twinflower (LIBO2), prince's pine (CHUM) or sidebells pyrola (PYSE). The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 140). Stands in this type may be densely stocked, but this is not as common as on the closely related Western Hemlock/Rhododendron-Salal type. Frequent fires have occurred in this type over the last 300 years. Many stands begin with a moderate component of rhododendron and beargrass following fire. As the canopy develops during the middle stages of succession, understory vegetation decreases in response to lack of light. As old-growth develops and tree mortality opens the canopy, ground vegetation dominated by rhododendron and beargrass is reestablished.

Ground mosses are sparse in this type. Our limited data for this association show an average moss cover of 5%. The common cryptogams include *Rhytidiopsis robusta*, *Cladonia* spp., *Rhacomitrium* sp., *Dicranum* sp., *Hypnum circinale* on down logs and lower boles, and the nitrogen-fixing lichen *Peltigera aphthosa*. Epiphytes are sparse; lichens which may occur include *Platismatia glauca*, *Bryoria* sp. and *Usnea* sp.

Successional Relationships

There is only one recognized successional pathway for this type. Seral stages are dominated by both Douglas-fir and western hemlock, and presumably western hemlock and western redcedar dominate the climax stand.

Other Biota

Wildlife observations are limited to one plot for this type. Deer sign included trails, scat and browse on red huckleberry. Birds observed were winter wren and woodpecker activity on western redcedar.

Table 116.Common plants in the TSHE/RHMA/XETE Association, based on stands >150 years (n=5).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	63.0	63.0	100	40-75
Douglas-fir	PSME	38.0	38.0	100	10-90
western redcedar	THPL	15.0	18.7	80	0-30
silver fir	ABAM	1.2	2.0	60	0-3
western white pine	PIMO	0.8	2.0	40	0-3
GROUND VEGETATION					
rhododendron	RHMA	44.6	44.6	100	8-95
salal	GASH	25.6	25.6	100	1-95
beargrass	XETE	8.6	8.6	100	5-15
red huckleberry	VAPA	4.4	4.4	100	1-12
Oregongrape	BENE	4.0	4.0	100	1-10
twinflower	LIBO2	0.8	1.3	60	0-2
prince's pine	CHUM	0.6	1.0	60	0-1
tiger lily	LICO4	0.6	1.0	60	0-1
sidebells pyrola	PYSE	0.6	1.0	60	0-1

Environment and Soils

This type occurs on moderate to steep, straight or convex, mid- to upper slopes. The slope varied from 38% to 80% and averaged 61%. The regolith consists of colluvium derived from metabasalt or sedimentary rocks.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as shallow, well-drained, rapidly permeable, colluvial soils. Textures are sandy loams, silt loam and loams. The coarse fragment fraction ranges from moderate to high.

The mean summer soil temperature was 9.3 deg C (48.7 deg F) which is one of the coldest soils in the Western Hemlock Zone. The temperature regime is frigid and the moisture regime is xeric.

Although no soil pits were dug in this type, one soil sample was analyzed for nutrients. It showed high organic matter, phosphorus, sulfate, zinc, manganese, and low sodium and nitrogen relative to the other types. The pH was 5.1 which is about average for the Forest.

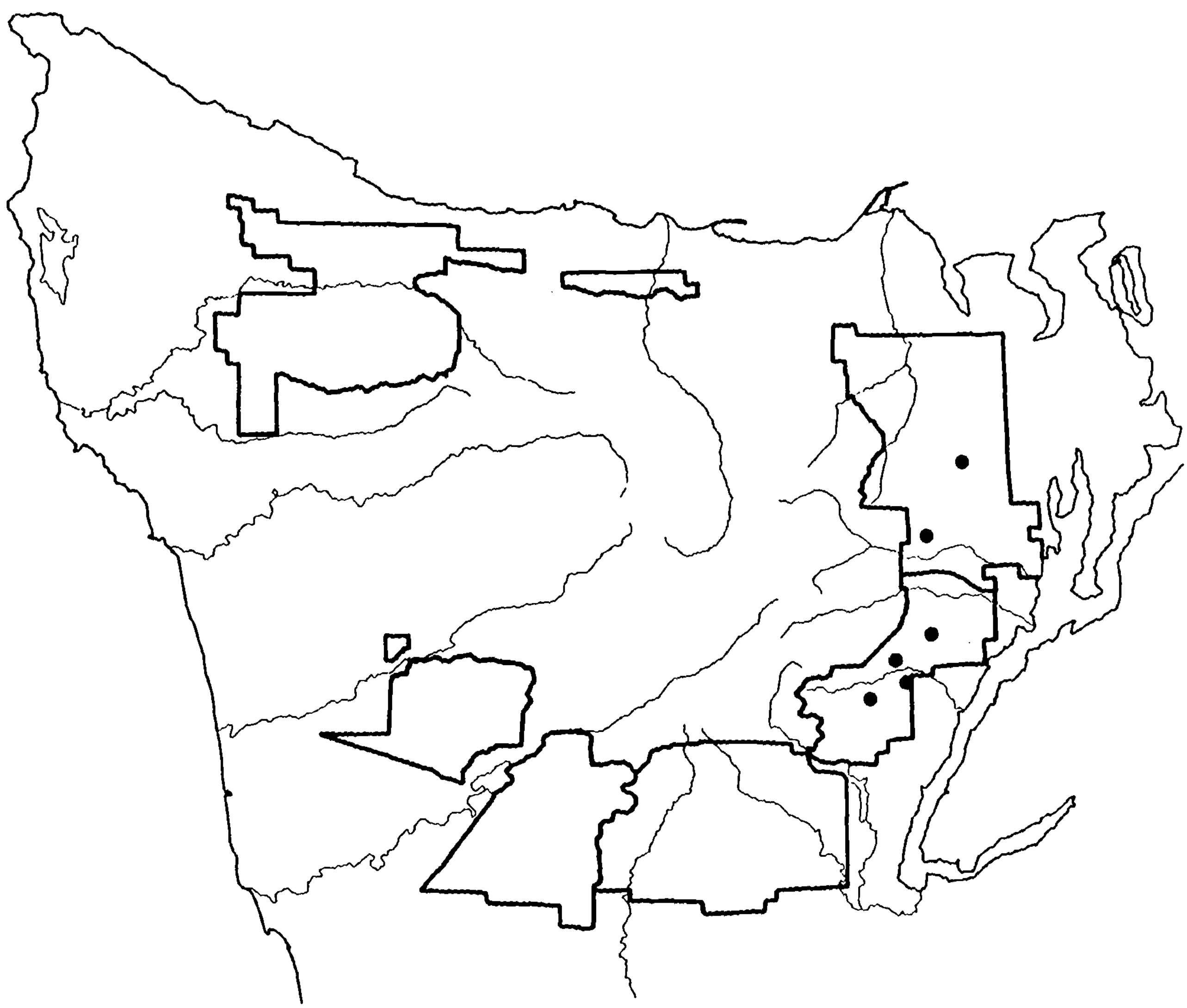


Figure 139. Map of plot locations for the Western Hemlock/Rhododendron/Beargrass Association.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the dryness of the site and poor soils. Site index of measured stands averaged 75 for Douglas-fir (Table 117). The productivity potential using the site index-yield table approach was 51 cu ft/ac/yr. The stockability of these sites is low but the stocking in wild stands can be very high. The empirical yield estimate is 69 cu ft/ac/yr. Many existing stands which are overstocked are growing at a rate of only 36 cu ft/ac/yr.

Management Considerations

Management considerations include regulation of stocking and enhancement of soil nutrients and organic matter. Soil organic matter and nitrogen should be preserved. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Soil water limitation should be addressed by regulating stocking and maintaining suitably low number of trees per acre.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Table 117. Timber productivity values for the Western Hemlock/Rhododendron/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [3]	SDI [4]	GBA TREES	GBA [5]	SIGBA [6]	EMAI [7]
Douglas-fir (McArdle [1])	2	5	75	9	51	388	5	228	52	69
Douglas-fir (McArdle [2])	4	4	81	20	60					

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[4] Stand Density Index (Reinecke 1933).

[5] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[6] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[7] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/ Rhododendron-Salal, Western Hemlock/ Rhododendron-Oregongrape, Western Hemlock/ Beargrass which occurs in slightly wetter areas to the south, and Western Hemlock/Rhododendron which occurs in slightly drier areas to the north. The Western Hemlock/Rhododendron/Beargrass Association occurs in the Olympics where it was originally included in the broadly defined Western Hemlock/Rhododendron Association (Henderson and Peter 1983a). Also the Western Hemlock/ Rhododendron/Kinnikinnick type of Smith and Henderson (1986) is comparable to this type. In Oregon it is recognized on the Mt. Hood National Forest (Halverson *et al.* 1986) and on the Willamette National Forest (Hemstrom *et al.* 1987).

Figure 140. Photo of the Western Hemlock/Rhododendron/Beargrass Association, Washington Creek, Hood Canal District.

WESTERN HEMLOCK/RHODODENDRON-OREGONGRAPE

Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa
TSHE/RHMA-BENE CHS3 33 (OLY)

The Western Hemlock/Rhododendron-Oregongrape Association is a type of dry areas, infertile soils and low timber productivity. It is common in the rainshadow area of the Olympics, particularly on the Hood Canal and Quilcene Districts (Figure 141). Soils are mostly shallow, or stony colluvium, or derived from very stony glacial till and outwash, and appear to be low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

Dominant understory species (Table 118) are rhododendron and Oregongrape, although in densely stocked stands these indicator species may be inconspicuous or absent. Other shrubs may include red huckleberry (VAPA), salal (GASH), occasionally vine maple (ACCI) and baldhip rose (ROGY). Twinflower (LIBO2), prince's pine (CHUM) and swordfern (POMU) may also occur. The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 142). Stands in this type are often densely to very densely stocked. This may make it difficult to accurately identify the type as the ground vegetation species will be sparse due to lack of light. Fires have occurred frequently in this type over the last 300 years. Many stands begin with a moderate component of rhododendron following fire. As the canopy develops during the middle stages of succession, understory vegetation decreases in response to lack of light. As old-growth develops and tree mortality opens the canopy, ground vegetation dominated by rhododendron and Oregongrape is reestablished.

Data for cryptogams are limited to one old-growth and one young-growth plot. There was quite a difference between these two plots, and neither one may be typical. Cover of ground mosses varied from 2% on the young-growth plot to 80% on the old-growth plot, where *Hylocomium splendens* was the dominant species. Species which were present in the young stand included *Dicranum* sp., *Rhytidiopsis robusta*, *Scapania bolanderi* on down logs, and *Cladonia* spp. Epiphytes were moderate in abundance on one sample plot, where the common species included crustose lichens, *Bryoria* sp., *Hypogymnia enteromorpha* and *Alectoria sarmentosa*.

Successional Relationships

There is only one recognized successional pathway for this type. Seral stages are dominated by both Douglas-fir and western hemlock, and presumably western hemlock and western redcedar dominate the climax stand.

Other Biota

Wildlife observations are limited to two plots for this type, where sign of deer, snowshoe hare and Douglas squirrel were recorded.

Birds observed were golden-crowned kinglet and gray jay.

Table 118. Common plants in the TSHE/RHMA-BENE Association, based on stands >150 years (n=5).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	68.0	68.0	100	20-90
Douglas-fir	PSME	37.8	37.8	100	4-70
western redcedar	THPL	7.8	13.0	60	0-15
silver fir	ABAM	1.4	3.5	40	0-5
Pacific yew	TABR	2.0	5.0	40	0-7
GROUND VEGETATION					
rhododendron	RHMA	26.4	26.4	100	2-60
Oregongrape	BENE	12.6	12.6	100	5-25
twinflower	LIBO2	3.2	3.2	100	1-10
prince's pine	CHUM	2.4	2.4	100	1-8
red huckleberry	VAPA	1.4	1.8	80	0-3
salal	GASH	1.4	2.3	60	0-4
swordfern	POMU	1.4	2.3	60	0-3
baldhip rose	ROGY	0.8	1.3	60	0-2
vanillaleaf	ACTR	0.6	1.0	60	0-1
evergreen violet	VISE	0.6	1.0	60	0-1

Environment and Soils

This type occurs on gentle to steep, straight, lower to upper slopes and benches. The slopes varied from 13% to 86% and averaged 54%. The regolith consists mostly of colluvium derived from metabasalt, but may also include alpine glaciofluvial deposits.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969), as shallow, well-drained and rapidly permeable soils. Subsoil compaction may sometimes render these soils effectively shallow. Textures tend to be sandy loams, but may be silt loams and clay loams as well. The coarse fragment fraction ranges from 5% to 70% near the surface and 5% to 80% in the subsoils.

The mean summer soil temperature was 11.9 deg C (53.4 deg F) which is about average for the Western Hemlock Zone. The temperature regime is frigid and the moisture regime is probably xeric.

Figure 141. Map of plot locations for the Western Hemlock/Rhododendron-Oregongrape Association.

Timber Productivity

Timber productivity of this type is moderately low (Site IV). This is due to the dryness of the site and poor soils. Site index for Douglas-fir in measured stands averaged 108 (base 100) and 80 (base 50). The productivity potential using the site index-yield table approach was 99 cu ft/ac/yr for Douglas-fir (Table 119). The stockability of these sites is low but the stocking in wild stands is sometimes very high. The empirical yield estimate was 69 cu ft/ac/yr. Some overstocked stands are growing at less than half the expected rate for this type. This is probably due to overstocking which is common to the Rhododendron types, or to root or stem diseases, such as armillaria root disease, which is fairly common in these dry types.

Management Considerations

Management considerations include regulation of stocking and enhancement of soil nutrients and organic matter. Soil organic matter and nitrogen should be preserved. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Soil water limitation should be addressed by regulating stocking and maintaining suitably low number of trees per acre.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock.

Table 119. Timber productivity values for the Western Hemlock/Rhododendron-Oregongrape Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle [1])	2	10	108	33	99	546	5	152	39	69
Douglas-fir (McArdle [2])	6	6	102	10	86					
Douglas-fir (King [3])	2	10	80	23	89					
Western Hemlock (Wiley [4])	1	4	94		193	659				

[1] Base age 100, Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.
[2] Base age 100, Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.
[3] Base age 50. Breast height age (King 1966). ages 25 to 120 years.
[4] Base age 50. Breast height age (Wiley 1978a,b). ages 25 to 120 years.
[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
[6] Stand Density Index (Reinecke 1933).
[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[8] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).
[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Comparison with Similar Types

Similar types include other Rhododendron types, especially Western Hemlock/Rhododendron-Salal at lower elevations, and the Western Hemlock/Rhododendron type. The Western Hemlock/Rhododendron-Oregongrape Association occurs in the eastern Olympics and northern Cascades of Oregon. It was included in the Western Hemlock/Rhododendron type of Henderson and Peter (1983a), and Smith and Henderson (1986). In Oregon it is recognized on the Mt. Hood National Forest (Halverson *et al.* 1986) and Willamette National Forest (Hemstrom *et al.* 1987, Dyrness *et al.* 1976).

Figure 142. Photo of the Western Hemlock/Rhododendron-Oregongrape Association, Dungeness River, Quilcene District.

WESTERN HEMLOCK/RHODODENDRON-SALAL

Tsuga heterophylla/Rhododendron macrophyllum-Gaultheria shallon
TSHE/RHMA-GASH CHS3 34 (OLY)

The Western Hemlock/Rhododendron-Salal Association is a type of dry areas, infertile soils and low timber productivity. It is common in the rainshadow area of the Olympics, particularly on the Quilcene District (Figure 143). Soils are mostly shallow, or stony colluvium, or derived from very stony glacial till and outwash, and appear to be low in organic matter and nitrogen. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

Dominant understory species (Table 120) are rhododendron and salal, although in densely stocked stands these indicator species may be inconspicuous or absent. Other shrubs may include Oregongrape (BENE), red huckleberry (VAPA) and occasionally vine maple (ACCI). Twinflower (LIBO2) and prince's pine (CHUM) may also occur. The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 144). Stands in this type are often densely to very densely stocked. This may make it difficult to accurately identify the type as the ground vegetation species will be sparse due to lack of light. Fires have burned frequently in this type over the last 300 years. Many stands begin with a moderate component of rhododendron following fire. As the canopy develops during the middle stages of succession, understory vegetation decreases in response to lack of light. As old-growth develops and tree mortality opens the canopy, ground vegetation dominated by rhododendron and salal is reestablished.

Ground mosses vary from sparse to abundant. Data from our sampled stands show mosses generally increasing in abundance with stand age. The cover values of ground mosses ranged from 1% to 95%, with an average of 41% cover. The most common and abundant species are *Hylocomium splendens* and *Eurhynchium oreganum*. Other common species which are less abundant include *Dicranum* sp., *Rhytidiopsis robusta*, and occasionally *Peltigera* spp., *Peltigera aphthosa* (in younger stands) and *Homalothecium megaptilum*.

Epiphytic lichens are conspicuous and often abundant. The common species include *Alectoria sarmentosa*, *Hypogymnia enteromorpha*, *Hypogymnia* spp., *Bryoria* spp., *Platismatia glauca* and crustose species.

Successional Relationships

There is only one recognized successional pathway for this type. Seral stages are dominated by both Douglas-fir and western hemlock, and presumably western hemlock and western redcedar dominate the climax stand.

Other Biota

Deer sign were frequently observed on this type, including trails, scat and browse, with signs of recent activity recorded in August. Heavy browsing was noted on red huckleberry and Pacific yew.

Table120.Common plants in the TSHE/RHMA-GASH Association, based on stands >150 years (n=34).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	46.5	46.5	100	10-85
western hemlock	TSHE	45.7	48.5	94	0-90
western redcedar	THPL	18.8	20.6	91	0-65
Pacific yew	TABR	1.9	4.3	44	0-15
silver fir	ABAM	0.5	1.8	29	0-4
grand fir	ABGR	0.1	1.0	8	0-1
red alder	ALRU	0.1	1.0	8	0-1
western white pine	PIMO	0.2	3.0	5	0-5
GROUND VEGETATION					
rhododendron	RHMA	39.3	39.3	100	1-99
salal	GASH	44.6	44.6	100	1-99
Oregongrape	BENE	4.4	4.5	97	0-35
twinflower	LIBO2	4.0	4.9	82	0-35
prince's pine	CHUM	1.1	1.4	76	0-5
red huckleberry	VAPA	3.3	4.4	73	0-25
swordfern	POMU	0.6	1.2	52	0-3

Salal, western redcedar, beargrass, oceanspray, red-flowering currant, douglas-fir, western hemlock, mock orange, fireweed and bitter cherry were also browsed. Other mammal signs observed were Douglas squirrel, mountain beaver, chipmunk, shrew and snowshoe hare.

Golden-crowned kinglets and woodpecker activity on snags were frequently observed on this type. Other birds recorded were chestnut-backed chickadee, red-breasted nuthatch, dark-eyed junco, hermit thrush, gray jay, red-shafted flicker, rufous hummingbird and band-tailed pigeon.

Envlronment and Soils

This type occurs on gentle to steep, straight to convex slopes in a variety of slope positions, although mid-slopes are most common. Slopes ranged from 4% to 85%, averaging 48%. Bedrock was almost always metabasalt but regolith varied from colluvial to alpine and continental glacial drift. Colluvial soils were the most common.

In three soil pits the soil texture varied from clay to loamy sand for individual horizons and the coarse fragment fraction averaged only 12%. Soils also varied from compacted to loose and friable. Soil horizons and structure were weakly to moderately well developed. Rooting depth was about average at 64.3 cm and roots were also abundant in the O2 layer. The O layer is about average with the O1 averaging 4.8 cm and 3.0 cm for the O2. Thus the O2 is thinner than average and the O1 a little thicker than average. Although they are variable, these soils tend to be about average in water holding capacity which reflects the low coarse fragment fraction. They also tend to be deep. The pits were classified as haplorthod, xerochrept and xerorthent.

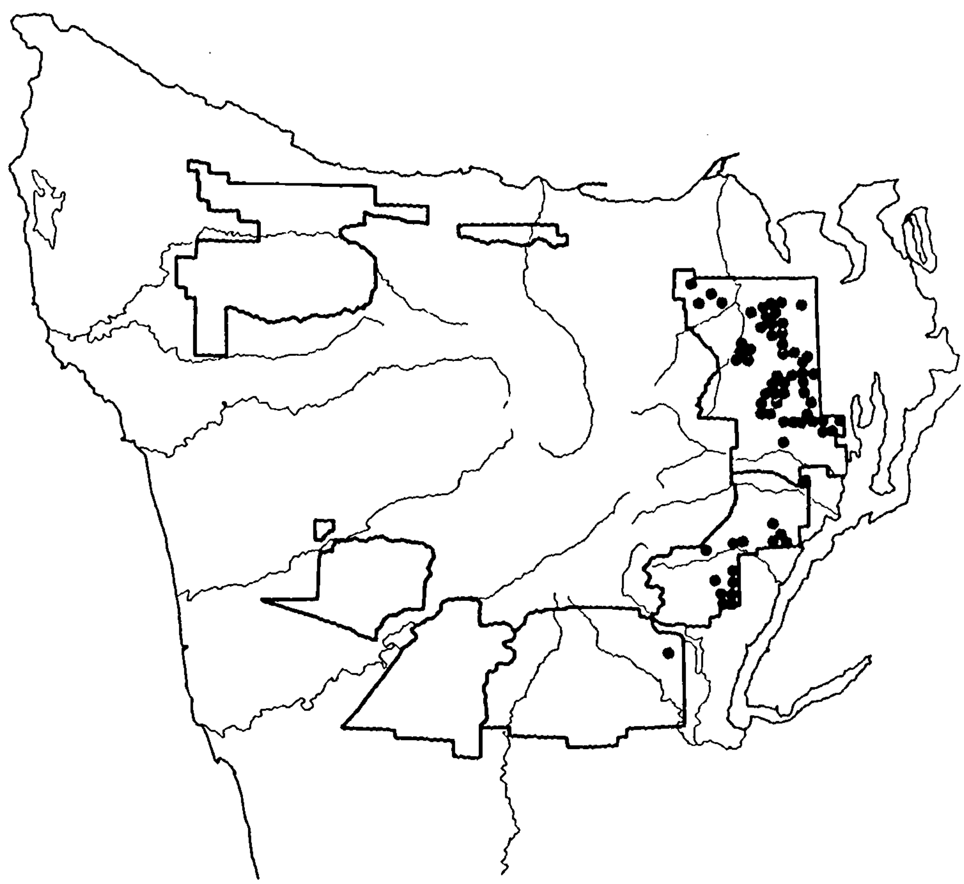


Figure 143. Map of plot locations for the Western Hemlock/Rhododendron-Salal Association.

Our plots occurred on a diversity of soil units as described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969). These soils are characterized as generally well drained, rapidly permeable and deep, although there are a number of units that are quite different. The coarse fragments range from 5% to 70% near the surface and 5% to 100% in the subsoils.

The mean summer soil temperature was 10.5 deg C (50.7 deg F), which is cool for the Western Hemlock Zone. The temperature regime is frigid and the moisture regime is xeric to sometimes udic.

Nutrient analyses from eight samples indicate that these soils tend to be high in potassium and calcium, and low in total nitrogen compared to other types. The pH was 5.6 which is above average for the series.

Timber Productivity

Timber productivity of this type is low (Site V). This is due to the dryness of the site and poor soils. Site index for Douglas-fir in measured stands averaged 88 (base 100) and 60 (base 50). The productivity potential using the site index-yield table approach was 70 cu ft/ac/yr (Table 121). The stockability of these sites is low but the stocking in wild stands tends to be very high. The empirical yield estimate for this association was 69 cu ft/ac/yr. Growth of some measured stands fell well below these estimates. There is a marked variation in productivity potential within this type relative to environmental zone. Zones 10 and 11 have a lower productivity potential and a greater problem with overstocking (and potential height growth suppression), compared to the wetter zones 8 and 9.

Management Considerations

Management considerations include regulation of stocking and enhancement of soil nutrients and organic matter. Stands in this type show a high tendency toward overstocking. Soil organic matter and nitrogen should be preserved. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. Soil water limitations should be addressed by regulating stocking and maintaining relatively low number of trees per acre. Wildlife values are important on this type, particularly for deer.

Table 121. Timber productivity values for the Western Hemlock/Rhododendron-Salal Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle [1])	19	88	88	26	70	478	82	257	71	69
Douglas-fir (McArdle [2])	39	39	88	20	70					
Douglas-fir (King [3])	12	56	60	21	62					
Western Hemlock (Wiley [4])	7	17	50	9	137	543	17	250		

[1] Base age 100. Total age (McArdle and Meyer 1930), Intensive plots only. ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930), Reconnaissance plots only. ages 25 to 400 years.

[3] Base age 50. Breast height age (King 1966). ages 25 to 120 years.

[4] Base age 50. Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[6] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock. Hemlock dwarf mistletoe may occur in western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Comparison with Similar Types

Similar types include Western Hemlock/Rhododendron-Oregongrape, Western Hemlock/Rhododendron/Beargrass, dry Salal types such as Western Hemlock/Salal-Oceanspray and Western Hemlock/Salal/Beargrass, and the Western Hemlock/Salal-Oregongrape type. The Western Hemlock/Rhododendron-Salal Association occurs in the eastern Olympics and northern Cascades of Oregon. It was included in the more broadly defined Western Hemlock/Rhododendron type by Henderson and Peter (1983a). It was recognized in Olympic National Park (Smith and Henderson 1986). In Oregon it is recognized on the Mt. Hood National Forest (Halverson *et al.* 1986) and Willamette National Forest (Hemstrom *et al.* 1987, Dyrness *et al.* 1976).

Figure 144. Photo of the Western Hemlock/Rhododendron-Salal Association, Dungeness River, Quilcene District.

WESTERN HEMLOCK/RHODODENDRON/SWORDFERN

Tsuga heterophylla/Rhododendron macrophyllum/Polystichum munitum
TSHE/RHMA/POMU CHS3 35 (OLY)

The Western Hemlock/Rhododendron/Swordfern Association is a minor type of warm, moist microsites and moderate timber productivity. It occurs in the drier climatic areas of the Olympics, particularly on the Quilcene and Hood Canal Districts (Figure 145). Soils are mostly deep and moderately fine textured, and derived from colluvium or glacial till. They are often subirrigated. The typical area of this type has burned once or twice in the last 300 years.

Floristic Composition

Dominant understory species (Table 122) are rhododendron, swordfern, Oregongrape (BENE) and salal (GASH), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Rhododendron often becomes established quickly after clearcut or fire. Other species may include red huckleberry (VAPA), twinflower (LIBO2) and Alaska huckleberry (VAAL) in small amounts. The tree layer may be dominated by Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 146). Stands in this type are sometimes overstocked. Most areas of this type have been cut over or burned. Therefore, little old-growth remains and most stands are less than 80 years old.

Cryptogam data are limited to one old-growth and one young-growth stand. Ground moss cover averaged 38%. *Eurhynchium oreganum* was the dominant species in the young-growth stand. The dominant species in the old-growth stand was *Rhytidiopsis robusta*; other common species include *Hylocomium splendens*, *Dicranum* sp., *Hypnum circinale* and *Scapania bolanderi* on down wood or lower boles, *Plagiothecium undulatum* and *Rhytidiadelphus loreus*. Data on epiphytes were only recorded for the old-growth stand where *Alectoria sarmentosa* and *Platismatia glauca* were dominant, but not very abundant. Other species present were *Hypogymnia enteromorpha*, *H. physodes*, *Sphaerophorus globosus* and *Platismatia herrei*.

Successional Relationships

Early successional stages are dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Wildlife observations are limited for this type. Red huckleberry and Alaska huckleberry were browsed. Western redcedar showed evidence of browsing by bear and porcupine. Douglas squirrel was heard. Bird observations include varied thrush, ruffed grouse, red-shafted flicker, gray jay, chestnut-backed chickadee, golden-crowned kinglet, winter wren, and woodpecker activity on a Douglas-fir snag.

Table122.Common plants in theTSHE/RHMA/POMU Association, based on stands >150 years (n=3).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	53.3	53.3	100	30-90
Douglas-fir	PSME	40.0	40.0	100	35-45
western redcedar	THPL	33.3	33.3	100	15-45
silver fir	ABAM	1.3	2.0	66	0-3
GROUND VEGETATION					
rhododendron	RHMA	24.7	24.7	100	9-50
Oregongrape	BENE	11.0	11.0	100	3-25
swordfern	POMU	8.7	8.7	100	8-10
red huckleberry	VAPA	4.0	4.0	100	2-8
salal	GASH	36.7	55.0	66	0-90
twinflower	LIBO2	1.7	2.5	66	0-4
little prince's pine	CHME	0.7	1.0	66	0-1
Alaska huckleberry	VAAL	0.7	1.0	66	0-1
evergreen violet	VISE	0.7	1.0	66	0-1

Environment and Soils

This type occurs on moderate to steep, straight slopes, mainly on mid- to lower slope positions. Slopes ranged from 19% to 77% and averaged 51%. The bedrock is usually metabasalt and the regolith is usually colluvium, although glacial deposits may be encountered.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as generally shallow colluvium, but occasionally deep glacial sediments with compacted or cemented subsoils. The colluvial soils tend to be shallow gravelly loams to very gravelly loams which are well drained and rapidly permeable. The coarse fragment fraction ranged from 25% to 65% near the surface and 10% to 100% in the subsoils. No soil pits were dug in this type.

The mean summer soil temperature was 10.1 deg C (50.2 deg F), which is cool for the Western Hemlock Zone. The temperature regime is probably frigid and the moisture regime xeric to udic.

One soil sample was analyzed for nutrients, which showed high sulfate and manganese compared to other types, but other nutrient levels were about average. The pH was 5.5 which is slightly above average for the series.

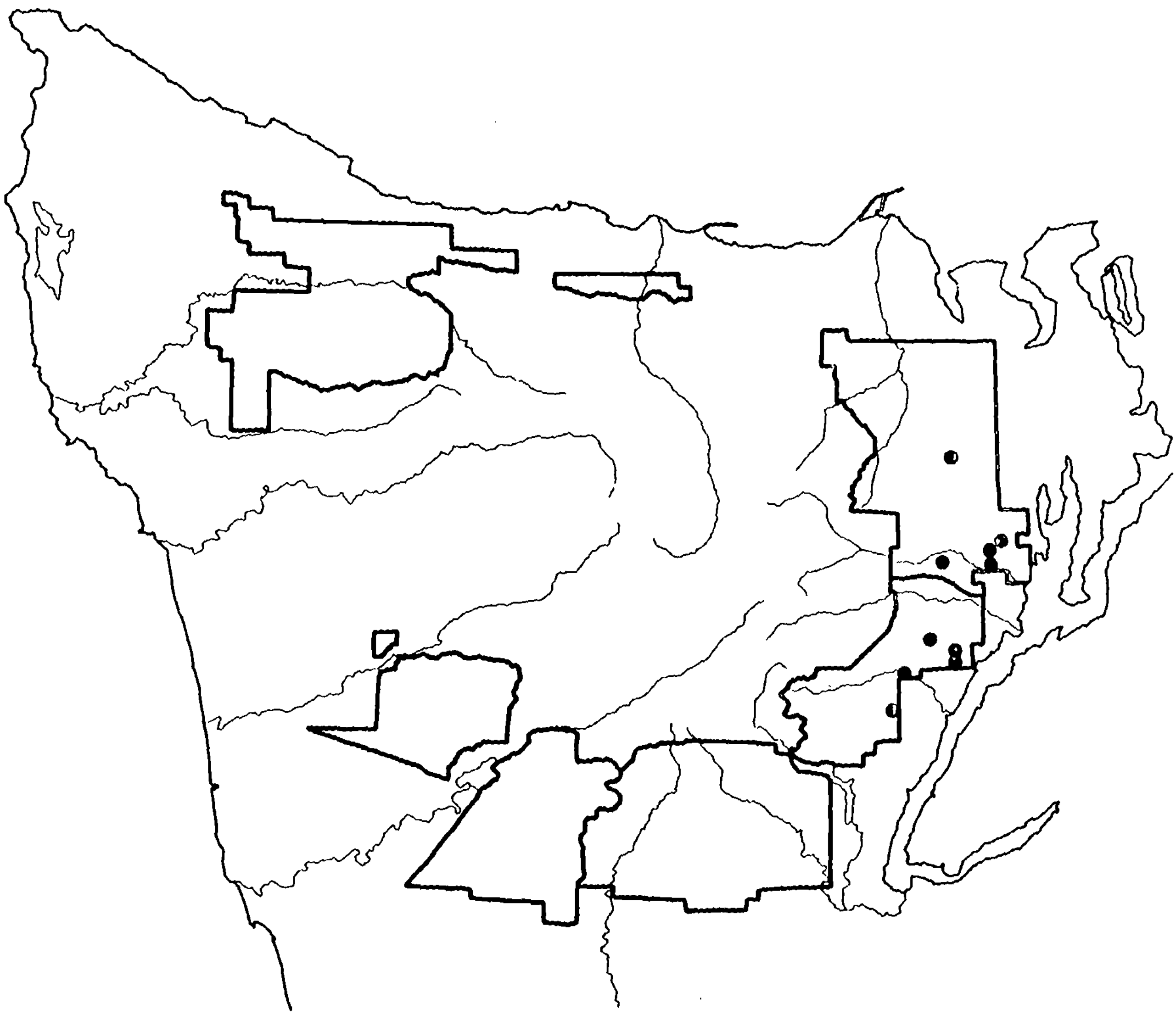


Figure 145. Map of plot locations for the Western Hemlock/Rhododendron/Swordfern Association.

Timber Productivity

Timber productivity of this type is moderate (Site IV). This is the most productive of the Rhododendron dominated types, and occurs on favorable soils, usually on toe-slopes. Site index for Douglas-fir averaged 119 (base 100) and 86 (base 50). The productivity potential using the site index-yield table approach was 115 cu ft/ac/yr (Table 123). There was no empirical yield estimate for this type. The stockability of these sites is moderate.

Management Considerations

The main management consideration is regulation of stocking. It is also important to maintain soil nutrients and organic matter. Soil organic matter and nitrogen in the ecosystem should be preserved. Response to fertilizer in this type is still unknown. There is a wider range of management options for this association than for other rhododendron types, because it is more productive and does not usually develop overstocked stand conditions.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Table 123. Timber productivity values for the Western Hemlock/Rhododendron/Swordfern Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI
Douglas-fir (McArdle [1])	3	14	119	24	115	363	13	286	110	
Douglas-fir (McArdle [2])	5	5	118	13	110					
Douglas-fir (King [3])	2	10	86	24	101					
Western Hemlock (Wiley [4])	1	3	66		155	124	3	91		

[1] Base age 100. Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 50. Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include other Rhododendron types and dry Swordfern types. Western Hemlock/Rhododendron-Salal and Western Hemlock/Rhododendron-Oregongrape occur on drier sites. The Western Hemlock/Oregongrape/Swordfern and the Western Hemlock/Salal/Swordfern types occur in somewhat wetter areas. The Western Hemlock/Rhododendron/Swordfern Association is previously recognized on the Suislaw National Forest in Oregon (Hemstrom and Logan 1986). It was previously included in the Western Hemlock/Rhododendron Association in the Olympics (Henderson and Peter 1983a).

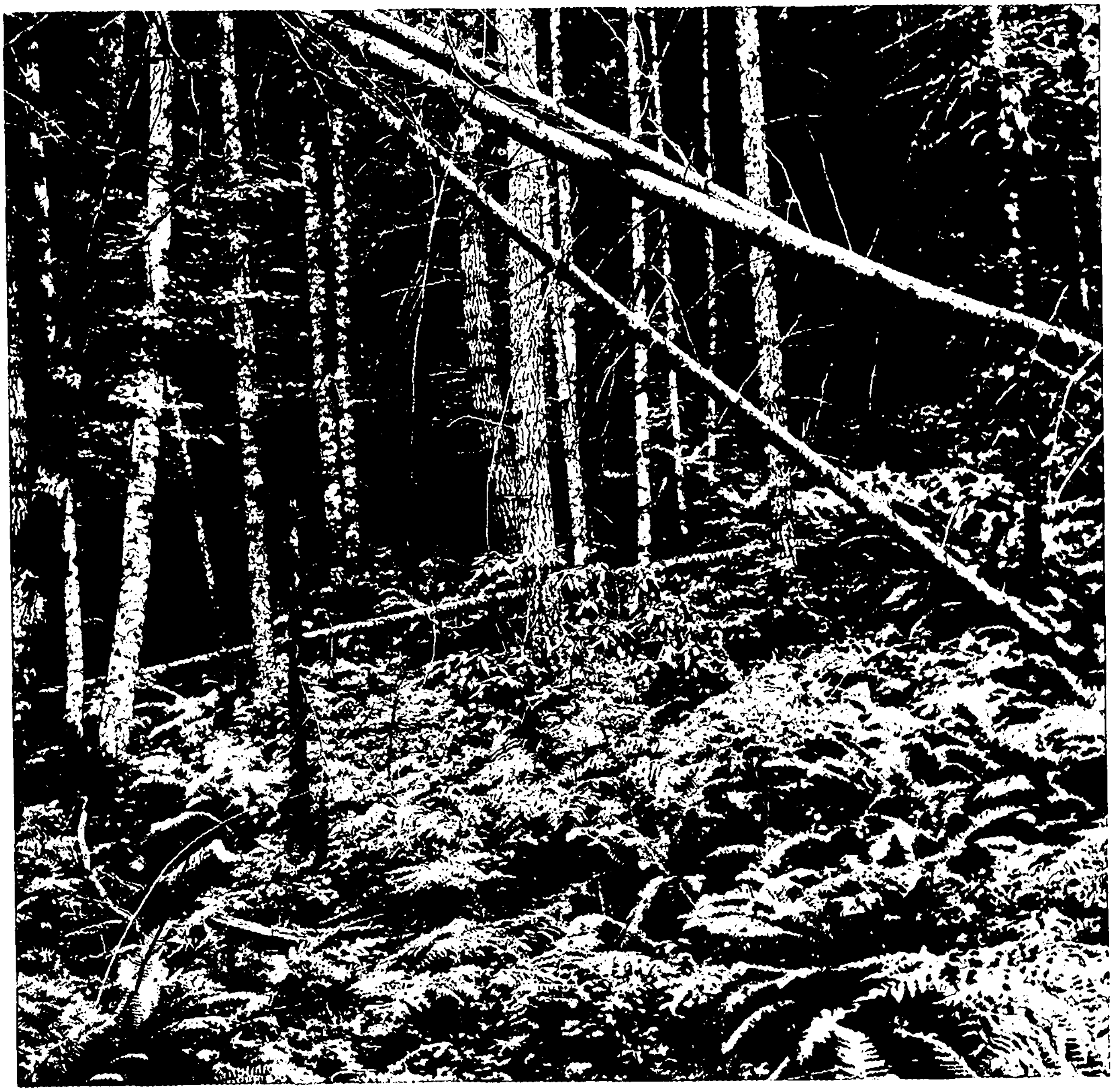


Figure 146. Photo of the Western Hemlock/Rhododendron/Swordfern Association, Jefferson Creek, Hood Canal District.

WESTERN HEMLOCK/SALAL
Tsuga heterophylla/Gaultheria shallon
TSHE/GASH CHS1 31 (OLY)

The Western Hemlock/Salal Association is a common type of moderately dry areas, warm soils and moderate to low timber productivity. It is found throughout the Forest (Figure 147), and is somewhat variable in environment and productivity potential. Soils are shallow to deep, derived from very stony colluvium, till or outwash, and often appear to be well drained. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 124) is salal. Few other shrubs or herbs are found, of these the most common are red huckleberry (VAPA), Alaska huckleberry (VAAL), Oregongrape (BENE) and twinflower (LIBO2). Vine maple (ACCI) may be common and abundant in young stands. The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 148).

Cryptogam data for this type are mainly for young-growth stands between 45 and 60 years. Ground mosses are moderate to abundant, ranging from 5% to 80% cover and averaging 38%. The dominant moss is *Eurhynchium oreganum*, *Hylocomium splendens* is generally codominant but less abundant. Other common species include *Plagiothecium undulatum* and *Dicranum* spp. *Rhizomnium glabrescens* may occur on down wood. Epiphytes are sparse to moderate in abundance. The common lichens include crustose species, *Hypogymnia enteromorpha*, *H. inactiva*, *H. imshaugii*, *H. physodes*, and the liverworts *Frullania* and *Porella*.

Successional Relationships

There are two probable successional pathways for this type. One dominated by Douglas-fir, the other by western hemlock, although the latter is much less common. Later seral stages are often dominated by both Douglas-fir and western hemlock; western hemlock and western redcedar dominate the climax stand.

Other Biota

Deer sign was frequently recorded on this type, with recent activity noted in early and late summer. Red huckleberry and vine maple were the most commonly browsed species. Other browse species include swordfern, salal, fool's huckleberry, Douglas-fir, beargrass, Oregongrape, baldhip rose, mountain-ash and redstem ceanothus. Douglas squirrel, elk and mountain beaver sign were also frequently observed. Recent activity of elk and bear was noted in early summer. Snowshoe hare and tree frog were recorded.

Birds frequently recorded were Wilson's warbler, dark-eyed junco, Swainson's thrush and rufous hummingbird. Other birds included chestnut-backed chickadee, golden-crowned kinglet, pileated woodpecker, northern harrier, western flycatcher, Steller's jay, red-breasted nuthatch, brown creeper, varied thrush, hermit thrush, rufous-sided towhee, black-throated gray and Townsend's warblers, western tanager and woodpecker activity.

Table 124. Common plants in the TSHE/GASH Association, based on stands >150 years (n=12).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	53.4	53.4	100	10-99
Douglas-fir	PSME	26.2	31.5	83	0-70
western redcedar	THPL	15.3	23.0	66	0-35
Pacific yew	TABR	0.7	2.0	33	0-3
silver fir	ABAM	0.7	4.0	16	0-6
GROUND VEGETATION					
salal	GASH	64.2	64.2	100	1-99
red huckleberry	VAPA	4.7	4.7	100	1-15
Oregongrape	BENE	1.1	1.6	66	0-3
Alaska huckleberry	VAAL	1.9	3.3	58	0-5
twinflower	LIBO2	1.3	2.7	50	0-10
fool's huckleberry	MEFE	0.9	2.2	41	0-4
swordfern	POMU	0.5	1.5	33	0-3
vine maple	ACCI	1.3	4.0	33	0-7
vanillaleaf	ACTR	0.4	1.3	33	0-2
deerfern	BLSP	1.8	7.0	25	0-15
bracken fern	PTAQ	0.8	2.2	16	0-4

Environment and Soils

This type can occur on flat to steep, generally straight, upper slopes to valley bottoms and terraces, but rarely in wet bottom situations. The slope varied from 0% to 100% and averaged 38%. Bedrock is sedimentary or metabasalt. The regolith is colluvial or glacial.

Two soil pits in this type show weak to moderate soil development. Both had duripans at 60 to 70 cm effectively rendering these soils shallow. The texture varied from gravelly silt loam to gravelly sandy loam and the coarse fragment fraction averaged 43% which is above average. The O1 was 1.5 cm and the O2 was 8.5 cm which is thicker than average. The rooting depth to the duripan was about 70 cm. The root mass also occupied the O2. These profiles are both classified as durochrepts.

About two-thirds of our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as glacial regolith and about one-third occurred on colluvium. Most of these soil units are moderately to well drained with rapidly permeable surface horizons and moderately to slowly permeable subsoils. Coarse fragments range from 5% to 65% near the surface and 5% to 100% in the subsoil.

The mean summer soil temperature was 12.5 deg C (54.5 deg F) which is warm for the Western Hemlock Zone. The temperature regime is probably mesic and the moisture regime is probably xeric.

Two soil samples were analyzed for nutrients, which showed very low magnesium, low nitrogen and organic matter but high sulfate and manganese compared to other types. The sodium content was lower than any other associaton tested. The pH was 5.3 which is average for the series.

Figure 147. Map of plot locations for the Western Hemlock/Salal Association.

Timber Productivity

Timber productivity of this type is moderate (Site IV). Site index of Douglas-fir averaged 113 (base 100) and 83 (base 50). The productivity potential using the site index-yield table approach was 106 cu ft/ac/yr (Table 125). The empirical yield estimate was 122 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations include ensuring rapid initial stocking and enhancement of soil nutrients and organic matter. Accumulated soil organic matter and nitrogen should be preserved by not burning sites in this type if fuel loadings and risk from adjacent stands permit; however salal competition can be severe and burning for brush control may be needed. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. This type offers moderate wildlife values, particularly for deer, although elk sign was also observed. Some young-growth stands offer good browse for deer, especially from red huckleberry.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock. Hemlock dwarf mistletoe may occur in older western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Table 125. Timber productivity values for the Western Hemlock/Salal Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	15	80	113	20	106	348	71	182	60	122
Douglas-fir (McArdle [2])	17	17	115	29	102					
Douglas-fir (King [3])	14	79	83	13	97					
Western Hemlock (Barnes [4])	2	2	113	16	166			312	106	
Western Hemlock (Wiley [5])	6	20	84	22	180	426	10	312		

[1] Base age 100, Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962). Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50. Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/Salal-Oregongrape which occurs on slightly moister sites, and the Western Hemlock/Salal/Beargrass type, which occurs on slightly drier and shallower or coarser soils. It is also related to the Western Hemlock/Rhododendron-Salal type which occurs in drier areas, mostly on the Hood Canal and Quilcene Districts. The Western Hemlock/Salal Association is widely recognized, however it is used in a more limited sense here. As a type, it is recognized in virtually all classifications from the central Oregon Cascades to British Columbia. Our Western Hemlock/Salal-Oregongrape and Western Hemlock/Salal-Oceanspray types were previously included in this type (Henderson and Peter 1983a).

Figure 148. Photo of the Western Hemlock/Salal Association, young-growth stand of Douglas-fir, Big Creek, Hood Canal District.

WESTERN HEMLOCK/SALAL/BEARGRASS

Tsuga heterophylla/Gaultheria shallon/Xerophyllum tenax
TSHE/GASH/XETE CHS1 32

The Western Hemlock/Salal/Beargrass Association is a minor type of warm dry sites and low timber productivity. It occurs in Environmental Zones 8 and 9 on the Hood Canal District (Figure 149), where it occurs primarily along upper slopes at lower elevations or on low flats. Soils are mostly shallow and derived from colluvium, or they may be deep but very coarse and well drained. Typical soils appear to be low in nitrogen and potassium. Much of this type has burned several times in the last 500 years. A wet phase of this type occurs on very wet soils in the Matheny Block of the Quinault District.

Floristic Composition

Dominant understory species (Table 126) are salal, beargrass, vine maple (ACCI) and Oregongrape (BENE), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Beargrass, salal, vine maple and bracken fern (PTAQ) can resprout or become established quickly after clearcut or fire. Other shrubs may include red huckleberry (VAPA). Prince's pine (CHUM), twinflower (LIBO2) and swordfern (POMU) often occur. The wet phase is characterized by false lily-of-the-valley (MADI2), deerfern (BLSP) and skunkcabbage (LYAM). The tree layer may be dominated by Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 150). Stands may be slow to regenerate. Most areas of this type have been cut over.

Ground mosses in old-growth stands are moderate to abundant, with cover values ranging from 5% to 85% and averaging 48%. *Eurhynchium oreganum* is the most common species. Other species include *Rhytidiopsis robusta*, *Hylocomium splendens*, *Pleurozium schreberi*, *Homalothecium megaptilum*, *Rhytidiadelphus loreus*, *Dicranum* sp., and *Hypnum circinale* and *Scapania bolanderi* on down wood and lower boles. Epiphytic lichens are sparse to moderate in abundance. The common species include *Hypogymnia enteromorpha*, *Alectoria sarmentosa* and *Platismatia glauca*.

Successional Relationships

The common successional pathway is dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Deer sign was frequently observed on this type, with signs of recent activity recorded in late July and early September. The most commonly browsed species was red huckleberry; vine maple, brackenfern and swordfern were also browsed. Other wildlife observations were recorded for elk, mountain beaver and Douglas squirrel.

Table 126. Common plants in the TSHE/GASH/XETE Association, based on stands >150 years (n=23).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	53.1	53.1	100	9-99
Douglas-fir	PSME	36.0	39.4	91	0-80
western redcedar	THPL	9.0	14.7	60	0-55
Pacific yew	TABR	1.9	4.4	43	0-9
silver fir	ABAM	1.0	4.0	26	0-10
Pacific dogwood	CONU	0.8	3.6	21	0-6
cascara	RHPU	0.3	2.7	13	0-5
lodgepole pine	PICO	1.0	11.5	8	0-15
western white pine	PIMO	0.3	3.5	8	0-5
GROUND VEGETATION					
salal	GASH	50.0	50.0	100	4-95
beargrass	XETE	15.3	15.3	100	2-80
Oregongrape	BENE	5.6	6.1	91	0-25
red huckleberry	VAPA	3.9	4.3	91	0-25
vine maple	ACCI	17.0	19.6	86	0-55
twinflower	LIBO2	1.7	2.1	78	0-8
swordfern	POMU	1.2	1.9	60	0-5
prince's pine	CHUM	1.0	1.6	60	0-6
vanillaleaf	ACTR	0.7	1.3	52	0-3
little prince's pine	CHME	0.5	1.0	52	0-1

Birds frequently observed were chestnut-backed chickadee, common raven and golden-crowned kinglet. Other birds recorded include red-tailed hawk, Cooper's hawk, red-shafted flicker, western flycatcher, Steller's jay, red-breasted nuthatch, brown creeper, winter wren, Swainson's thrush and dark-eyed junco.

Environment and Soils

This type occurs on flat to steep, straight slopes. The majority of the plots occur on mid- to upper slopes with colluvial regolith, while fewer plots are on glacial drift along flats or broad benches on plains, or near river bottoms. Slopes range from 0% to 78% and averaged 47%. Bedrock is usually basalt but a few plots occurred in areas of sedimentary rocks.

Soils tend to be poorly developed. Texture is gravelly to very gravelly sandy loam. Two pits were dug on mountain slopes and one on a glacial terrace. On the mountain slope the soils were shallow. The soil on the glacial terrace was rendered effectively shallow by a duripan at 67 cm. Coarse fragments averaged 46% which is a little above average. The O1 averaged 2.3 cm (about average) and the O2 averaged 3.3 cm, which is below average. The rooting depth extended to 82 cm, which is deep, and up into the O2. The water holding capacity is low due to a combination of coarse texture and coarse fragments.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as generally shallow or effectively shallow (due to compacted subsoils), gravelly to very gravelly sandy to silt loams. Most are colluvial underlain by metabasalt with some on glacial terrace. They are all well drained and rapidly permeable except for some of the compacted subsoils in glacial material. The coarse fragment fraction ranges from 15% to 65% near the surface and 50% to 100% in the subsoils.

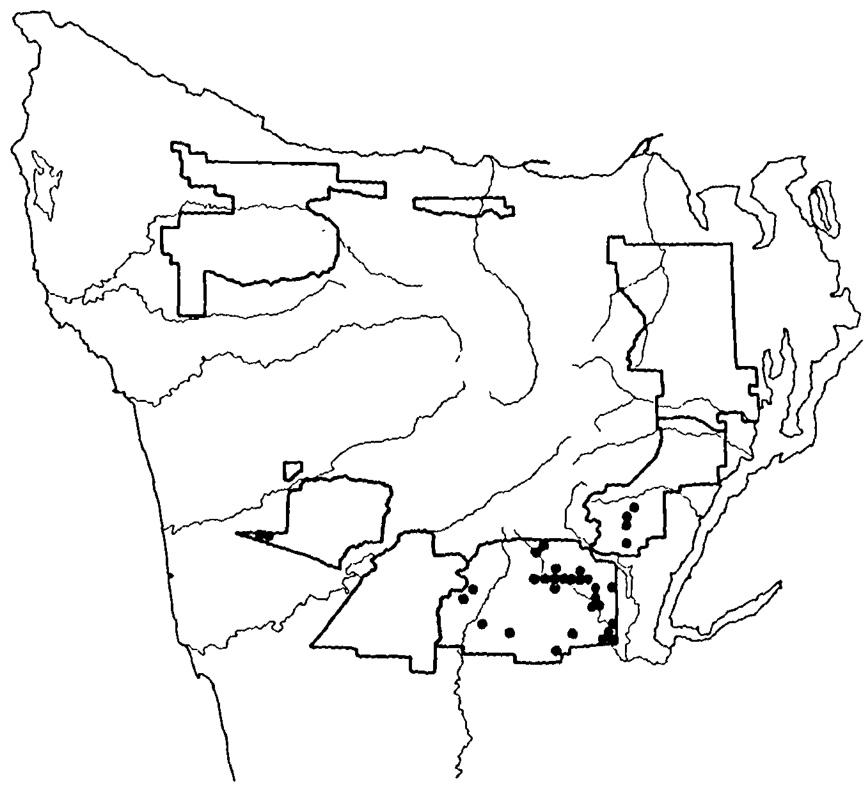


Figure 149. Map of plot locations for the Western Hemlock/Salal/Beargrass Association.

The mean summer soil temperature was 13.4 deg C (56.1 deg F), which indicates that this type is relatively warm. The elevation and environmental zones where most of the plots occur would indicate a mid- to warm frigid temperature regime. The moisture regime is probably xeric.

Nutrient analyses of three samples indicate that soils in this type may be high in phosphorus and sulfate, and low in organic matter, total nitrogen and boron compared to other types. The pH was 5.5 which is a little above average for the series.

Timber Productivity

Timber productivity of this type is moderately low (Site IV or V). This is often due to the dryness of the site, the well-drained soils and poor nutrient regime. Site index for Douglas-fir averaged 89 (base 100) on Intensive plots and 102 on Reconnaissance plots. The productivity potential using the site index-yield table approach averaged 79 cu ft/ac/yr (Table 127). The empirical yield estimate was 69 cu ft/ac/yr. The stockability of these sites is moderate to low.

Management Considerations

Management considerations include soil maintenance and ensuring suitable regeneration. Maintenance of soil nutrients and organic matter is critical in this type. Response to fertilizer in this type is still unknown. Red alder cannot be easily cultivated on this type, so it is probably not a management option. Douglas-fir is the preferred species. Beargrass and/or salal can pose brush problems. This type has moderate wildlife values, mostly for deer.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock.

Table 127. Timber productivity values for the Western Hemlock/Salal/Beargrass Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	6	26	89	11	71	447	25	245	65	69
Douglas-fir (McArdle [2])	13	13	102	19	87					
Douglas-fir (King [3])	3	12	73	2	73					
Western Hemlock (Wiley [4])	2	2	63	21	152	386	2	234		
Lodgepole Pine (Hegyi [5])	2	4	74	5	50	334	4	150	34	

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.
[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only, ages 25 to 400 years.
[3] Base age 50. Breast height age (King 1966), ages 25 to 120 years.
[4] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.
[5] Base age 100. Total age (Hegyi et al. 1979).
[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
[7] Stand Density Index (Reinecke 1933).
[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).
[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).
[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include the Salal types. The Western Hemlock/Salal-Oregongrape type occurs on cooler and wetter sites. The Western Hemlock/Salal type is slightly wetter. The Western Hemlock/Alaska Huckleberry/Beargrass type occurs at higher elevations with more snow. Western Hemlock/Salal-Oceanspray is a similar type of drier areas. The Western Hemlock/Salal/Beargrass Association is only recognized in the Olympic Mountains. In Mt. Rainier National Park it appears to have been included in the more broadly defined Western Hemlock/Salal Association (Franklin *et al.* 1988).

Figure 150. Photo of the Western Hemlock/Salal/Beargrass Association, near Le Bar Pass, Hood Canal District.

WESTERN HEMLOCK/SALAL-EVERGREEN HUCKLEBERRY

Tsuga heterophylla/Gaultheria shallon-Vaccinium ovatum
TSHE/GASH-VAOV2 CHS1 33

The Western Hemlock/Salal-Evergreen Huckleberry Association is a minor type of warm sites and moderate timber productivity. It is found mostly in the vicinity of Seal Rock on the Quilcene District (Figure 151), although it is common in adjacent areas off the Forest. Slopes are gentle. Soils are mostly deep and derived from continental glacial till. The typical area of this type has burned several times in the last 500 years.

Floristic Composition

Dominant understory shrubs (Table 128) are salal, evergreen huckleberry, oceanspray (HODI), rhododendron (RHMA), Oregongrape (BENE), red huckleberry (VAPA) and occasionally vine maple (ACCI). Common understory herbs include swordfern (POMU), twinflower (LIBO2) and bracken fern (PTAQ). Salal, evergreen huckleberry and oceanspray become established quickly after clearcut or fire. The tree layer may be dominated by Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 152).

Cryptogam data are limited to two young-growth plots, with stand ages of 55 and 79 years. Cover of ground mosses was moderate, with an average of 17%. *Eurhynchium oreganum* was most abundant on both plots. Other species include *Hylocomium splendens*, *Plagiothecium undulatum*, *Cladonia* spp. and *Peltigera* sp. Epiphytic lichens and mosses were sparse, which may relate to the stand age or stocking. *Isothecium stoloniferum* and crustose lichens were most common.

Successional Relationships

Successional pathways are dominated by Douglas-fir, western redcedar and/or western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Wildlife observations are limited to two plots for this type. Deer sign, Douglas squirrel and shrew were recorded.

Bird observations are also limited to two plots. Chestnut-backed chickadee, red-breasted nuthatch, golden-crowned kinglet, winter wren, American robin, dark-eyed junco and pine siskin were recorded.

Table 128. Common plants in the TSHE/GASH-VAOV2 Association (n=4).*

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	69.7	69.7	100	45-99
western redcedar	THPL	30.0	30.0	100	15-60
western hemlock	TSHE	14.7	14.7	100	4-25
madrone	ARME	6.3	12.5	50	0-15
bigleaf maple	ACMA	2.8	5.5	50	0-10
Scouler's willow	SASC	2.0	8.0	25	0-8
grand fir	ABGR	0.3	1.0	25	0-1
red alder	ALRU	0.3	1.0	25	0-1
GROUND VEGETATION					
salal	GASH	67.5	67.5	100	35-85
evergreen huckleberry	VAOV2	8.8	8.8	100	5-15
rhododendron	RHMA	4.3	4.3	100	1-7
swordfern	POMU	4.0	4.0	100	1-9
Oregongrape	BENE	2.8	2.8	100	1-6
oceanspray	HODI	1.5	1.5	100	1-2
red huckleberry	VAPA	3.3	4.3	75	0-5
trailing blackberry	RUUR	0.8	1.0	75	0-1
twinflower	LIBO2	1.5	3.0	50	0-4
bracken fern	PTAQ	0.5	1.0	50	0-1

* Stand ages range from 55 to 98 years.

Environment and Soils

This type occurs on gentle, straight or concave slopes, usually on lower or toe-slope positions. The slope ranged from 7% to 24% and averaged 17%. Bedrock is probably metabasalt but is buried by deep continental glacial deposits.

Soil development was poorly expressed in one soil pit profile. The C horizon occurred at 79 cm and was strongly compacted and cemented. There were 59% coarse fragments in the profile which is fairly high compared to most other types. The rooting depth was to the hardpan (77 cm) and up into the O2. The O1 layer was 3 cm thick and the O2 was 6 cm. Both of these are near average compared to other types. The texture was very gravelly loamy sand and sand. Coarse texture and coarse fragments combine to make this a very drouthy soil. This soil was classified a durochrept.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as deep continental glacial drift over basalt. Surface soils tend to be gravelly and very gravelly sandy loam and loam. Subsoils consist of stratified sandy gravel and very gravelly sandy silt loams that are weakly to moderately compacted. These soils are well to imperfectly drained with rapid surface permeability and moderate subsoil permeability. Coarse fragments range from 35% to 60% near the surface and 65% to 100% in the subsoils.

No soil temperature data were taken on our plots of this type, but the elevation and environmental zones indicate a mesic temperature regime and a xeric moisture regime.

Nutrient analysis from one sample showed low nitrogen, sodium, boron and zinc, and high sulfate compared to other types. The pH was 5.7 which is above the average for the series.

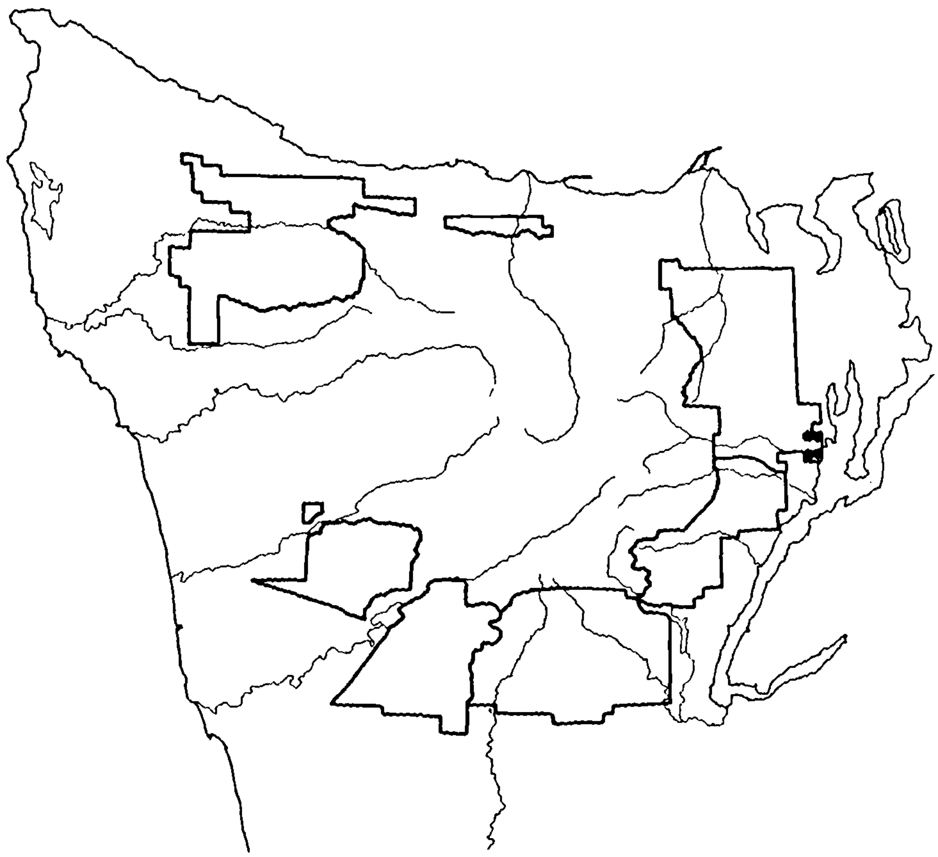


Figure 151. Map of plot locations for the Western Hemlock/Salal-Evergreen Huckleberry Association.

Timber Productivity

Timber productivity for this type is moderate (Site III). Site index of Douglas-fir averaged 134 (base 100) and 103 (base 50). The productivity potential using the site index-yield table approach was 136 cu ft/ac/yr for Douglas-fir (Table 129). The empirical yield estimate was 122 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations include controlling brush competition and maintenance of soil nutrients and organic matter. Response to fertilizer in this type is still unknown. Red alder apparently cannot be cultivated on this type. Douglas-fir is the preferred species. Salal and/or evergreen huckleberry can pose brush problems.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock, and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Black stain root disease may occur in Douglas-fir plantations. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 129. Timber productivity values for the Western Hemlock/Salal-Evergreen Huckleberry Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [5]	SDI [6]	GBA TREES	GBA [7]	SIGBA [8]	EMAI [9]
Douglas-fir (McArdle [1])	2	10	134	1	136	504	10	582	233	122
Douglas-fir (McArdle [2])	2	2	129	5	127					
Douglas-fir (King [3])	2	10	103	7	141					
Western Hemlock (Wiley [4])	2	3	91	14	189	504	3	238		

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[5] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[6] Stand Density Index (Reinecke 1933).

[7] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[8] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[9] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/Salal-Oregongrape, Western Hemlock/Salal and Western Hemlock/Rhododendron-Salal. The Western Hemlock/Salal-Oregongrape and Western Hemlock/Salal types occur on somewhat moister soils or at higher elevations. The Western Hemlock/Rhododendron-Salal type occurs on colder or higher elevation sites. The Western Hemlock/Salal/Swordfern type occurs on similar topographic positions but on finer textured soils or in wetter environmental zones. The Western Hemlock/Salal-Evergreen Huckleberry Association is not previously recognized. It was earlier considered part of the Western Hemlock/Salal type (Henderson and Peter 1983a).

Figure 152. Photo of the Western Hemlock/Salal-Evergreen Huckleberry Association, Seal Rock Campground, Quilcene District.

WESTERN HEMLOCK/SALAL-OCEANSPRAY
Tsuga heterophylla/Gaultheria shallon-Holodiscus discolor
TSHE/GASH-HODI CHS1 34

The Western Hemlock/Salal-Oceanspray Association is a type of dry areas, warm soils and moderately low timber productivity. It is found mostly on the Quilcene District (Figure 153). Soils are typically shallow, derived from very stony colluvium, till or outwash, and appear to be well drained. Stands in this type have burned frequently in the past, which has contributed partially to the low fertility of these sites.

Floristic Composition

The dominant understory species (Table 130) are salal, oceanspray, Oregongrape (BENE) and baldhip rose (ROGY). Herbs are sparse but may include twinflower (LIBO2), prince's pine (CHUM), vanillaleaf (ACTR) and swordfern (POMU). The tree layer is dominated by Douglas-fir, with smaller amounts of western redcedar and western hemlock (Figure 154). Old-growth stands in this type are often about 300 years old, having originated from fires about 280 and 320 years ago.

Data on ground mosses and lichens are limited for this type to two young-growth plots and three old-growth plots. The young stands were quite different, one had only 1% cover of ground moss. The other stand had 60% cover where *Rhacomitrium canescens*, *R. lanuginosum*, *R. heterostichum* and *Cladonia* spp. were the most abundant species. Moss cover on the old-growth plots varied from 12% to 95%. *Hylocomium splendens* was the most common moss, *Rhytidiadelphus triquetrus* and *Eurhynchium oreganum* were less abundant. Data on epiphytes are limited to one old-growth plot, where they occurred in moderate abundance. The common species were *Hypogymnia enteromorpha*, *H. physodes*, *Platismatia glauca*, *Alectoria sarmentosa*, and the liverwort *Frullania* sp.

Successional Relationships

There is one probable successional pathway for this type, dominated by Douglas-fir. Later seral stages are often dominated by Douglas-fir with some western hemlock. Western hemlock and western redcedar dominate the climax stand, although given the fire history of this type, this stand condition is extremely rare.

Other Biota

Deer sign, particularly browse, was frequently observed on this type, with signs of recent activity recorded in early August. Red huckleberry and oceanspray were the most commonly browsed species; fireweed, thimbleberry, blackcap, grand fir and Douglas-fir were also browsed. Observations were recorded for Douglas squirrel, chipmunk and snowshoe hare.

American robins were frequently observed; other birds recorded were chestnut-backed chickadee, gray jay and olive-sided flycatcher.

Table 130. Common plants in the TSHE/GASH-HODI Association, based on stands >150 years (n=5).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
Douglas-fir	PSME	60.0	60.0	100	35-75
western hemlock	TSHE	24.0	24.0	100	5-45
western redcedar	THPL	6.0	10.0	60	0-20
grand fir	ABGR	6.0	15.0	40	0-25
GROUND VEGETATION					
salal	GASH	62.0	62.0	100	20-95
Oregongrape	BENE	13.6	13.6	100	4-35
oceanspray	HODI	3.0	3.0	100	1-4
baldhip rose	ROGY	2.6	2.6	100	1-4
twinflower	LIBO2	2.0	2.0	100	1-5
prince's pine	CHUM	1.2	1.2	100	1-2
vanillaleaf	ACTR	1.8	2.3	80	0-4
creeping snowberry	SYMO	1.0	1.3	80	0-2
swordfern	POMU	1.4	2.3	60	0-4
red huckleberry	VAPA	1.2	2.0	60	0-4
Scouler's harebell	CASC2	0.8	1.3	60	0-2
rattlesnake plantain	GOOB	0.8	1.3	60	0-2
starflower	TRLA2	0.8	1.3	60	0-2
pachistima	PAMY	0.6	1.0	60	0-1

Environment and Soils

This type occurs on flat to steep, straight to convex, mainly mid- to upper slopes. The slope ranged from 3% to 100% with a mean of 52%. Bedrock can be metabasalt or sandstone. This type is usually found on colluvium, although it may occur on glacial sediments.

Our plots generally occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as colluvial soils. These soils are mostly shallow (one to three feet) with metabasalt or sedimentary bedrock. Coarse fragments range from 20% to 70% near the surface and 35% to 80% in the subsoils. Textures are generally gravelly loams, silt loams and sandy loams. They are well drained and rapidly permeable. The glacial soils tend to have similar textures and coarse fragments ranging from 5% to 65% near the surface and 5% to 80% in the subsoils. Although they are deep, they tend to have compacted or cemented subsoils which may render them effectively shallow.

The mean summer soil temperature was 11.9 deg C (53.4 deg F) which is about average for the Western Hemlock Zone. The temperature regime is cool to mid-frigid and the moisture regime is mesic.

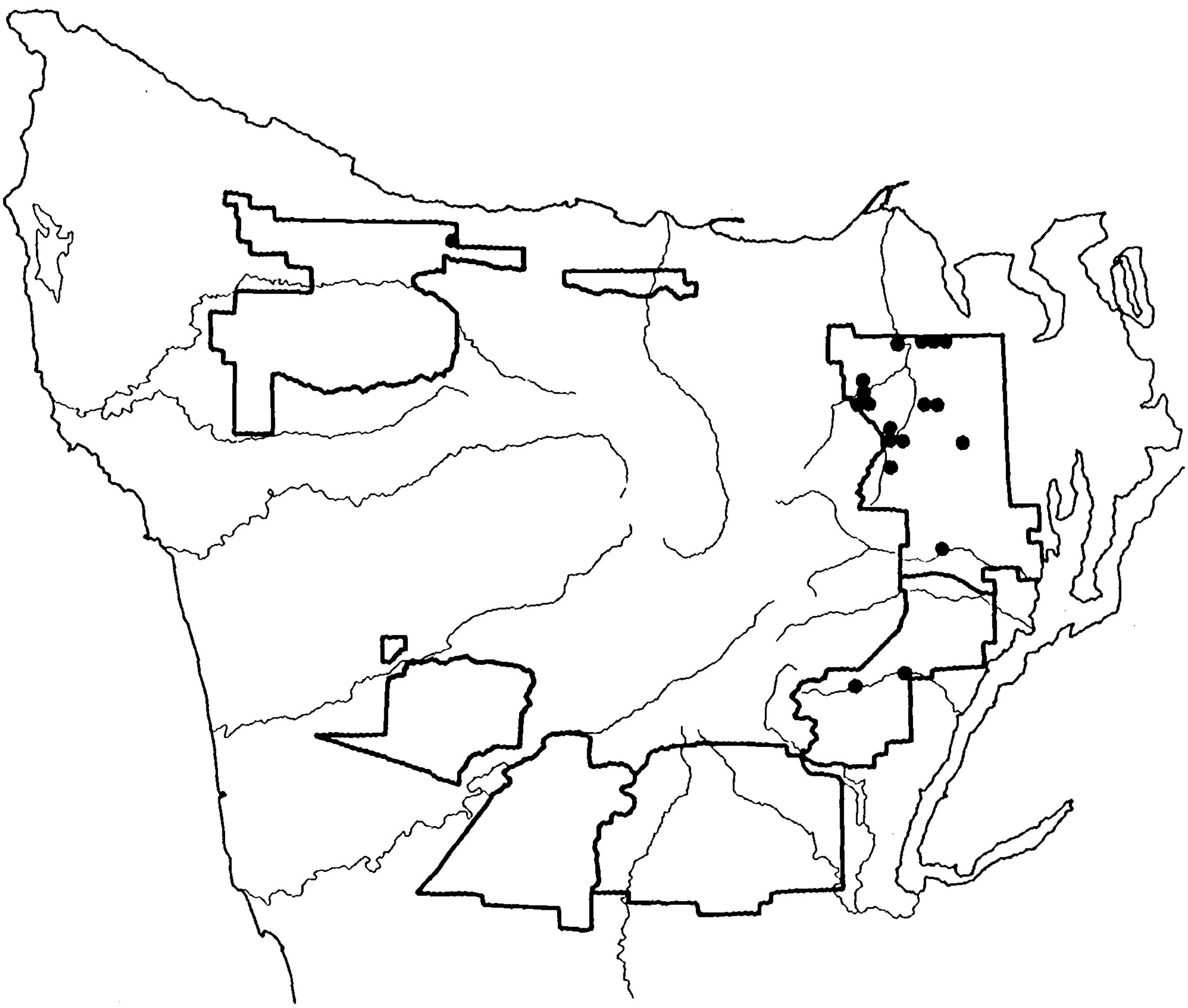


Figure 153. Map of plot locations for the Western Hemlock/Salal-Oceanspray Association.

Timber Productivity

Timber productivity of this type is moderately low (Site IV). Site index of measured stands averaged 104 (base 100) and 83 (base 50). The productivity potential using the site index-yield table approach was 94 cu ft/ac/yr (Table 131). The empirical yield estimate was 69 cu ft/ac/yr. The stockability of these sites is low.

Management Considerations

Management considerations include ensuring rapid initial stocking and enhancement of soil nutrients, organic matter, and preservation of the shallow soil litter layer. When this type occurs on steep slope positions there is an increased problem from surface erosion and unraveling. Accumulated soil organic matter and nitrogen should be preserved, and the litter layer should be kept intact to help keep the unstable soil in place. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. The steepness of slope and instability of the soil in many stands of this type should be considered when planning commercial thinning in these situations. Because of the warm exposed site conditions where this type occurs and the dense salal dominated ground vegetation, it offers low to moderate wildlife values in mature and old-growth stands. Young-growth offers moderate to good browse for deer.

Root disease problems can include Armillaria root disease and laminated root rot in Douglas-fir, and possibly annosus root disease in western hemlock. Armillaria root disease centers that develop on these sites may continue to be a problem in plantations past 30 to 40 years. Laminated root rot and Armillaria root disease appear to represent the most serious problems on this type. Black stain root disease may occur in plantations of Douglas-fir. Heart and butt rots such as red ring rot, brown cubical butt rot and brown trunk rot are particularly important in Douglas-fir on these sites. Red ring rot can also be expected on western hemlock.

Insect problems can include Douglas-fir beetle in windthrown, stressed or diseased Douglas-fir. Western blackheaded budworm may be present on buds of Douglas-fir and western hemlock. Carpenter ants often live in butts of Douglas-fir decayed by brown cubical butt rot.

Table 131. Timber productivity values for the Western Hemlock/Salal-Oceanspray Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA [6]	SIGBA [7]	EMAI [8]
Douglas-fir (McArdle [1])	2	10	104	7	94	272	10	232	72	69
Douglas-fir (McArdle [2])	13	13	101	18	87					
Douglas-fir (King [3])	1	5	83		95					

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[7] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[8] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/Salal-Oregongrape which occurs on slightly moister sites and the Western Hemlock/Salal/Beargrass type, which occurs on slightly drier and shallower soils. It is also related to the Western Hemlock/ Rhododendron-Salal type which occurs in drier areas, but on flatter sites and colder soils. The Western Hemlock/Salal-Oceanspray Association is not previously recognized. It is similar to Western Hemlock/Oceanspray Association recognized on the old Shelton District (Henderson and Peter 1981a). It is also similar to the Western Hemlock-Douglas-fir/Oceanspray Association recognized on the Mt. Hood National Forest (Halverson *et al.* 1986). It may be widespread in the Puget Trough of western Washington but it is not yet formally described there.

Figure 154. Photo of the Western Hemlock/Salal-Oceanspray Association, Gold Creek, Quilcene District.

WESTERN HEMLOCK/SALAL-OREGONGRAPE
Tsuga heterophylla/Gaultheria shallon-Berberis nervosa
TSHE/GASH-BENE CHS2 35

The Western Hemlock/Salal-Oregongrape Association is a type of moderately dry areas, warm soils, and moderate timber productivity. It is found commonly in the South Fork Skokomish, but also in the Wynoochee and along the eastern front of the Olympics (Figure 155). Soils are shallow to deep, derived from very stony colluvium, till or outwash.

Floristic Composition

The dominant understory species (Table 132) is salal. Other shrubs include Oregongrape, red huckleberry (VAPA) and vine maple (ACCI). Herbs are sparse but may include twinflower (LIBO2), vanillaleaf (ACTR), swordfern (POMU) and trillium (TROV). The tree layer is dominated by Douglas-fir and western hemlock with smaller amounts of western redcedar (Figure 156).

Ground mosses are generally moderate to abundant on this type, varying from 2% to 95% cover in our sample plots. Moss cover averaged 29% for stands under 140 years, and 36% for stands over 140 years. The most common species in young stands is *Eurhynchium oreganum*; *Plagiothecium undulatum* and species of *Polytrichum*, *Dicranum*, *Cladonia* and *Peltigera* may also occur. The most common and abundant moss in old-growth stands is *Hylocomium splendens*. Epiphytes are sparse to moderate in abundance. The common species include *Hypogymnia enteromorpha*, *Platismatia glauca*, *Sphaerophorus globosus* and *Alectoria sarmentosa* in small amounts. The nitrogen-fixer *Lobaria oregana* may occur in stands older than 150 years.

Successional Relationships

There are two probable successional pathways for this type. One dominated by Douglas-fir, the other by western hemlock, although the latter is much less common. Later seral stages are often dominated by both Douglas-fir and western hemlock. Western hemlock and western redcedar dominate the climax stand.

Other Biota

Deer sign was frequently observed on this type. Red huckleberry, swordfern, vine maple, oceanspray, serviceberry, Oregongrape, trailing blackberry, western redcedar and bracken fern showed evidence of browse. Douglas squirrel was frequently observed. Other wildlife observations include elk, recent mountain beaver activity in late spring and early summer, black bear, chipmunk, garter snake and red-legged frog.

Birds frequently recorded were red-breasted nuthatch, winter wren, golden-crowned kinglet, Swainson's thrush, dark-eyed junco and rufous hummingbird. Other birds observed include red-shafted flicker, pileated woodpecker, western flycatcher, Steller's jay, common crow, gray jay, black-capped chickadee, varied thrush and hermit thrush.

Table132.Common plants in the TSHE/GASH-BENE Association, based on stands >150 years (n=16).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	45.6	45.6	100	2-99
Douglas-fir	PSME	50.6	54.0	93	0-85
western redcedar	THPL	5.0	7.3	68	0-20
Pacific yew	TABR	0.9	3.5	25	0-7
silver fir	ABAM	0.3	2.0	12	0-2
GROUND VEGETATION					
salal	GASH	63.4	63.4	100	15-95
red huckleberry	VAPA	10.7	10.7	100	2-60
Oregongrape	BENE	9.9	9.9	100	1-30
vine maple	ACCI	6.3	8.3	75	0-40
twinflower	LIBO2	11.4	16.6	68	0-60
vanillaleaf	ACTR	1.8	2.8	62	0-15
swordfern	POMU	0.9	1.4	62	0-2
trillium	TROV	0.6	1.0	62	0-1
trailing blackberry	RUUR	0.7	1.2	56	0-3
rattlesnake-plantain	GOOB	0.6	1.0	56	0-1

Environment and Soils

This type occurs on flat to steep slopes of various configurations and positions. It occurs most often on either mid- to upper slopes or benches. Slopes ranged from 0% to 85% and averaged 36%. Bedrock is usually metabasalt. Regolith may be colluvium, or less often glacial material.

Four pits were dug in this association. Three occurred on glacial material and one on colluvium. The pits showed weak to moderate structure and soil development. Three were either gravelly or very gravelly, and all the pits in glacial materials had sandy loam texture. Two of the three pits in glacial regolith had compact, cemented C horizons (at 59 cm and 73 cm). The soil at the colluvial site was only 34 cm deep over sandstone bedrock and had a very gravelly clay loam texture. The mean coarse fragment fraction of all pits was 48%. In three cases rooting depth was restricted either by hardpan or bedrock and averaged 64 cm. Roots also occupied 2.9 cm of the O2. The O1 averaged 2.0 cm (about average) and the O2 averaged 3.1 cm which is thin. These soils are about average to a slightly below average in their water holding capacity. The colluvial soil was a haplorthod and the glacial soils included a dystrandept, haplorthod and a durochrept.

The mean summer soil temperature was 12.2 deg C (54.0 deg F), which is a little warmer than average for the Western Hemlock Zone. The soil temperature regime is borderline between mesic and frigid, but probably mostly warm frigid. The moisture regime is in the dry end of udic.

Three soil samples were analyzed for nutrients which showed low calcium, magnesium, nitrogen, and organic matter, but high phosphorus compared to other types. The pH was 5.3 which is average for the series.

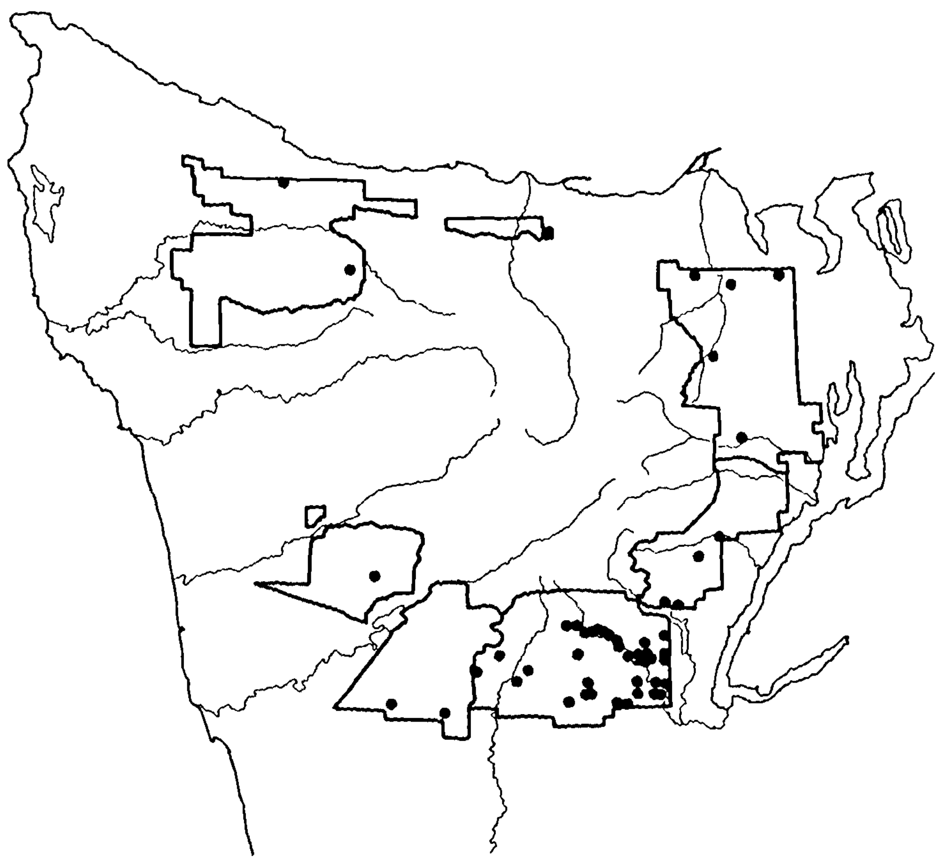


Figure 155. Map of plot locations for the Western Hemlock/Salal-Oregongrape Association.

Timber Productivity

Timber productivity of this type is moderate (Site III). Site index for Douglas-fir averaged 126 (base 100) and 87 (base 50) (Table 133). The productivity potential using the site index-yield table approach was 124 cu ft/ac/yr. The empirical yield estimate was 142 cu ft/ac/yr. The stockability of these sites is moderate.

Management Considerations

Management considerations include ensuring rapid initial stocking and enhancement of soil nutrients, organic matter, and controlling brush competition. When this association occurs on steep slope positions, there is an increased problem from surface erosion and unraveling. Accumulated soil organic matter and nitrogen should be preserved, and the litter layer should be kept intact to help keep the unstable soil in place; however burning may be needed for site preparation or for controlling competition from salal and vine maple. Fertilizing with nitrogen should enhance the productivity of this type, however enhancing organic matter and soil structure should increase the effectiveness of nitrogen fertilizer. This type offers low to moderate wildlife values in mature and old-growth stands. Young-growth stands often offer good browse for deer. Game trails and scat are common in this type, indicating that it gets regular use, probably as thermal and hiding cover. This type represents average growing conditions and limitations for the Forest.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock, and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also. Hemlock dwarf mistletoe may be present on older western hemlock.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 133. Timber productivity values for the Western Hemlock/Salal-Oregongrape Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	20	106	126	24	124	431	71	369	147	142
Douglas-fir (McArdle [2])	14	14	139	17	141					
Douglas-fir (King [3])	10	56	87	20	107					
Western Hemlock (Barnes [4])	2	2	121	8	182					
Western Hemlock (Wiley [5])	3	6	72	24	164	263				

[1] Base age 100. Total age (McArdle and Meyer 1930). Intensive plots only. ages 25 to 400 years.

[2] Base age 100. Total age (McArdle and Meyer 1930). Reconnaissance plots only. ages 25 to 400 years.

[3] Base age 50. Breast height age (King 1966). ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962). Reconnaissance plots only. ages 25 to 400 years.

[5] Base age 50. Breast height age (Wiley 1978a.b). ages 25 to 120 years.

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr. based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include Western Hemlock/Alaska Huckleberry-Salal which occurs on slightly moister sites, Western Hemlock/Salal/Beargrass, which occurs on drier soils, and Western Hemlock/Salal on slightly drier sites. It is also related to the Western Hemlock/Rhododendron-Salal type which occurs in drier areas, mostly on the Hood Canal and Quilcene Districts. The Western Hemlock/Salal-Oregongrape Association is not previously recognized. As defined here it is common in the Cascades and Olympics of Washington. It was previously included in the more broadly defined Western Hemlock/Salal type (Henderson and Peter 1981a,b,c,d, 1982a,b, 1983a,b, 1984, 1985). It is similar to the Western Hemlock/Oregongrape-Salal Association recognized on the Gifford Pinchot National Forest (Topik *et al.* 1986), Mt. Hood National Forest (Halverson *et al.* 1986), Willamette National Forest (Hemstrom *et al.* 1987) and Siuslaw National Forest (Hemstrom and Logan 1986). Their Western Hemlock/Oregongrape-Salal type however, includes a significant amount of swordfern and is therefore more similar to our Western Hemlock/Salal/Swordfern Association. In the Olympics it is called the Western Hemlock/Salal Associaton Oregongrape Phase by Smith and Henderson (1986). It is apparently a major component of what was called the Western Hemlock/Douglas-fir type by Fonda and Bliss (1969). Early work by Spilsbury and Smith (1947) recognized a "Salal" type which mostly includes our Western Hemlock/Salal and Western Hemlock/Salal-Oregongrape Associations.

Figure 156. Photo of the Western Hemlock/Salal-Oregongrape Association, Dungeness River, Quilcene District.

WESTERN HEMLOCK/SALAL/OXALIS

Tsuga heterophylla/Gaultheria shallon/Oxalis oregana
TSHE/GASH/OXOR CHS1 36

The Western Hemlock/Salal/Oxalis Association is a type of moist sites at low elevations and moderately high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault District (Figure 157). Soils are mostly deep, moderately fine textured and derived from colluvium. Little snow accumulates in this type during the winter. The typical area of this type has burned very seldom in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

Dominant understory species (Table 134) are salal and oxalis, which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Red huckleberry (VAPA), swordfern (POMU), Alaska huckleberry (VAAL), deerfern (BLSP) and trillium (TROV) are usually present. Oregongrape (BENE), salmonberry (RUSP) and vine maple may also occur. Early seral species include salal, oxalis, salmonberry, trailing blackberry (RUUR), and occasionally swordfern, Oregongrape and red huckleberry. The tree layer may be dominated by western hemlock, Douglas-fir, western redcedar, or any combination of these trees, although Douglas-fir is not common (Figure 158). There are no data available for mosses and lichens on this type.

Successional Relationships

There are successional pathways are dominated by Douglas-fir and western hemlock, with the hemlock sere being more common. Climax stages are dominated by western hemlock, or by both western redcedar and western hemlock.

Other Biota

Wildlife observations for this type are limited to one plot, where moderate activity of mountain beaver was recorded.

Table134.Common plants in the TSHE/GASH/OXOR Association, based on stands >150 years (n=4).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	90.0	90.0	100	75-99
western redcedar	THPL	4.5	9.0	50	0-12
silver fir	ABAM	1.8	3.5	50	0-6
GROUND VEGETATION					
salal	GASH	17.5	17.5	100	5-30
oxalis	OXOR	16.2	16.2	100	3-50
red huckleberry	VAPA	6.5	6.5	100	2-10
swordfern	POMU	3.5	3.5	100	1-7
Alaska huckleberry	VAAL	3.3	3.3	100	1-7
deerfern	BLSP	2.3	2.3	100	1-5
trillium	TROV	1.0	1.0	100	1-1
Oregongrape	BENE	5.3	10.5	50	0-20
salmonberry	RUSP	2.0	4.0	50	0-7
vine maple	ACCI	1.5	3.0	50	0-5
fool's huckleberry	MEFE	1.0	2.0	50	0-3
false lily-of-the-valley	MADI2	0.8	1.5	50	0-2

Environment and Soils

This type occurs on flat to steep, straight slopes in a variety of slope positions. Slope varied from 0% to 70% and averaged 43%. The soils form mostly in colluvial deposits, but occasionally in glacial deposits as well. Bedrock was mostly metabasalt with a few occurrences of sandstone.

Two soil pits showed moderately well developed soils. Texture varied from clay loam to sandy loam. Coarse fragments increased with depth but averaged 29% which is fairly low. This results in a soil with a higher than average water holding capacity. The O1 was thicker than average at 3 cm and the O2 was narrower than average at 1.5 cm. Rooting depth was only to 46 cm but roots also occupied the O2. One pit was classified as a dystrochrept and the other a haplorthod.

Our plots occurred on soils units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as deep or moderately deep colluvial (and some glacial) soils. Drainage is good to moderately good, with rapid permeability in the surface horizons and moderate to slow in the subsoil horizons. Subsoil compaction is usually not a problem. Textures range from silt loam to clay loam. Coarse fragments range from 5% to 65% near the surface and 5% to 80% in the subsoil.

The mean summer soil temperature was 14.3 deg C (57.7 deg F) which is quite warm for the Western Hemlock Zone, although our sample includes a high proportion of seral stands. The elevation and environmental zone data suggest a regime borderline between mesic and frigid. The moisture regime is udic.

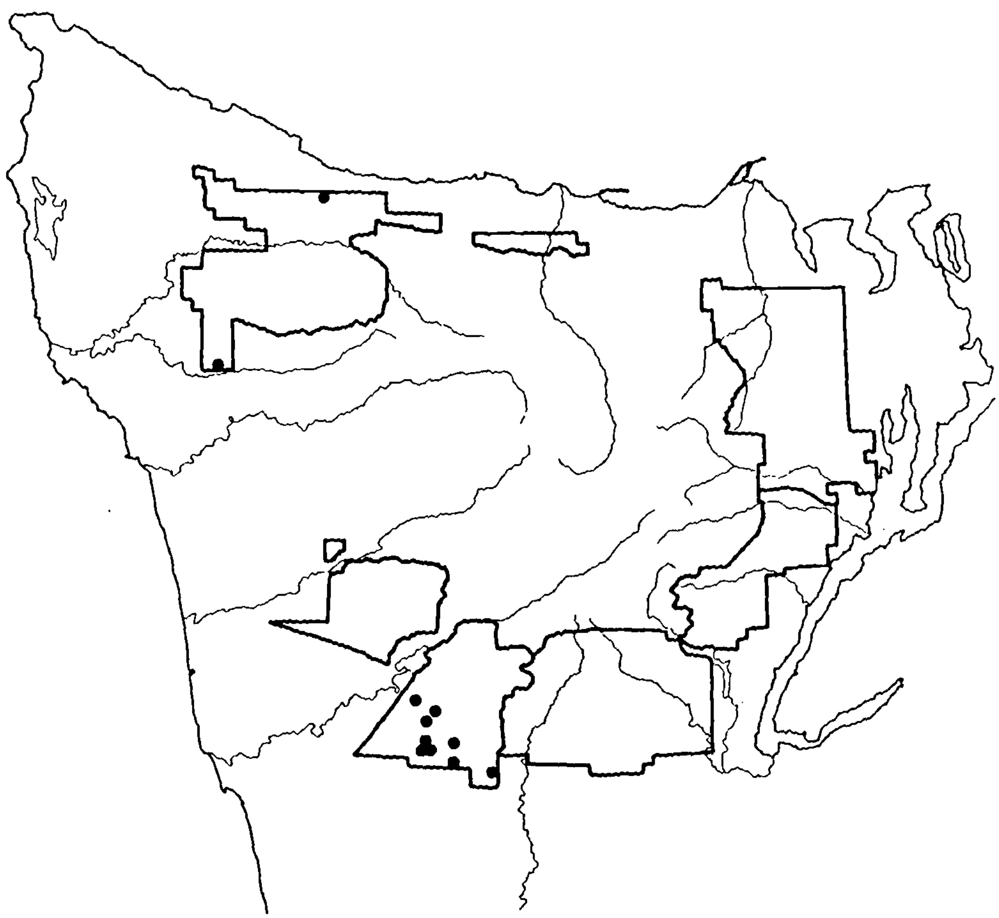


Figure 157. Map of plot locations for the Western Hemlock/Salal/Oxalis Association.

Timber Productivity

Timber productivity of this type is moderately high (Site II or III). This is due to the moistness of the site, favorable soils and relatively long growing season. Site index for Douglas-fir on one Intensive plot was 145 (base 100). Western hemlock averaged 120 (base 100) based on six Reconnaissance plots (Table 135). The productivity potential using the site index-yield table approach was 151 cu ft/ac/yr for Douglas-fir and 180 to 204 cu ft/ac/yr for western hemlock. The stockability of these sites is high. Western hemlock is the preferred species.

Management Considerations

Management considerations include controlling species composition and regulation of stocking. Accumulated soil organic matter and nutrients should be preserved. Response to fertilizer in this type is still unknown. Many oxalis types show very low amounts of calcium and phosphorus. This may be limiting growth or affecting tree development on these sites. We recommend that any fertilizer applications on this type include calcium and phosphorus. Wildlife values can be moderately high, especially for elk winter range.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Armillaria may also be important in younggrowth Douglas-fir plantations, but by age 30 impacts should be minimal. Annosus root disease appears to represent the most serious potential problem on this type to thinned western hemlock, reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe is usually abundant in old-growth stands of this type.

Potential insect pests which may occur on this type include the hemlock looper which may be present on western hemlock, and the western blackheaded budworm which occur on buds of western hemlock or Douglas-fir.

Table 135. Timber productivity values for the Western Hemlock/Salal/Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI[5]	SDI[6]	GBA TREES	GBA	SIGBA	EMAI[7]
Douglas-fir (McArdle[1])	1	5	145		151	353				189
Douglas-fir (King[2])	1	5	106		148					
Western Hemlock (Barnes[3])	6	6	120	25	180					
Western Hemlock (Wiley[4])	1	4	102		204	353				

1 Base age 100, Total age (McArdle and Meyer 1930). Intensive plots only, ages 25 to 400 years.
2 Base age 50, Breast height age (King 1966). ages 25 to 120 years.
3 Base age 100, Total age (Barnes 1962), Reconnaissance plots only. ages 25 to 400 years.
4 Base age 50. Breast height age (Wiley 1978a,b). ages 25 to 120 years.
5 Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).
6 Stand Density Index (Reinecke 1933).
7 Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include other Oxalis types. The Western Hemlock/Swordfern-Oxalis and Western Hemlock/Oxalis types occur on wetter sites often at lower elevations. The Silver Fir/Oxalis types occur at higher elevations. The Western Hemlock/Salal/Oxalis Association is not previously recognized. It was earlier included in the Western Hemlock/Oxalis type (Henderson and Peter 1981b, 1982a). A closely related type, Western Hemlock/Oregongrape/Oxalis is recognized on the Willamette National Forest (Hemstrom *et al.* 1987).

Figure 158. Photo of the Western Hemlock/Salal/Oxalis Association, West Fork Humptulips River, Quinault District.

WESTERN HEMLOCK/SALAL/SWORDFERN

Tsuga heterophylla/Gaultheria shallon/Polystichum munitum
TSHE/GASH/POMU CHS1 37

The Western Hemlock/Salal/Swordfern Association is a major type of warm, moist sites and moderately high timber productivity. It is common in the drier climatic areas of the Olympics, particularly on the Hood Canal and Quilcene Districts (Figure 159). Soils are mostly deep and derived from colluvium or glacial till. They are often subirrigated. Soils appear to be moderate in terms of soil nutrients.

Floristic Composition

Dominant understory species (Table 136) are swordfern (POMU) and salal (GASH), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Salal becomes established more quickly after clearcut or fire, and swordfern may be sparse in young stands. Shrubs may include Oregongrape (BENE), red huckleberry (VAPA) and vine maple (ACCI). Twinflower (LIBO2) and vanillaleaf (ACTR) may also occur. The tree layer may be dominated by Douglas-fir, western hemlock and western redcedar (Figure 160), with red alder and bigleaf maple in younger stands.

Ground mosses are moderately abundant. Young-growth stands averaged 38% moss cover and old-growth stands averaged 42%. The common species in both young stands and old-growth are *Eurhynchium oreganum* and *Hylocomium splendens*. Other species which can occur in young stands are *Plagiothecium undulatum*, *Dicranum* sp., *Polytrichum* spp. and *Hypnum circinale*, while *Rhytidiadelphus loreus* is more common in old-growth. Data for epiphytic mosses and lichens are limited for this type. *Isothecium stoloniferum* was the most common epiphytic moss. Common lichens include *Platismatia glauca*, *Sphaerophorus globosus* and *Hypogymnia* spp.

Successional Relationships

Red alder often dominates early seral stages in this association. It dies out by about 60 years, often leaving an understocked stand of western hemlock, western redcedar or Douglas-fir. Besides this red alder dominated sere, there are successional pathways dominated by Douglas-fir and western hemlock. Climax stages are dominated by western redcedar and western hemlock.

Other Biota

Deer sign was frequently observed on this type with recent activity noted in late summer. Commonly browsed species were red huckleberry, Alaska huckleberry, swordfern and western redcedar. Other wildlife observations were recorded for elk, coyote, bear, mountain beaver and Douglas squirrel.

Bird observations included an active grouse nest, red-breasted nuthatch, winter wren, Swainson's thrush, hermit thrush, chestnut-backed chickadee, golden-crowned kinglet, brown creeper, western flycatcher, common raven, Steller's jay, red-breasted sapsucker and dark-eyed junco.

Table136.Common plants in theTSHE/GASH/POMU Association, based on stands >150 years (n=34).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	47.8	47.8	100	1-99
Douglas-fir	PSME	41.5	44.1	94	0-95
western redcedar	THPL	11.6	17.1	67	0-60
Pacific yew	TABR	1.5	3.5	44	0-10
Pacific dogwood	CONU	1.1	3.7	29	0-10
bigleaf maple	ACMA	1.4	5.2	26	0-10
silver fir	ABAM	0.2	1.4	14	0-2
cascara	RHPU	0.2	2.0	11	0-3
red alder	ALRU	0.2	3.5	5	0-5
GROUND VEGETATION					
salal	GASH	45.3	45.3	100	5-95
swordfern	POMU	19.4	19.4	100	3-60
red huckleberry	VAPA	8.8	9.7	91	0-40
vine maple	ACCI	22.9	26.8	85	0-75
Oregongrape	BENE	11.8	13.4	88	0-50
vanillaleaf	ACTR	1.7	2.2	76	0-10
twinflower	LIBO2	3.5	5.1	67	0-35
trailing blackberry	RUUR	0.8	1.4	58	0-4
trillium	TROV	0.6	1.1	58	0-2

Environment and Soils

This type occurs on flat to very steep slopes of various configurations, mainly on mid- to lower slopes, toe-slopes, benches and bottoms. Many plots were straight in configuration (67%), with 20% on concave sites. Slopes varied from flat to 105% but averaged 44%. Bedrock was most commonly metabasalt. Regolith may be glacial or colluvium.

Soil pits showed weak to moderate soil development. Texture varied from clay loam to sandy loam. A duripan was found in one pit and probably exists elsewhere. Coarse fragments averaged 48%. Soil depth varied from 43 cm to greater than 100 cm. Rooting depth averaged 64 cm and roots extended up into the O2 as well. The O2 averaged 7.7 cm which is more than average and the O1 averaged 2.4 cm which is about average. The water holding capacity of this soil is about average. The ten soil pits were classified as follows: one each of xerochrept, durochrept, xerorthent and udorthent, and two each of dystrochrept, dystrandept and haplorthod. Earthworms have rarely been observed in the pits anywhere on the Olympic National Forest, but were observed in two pits in this type in the Raft River area.

Our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as deep glacial soils with subsoil compaction or cementation which could render them effectively shallow, or colluvial soils that are shallow, well drained and rapidly permeable. The glacial soils are mostly moderately well drained and rapidly permeable only in the surface horizons.

The average summer soil temperature was 12.3 deg C (54.1 deg F) which is warm for the Western Hemlock Zone. The temperature regime is borderline between mesic and frigid but probably is more often frigid. The moisture regime is on the dry end of udic or xeric.

Five soil samples analyzed for nutrients showed most nutrients to be about average compared to other types. The pH was 5.4 which is about average for the series.

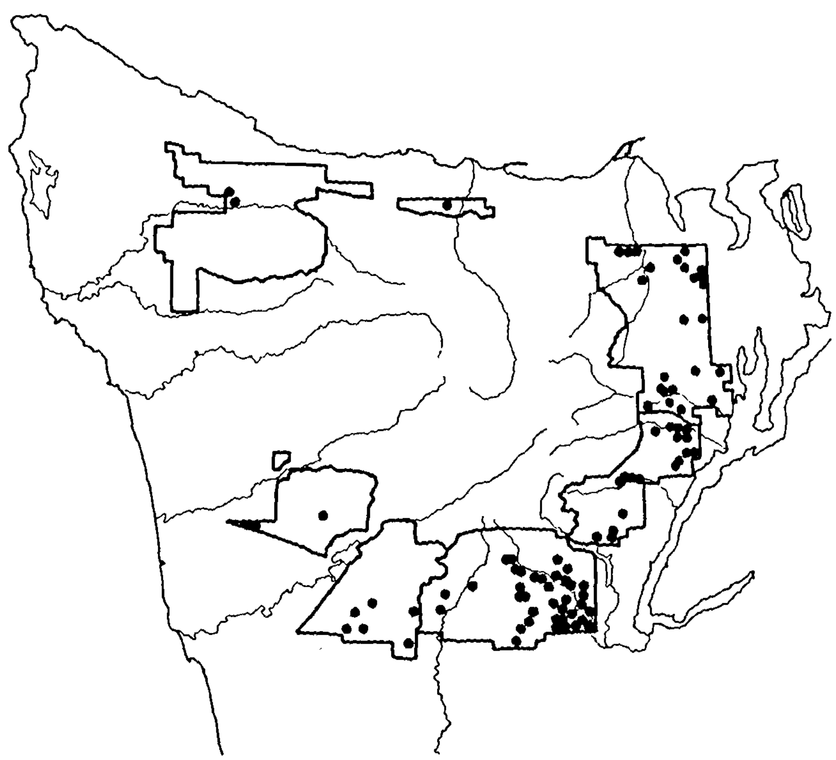


Figure 159. Map of plot locations for the Western Hemlock/Salal/Swordfern Association.

Timber Productivity

Timber productivity of this type is moderately high (Site III). Site index of Douglas-fir on Intensive plots averaged 149 (base 100) and 108 (base 50). Western hemlock averaged 139 (base 100) on four Reconnaissance plots. The productivity potential using the site index-yield table approach was 155 cu ft/ac/yr for Douglas-fir and 181 to 212 cu ft/ac/yr for western hemlock (Table 137). The empirical yield estimate was 142 cu ft/ac/yr. The stockability of these sites is high, but the stocking in wild stands can sometimes be relatively low. This usually occurs when either there is significant brush competition at the time of establishment or red alder becomes established concurrently with conifers and then dies out by about age 60. In these cases individual tree growth is high but stand growth can be low due to understocking.

Management Considerations

Management considerations include manipulation of species composition and regulation of stocking. It is also important to maintain soil nutrients and organic matter. Accumulation of soil organic matter and nitrogen could be preserved by reducing burning sites in this type and by maintaining a component of red alder in the ecosystem. Response to fertilizer in this type is still unknown. This is a type of moderate to high productivity potential and relatively few constraints. This type may provide moderate to high values for wildlife, particularly for deer.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also. Hemlock dwarf mistletoe may occur on older western hemlock.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 137. Timber productivity values for the Western Hemlock/Salal/Swordfern Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [6]	SDI [7]	GBA TREES	GBA [8]	SIGBA [9]	EMAI [10]
Douglas-fir (McArdle [1])	20	91	149	22	155	426	78	434	199	142
Douglas-fir (McArdle [2])	50	50	143	25	144					
Douglas-fir (King [3])	11	57	108	14	153					
Western Hemlock (Barnes [4])	4	4	139	16	212		20	403	168	
Western Hemlock (Wiley [5])	7	16	85	19	181	398				

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[7] Stand Density Index (Reinecke 1933).

[8] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[9] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[10] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include other Swordfern types. The Western Hemlock/Oregongrape/Swordfern type occurs on colder and somewhat wetter sites. The Western Hemlock/Swordfern-Foamflower type occurs on moister and more productive sites. The Western Hemlock/Salal/Swordfern Association is not previously recognized in Oregon or Washington, however it is very similar to the "Swordfern-Salal" site types of Spilsbury and Smith (1947). In Washington it was included in the more broadly defined Western Hemlock/Swordfern type (Smith and Henderson 1986, Henderson and Peter 1981a,b,c,d, 1982a,b, 1983a,b, 1984, 1985, Franklin *et al.* 1988, Topik *et al.* 1986). In the Olympics it was included in the very broadly defined Western Hemlock-Douglas-fir type of Fonda and Bliss (1969). However, it is very similar to the Western Hemlock/Oregongrape-Salal type as defined by Topik *et al.* (1986) on the Gifford Pinchot National Forest, Halverson *et al.* (1986) on the Mt. Hood National Forest, and Hemstrom *et al.* (1987) on the Willamette National Forest.

Figure 160. Photo of the Western Hemlock/Salal/Swordfern Association, Brown Creek, Hood Canal District.

WESTERN HEMLOCK/SKUNKCABBAGE
Tsuga heterophylla/Lysichitum americanum
TSHE/LYAM CHM1 11 (OLY)

The Western Hemlock/Skunkcabbage Association is a minor type of wet sites with organic soils at low to middle elevations, and moderate timber productivity. It is found sporadically in moist areas of the Forest (Figure 161). Soils are mostly deep with very high organic matter, and are derived from alluvium or colluvium, or occur in filled-in ponds in areas of outwash or glacial till. They are very wet from subirrigation and occur in flat areas, sometimes on river terraces or broad stream bottoms. Little snow accumulates in this type during the winter. The typical area of this type has burned very seldom in the last 1000 years, and most old-growth of this type is very old.

Floristic Composition

Dominant understory species (Table 138) are skunkcabbage and salmonberry (RUSP), which are usually present in all ages of stands, although they may both be browsed by elk. Salmonberry often resprouts rapidly after clearcut or fire. Other species may include foamflower (TITR), ladyfern (ATFI), deerfern (BLSP), enchanter's nightshade (CIAL), and Alaska huckleberry (VAAL). The tree layer may be dominated by red alder, western hemlock, western redcedar, or any combination of these trees (Figure 162), and occasionally Douglas-fir, which is uncommon. Stands in this type are often understocked.

Data for mosses and lichens are limited to one old-growth plot in this type. Ground moss cover is 10%; *Rhytidiadelphus loreus* is the dominant moss, other species include *Eurhynchium oreganum* and *Hylocomium splendens*. The common epiphytes are crustose lichens, species of *Bryoria*, *Hypogymnia*, *Parmelia* and liverworts.

Successional Relationships

Red alder often dominates or codominates early seral stages in this association. It dies out by about 80 years, often leaving an understocked stand of hemlock and redcedar, with some Douglas-fir, if it was present in early stages. Besides this red alder dominated sere, early successional stages can be dominated by western hemlock. Climax stages are dominated by western hemlock, or by both western redcedar and western hemlock.

Other Biota

Wildlife observations were only recorded on one plot for this type. Red huckleberry and Sitka spruce saplings were browsed. Birds observed include chestnut-backed chickadee, rufous hummingbird and Steller's jay.

Table 138. Common plants in the TSHE/LYAM Association, based on stands >150 years (n=1).

Common name	Code	Abs. Cover	Rel. Cover	Const
TREES				
western hemlock	TSHE	45	45	100
western redcedar	THPL	21	21	100
cascara	RHPU	4	4	100
GROUND VEGETATION				
salmonberry	RUSP	45	45	100
boykinia	BOMA	40	40	100
skunkcabbage	LYAM	15	15	100
Alaska huckleberry	VAAL	10	10	100
vine maple	ACCI	5	5	100
three-leaved foamflower	TITR	3	3	100
false lily-of-the-valley	MADI2	1	1	100
fool's huckleberry	MEFE	1	1	100
five-leaved bramble	RUPE	1	1	100
red huckleberry	VAPA	1	1	100
salal	GASH	1	1	100
swordfern	POMU	1	1	100

Environment and Soils

This type occurs on flat to gentle, straight or concave slopes in toe-slope or bottom positions. The slope varied from flat to 13% and averaged 6%. Bedrock varies as does regolith but in our sample all were on glacial or alluvial deposits.

No pits were dug but we expect that the soils are saturated and probably gleyed with highly variable textures and coarse fragment fractions. The O layer thickness is variable and often depends on the history of flooding. Rooting depth is probably shallow due to saturation of the profile.

Our plots occurred on areas which are deep glacial soils with moderate subsoil compaction, according to the Olympic Soil Resource Inventory (Snyder *et al.* 1969). Drainage is moderate to imperfect and permeability appears to be rapid at the surface but slow in subsoils. Textures range from silty clay loam to gravelly silt loam. Coarse fragments range from 15% to 65% near the surface and 35% to 80% in the subsoil.

The temperature regime based on elevation and environmental zone is frigid. The moisture regime varies from udic to aquic.

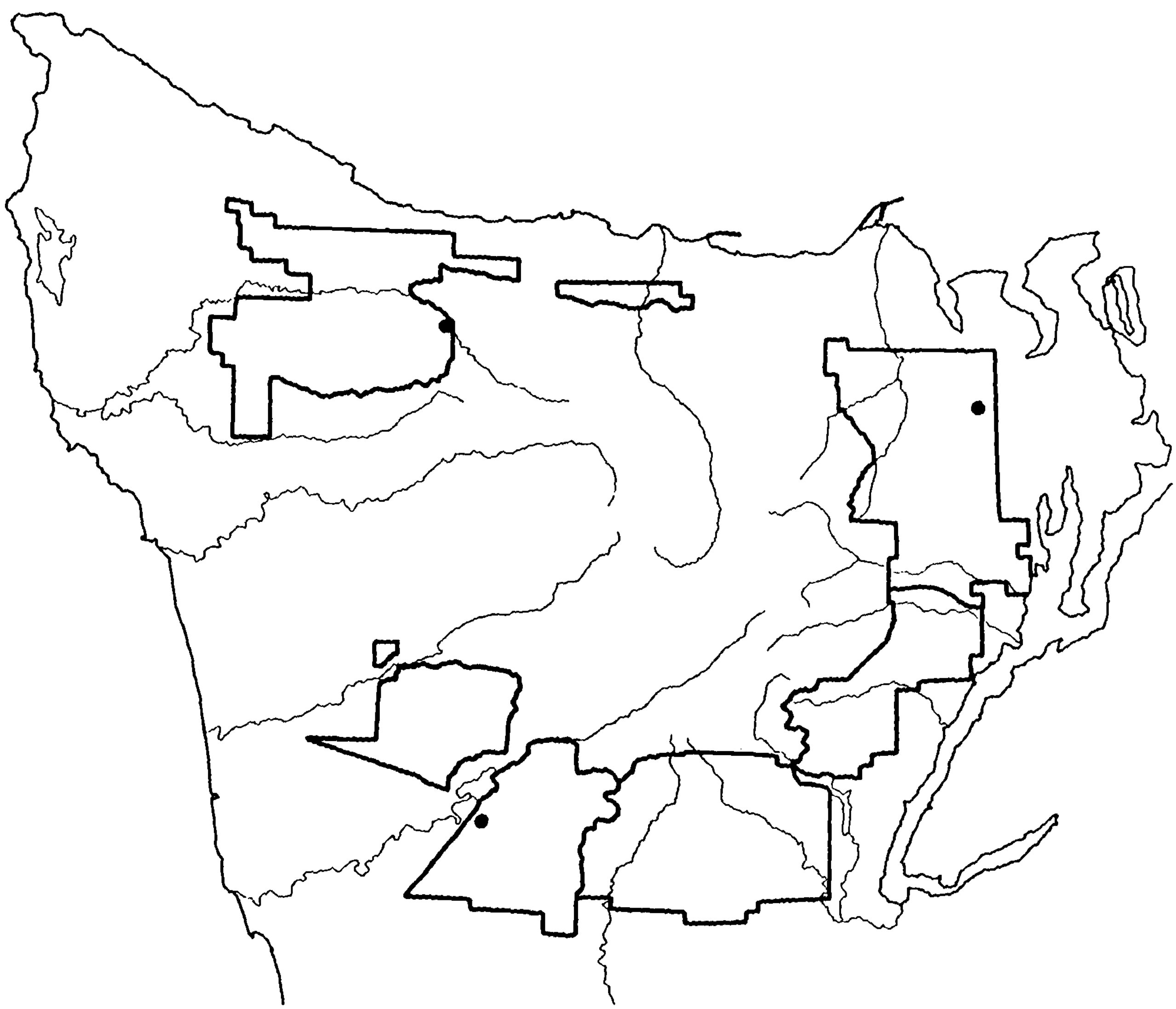


Figure 161. Map of plot locations for the Western Hemlock/Skunkcabbage Association.

Timber Productivity

Timber productivity of this type is unknown, but is probably moderate (Site III). Site index for red alder on one young-growth plot was 77 (base 50). The productivity potential for red alder is 79 cu ft/ac/yr (Table 139). The stockability of these sites appears to be low. Western hemlock or western redcedar are probably the preferred species on this type.

Management Considerations

Management considerations include protection of fragile organic soils and manipulation of species composition and regulation of stocking. Because of the wetness of these sites it may not be possible to burn in this type. Response to fertilizer in this type is still unknown. Wildlife values can be moderately high, especially for elk winter range.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Annosus root disease appears to represent the most serious potential problem on this type to thinned western hemlock, reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe is sometimes present in old-growth stands of this type.

Potential insect pests which may occur on this type include the hemlock looper which may be present on western hemlock, and the western blackheaded budworm which occur on buds of western hemlock or Douglas-fir.

Table 139. Timber productivity values for the Western Hemlock/Skunkcabbage Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [2]	SDI [3]	GBA TREES	GBA [4]	SIGBA	EMAI
Red Alder (Worthington [1])	1	5	77		79	380	5	201		

[1] Base age 50. Total age (Worthington et al. 1962).

[2] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[3] Stand Density Index (Reinecke 1933).

[4] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

Comparison with Similar Types

Similar types include Western Hemlock/Swordfern-Foamflower and Western Hemlock/Swordfern-Oxalis which occur on drier sites. The Western Hemlock/Devil's Club type occurs on similar sites with more running water and less organic soil. The Western Hemlock/Skunkcabbage Association is not widely recognized. It is described on the Mt. Hood National Forest (Halverson *et al.* 1986), on the Mt. Baker District of the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1985) and in British Columbia (Haeussler *et al.* 1982).

Figure 162. Photo of the Western Hemlock/Skunkcabbage Association, Gold Creek, Quilcene District.

WESTERN HEMLOCK/SWORDFERN-FOAMFLOWER

Tsuga heterophylla/Polystichum munitum-Tiarella trifoliata

TSHE/POMU-TITR CHF1 32

The Western Hemlock/Swordfern-Foamflower Association is a major type of warm, moist sites and high timber productivity. It is found throughout much of the lowlands of the Olympics, although apparently not in the wettest environmental zones (Figure 163). Soils are mostly deep and fine textured, or coarse textured if well-watered, and derived from colluvium or glacial till. They are often subirrigated, and occur on river terraces or along toe-slopes. Soils appear to be above average in the most important nutrients. The typical area of this type has burned once or twice in the last 700 years.

Floristic Composition

The dominant understory species (Table 140) is swordfern, which is usually present in all ages of stands, although it may be inconspicuous or absent in densely stocked second growth. Red alder and salmonberry (RUSP) may become established quickly after clearcut or fire, and can be a management problem. Shrubs are usually sparse but may include red huckleberry (VAPA) and vine maple (ACCI). Foamflower (TITR, TIUN), fragrant bedstraw (GATR), vanillaleaf (ACTR), twinflower (LIBO2), and deerfern (BLSP) are common herbs. Enchanter's nightshade (CIAL) and candyflower (MOSI) may also occur, especially in young stands. The tree layer may be dominated by red alder, Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 164). Stands in this type are often understocked, which allows a thick understory to develop.

Ground mosses are generally moderate to abundant in this type. Moss cover averaged 26% for young stands and 48% for old-growth stands. The most common and abundant species is *Eurhynchium oreganum*, other common species which are less abundant include *Rhytidiadelphus loreus*, *Plagiothecium undulatum* and *Hylocomium splendens*. Epiphytic mosses and lichens which are expected to occur are *Isothecium stoloniferum*, *Sphaerophorus globosus*, *Porella* sp. and *Neckera douglasii* on hardwoods, *Hypogymnia enteromorpha*, and the nitrogen-fixer *Lobaria oregana* in old-growth stands.

Successional Relationships

Red alder often dominates or codominates early seral stages in this association. It dies out by about 80 years, often leaving an understocked stand of hemlock and redcedar, with some Douglas-fir, if it was present in early stages. Besides this red alder dominated sere, there are successional pathways dominated by Douglas-fir and western hemlock. Climax stages are dominated by both western redcedar and western hemlock.

Table 140. Common plants in the TSHE/POMU-TITR Association, based on stands >150 years (n=17).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	53.4	53.4	100	11-99
Douglas-fir	PSME	38.8	43.9	88	0-85
western redcedar	THPL	15.5	22.0	70	0-93
silver fir	ABAM	1.2	3.5	35	0-8
bigleaf maple	ACMA	3.4	19.0	17	0-40
Pacific dogwood	CONU	0.1	1.0	11	0-1
grand fir	ABGR	0.2	2.0	11	0-3
cascara	RHPU	0.2	1.5	11	0-2
Pacific yew	TABR	0.1	1.0	11	0-1
GROUND VEGETATION					
swordfern	POMU	32.9	32.9	100	5-80
red huckleberry	VAPA	3.1	3.3	94	0-10
three-leaved foamflower	TITR	5.7	6.5	88	0-35
vanillaleaf	ACTR	3.6	4.8	76	0-35
fragrant bedstraw	GATR	1.6	2.2	76	0-15
deerfern	BLSP	2.6	3.7	70	0-15
salal	GASH	1.2	1.8	70	0-4
trillium	TROV	0.8	1.1	76	0-2
Oregongrape	BENE	1.1	1.8	58	0-3
starflower	TRLA2	0.7	1.1	64	0-2

Other Biota

Wildlife observations included elk and deer browse on this type. Commonly browsed species include red huckleberry, swordfern, salmonberry, western redcedar, baldhip rose and devil's club. Recent elk sign was recorded in late spring and early summer. On one plot in this type a baby elk was observed, which indicated this site was used as a calving area. Recent deer sign was recorded in early summer. Douglas squirrel, shrew and coyote were also observed.

Bird observations included western flycatcher, chickadee, winter wren, hairy woodpecker, pileated woodpecker, Swainson's thrush, song sparrow, white-crowned sparrow, Townsend's warbler and brown creeper.

Environment and Soils

This type occurs on flat to steep, straight or concave, mid- to lower slopes, toe-slopes, benches and bottoms. The slope varied from 0% to 90% and averaged 39%. It occurs on glacial, colluvial or alluvial regoliths underlain most often by metabasalt but also by sedimentary rocks.

Five pits dug in this type showed weak to moderate soil development. Textures tend to be nongravelly to gravelly silt loams to sandy loams. Coarse fragments averaged 33% which is about average. The O1 averaged 1.8 cm and the O2 averaged 1.6 cm. Even on the old-growth plots the O layers were thinner than average indicating a fairly high rate of decomposition. Rooting depth averaged 44.6 cm which is shallower than average but roots also oc-

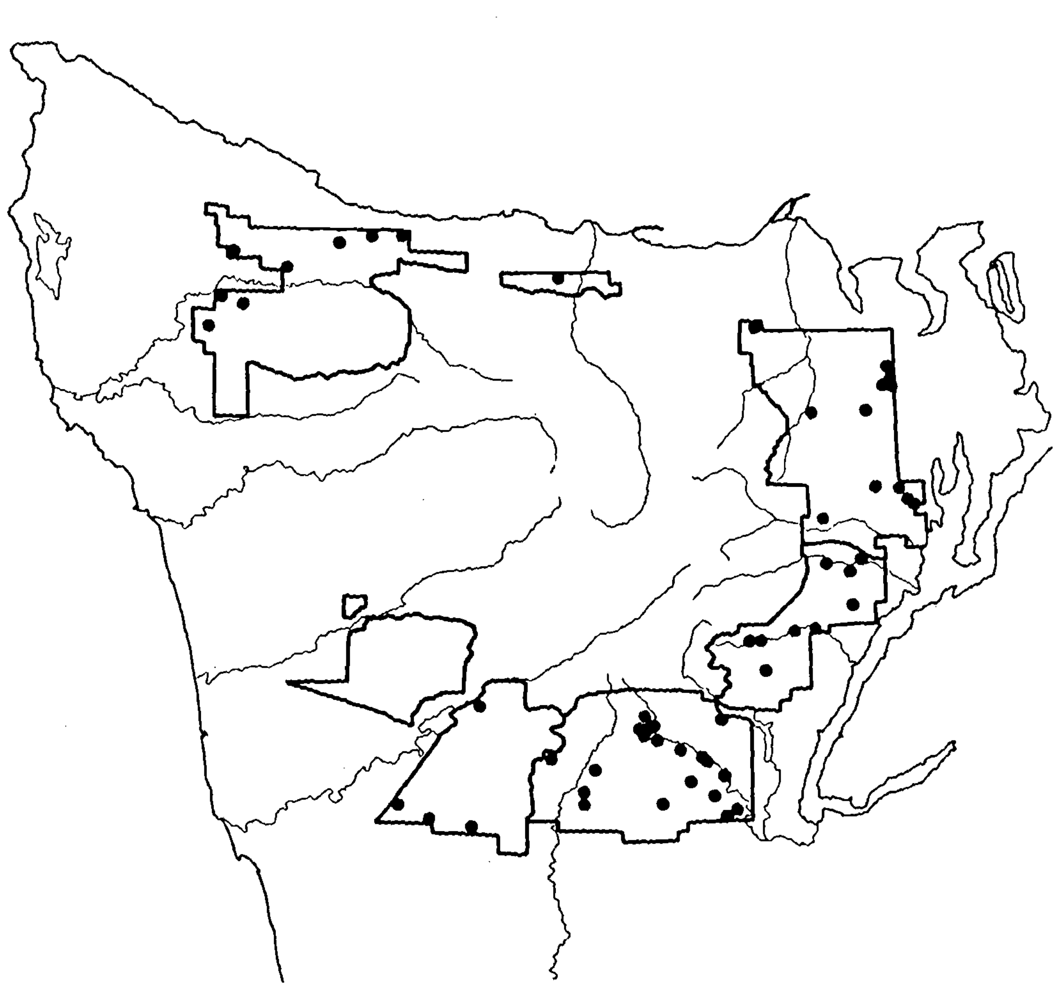


Figure 163. Map of plot locations for the Western Hemlock/Swordfern-Foamflower Association.

cupied the O2 layer. The water holding capacity of these soils is about average. The apparently shallow rooting depth may be a response to abundant and dependable climatic and topographic moisture. Of these five soils, two were classified as haplorthods, two as dysterochrepts, and one as a haplumbrept.

Our plots occurred on soils units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as glacial soils which tend to be deep gravelly and very gravelly silty clay loam to sandy loam with compacted subsoils. They tend to be moderately well drained, rapidly permeable in the surface horizons and have moderately permeable subsoil. The colluvial soils tend to be shallow, well-drained, rapidly permeable sandy loams to loams. Coarse fragments range from 5% to 70% near the surface and 5% to 100% in the subsoil.

The mean summer soil temperature was 11.2 deg C (52.2 deg F) which is average for the Western Hemlock Zone. The temperature regime is borderline between mesic and frigid, but probably is mesic. The moisture regime is udic.

Ten soil samples were analyzed for nutrients. The levels of macronutrients were above average, while the pH was 5.2 which is about average.

Timber Productivity

Timber productivity of this type is moderately high (Site II). This is due to the moistness of the site, favorable soils, and relatively long growing season. Site index of Douglas-fir averaged 166 (base 100) and 116 (base 50), while western hemlock was 139 (base 100). The productivity potential using the site index-yield table approach was 175 cu ft/ac/yr for Douglas-fir, 216 cu ft/ac/yr for western hemlock and 106 cu ft/ac/yr for red alder (Table 141). The stockability of these sites is high, but the stocking in wild stands can be relatively low. The empirical yield estimate was 164 cu ft/ac/yr for predominantly Douglas-fir stands and 126 cu ft/ac/yr for red alder stands. Old-growth stands exhibit a large range in basal area and volume. Douglas-fir is the preferred timber species.

Table 141. Timber productivity values for the Western Hemlock/Swordfern-Foamflower Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA [10]	EMAI [11]
Douglas-fir (McArdle [1])	17	74	166	21	175	437	47	462	228	164
Douglas-fir (McArdle [2])	28	28	166	29	175					
Douglas-fir (King [3])	12	53	116	12	171					
Western Hemlock (Barnes [4])	3	3	139	39	216			591	246	
Western Hemlock (Wiley [5])	6	18	106	18	213	534	12	591		
Red Alder (Worthington [6])	8	39	93	11	106	318	13	217		126

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

[5] Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

[6] Base age 50, Total age (Worthington et al. 1962).

[7] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[8] Stand Density Index (Reinecke 1933).

[9] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[10] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

[11] Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Management Considerations

Management considerations include optimizing timber production and wildlife values. Prompt establishment (usually of Douglas-fir) is important. Soil organic matter and nitrogen should be conserved by reducing burning sites in this type and by maintaining a component of red alder in the ecosystem. Response to fertilizer in this type is still unknown. If a Douglas-fir plantation is the management objective, brush competition from salmonberry, vine maple or red alder can be a problem.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Armillaria may also be important in young-growth Douglas-fir plantations, but by age 30 impacts should be minimal. Annosus root disease appears to represent the most serious potential problem on this type to thinned western hemlock, reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe may occur in old-growth stands of this type.

Potential insect pests which may occur on this type include the hemlock looper which may be present on western hemlock, and the western blackheaded budworm which occur on buds of western hemlock or Douglas-fir.

Comparison with Similar Types

Similar types include Western Hemlock/Oregongrape/Swordfern which occurs on colder and somewhat drier sites, and Western Hemlock/Salal/Swordfern which occurs on drier and less productive sites. The Western Hemlock/Swordfern-Foamflower Association is not previously recognized. It represents the wetter (and more productive) part of what was earlier defined as the Western Hemlock/Swordfern type on the Olympic National Forest (Henderson and Peter 1981a,b, 1982a, 1983a). This association also occurs on the Mt. Baker-Snoqualmie National Forest (Henderson and Peter 1981c,d 1982b, 1983b, 1984, 1985). It may be represented in the more broadly defined Western Hemlock/Swordfern type in Mt. Rainier National Park (Franklin *et al.* 1988) and to the south.

Figure 164. Photo of the Western Hemlock/Swordfern-Foamflower Association, Wynoochee Valley, Hood Canal District.

WESTERN HEMLOCK/SWORDFERN-OXALIS

Tsuga heterophylla/Polystichum munitum-Oxalis oregana
TSHE/POMU-OXOR CHF1 31 (OLY)

The Western Hemlock/Swordfern-Oxalis Association is a major type of moist sites at low elevations and high timber productivity. It is common in the wetter climatic areas of the Olympics, particularly on the Quinault District (Figure 165). Soils are mostly deep and moist. They are derived from colluvium, outwash or glacial till and occur along toe-slopes and in areas of high precipitation, high humidity or fog. Little of this type has burned in the last 500 years, and most old-growth of this type is very old. Some younger stands have originated from windstorms or small fires.

Floristic Composition

Dominant understory species (Table 142) are swordfern and oxalis. Shrubs may include red huckleberry (VAPA), salmonberry (RUSP) and Alaska huckleberry (VAAL). Herbs may include deerfern (BLSP) and foamflower (TITR). The tree layer may be dominated by red alder, western hemlock, western redcedar or Douglas-fir (Figure 166).

Ground mosses are moderate to abundant in this type. Moss cover averaged 48% in young stands and 33% in old-growth stands. The common species include *Eurhynchium oreganum*, *Hylocomium splendens*, *Plagiothecium undulatum* and *Rhytidiadelphus loreus*. *Hypnum circinale* and *Scapania bolanderi* may occur on down wood and lower boles. Data are limited for epiphytic mosses and lichens. Based on our sample plots, the common species is *Isothecium stoloniferum*. The nitrogen-fixer *Lobaria oregana* may occur in old-growth stands.

Successional Relationships

Red alder may dominate early seral stages in this association. Besides this red alder dominated sere, there are successional pathways dominated by Douglas-fir (rarely) and western hemlock, with the hemlock sere being more common. Climax stages are dominated by western hemlock, or by both western redcedar and western hemlock.

Other Biota

Elk sign was frequently observed on this type, with heavy browsing on red huckleberry and salmonberry. Other browse species were Alaska huckleberry, fool's huckleberry, deerfern, woodfern, ladyfern, fireweed, red elderberry, vine maple and western hemlock seedlings. Other wildlife signs include mountain beaver, bear damage on western hemlock, and Douglas squirrel.

Birds recorded were winter wren, cedar waxwing, gray jay, chestnut-backed chickadee, common crow, brown creeper, pileated woodpecker, dark-eyed junco, western flycatcher, nighthawk, and woodpecker activity on a western hemlock snag.

Table142.Common plants in theTSHE/POMU-OXOR Association, based on stands >150 years (n=25).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	80.8	80.8	100	42-99
western redcedar	THPL	7.0	13.5	52	0-42
Sitka spruce	PISI	1.0	2.4	44	0-9
silver fir	ABAM	1.8	5.6	32	0-10
Douglas-fir	PSME	6.9	28.7	24	0-90
cascara	RHPU	1.6	6.8	24	0-20
Pacific yew	TABR	0.2	2.0	7	0-3
GROUND VEGETATION					
oxalis	OXOR	36.4	36.4	100	3-75
swordfern	POMU	24.5	24.5	100	5-70
red huckleberry	VAPA	4.9	5.1	96	0-35
deerfern	BLSP	5.4	5.9	92	0-45
three-leaved foamflower	TITR	1.8	2.0	88	0-8
Alaska huckleberry	VAAL	4.8	5.7	84	0-30
salmonberry	RUSP	4.7	6.6	72	0-30
salal	GASH	1.6	2.2	72	0-10
trillium	TROV	0.6	1.0	64	0-1
ladyfern	ATFI	0.8	1.4	60	0-3
fool's huckleberry	MEFE	1.7	3.0	56	0-15

Environment and Soils

This type occurs on flat to steep, straight or concave slopes in various topographic positions but mainly on mid-slope and lower landforms, toe-slopes and bottoms.

Slopes ranged from 0% to 96% slope but averaged 38%. Soils in this type occurred in colluvium and glacial deposits; with alpine glacial till considerably more common than continental till. Bedrock was usually metabasalt, but sedimentary rocks, especially shale and sandstone were also common.

Soil descriptions from five pits showed weak soil development. Textures varied from silt loam to clay, coarse fragments averaged 29% which is low. These factors result in a soil with high water holding capacity. Both O layers were thinner than average which probably reflects a high rate of decomposition but also reflects the high proportion of early seral stages in the sample. Rooting depth was 66.5 cm which is about average but roots also occupied the O2. The five profiles were classified as dystrandept, haplumbrept, dystrochrept, haplorthod and udifluvent.

Plots from this type occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as glacial soils which tend to be deep, gravelly and very gravelly clay loams to sandy loams, commonly with subsoil compaction. Surface permeability is rapid and subsoil permeability moderate or low. These soils tend to be moderately well drained. The colluvial soils in this type are usually described as shallow, well-drained, rapidly permeable soils with loam to clay loam texture. Coarse fragments range from 5% to 65% near the surface and 10% to 100% in the subsoil.

The mean summer soil temperature in this type was 12.2 deg C (54.0 deg F) which is near average or slightly warmer for the Western Hemlock Zone. The temperature regime is at the warm end of frigid. The mositure regime is udic.

Two soil samples analyzed for nutrients showed higher than average calcium, magnesium, organic matter, total nitrogen, zinc, copper and manganese, and lower than average sulfate, phosphorus and potassium compared to other types. The pH was 5.5 which is a little higher than average for the series.

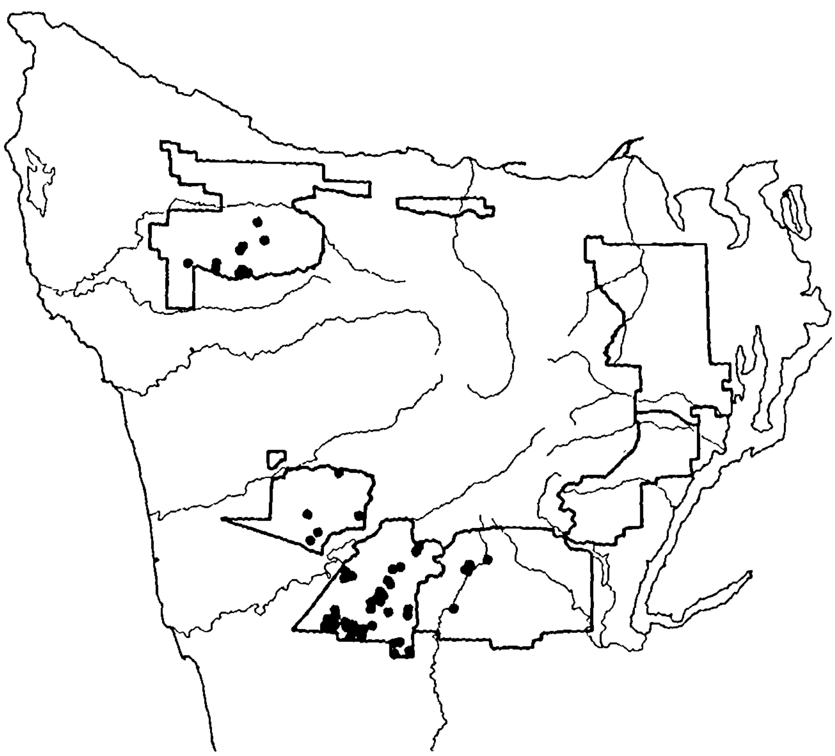


Figure 165. Map of plot locations for the Western Hemlock/Swordfern-Oxalis Association.

Timber Productivity

Timber productivity of this type is high (Site II). This is due to the moistness of the site, favorable soils and relatively long growing season. Site index for Douglas-fir averaged 181 (base 100) and 117 (base 50), western hemlock averaged 134 (base 100). The productivity potential using the site index-yield table approach was 190 cu ft/ac/yr for Douglas-fir and 207 cu ft/ac/yr for western hemlock (Table 143). The empirical yield estimates were 164 cu ft/ac/yr for Douglas-fir and 185 cu ft/ac/yr for western hemlock. The stockability of these sites is high.

Management Considerations

Management considerations include maximizing timber management opportunites and wildlife habitat management. In some stands there may be excess litter and burning might be desirable to reduce the amount of litter. Low amounts of potassium and phosphorus may be limiting growth or affecting tree development on these sites. Wildlife values can be moderately high, especially for elk winter range.

Root disease problems can include annosus root disease in western hemlock older than 120 years, and Armillaria root disease in suppressed understory trees. Armillaria may also be important in young-growth Douglas-fir plantations, but by age 30 impacts should be minimal. Annosus root disease appears to represent the most serious potential problem on this type to thinned western hemlock, reducing stand entries will help limit the spread of this disease (see discussion on annosus root disease, p. 68). Heart and butt rots of concern are red ring rot and annosus root disease in older western hemlock. Hemlock dwarf mistletoe can be abundant in old-growth stands of this type.

Potential insect pests which may occur on this type include the hemlock looper which may be present on western hemlock, and the western blackheaded budworm which occur on buds of western hemlock or Douglas-fir.

Table 143. Timber productivity values for the Western Hemlock/Swordfern-Oxalis Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [7]	SDI [8]	GBA TREES	GBA [9]	SIGBA [10]	EMAI [11]
Douglas-fir (McArdle [1])	5	16	1B1	26	190	593	16	57B	322	164
Douglas-fir (McArdle [2])	4	4	,172	42	182					
Douglas-fir (King [3])	2	5	117	20	172					
Western Hemlock (Barnes [4])	20	20	134	19	207			400	161	
Western Hemlock (Wiley [5])	4	19	122	7	238	469		400		185
Sitka Spruce (Meyer [6])	2	2	225	15	332	654				

1 Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

2 Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

3 Base age 50, Breast height age (King 1966), ages 25 to 120 years.

4 Base age 100, Total age (Barnes 1962), Reconnaissance plots only, ages 25 to 400 years.

5 Base age 50, Breast height age (Wiley 1978a,b), ages 25 to 120 years.

6 Base age 100, Total age (Meyer 1937).

7 Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

8 Stand Density Index (Reinecke 1933).

9 Growth Basal Area (Hall 1987) (see Table 174 p. 494).

10 Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

11 Estimated Mean Annual Increment derived empirically from plot data from stands 20 to 300 years old (see Figure 190 p. 497).

Comparison with Similar Types

Similar types include the Western Hemlock/Salal/Swordfern and Western Hemlock/Oregongrape/Swordfern types which occur on drier sites in drier environmental zones. The Western Hemlock/Swordfern-Foamflower type occurs on similar sites in slightly drier areas. It is also closely related to the Western Hemlock/Salal/Oxalis and Western Hemlock/Oxalis types which occur on slightly drier and wetter sites, respectively, but still in the wetter environmental zones. The Western Hemlock/Swordfern-Oxalis Association is previously recognized in the Olympics as the Western Hemlock/Swordfern Association Oxalis Phase (Smith and Henderson 1986), on the Gifford Pinchot National Forest (Topik *et al.* 1986) and in the H.J. Andrews Experimental Forest (Dyrness *et al.* 1976). On the Olympic National Forest it was earlier included in the broader Western Hemlock/Oxalis Association (Henderson and Peter 1981a,b, 1982a).

Figure 166. Photo of the Western Hemlock/Swordfern-Oxalis Association, West Fork Humptulips River, Quinault District.

WESTERN HEMLOCK/VANILLALEAF

Tsuga heterophylla/Achlys triphylla

TSHE/ACTR CHF2 11 (OLY)

The Western Hemlock/Vanillaleaf Association is a minor type in certain areas on the Forest (Figure 167). It occurs mainly on warm, moist sites, at higher elevations in the Western Hemlock Zone. Soils are often deep and are derived from colluvium or glacial till. They are often subirrigated by topographic moisture. The typical area of this type has burned once or twice in the last 500 years.

Floristic Composition

The dominant understory species (Table 144) are vanillaleaf (ACTR), star-flowered solomon's seal (SMST) and Oregongrape (BENE), which are usually present in all ages of stands, although they may be inconspicuous or absent in densely stocked second growth. Shrub cover is usually low, but often includes red huckleberry (VAPA). Twinflower (LIBO2), swordfern (POMU), foamflower (TITR) and evergreen violet (VISE) may also occur. The tree layer may be dominated by Douglas-fir, western hemlock, western redcedar, or any combination of these trees (Figure 168).

Ground mosses were sparse to abundant in four old-growth plots. The moss cover ranged from 5% to 65% with an average of 26% cover. The common and abundant species were *Rhytidiopsis robusta*, *Hylocomium splendens* and *Dicranum* sp. Other species included *Plagiothecium undulatum*, *Rhytidiadelphus loreus*, and *Hypnum circinale* on down wood and lower tree boles. Data for epiphytic mosses and lichens are limited to one plot where *Alectoria sarmentosa* and *Platismatia glauca* were the common lichens. Other species included *Hypogymnia enteromorpha*, *Sphaerophorus globosus*, *Parmeliopsis hyperopta* and *Lobaria oregana*.

Successional Relationships

Seral stages are usually dominated by Douglas-fir. Climax stages are dominated by both western redcedar and western hemlock.

Other Biota

Deer sign was frequently observed, with browsing noted on Pacific yew, western redcedar, Oregongrape, red huckleberry and beargrass. Mountain beaver activity and porcupine damaged trees were recorded on one plot. Douglas squirrel and small mammal activity were also observed.

Bird observations were recorded for red-breasted nuthatch, gray jay, Steller's jay, common raven, chestnut-backed chickadee, black-headed grosbeak, mountain chickadee, hairy woodpecker and red-tailed hawk.

Table 144. Common plants in the TSHE/ACTR Association, based on stands >150 years (n=10).

Common name	Code	Abs. Cover	Rel. Cover	Const	Range
TREES					
western hemlock	TSHE	53.6	53.6	100	25-85
Douglas-fir	PSME	45.5	45.5	100	5-75
western redcedar	THPL	10.5	17.5	60	0-35
silver fir	ABAM	0.7	1.4	50	0-3
Pacific yew	TABR	0.2	1.0	20	0-1
GROUND VEGETATION					
vanillaleaf	ACTR	14.7	14.7	100	3-60
evergreen violet	VISE	1.2	1.2	100	1-2
red huckleberry	VAPA	3.1	3.4	90	0-15
swordfern	POMU	1.7	1.9	90	0-4
queen's cup	CLUN	1.8	2.3	80	0-4
prince's pine	CHUM	1.2	1.5	80	0-4
Oregongrape	BENE	6.1	8.7	70	0-20
twinflower	LIBO2	3.7	5.3	70	0-25
three-leaved foamflower	TITR	2.9	4.1	70	0-15
star-flowered solomon's seal	SMST	6.9	11.5	60	0-50
bunchberry	COCA	1.8	3.0	60	0-7
baldhip rose	ROGY	0.7	1.2	60	0-2
little prince's pine	CHME	0.6	1.0	60	0-1
trillium	TROV	0.6	1.0	60	0-1
Alaska huckleberry	VAAL	0.8	1.6	50	0-3
sidebells pyrola	PYSE	0.7	1.4	50	0-2

Environment and Soils

This type occurs on gentle to steep, straight, concave or convex, mid- to lower slopes and benches. Slope varied from 3% to 90% and averaged 47%. Bedrock is usually metabasalt and regolith is usually colluvium, although it may also be glacial or alluvial.

No soil pits were dug in this type, however our plots occurred on soil units described by the Olympic Soil Resource Inventory (Snyder *et al.* 1969) as well-drained, gravelly soils with loamy textures. These soils developed from either deep glacial or shallow colluvial regoliths. Coarse fragments range from 5% to 50% near the surface to 5% to 75% in the subsoils.

The mean summer soil temperature was 11.6 deg C (50.4 deg F) which is average for the Western Hemlock Zone. The temperature regime is probably frigid and the moisture regime is probably udic.

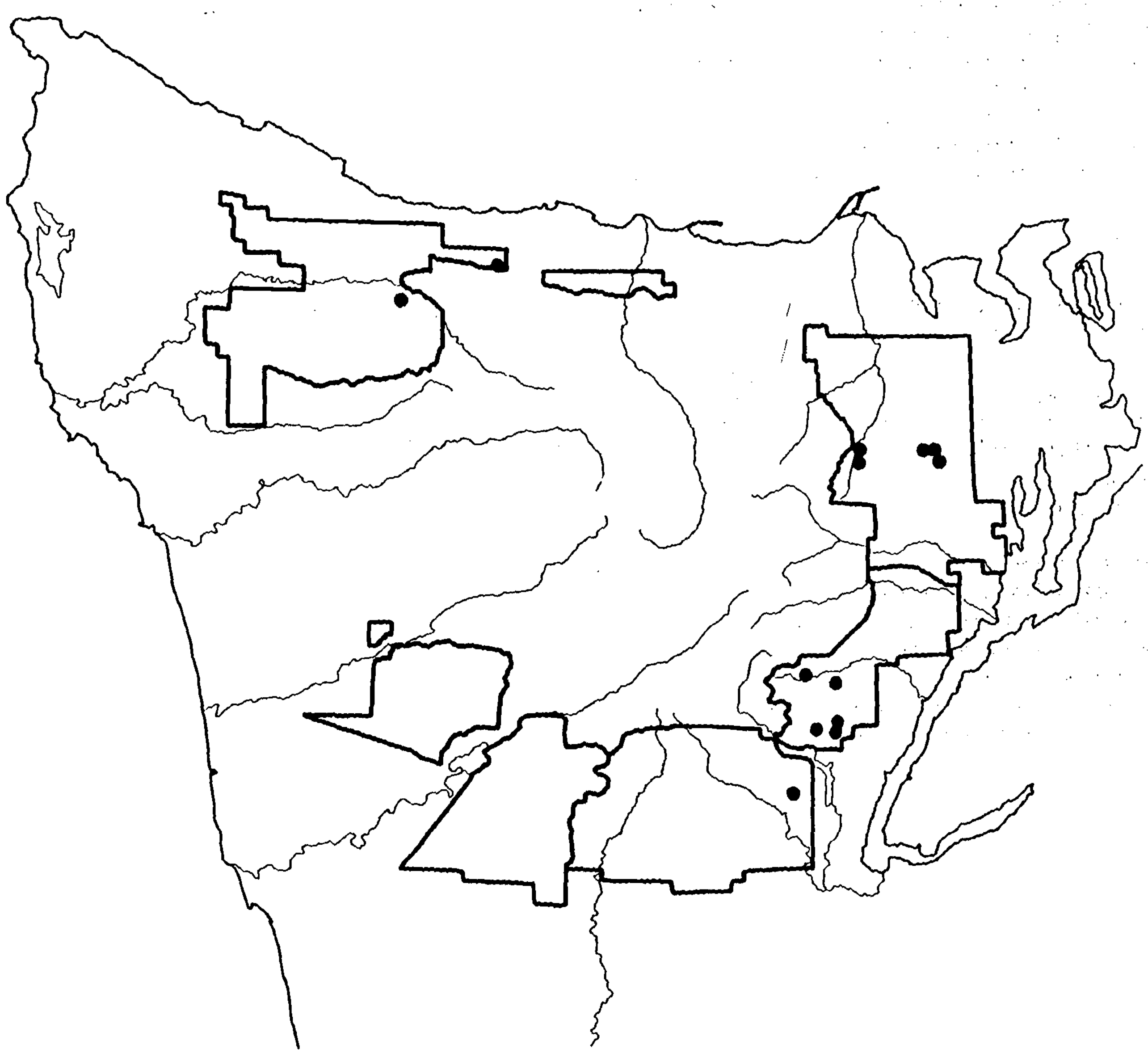


Figure 167. Map of plot locations for the Western Hemlock/Vanillaleaf Association.

Timber Productivity

Timber productivity of this type is moderate (Site III). Site index of Douglas-fir averaged 149 (base 100) and 107 (base 50). The productivity potential using the site index-yield table approach was 156 cu ft/ac/yr (Table 145). The stockability of these sites is moderate.

Management Considerations

Management considerations include ensuring rapid restocking and maintaining full site occupancy. Response to fertilizer in this type is still unknown. Red alder is apparently not a management option on this type. Douglas-fir is the preferred species. There are few brush problems on this type. This type may provide moderate wildlife values, particularly for deer.

Root disease problems may include laminated root rot on Douglas-fir, Armillaria root disease on Douglas-fir and western hemlock, and annosus root disease on western hemlock. When present, laminated root rot is the most serious disease of Douglas-fir on this type. Armillaria root disease can be a major problem on Douglas-fir plantations up to about 30 years, when impact should lessen. Heart and butt rots of concern are brown cubical butt rot, red ring rot and brown trunk rot on Douglas-fir, especially old-growth. Annosus root disease can heavily damage western hemlock after 120 years of age, and red ring rot may be present on western hemlock also.

Insect problems may include hemlock looper on western hemlock, western blackheaded budworm on western hemlock and Douglas-fir, and Douglas-fir beetle on diseased, windthrown, or stressed Douglas-fir.

Table 145. Timber productivity values for the Western Hemlock/Vanillaleaf Association.

TREE SPECIES	PLOTS	SITE TREES	SITE INDEX	s.d.	CMAI [4]	SDI [5]	GBA TREES	GBA [6]	SIGBA [7]	EMAI
Douglas-fir (McArdle [1])	3	15	149	5	156	563	10	492	233	
Douglas-fir (McArdle [2])	10	10	146	22	148					
Douglas-fir (King [3])	1	5	107		151					

[1] Base age 100, Total age (McArdle and Meyer 1930), Intensive plots only, ages 25 to 400 years.

[2] Base age 100, Total age (McArdle and Meyer 1930), Reconnaissance plots only, ages 25 to 400 years.

[3] Base age 50, Breast height age (King 1966), ages 25 to 120 years.

[4] Culmination of Mean Annual Increment derived from the site index curve for the species (see Figure 189 p. 496).

[5] Stand Density Index (Reinecke 1933).

[6] Growth Basal Area (Hall 1987) (see Table 174 p. 494).

[7] Index of potential volume growth in cu ft/ac/yr, based on the equation SI*GBA*0.003 (Hall 1987).

Comparison with Similar Types

Similar types include Western Hemlock/Oregongrape/Swordfern which occurs on warmer and somewhat lower elevation sites, Western Hemlock/Swordfern-Foamflower which occurs on moister and more productive sites, and Western Hemlock/Oregongrape which occurs on similar sites that may be topographically drier. The Western Hemlock/Vanillaleaf Association is widespread in Oregon and Washington but is apparently not very common. It was previously recognized on the Olympic National Forest (Henderson and Peter 1982a). A similar type was also recognized on the Quilcene District (Henderson and Peter 1983a) and in the Olympic National Park (Smith and Henderson 1986). It was recognized in Mt. Rainier National Park (Franklin *et al.* 1988), but was not recognized by this project on the Mt. Baker-Snoqualmie National Forest. It is recognized in various forms on the Gifford Pinchot (Topik *et al.* 1986), Mt. Hood (Halverson *et al.* 1986) and Willamette National Forests (Hemstrom *et al.* 1987).

Figure 168. Photo of the Western Hemlock/Vanillaleaf Association, Dungeness River, Quilcene District.

SECTION 3

- References
- Appendices
  1. Field Procedures and Plot Cards
  2. Soil Data
  3. Species Lists and Codes
  4. Curves and Equations

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APPENDICES

APPENDIX 1

- Field Procedures
- Methods for Estimating Cover
- Field Codes

FIELD PROCEDURES

1. Stand selection and plot location

The stand to be sampled will usually be selected by the Ecologist or his assistants. The objective for reconnaissance sampling is to put a plot near the center of each section of land. The objective for intensive sampling is to complete sampling of each section and in addition to obtain an even distribution of plots across types and age classes. For Recon plots, select a section to be sampled, travel by road or trail to the closest accessible point to the section center. Leave the road or trail walking toward the center of the section. Establish the plot along the line of travel, beyond the influence of the road or trail.

Plot location will be randomized within the stand. Once the stand or general location is selected, generate a random plot center which represents the series, association and age to be sampled. Throw out any points which would put the plot too close to edge effects or across type/age class boundaries. The plot should represent *one* type and age condition. The second hand of a watch can give a random number from 1-60. Two watches, or two observations of the same watch at an interval of several minutes generates 2 random numbers. Use one of these to represent a random direction by multiplying the number (from 1-60) by 6. A time of 8:31:16 would give a random direction of (16 x 6) 96 . If the second watch gave a time of 8:32:45, the "45" could represent 45 feet, meters, paces or whatever was decided *before* the "random second hand" number was determined. The "random" plot center is therefore 45 feet at 96 degrees from wherever the random numbers were generated. The random distance should be small enough to keep the plot within the type and age class to be sampled.

2. Plot size and layout

For Recon plots choose a plot size of 1/10 acre, mark the plot center and the cardinal radii with flagging. Correct all distance measurements for steepness of slope. Complete the Recon card. For Intensive plots, choose a plot size which will give about 30-70 trees on the tree tally card. Often this will be 1/5 acre in young old-growth, 1/10 acre in young-growth and 4/10 acre in very old old-growth. As a rule, 30 trees is sufficient in a very evenly spaced (thinned) stand, but 35 may not be enough trees if the stand is irregular or patchy.

For Intensive plots mark the plot center with a cedar stake driven at least halfway into the ground. Optionally, a nail may be driven into the top of the stake to attach measuring tapes. Refer to Table 148 (p. 421) to determine the radius of the plot (e.g. 1/5 ac=52.66'). Measure the plot boundaries along cardinal directions, usually starting with north. All such measurements are corrected for slope. Mark these points with 2-3 foot long flagging which is clearly visible from plot center. Hang another "flag" above the center stake which can be seen from the periphery of the plot. Additional radii will be measured to complete the outer perimeter of the plot as needed--usually about 4 or 5 more for 1/5 acre plot. Mark these points with a small flag. This aspect of the plot is critical. Missed or extra trees in the plot significantly affects the plot statistics. Any questionable or marginal tree must be measured. Hang flags on or near any marginal trees so it is clear to someone else whether the tree is in or out.

Number all trees starting at due north with yellow paint. The numbers should be clearly visible, 4-8" tall, and should face plot center. The top of the number should be at breast height. On steep slopes this may not be possible. Site trees are also marked with an aluminum tag placed at the top of the yellow number. In visually sensitive areas, painted numbers may be aimed away from trails etc. or may have to be omitted.

Seedlings are tallied on a subplot whose center is 20 feet north of the plot center; saplings are tallied on the NE quarter of the plot or occasionally the entire plot for very sparse regeneration or for very young stands. The point 20 feet north of plot center is marked by a yellow wire flag. Refer to Table 148 for subplot sizes and radii for seed/sap subplots.

3. Referencing the plot

The plot center stake (Intensive plots only) is referenced to a nearby tree (or rock or stump) for relocation. The reference tree is usually the closest tree above or level with the center stake. Paint a yellow arrow with the point of the arrow near the ground (below stump height), facing plot center. Nail a yellow plastic tag marked with the plot number, date, "ECOLOGY" and initials of crew, over the point of the arrow. Nail an oval aluminum tag with plot number above the yellow plastic tag, or on a second RP tree, at the point of the arrow and referenced the same as above. Record azimuth and distance *from* the point of the arrow to the point where the cedar stake enters the ground. This is the only distance measurement on the plot which is not corrected for slope.

The plot location is referenced to an "E" painted on a tree, stump or rock, clearly visible from a road or trail. In high use or visually sensitive areas, paint a small, relatively inconspicuous "E", or in very sensitive areas paint a yellow dot at the base of a tree and paint an "E" away from the road or trail. Record the azimuth and the measured horizontal distance from the "E" to the plot center on the back of the Seedling/Sapling card. Record a verbal description of the location of the E and any special instructions or directions for locating the E or the plot.

The plot location is marked with a permanent red dot and plot number on the appropriate plot map. Use a safety pin to mark the location of the plot on an aerial photo. Draw a circle around the pin prick and label with the plot number on both sides of the photo. Record the aerial photo number and map name on the front of the recon card.

4. Field Instructions

A. RECON CARD (Figure 169) - The left column of the front of the card is set up to be entered directly into the computer. The right column includes important narrative information. Use the following guide for completing the front of the Recon card (Table 146).

The back of the Recon card is for recording tree, shrub and herb coverages. Enter the plot number again before "T", "S" and "H". Identify and record all trees, shrubs and herbs on the plot. Trees that are rooted outside of the plot boundary but have any part of the crown overhanging the plot are recorded. Record coverage of each tree species by size class and record a cover estimate for the species. Tally trees by species using a BAF (English) 40 prism using plot center plus 3 of the cardinal points of the plot. Record cover estimates for each shrub and herb species on the plot. Use the scale of nearest 5% cover for coverage >10% and to the nearest 1% for coverages <10%. A recorded value of "1" means >0 but not more than 1%. A value of "2" means >1% up to 2.5%. A value of "3" means 2.6-3.5%, etc. Phenological stage of the typical plant of each species is recorded in the "Ph" column using the following codes:

V	=	vegetative or (blank)
b	=	bud but no flowers or fruits
f	=	early flower
F	=	full flower
fr	=	early ("green") fruit
Fr	=	full ("ripe") fruit
S	=	seed shed

Mark the column "V" if the species is collected for later identification or verification. Such specimens should go into a plant press labeled with plot number, preliminary identification, date and collector's initials. In the column after "V" record the species name if it is an uncommon species or note browsing or other items of interest.

B. FIXED AREA TREE TALLY CARD (Figure 170) - All trees, standing dead trees and snags which are greater than 4.95 inches DBH are numbered and recorded on this card. Tree number 1 is the first tree beginning at due north and moving clockwise around the plot. Record tree history (Table 147), live tree, site tree, dead tree, *etc.* in second column. Next record species using the 4-letter TRI codes. Douglas-fir=PSME *etc.* (Table 164). In the fourth column (DBH) record the Diameter at Breast Height (DBH=4.5 ft above the ground), to the nearest tenth of an inch, but omit the decimal point, *e.g.* a tree which is 25.7 inches DBH is recorded as 257. In the fifth column (RI) record the width of the last complete 10 years of growth in 20th of an inch. For example, if the measurement is taken during the middle of the growing season, ignore the current year's growth and count inward 10 more years. Mark the beginning and ending point on the core (with a Sharpie pen) and measure the length of this core segment. If it is exactly 1/2 inch (1/2 in = 10 20ths) record the

FIELD CODES--RECON CARD

Table 146. Field codes-Recon card.

PLOT Number: unique number for plot

COMPARTMENT NO., First digit is District:

1 = Hood Canal	2 = Quilcene
3 = Quinault	5 = Soleduck

LANDFORM

15 = glacial cirque	70 = alluvium
17 = glacial side slope	71 = alluvial fan
19 = glacial valley	73 = alluvial terrace
41 = glacial moraine	75 = alluvial valley
35 = cliffs	77 = mudflow
60 = colluvial (talus,etc)	63 = colluvial fan
61 = talus	64 = colluvial-fluvial fan
62 = scree	81 = mountain slope

TOPOGRAPHIC MOISTURE	MACROPOSITION
1 = extremely dry	1 = ridgetop
3 = dry, well drained	2 = upperslope
5 = mesic	3 = mid-slope
7 = moist, well watered	4 = lower slope
9 = standing water	5 = bottom
	6 = plain

MICROPOSITION

1 = ridgetop	6 = toe of slope
2 = upper 1/3	7 = river bottom
3 = mid 1/3	8 = edge of or in basin or wetland
4 = lower 1/3	9 = draw, intermittent stream bottom (V and H)
5 = bench, flat	

MICROCONFIGURATION

1 = convex	3 = concave
2 = straight	4 = undulating

SUCCESSIONAL STAGE

1 = CC, not burned
2 = Grass-forb (1-10 yrs after burning)
3 = shrub-seedling (1-10 years)
4 = sapling (5-150)
5 = young forest (16-50)
6 = mature forest (50-200)
7 = young old-growth (200-400)
8 = old old-growth (400-1000)
9 = climax, both composition and structure
0 = other

REGOLITH

11 = erosional colluvium	31 = tephra
12 = neutral colluvium	32 = pyroclastic
13 = depositional coll.	40 = residual
21 = alpine glacial	50 = organic
22 = continental glacial	60 = talus
23 = glacial-fluvial	70 = alluvium
30 = volcanic	80 = lacustrine

BEDROCK

1020 = granite	5640 = shale
2240 = andesite	5650 = sandstone
2260 = basalt	5670 = conglomerate
2300 = pyroclastic	3420 = slate
2220 = rhyolite	3440 = schist
2370 = pumice	3460 = gneiss
6770 = limestone	4540 = serpentine
8000 = mixed	4550 = greenstone
9999 = unknown	

radial increment as "10". Measure the length of core which is sapwood and record this measurement (in 20th inch) in the next column (SAPW). If radial increment cannot be reliably made in the field, mark an x in the corner of the RI box, mark and store the core for later measurement under the microscope. RI is recorded for all "GBA" trees, i.e at least 5 dominant and codominants of the dominant species, and at least 3 dominant and codominants for each other species present on the plot. A sample of ages are taken of the dominant trees and for the subordinant size classes. Mark column "RINGS" with an "x" if a core is taken but not recorded in the field. If the core is counted in the field, record the number of annual rings actually counted in the core in the "Rings" column. Record this number and record the length of the core (if the core did not include the pith) elsewhere on the card. If the core did not include the pith, estimate the number of rings from the inside of the core to the pith and add this to the ring count, already recorded in column 7. This number is the age at breast height and is recorded in the next column "BH AGE". In the 9th column "TOTAL AGE", record the estimated total age of the tree by adding the estimated time for *that* tree to breast height to the breast height age. Total height is measured on all dominant and most codominant trees and for a sample of size classes and species represented on the plot. All trees used for GBA calculations, all potential site index trees and all trees with a significant proportion of the volume of the plot should be measured. Tree heights for all unmeasured trees are estimated from the sample of measured heights using computer programs. Therefore the range in heights and diameters by species must be covered. A typical plot will have height measurements on about 1/4 of the trees and have heights estimated for all dead trees and snags. For trees which have a top out, measure the height of the tree and estimate the amount of top which is out; record both values in the height column. Record Crown Ratio (CR) which is the percent of the length of the tree which is in live crown. See Table 147 for codes. In column 12 (CC) record the crown class 2=dominant, 3=codominant, 4=intermediate etc. In the last column (DAMAGE) record the presence of damage using the codes in Table 147, 29=mistletoe, 76=broken top etc. If 20 (disease) is recorded, then record the kind of disease on Tree Damage card.

C. OTHER ORGANISM CARD (Figure 171) - The "other organism" card has 5 sections: Ground mosses and lichens, Epiphytic lichens and mosses, Mammals etc., Birds, and Insects etc.

1. Ground mosses: Record crown cover for all recognized mosses, lichens, and other cryptogams growing on the ground, on litter, logs, or the base of trees. Record "Total Moss" cover. Collect voucher specimens of common cryptogams which are unknown, and voucher specimens of nitrogen-fixing lichens--*Lobaria* and *Peltigera* spp. Label cryptogam packets for these voucher specimens.

2. Epiphytic lichens: Record the relative abundance of all recognized epiphytic lichens, mosses and other cryptogams using the abundance codes given at the top of the card. These sould be interpreted as abundance codes where 1=very rare, 2=uncommon, 3=common, 4=abundant, and 5=very abundant. "Available substrate" is sometimes difficult to assess, since it is specific to the species. Collect voucher specimens of common cryptogams which are unknown, and voucher specimens of nitrogen-fixing lichens--*Lobaria*. Label cryptogam packets for these voucher specimens.

3. Mammals etc: Record the presence of animal sign. Note if it is recent (*e.g.* fresh scat) or not. If browsing is noted also record the plant species which is browsed.

4. Birds: For all birds which are heard or seen, check H (heard) or S (seen). Check P if the record is actually on the plot. Use a question mark (?) if the identification is uncertain.

5. Insects etc: Record the abundance (L,M,H) of all insects identified on the plot. Check if nest is found. If appropriate note the host of the insect (e.g. yellowjacket nest on western hemlock, or aphids on silver fir).

D. SEEDLING/SAPLING CARD (Figure 172) - Select a suitable seeding subplot size. Be sure to record the plot size, the subplot size and radius for each size class of seedling or sapling. For saplings, use the northeast quadrant or the entire plot. The center of the seedling subplot is 20 feet north of the plot center stake. Avoid trampling seedlings in this area. Refer to Table 148 for radii for different subplot sizes. Record age (total age) and height for a sample of each size class. On the back of this card record information on the plot "E" and plot center reference points. Also describe the abundance and condition of the dead and down stems in the plot, and the depth of the overall litter layer.

E. TREE DAMAGE CARD (Figure 173) - (front of card is optional, back of card is *required*). On the front of this card record all damage for all trees on the NE quarter of the plot and any significant disease occurrence for any other tree, dead tree or snag. On the back of the card note the relative abundance for the major diseases and their principal host. If the front of this card is not done, draw a light diagonal line across the card. If the front of the card is done but there were no damaging agents observed, write NONE in the first line.

F. SOIL CARD (Figure 174) - Complete the soil pit descriptions in accordance with accepted Soil Taxonomy techniques.

Table 147. Tree condition codes.

HISTORY	DAMAGE	DAMAGE
10 = Live Tree	00 (or blank) No damage	54 Other weather
11 = Growth Sample Tree	10 Insect	60 Suppression
12 = Site Tree	11 Bark beetle	70 Physical Damage or unknown
30 = Cut Stump (do not number)	12 Defoliators	71 Natural mechanical
50 = Dead Tree (last 10 years)	20 Disease	72 Deformed top
60 = Snag (dead > 10 years)	21 White Pine Blister Rust	73 Forked
	22 Rust or Canker	74 Deformed stem
CROWN RATIO	23 Conk	75 Dead top
1 = 0-15	24 Visible interior rot	76 Broken top
2 = 16-25	25 Root disease	77 Excessive lean
3 = 26-35	27 Other disease	80 Man-caused
4 = 36-45	28 Heart or butt rot	81 Logging or construction
5 = 46-55	29 Mistletoe	82 Other man-caused
6 = 56-65	30 Fire	91 Stem not rotted
7 = 66-75	40 Animal	92 Hard snag or DT with bark
8 = 76-85	41 Domestic ungulates	93 Soft snag or DT with bark
9 = 86-95	42 Wild ungulates	94 Rotted core, hard shell
	43 Small animals	95 Soft snag (well rotted)
CROWN CLASS	44 Birds	
Record for all trees > 5" DBH	45 Bears	
1 = Isolated	46 Porcupine	
2 = Dominant	50 Weather	
3 = Codominant	51 Lightning	
4 = Intermediate	52 Wind	
5 = Overtopped	53 Frost crack	

METHODS FOR ESTIMATING COVER

Cover is the percent of an area (usually a plot) which is occupied by the crowns of an individual species. To determine the area occupied by an individual plant, mentally connect the outer portions of the crown with a line, thus making a polygon. Do not subtract for small areas between leaves or small gaps between branches. Project this polygon to the ground as if it were a shadow. Determine the area of this "shadow" or determine the total area of all the "shadows" of the plants of each species. Convert this area to a percentage of the plot. This is percent cover.

There are numerous ways to estimate cover of a species on a plot. First determine the size of the plot. A 1/10 acre plot (4356 sq ft or 37.24 foot radius) works well, but any size will do. Mark the plot boundary in at least one place. (The rest of this summary will assume a 1/10 acre plot.) Begin by choosing one of the dominant species on the plot. Do this species very carefully using one or more of the following methods:

1. Quickly estimate whether the species covers more or less than half of the plot; then more or less than 1/4 or 3/4 of the plot. If the species is greater than 75% use methods 5,6, if the species is 25-75% use methods 3,4,5,6, and if the species is less than 25% use methods 2,3,4.

2. Measure or estimate areas which are 1% and 10% of the plot (Table 149). One percent of a 1/10 acre plot is an area with a radius of 3.724 feet. 10% of a 1/10 acre plot (or 1/100 acre) is an area with a radius of 11.78 feet. Many types key out on the basis of whether a species is more or less than 10%, so this is a critical area. For species near this amount of cover, mentally try to fill a 10% area with plants so that their crowns don't overlap. For species with low cover in the plot, it is often useful to try to mentally fill a one percent area. If you fill the one percent area with plants and still have plants left over, fill another. This would give you 2%. Or if there are still some plants left over, fill another, and so on.

3. Measure the actual area covered by individual plants or clumps. This works well for large or clumpy plants such as vine maple, oceanspray or trees. For example, given a large clump of vine maple, measure a typical radius of the clump and convert to area. If the *radius* were 9.5 feet (3.1417 x 9.5 x 9.5 = 284 sq ft) then that clump would be (284/4356) 6.5 percent of the plot.

4. Measure or estimate the size of a typical individual of a species and then count the individuals of that species. This works well for small to medium-sized plants such as swordfern or beargrass. If the typical swordfern on a plot was 1/2 of one percent (2.6 ft radius) and there were 24 plants, the cover for swordfern would be 12%.

5. Estimate the area *not* covered by a species. Use this method when a species has more than 75% cover. Use methods 2,3, or 4 but apply them to areas not covered by a species. This often works well for dense salal. For example, if there are 4 openings in a plot which are not occupied by salal and each has a radius of about 5.0 feet (5 x 5 x 3.1417 = 78.5 sq ft = 1.8% of 4356 sq ft [1/10 acre]), there would be (1.8 + 1.8 + 1.8 + 1.8) 7.2 percent of the area which is not salal or 92.8 (rounded to 95) percent salal.

6. Divide the plot into quarters or halves if the species is very unevenly distributed or if the plot is large. If you divide a plot into quarters estimate each quarter separately then average the four quarters together. If most of the plants of one species falls in one of the quarters, mentally try to fill in the holes with plants from the other quarters.

7. Check your cover estimates by:
   a. comparing each species to one that you are relatively certain about
   b. comparing estimates on the same species done by different methods
   c. comparing to someone else's estimates.

Table 148. Plot sizes.

Area (acre)	Radius (feet)	Conversion to 1/10 ac
4/10	74.47	.25
1/5	52.66	.5
1/7	44.51	.7
1/10	37.24	1.0
1/20	26.33	2.0
1/100	11.78	10.0
1/300	6.80	30.0
1/1000	3.72	100.0

Table 149. Critical areas (in feet) for plot sizes.

	1/10 ACRE		1/5 ACRE		4/10 ACRE	
Area	Radius	Square	Radius	Square	Radius	Square
100%	37.24	66.00	52.66	93.34	74.47	132.00
25%	18.62	33.00	26.33	46.67	37.24	66.00
10%	11.78	20.87	16.65	29.52	23.55	41.74
9%	11.17	19.80	15.80	28.00	22.34	39.60
8%	10.53	18.67	14.89	26.40	21.06	37.34
7%	9.85	17.46	13.93	24.69	19.70	34.92
6%	9.12	16.17	12.90	22.86	18.24	32.33
5%	8.33	14.76	11.78	20.87	16.65	29.52
4%	7.45	13.20	10.53	18.67	14.89	26.40
3%	6.45	11.43	9.12	16.17	12.90	22.86
2%	5.27	9.33	7.45	13.20	10.53	18.67
1%	3.72	6.60	5.27	9.33	7.45	13.20

Figure 169. Plot card 1 - Reconnaissance Card.

_ _ _ _ A PLOT
_ _ _ _ FOREST/DIST
_ _ _ ELEV (10 FT)
_ _ _ ASPECT
_ _ _ SLOPE
± _ _ TOWNSHIP N
_ _ _ RANGE _
_ _ SECTION
_ MACTOP
_ MICTOP
_ MACPOS
_ MICPOS
_ MICRO V
_ MICRO H
_ SUCC STAGE
_ _ _ _ Stand Age
_ _ _ _ MAX TREE AGE
_ _ TOP HT (M)
_ _ _ Top ht (ft)
_ _ _ _ B Plot
_ _ BA (M^2/HA)
_ _ _ BA (ft^2/ac)
_ _ _ SI (d.f.)
_ _ _ SI (w.h.)
_ _ _ SI (   )
_ _ CC OVER
_ _ CC UNDER
_ _ AVE DIA (DM)
_ _ _ _ Form/Series ____
_ _ _ _ Hab Type ____
_ _ _ Soil Type ____
_ _ Regolith ____
_ _ Bedrock ____

Crew ____
Plot ____ **Date** ____
Location ____

Map ____
Air photo ____
Photo no. ____
Topography & Landform ____

Stand structure & Succession ____

GPO 992-228 JAN 1-81

_ _ _ _ T	%C	<1m	<1dm	1-3 dm	3-10	>10	DBH (cm)	Ht. (m)	Age (yrs)	Rings	BA
_ _ _ _	_ _										
_ _ _ _	_ _										
_ _ _ _	_ _										
_ _ _ _	_ _										
_ _ _ _	_ _										
_ _ _ _	_ _										
_ _ _ _	_ _										
_ _ _ _	_ _										

_ _ _ _ S	%C	Ph	V		_ _ _ _ H	%C	Ph	V	
_ _ _ _	_ _				_ _ _ _	_ _			
_ _ _ _	_ _				_ _ _ _	_ _			
_ _ _ _	_ _				_ _ _ _	_ _			
_ _ _ _	_ _				_ _ _ _	_ _			
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_ _ _ _	_ _				_ _ _ _	_ _			
_ _ _ _	_ _				_ _ _ _	_ _			
_ _ _ _	_ _				_ _ _ _	_ _			
_ _ _ _	_ _				_ _ _ _	_ _			

FIXED-AREA TREE TALLY CARD

CREW ______________ PLOT SIZE ________ DATE ________

LOCATION ____

ass'n ________ age ______ vol ______ si ______ ba ______ tpa ______ gha ______

tr no	h_s	SPP	DBH (.1 in)	RI (20ths)	SAPW (20ths)	rings	BH AGE	total age	HT (ft)	CR	CC	DAMAGE
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

tr no	h_s	SPP	DBH	RI	SAPW	rings	BH AGE	total age	HT	CR	CC	DAMAGE
31												
32												
33												
34												
35												
36												
37												
38												
39												
40												
41												
42												
43												
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48												
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50												
51												
52												
53												
54												
55												
56												
57												
58												
59												
60												

Figure 170. Plot card 2 - Fixed Area Tree Tally Card.

Figure 171. Plot card 3 - Other Organism Card.

BIRDS	H	S	P
Cooper's Hawk			
Red-tailed Hawk			
Sharp-shinned Hawk			
Blue Grouse (hoots)			
Ruffed Grouse (drums)			
Band-tailed Pigeon			
Common Nighthawk			
Vaux's Swift			
Rufous Hummingbird			
Northern Flicker			
Downy Woodpecker			
Hairy Woodpecker			
Pileated Woodpecker			
Red-breasted Sapsucker			
Olive-sided Flycatcher			
Western Flycatcher			
Western Wood Pewee			
Gray Jay			
Steller's Jay			
Common Raven			
American Crow			
Black-capped Chickadee			
Chestnut-backed Chickadee			
Red-breasted Nuthatch			
Brown Creeper			
Winter Wren			
Golden-crowned Kinglet			
Ruby-crowned Kinglet			
Varied Thrush			
Swainson's Thrush			
Hermit Thrush			
American Robin			
Solitary Vireo			
Hutton's Vireo			
Yellow-rumped Warbler			
Wilson's Warbler			
Hermit Warbler			
Townsend's Warbler			
Rufous-sided Towhee			
Song Sparrow			
White-crowned Sparrow			
Fox Sparrow			
Dark-eyed Junco			
Pine Siskin			
Red Crossbill			

INSECTS (etc.)	A	N	HOST
Bumblebee			
Yellow jacket			
Honey bee			
Bald-faced hornet			
Solitary nesting bee			
Syrphid fly			
Black fly			
Deer fly			
Horse fly			
Mosquito			
No-see-ums			
gnats			
Pine butterfly			
defoliators (catepillars)			
Predacious ground beetle			
Douglas-fir bark beetle			
Scolytid bark beetle			
Ambrosia beetle			
Wood-borer			
Spruce adelgid			
Balsam woolly aphids			
Aphids			
scale insect			
ants			
Carpenter ants			
black & orange millipede			
spider			
Banana slugs			
other slugs			
snails			

CREW　　　　PLOT #

COVER CLASSES FOR EPIPHYTES: 1 = ≤1%, 2 = 2-10%, 3 = 11-25%, 4 = 26-50%
5 = > 50% of available substrate occupied.

GROUND MOSSES AND LICHENS		%C
Hylocomium splendens	HYSP	
Eurhynchium oreganum	EUOR	
Eurhynchium praelongum	EUPR	
Rhytidiadelphus loreus	RHLO	
Rhytidiadelphus triquetrus	RHTR	
Rhytidiopsis robusta	RHRO	
Plagiothecium undulatum	PLUN	
Dicranum fuscescens	DIFU	
Dicranum scoparium	DISC	
Peltigera aphthosa	PEAP	
Peltigera	PE	
Sphagnum	SPHAG	
Hypnum circinale	HYCI	
Scapania bolanderi	SCBO	
Rhizomnium glabrescens	RHGL	
Plagiomnium insigne	PLIN	
Polytrichum	PO	
Pogonatum	PO	
Cladonia	CL	
Cladina	CL	
Rhacomitrium	RH	
Stereocaulon	ST	
Leucolepis menziesii	LEME	
Homalothecium megaptilum	HOME	
Pleurozium schreberi	PLSC	
Claopodium crispifolium	CLCR	
Total cryptogam cover		

EPIPHYTIC LICHENS, MOSSES		CC
Lobaria oregana	LOOR	
Alectoria sarmentosa	ALSA	
Bryoria fuscescens	BRFU	
Bryoria trichodes	BRTR	
Hypogymnia enteromorpha	HYEN	
Hyopgymnia physodes	HYPH	
Isothecium stoloniferum	ISST	
Sphaerophorous globosus	SPGL	
Platismatia glauca	PLGL	
Platismatia herrei	PLHE	
Hypnum circinale	HYCI	
Scapania bolanderi	SCBO	
Porella	PO	
Parmelia sulcata	PASU	
Parmelia saxatilis	PASA	
Parmeliopsis hyperopta	PAHY	
Lobaria pulmonaria	LOPU	
Cladonia	CL	
Neckera douglasii	NEDO	
Metaneckera menziesii	MEME	
Usnea	US	
Cetraria	CE	
Frullania tamarasci	FRTA	
Letharia vulpina	LEVU	
Letharia columbiana	LECO	
CRUSTOSE LICHENS	CRUST	

MAMMALS, AMPHIBIANS AND REPTILES (mark 'R' for recent sign, otherwise ✓)

	Track	Trail	Scat	Browse	Nest	
Deer						
Elk						
Mtn. Beaver						
Bear						
Porcupine						
Squirrel						

PLOT LOCATION/REFERENCE POINT SUMMARY

E ________________ o

From E to plot ________ ' at ________

RP#1 tree no. ________ ________________

from base of Arrow to PC ________ ' ________ o

at ________

RP#2 tree no. ________ ________________

from base of Arrow to PC ________ ' ________ o

at ________

DEAD, DOWN and LITTER

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

SEEDLINGS/SAPLINGS

RECORDER ________ PLOT SIZE ________

	G	<6"	6"-1" DBH	1"-3"	3"-5"
subplot size					
radius					
conversion factor					

SPECIES	no	age	ht	no	age	ht	no	age	ht	no	age	ht	no	age	ht

Figure 172. Plot card 4 - Seedling/Sapling Card.

TREE DAMAGE CARD

CREW ______ PLOT SIZE ___ SUBPLOT SIZE ___ DATE ______

TREE NO	TREE CODE	SIGNS, SYMPTOMS AND INDICATIONS
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

FUNGI: PATHOGENS AND OTHER	A	HOST	
Armellaria mellea			
Poria wierii			
Fomes annosus			
Verticioladella wagneri			
Phaeolus schwienitzii			
Fomitopsis pinicola			
Fomitopsis officionalis			
Phellinus pini			
Fomitopsis cajanderi			
Laetiporus sulfureus			
Ganoderma applanatum			
Ganoderma oregonense			
Fir Broom Rust			
Chanterelle			

Figure 173. Plot card 5 - Tree Damage Card.

LOCATION & DESCRIPTION ON BACK

BRGRD	GRAVEL	ROCK	BDROCK	MOSS	RTDPTH	TDPTH	EDPTH	PARMAT
___	___	___	___	___	___	___	___	___

PL ASSN	DATE
SOIL TYPE	DAY & TIME
AIR PHOTO	CREW
PHOTO	WEATHER

H	DPTH	COLOR	MOTT	TEXT	STRUC	CONSIST			CFRAG			ROOTS	PORES	BN DR	HO MO	T
				CL SI SA		M	W	WP	G	C	S					
				. .												
				. .												
				. .												
				. .												
				. .												
				. .												
				. .												

Figure 174. Plot card 6 - Soil Pit Card.

APPENDIX 2

- Soil Classification
- Soil Nutrient Data
- Soil Temperature Data

Table 150. Summary of plant associations by Great Group.[1]

ENTISOLS		
FLUVENTS		
	Udifluvent	PISI/POMU-OXOR, TSHE/POMU-OXOR
	Xerofluvent	ACMA/ACCI[2]
ORTHENTS		
	Udorthent	TSHE/GASH/POMU, ABAM/VAME/XETE
	Xerorthent	TSHE/XETE, TSHE/RHMA-GASH, TSHE/GASH/POMU (2), PSME/HODI-ROGY (2)
INCEPTISOLS		
OCHREPTS		
	Cryochrept	TSME/VAAL/ERMO
	Durochrept	TSHE/GASH/XETE, TSHE/GASH-VAOV2 (2), TSHE/GASH, TSHE/GASH-BENE, TSHE/GASH/POMU, ABAM/XETE
	Dystrochrept	TSHE/GASH/XETE, TSHE/GASH-BENE, TSHE/GASH/POMU (2), TSHE/VAAL, TSHE/GASH/OXOR, TSHE/POMU-OXOR (2), TSHE/POMU-TITR (2), TSHE/VAAL/OXOR, ABAM/XETE, ABAM/RHMA-VAAL, ABAM/VAAL/ERMO (2), ABAM/VAAL-BENE, ABAM/VAAL/CLUN, ABAM/VAAL, APAM/POMU, ABAM/POMU-OXOR, ABAM/OXOR (2), ABAM/GASH/BLSP (2), ABAM/VAAL/TIUN (2), ABAM/VAAL/OXOR, PSME/GASH
	Fragiochrept	TSHE/RHMA
	Xerochrept	TSHE/RHMA-GASH, TSHE/GASH/XETE, TSHE/GASH/POMU, PSME/GASH
UMBREPTS		
	Fragiumbrept	PISI/POMU-OXOR
	Haplumbrept	TSHE/GASH-BENE, TSHE/GASH/POMU, TSHE/VAAL-GASH, TSHE/POMU-OXOR, TSHE/OXOR, TSHE/POMU-TITR, ABAM/GASH/OXOR, ABAM/POMU-OXOR, ABAM/OXOR (2), ABAM/VAAL/OXOR
	Xerumbrept	PSME/HODI-ROGY
SPODOSOLS		
HUMODS		
	Cryohumod	TSME/VAAL/ERMO
	Haplohumod	ABAM/VAAL/CLUN
ORTHODS		
	Cryorthod	ABAM/VAAL/ERMO, ABAM/GASH/OXOR, TSME/VAAL, TSME/VAAL/ERMO (4)
	Fragiorthod	ABAM/VAAL/TIUN
	Haplorthod	TSHE/RHMA-GASH, TSHE/GASH-BENE, TSHE/GASH/POMU (2), TSHE/VAAL (2), TSHE/GASH/OXOR, TSHE/POMU-OXOR, TSHE/OXOR TSHE/POMU-TITR (2), TSHE/VAAL/OXOR, TSHE/OPHO, ABAM/RHMA-VAAL ABAM/VAAL/ERMO, ABAM/VAAL-BENE, ABAM/VAAL/CLUN (2), ABAM/VAAL, ABAM/GASH/OXOR, ABAM/POMU, ABAM/OXOR
HISTOSOLS		
HEMISTS		
	Medihemist	TSHE/VAAL-GASH, TSHE/PYFU/GASH/XETE[2]

1 Number of occurrences is one unless otherwise indicated in ( ).

2 Suggested names for rare plant communities of uncertain successional status.

Table 151. Summary of Great Groups by plant association.

ASSOCIATION	No. of Plots	GREAT GROUPS
PISI/POMU-OXOR	2	1 fragiumbrept, 1 udifluvent
TSHE/XETE	1	1 xerorthent
TSHE/RHMA-GASH	3	1 haplorthod, 1 xerochrept, 1 xerorthent
TSHE/RHMA	1	1 fragiochrept
TSHE/GASH/XETE	3	1 durochrept, 1 dystrochrept, 1 xerochrept
TSHE/GASH	2	2 durochrept
TSHE/GASH-VAOV2	2	2 durochrept
TSHE/GASH-BENE	4	1 durochrept, 1 dystrochrept, 1 haplorthod, 1 haplumbrept
TSHE/GASH/POMU	10	1 durochrept, 3 dystrochrept, 2 haplorthod, 1 udorthent, 1 xerochrept, 1 xerorthent, 1 haplumbrept
TSHE/VAAL/GASH	2	1 haplumbrept, 1 medihemist
TSHE/VAAL	3	1 dystrochrept, 2 haplorthod
TSHE/GASH/OXOR	2	1 dystrochrept, 1 haplorthod
TSHE/POMU-OXOR	5	2 dystrochrept, 1 haplorthod, 1 haplumbrept, 1 udifluvent
TSHE/OXOR	2	1 haplorthod, 1 haplumbrept
TSHE/POMU-TITR	5	2 dystrochrept, 2 haplorthod, 1 haplumbrept
TSHE/VAAL/OXOR	2	1 dystrochrept, 1 haplorthod
TSHE/OPHO	1	1 haplorthod
TSHE/PYFU/GASH/XETE[1]	1	1 medihemist
ABAM/XETE	2	1 dystrochrept, 1 durochrept
ABAM/VAME/XETE	1	1 udorthent
ABAM/RHMA-VAAL	2	1 dystrochrept, 1 haplorthod
ABAM/VAAL/ERMO	4	1 cryorthod, 2 dystrochrept, 1 haplorthod
ABAM/VAAL-BENE	2	1 dystrochrept, 1 haplorthod
ABAM/VAAL/CLUN	4	1 dystrochrept, 1 haplohumod, 2 haplorthod
ABAM/VAAL	2	1 dystrochrept, 1 haplorthod
ABAM/GASH/OXOR	3	1 cryorthod, 1 haplorthod, 1 haplumbrept
ABAM/POMU	2	1 dystrochrept, 1 haplorthod
ABAM/POMU-OXOR	2	1 dystrochrept, 1 haplumbrept
ABAM/OXOR	5	2 dystrochrept, 1 haplorthod, 2 haplumbrept
ABAM/GASH/BLSP	2	2 dystrochrept
ABAM/VAAL/TIUN	3	2 dystrochrept, 1 fragiorthod
ABAM/VAAL/OXOR	2	1 dystrochrept, 1 haplumbrept
TSME/VAAL	1	1 cryorthod
TSME/VAAL/ERMO	6	4 cryorthod, 1 cryochrept, 1 cryohumod
PSME/HODI-ROGY	3	2 xerorthent, 1 xerumbrept
PSME/GASH	2	1 dystrochrept, 1 xerochrept
ACMA/ACCI[1]	1	1 xerofluvent

1 Suggested names for rare plant communities of uncertain successional status.

Table 152. Summary of selected soil pit data by plant association. Values are means and units are in centimeters unless otherwise indicated (n=number of plots).

ASSOCIATION	n	O1 HOR.	O2 HOR.	COARSE FRAG.%	SOIL DEPTH[1]	ROOT DEPTH (ORG.)[2]	ROOT DEPTH (MIN.)[3]	EFFECTIVE DEPTH[4]	A HOR. THICK.	HARD PAN[5]
PISI/POMU-OXOR	2	3.5	2.5	47.0	56-100.0+	2.5	68.0	30-53.0+		34.0
TSHE/XETE	1	1.0	2.0	63.0	100.0+	2.0	105.0	37.0+		
TSHE/RHMA-GASH	3	4.8	3.0	12.0	100.0+	3.0	64.3	88.0+		
TSHE/RHMA	1	2.0	3.0	3.0	49.0	3.0	37.0	36.0		49.0
TSHE/GASH/XETE	3	2.3	3.3	45.8	67-100.0+	3.3	82.0	36-54.0+		67.0
TSHE/GASH	2	1.5	8.5	43.0	69.5	7.0	69.5	39.6		69.5
TSHE/GASH-VAOV2	1	3.0	6.0	59.0	79.0	6.0	77.0	32.2		79.0
TSHE/GASH-BENE	4	2.0	3.1	48.4	68.3	2.9	65.4	35.2		68.5
TSHE/GASH/POMU	10	2.4	7.7	47.7	43-100.0+	6.5	63.9	28-52.0+		54.5
TSHE/VAAL-GASH	2	0.5	11.5	11.0	100.0+	11.5	40.0	89.0+		
TSHE/VAAL	3	1.6	5.3	51.7	87-100.0+	5.3	44.3	42-48.0+		
TSHE/GASH/OXOR	2	3.0	1.5	29.5	100.0+	1.5	46.0	70.5+		
TSHE/POMU-OXOR	5	1.2	1.6	28.8	100.0+	1.6	66.4	71.2+		
TSHE/OXOR	2	1.0	3.9	13.5	100.0+	3.9	61.5	86.5+		
TSHE/POMU-TITR	5	1.8	1.6	32.8	100.0+	1.6	44.6	67.2+		
TSHE/VAAL/OXOR	2	1.0	12.9	54.5	100.0+	12.9	55.0	45.5+	12.0	
TSHE/OPHO	1	2.0	2.0	4.0	100.0+	2.0	30.0	96.0+		
ABAM/XETE	2	2.3	3.6	66.0	100.0+	4.8	49.0	34.0+		
ABAM/VAME/XETE	1	3.0	3.0	70.0	100.0+	3.0	50.0	30.0+		
ABAM/RHMA-VAAL	2	2.5	5.0	28.0	66-100.0+	5.0	73.0	48-72.0+		
ABAM/VAAL/ERMO	4	0.4	5.0	46.4	34-100.0+	4.5	50.9	18-54.0+	18.0	
ABAM/VAAL-BENE	2	0.9	7.0	61.5	100.0+	7.0	76.0	38.5+		
ABAM/VAAL/CLUN	4	2.9	6.5	33.9	100.0+	6.5	51.5	66.1+	10.0	
ABAM/VAAL	2	3.9	24.5	74.0	100.0+	24.5	56.0	26.0+		
ABAM/GASH/OXOR	3	1.3	4.8	40.8	100.0+	4.8	62.3	59.2+		
ABAM/POMU	2	3.0	7.0	67.5	75.0	7.0	75.0	24.4	9.0	
ABAM/POMU-OXOR	2	2.5	1.5	45.0	100.0+	1.5	76.5	55.0+		
ABAM/OXOR	5	1.0	4.0	10.8	88-100.0+	3.2	55.4	78-89.0+	4.8	
ABAM/GASH/BLSP	2	1.0	5.0	11.0	100.0+	5.0	54.0	89.0+		
ABAM/VAAL/TIUN	3	1.3	11.3	43.3	38-100.0+	11.3	49.3	22-57.0+	6.0	38.0
ABAM/VAAL/OXOR	2	0.5	0.0	24.0	100.0+	0.0	40.0	76.0+		
TSME/VAAL	1	3.0	8.0	41.0	60.0	8.0	50.0	35.4		
TSME/VAAL/ERMO	6	1.3	4.8	41.0	46.3	5.0	36.2	27.3	12.6	
PSME/HODI-ROGY	3	2.3	0.3	48.8	100.0+	0.0	123.8	51.2+		
PSME/GASH	2	3.4	2.5	36.5	100.0+	2.5	74.5	63.5+		
ACMA/ACCI[6]	1	6.0	6.0	0.0	100.0+	0.0	115.0	100.0+		

[1] A "+" indicates that no bedrock or hardpan was encountered.
[2] Thickness of O horizon in which roots were found.
[3] Depth to which 90% of the roots penetrate.
[4] Effective depth is the soil depth minus the percent of coarse fragments. If soil is deeper than 100 cm the effective depth is calculated using only the top 100 cm. A "+" indicates that the effective depth was calculated in this way.
[5] Strongly compacted and/or cemented layer such as a fragipan or a duripan. Used to define soil depth and effective depth where present.
[6] Suggested name for rare plant community of uncertain successional status.

Table 153. Macronutrient concentrations by plant association. Mean values from samples taken at 20 cm depth. P, K, and SO_4 expressed in ppm. Ca and Mg expressed in meq/100g. (See Soil Methods p. 82, Table 160 p. 440).

ASSOCIATION	n	pH	P	K	Ca	Mg	OM%	TN%	SO_4
PISI/POMU-OXOR	1	5.20	0.50	27.00	0.60	0.41	8.30	0.20	5.90
TSHE/XETE	1	5.10	5.00	148.00	1.10	0.35	16.50	0.15	3.68
TSHE/RHMA/XETE	1	5.10	20.00	98.00	2.50	0.87	12.06	0.15	7.45
TSHE/RHMA-GASH	8	5.60	8.13	127.63	5.65	1.20	6.54	0.07	3.73
TSHE/RHMA	4	5.53	33.50	125.00	4.23	1.43	2.79	0.05	3.21
TSHE/RHMA/POMU	1	5.50	6.00	70.00	2.30	0.74	6.90	0.12	6.90
TSHE/GASH/XETE	3	5.40	10.67	53.33	2.07	0.58	5.62	0.07	8.57
TSHE/GASH	2	5.30	9.00	57.00	0.90	0.24	4.06	0.08	7.81
TSHE/GASH-VAOV2	1	5.70	7.00	55.00	2.20	0.48	5.18	0.09	4.49
TSHE/DEP	1	5.60	0.50	35.00	2.20	0.74	13.93	0.17	2.52
TSHE/GASH-BENE	3	5.27	29.00	71.33	0.87	0.35	4.92	0.11	3.53
TSHE/BENE/POMU	5	5.60	7.40	82.60	10.06	2.26	10.25	0.22	3.12
TSHE/GASH/POMU	5	5.48	9.20	60.80	3.96	0.81	10.28	0.15	4.56
TSHE/VAAL-GASH	1	4.70	2.00	179.00	3.50	1.30	38.95	0.39	5.30
TSHE/POMU-OXOR	2	5.50	2.75	52.50	16.30	1.76	25.05	0.44	1.78
TSHE/OXOR	2	5.05	0.50	41.00	1.10	0.56	15.86	0.35	3.05
TSHE/POMU-TITR	10	5.32	10.65	77.10	6.11	1.36	12.07	0.23	3.83
TSHE/OPHO	1	5.10	3.00	51.00	0.90	0.36	7.10	0.21	1.80
ABAM/XETE	1	5.00	0.50	31.00	0.70	0.27	13.88	0.21	4.46
ABAM/VAME/XETE	1	4.90	8.00	98.00	1.60	0.67	13.76		3.09
ABAM/RHMA-VAAL	2	5.35	21.00	160.00	6.40	2.19	10.55	0.14	1.23
ABAM/VAAL/CLUN	1	5.00	4.00	66.00	0.90	0.62	24.03	0.36	1.84
ABAM/VAAL	1	5.00	2.00	62.00	2.20	0.60	15.37	0.18	1.84
ABAM/GASH/OXOR	3	4.80	0.67	62.33	0.63	0.53	17.08	0.28	2.77
ABAM/POMU-OXOR	1	5.00	6.00	179.00	1.90	0.82	5.66	0.51	1.74
ABAM/OXOR	4	4.60	1.88	50.75	0.93	0.62	13.68	0.30	2.15
ABAM/GASH/BLSP	2	4.80	0.75	55.00	0.70	0.55	16.22	0.27	3.15
ABAM/VAAL/OXOR	1	5.40	0.50	51.00	0.80	0.33	15.84	0.30	2.30
TSME/RHAL-VAME	1	4.20	25.00	456.00	11.40	2.40	84.66	0.54	
TSME/VAAL	1	5.10	3.00	59.00	1.00	0.53	20.80	0.33	1.97
TSME/VAAL/ERMO	2	4.30	4.50	70.50	0.35	0.35	8.44	0.18	2.03
PSME/HODI-ROGY	3	5.77	27.00	309.33	7.47	2.47	7.07	0.06	1.33
PSME/GASH	2	5.30	12.50	148.00	4.30	1.46	11.31	0.19	1.70

Table 154. Micronutrient concentrations by plant association. Mean values from samples taken at 20 cm depth. B, Zn, Cu and Mn expressed in ppm. (See p. 82, Table 160 p. 440).

ASSOCIATION	n	Na	B	Zn	Cu	Mn
PISI/POMU-OXOR	1	0.14	0.55	0.12	0.32	0.40
TSHE/XETE	1	0.13	0.60	1.00	1.48	14.20
TSHE/RHMA/XETE	1	0.08	0.80	0.84	0.64	58.40
TSHE/RHMA-GASH	8	0.10	0.26	0.43	0.78	22.25
TSHE/RHMA	4	0.08	0.34	0.43	1.04	11.48
TSHE/RHMA/POMU	1	0.11	0.76	0.60	0.92	24.00
TSHE/GASH/XETE	3	0.09	0.38	0.37	1.02	8.83
TSHE/GASH	2	0.06	0.33	0.78	1.08	19.30
TSHE/DEP	1	0.24	0.33	0.16	1.62	1.60
TSHE/GASH-VAOV2	1	0.09	0.31	0.36	1.16	16.20
TSHE/GASH-BENE	3	0.10	0.51	0.35	0.70	13.75
TSHE/BENE/POMU	5	0.14	0.99	0.78	1.41	29.60
TSHE/GASH/POMU	5	0.13	0.62	0.84	1.05	30.74
TSHE/VAAL-GASH	1	0.26	1.16	2.82	1.78	26.00
TSHE/POMU-OXOR	2	0.15	0.86	0.96	2.25	24.30
TSHE/OXOR	2	0.18	0.68	0.16	0.63	0.59
TSHE/POMU-TITR	10	0.13	1.01	0.85	1.84	15.89
TSHE/OPHO	1	0.16	1.70	0.26	0.54	4.80
ABAM/XETE	1	0.10	0.51	0.62	1.62	9.46
ABAM/VAME/XETE	1	0.14	0.58	0.16	0.22	3.42
ABAM/RHMA-VAAL	2	0.14	0.27	0.34	0.77	10.48
ABAM/VAAL/CLUN	1	0.22	0.26	0.38	0.76	0.92
ABAM/VAAL	1	0.18	0.54	1.00	2.50	17.82
ABAM/GASH/OXOR	3	0.14	0.93	0.55	0.92	4.19
ABAM/POMU-OXOR	1	0.31	1.12	0.54	0.38	2.38
ABAM/OXOR	4	0.17	1.03	0.27	0.43	2.62
ABAM/GASH/BLSP	2	0.17	0.91	0.35	0.33	5.50
ABAM/VAAL/OXOR	1	0.13	0.72	0.08	0.60	0.26
TSME/RHAL-VAME	1	0.30	7.52	28.00	2.64	12.82
TSME/VAAL	1	0.15	0.56	0.20	0.94	0.84
TSME/VAAL/ERMO	2	0.09	0.19	0.33	0.35	1.06
PSME/HODI-ROGY	3	0.07	0.32	0.38	0.63	32.00
PSME/GASH	2	0.17	0.56	0.42	1.13	4.63

Table 155. Plant associations of the Western Hemlock, Sitka Spruce and Douglas-fir Series ranked by three moisture variables. Each list orders the plant associations on a moisture gradient from dry to wet. (See footnotes on page 437).

POTENTIAL SOIL MOISTURE [1]		TOPOGRAPHIC MOISTURE [2]		ENVIRONMENTAL ZONE [3]	
1	TSHE/GASH-VAOV2	1	TSHE/XETE	1	PSME/HODI-ROGY
2	TSHE/GASH/XETE	2	PSME/HODI-ROGY	2	TSHE/GASH-VAOV2
3	TSHE/POMU-TITR	3	PSME/GASH	3	TSHE/RHMA
4	TSHE/XETE	4	TSHE/GASH/XETE	4	TSHE/RHMA-GASH
5	TSHE/VAAL	5	TSHE/RHMA	5	PSME/GASH
6	TSHE/GASH-BENE	6	TSHE/RHMA-GASH	6	TSHE/OPHO
7	PISI/POMU-OXOR	7	TSHE/GASH	7	TSHE/XETE
8	TSHE/OPHO	8	TSHE/GASH-BENE	8	TSHE/GASH/POMU
9	PSME/HODI-ROGY	9	TSHE/GASH/OXOR	9	TSHE/GASH-BENE
10	TSHE/RHMA	10	TSHE/VAAL-GASH	10	TSHE/GASH
11	PSME/GASH	11	TSHE/VAAl	11	TSHE/GASH/XETE
12	TSHE/GASH/POMU	12	TSHE/GASH/POMU	12	TSHE/POMU-TITR
13	TSHE/GASH	13	TSHE/OXOR	13	TSHE/VAAL
14	TSHE/GASH/OXOR	14	TSHE/VAAL/OXOR	14	TSHE/VAAL-GASH
15	TSHE/VAAL/OXOR	15	PISI/POMU-OXOR	15	TSHE/OXOR
16	TSHE/RHMA-GASH	16	TSHE/POMU-OXOR	16	TSHE/GASH/OXOR
17	TSHE/POMU-OXOR	17	TSHE/GASH-VAOV2	17	TSHE/POMU-OXOR
18	TSHE/VAAL-GASH	18	TSHE/POMU-TITR	18	TSHE/VAAL/OXOR
19	TSHE/OXOR	19	TSHE/OPHO	19	PISI/POMU-OXOR

Table 156. Plant associations of the Silver Fir, Mountain Hemlock and Subalpine Fir Series ranked by three moisture variables. Each list orders the plant associations on a moisture gradient from dry to wet. (See footnotes on page 437).

POTENTIAL SOIL MOISTURE [1]		TOPOGRAPHIC MOISTURE [2]		ENVIRONMENTAL ZONE [3]	
1	ABAM/VAME/XETE	1	ABAM/VAME/XETE	1	ABAM/RHMA-VAAL
2	TSME/VAAL/ERMO	2	TSME/VAAL-RHAL	2	ABAM/VAME/XETE
3	ABAM/XETE	3	ABAM/VAAL/ERMO	3	ABAM/XETE
4	ABAM/POMU	4	ABAM/XETE	4	ABAM/VAAL/TIUN
5	ABAM/VAAL/ERMO	5	ABAM/VAAL	5	ABAM/VAAL-BENE
6	ABAM/VAAL/OXOR	6	TSME/VAAL	6	ABAM/POMU
7	ABAM/VAAL-BENE	7	ABAM/GASH/BLSP	7	TSME/VAAL
8	TSME/VAAL	8	ABAM/OXOR	8	ABAM/VAAL
9	ABAM/POMU-OXOR	9	ABAM/GASH/OXOR	9	ABAM/VAAL/CLUN
10	ABAM/GASH/OXOR	10	ABAM/VAAL/CLUN	10	ABAM/VAAL/ERMO
11	ABAM/VAAL/CLUN	11	ABAM/VAAL-BENE	11	ABAM/GASH/OXOR
12	ABAM/RHMA-VAAL	12	ABAM/RHMA-VAAL	12	ABAM/POMU-OXOR
13	ABAM/VAAL/TIUN	13	ABAM/VAAL/OXOR	13	ABAM/OXOR
14	ABAM/GASH/BLSP	14	ABAM/POMU-OXOR	14	TSME/VAAL/ERMO
15	ABAM/VAAL	15	ABAM/POMU	15	ABAM/VAAL/OXOR
16	ABAM/OXOR	16	ABAM/VAAL/TIUN	16	ABAM/GASH/BLSP

Table 157. Plant associations of the Western Hemlock, Sitka Spruce and Douglas-fir Series ordered by values for three moisture variables. Each list orders the plant associations on a moisture gradient from dry to wet. An "*" indicates that potential soil moisture data are available for that association.

POTENTIAL SOIL MOISTURE [1]		TOPOGRAPHIC MOISTURE [2]		ENVIRONMENTAL ZONE [3]	
*TSHE/GASH-VAOV2	2.52	PSME/ARUV	3.0	PSME/ARUV	11.5
*TSHE/GASH/XETE	2.83	TSHE/VAAL/XETE	3.0	*PSME/HODI-ROGY	11.2
*TSHE/POMU-TITR	2.85	*TSHE/XETE	3.2	TSHE/RHMA-BENE	10.6
*TSHE/XETE	3.04	*PSME/HODI-ROGY	3.6	TSHE/GASH-HODI	10.5
*TSHE/VAAL	3.37	*PSME/GASH	3.6	*TSHE/GASH-VAOV2	9.8
*TSHE/GASH-BENE	3.44	TSHE/RHMA/XETE	4.0	*TSHE/RHMA	9.7
*PISI/POMU-OXOR	3.45	TSHE/RHMA-BENE	4.1	*TSHE/RHMA-GASH	9.6
*TSHE/OPHO	3.54	TSHE/BENE	4.1	TSHE/RHMA/POMU	9.4
*PSME/HODI-ROGY	3.80	*TSHE/GASH/XETE	4.2	*PSME/GASH	9.2
*TSHE/RHMA	4.05	TSHE/GASH-HODI	4.3	TSHE/RHMA/XETE	9.2
*PSME/GASH	4.45	*TSHE/RHMA	4.3	TSHE/ACTR	9.2
*TSHE/GASH/POMU	4.93	*TSHE/RHMA-GASH	4.5	*TSHE/OPHO	8.6
*TSHE/GASH	5.30	*TSHE/GASH	4.5	TSHE/BENE	8.5
*TSHE/GASH/OXOR	5.30	*TSHE/GASH-BENE	4.6	TSHE/VAAL/XETE	8.3
*TSHE/VAAL/OXOR	5.54	*TSHE/GASH/OXOR	4.6	TSHE/BENE/POMU	8.3
*TSHE/RHMA-GASH	5.76	TSHE/Dep	4.9	*TSHE/XETE	8.0
*TSHE/POMU-OXOR	6.05	*TSHE/VAAL-GASH	4.9	*TSHE/GASH/POMU	8.0
*TSHE/VAAL-GASH	6.23	TSHE/RHMA/POMU	5.0	*TSHE/GASH-BENE	7.7
*TSHE/OXOR	6.56	TSHE/ACTR	5.2	*TSHE/GASH	7.5
		*TSHE/VAAL	5.2	TSHE/Dep	7.1
		*TSHE/GASH/POMU	5.3	*TSHE/GASH/XETE	7.0
		*TSHE/OXOR	5.4	*TSHE/POMU-TITR	6.9
		*TSHE/VAAL/OXOR	5.4	TSHE/LYAM	6.0
		TSHE/BENE/POMU	5.5	*TSHE/VAAL	5.4
		*PISI/POMU-OXOR	5.5	*TSHE/VAAL-GASH	4.1
		*TSHE/POMU-OXOR	5.7	*TSHE/OXOR	4.0
		*TSHE/GASH-VAOV2	5.8	*TSHE/GASH/OXOR	3.8
		*TSHE/POMU-TITR	5.8	*TSHE/POMU-OXOR	3.4
		*TSHE/OPHO	6.9	*TSHE/VAAL/OXOR	3.4
		TSHE/LYAM	8.0	*PISI/POMU-OXOR	2.1

[1]Potential Soil Moisture--percent available water based on soil texture (Brady 1974) of the effective rooting zone (root zone thickness - % of that thickness occupied by coarse fragments). Mean of all pits in type.

[2]Topographic Moisture--estimate of tendency for precipitation to be redistributed by topography. The scale is 1 - 9 with 1 the driest (steep, rocky ridge) and 9 aquatic.

[3]Environmental Zones are zones of roughly equivalent environments. Ranked from 0-12 with 0 the wettest and 12 the driest. Mean of all plots in type. Most types extend across several zones although as they do so moisture is compensated up or down by other factors including 1 and 2.

Table 158. Plant associations of the Silver Fir, Mountain Hemlock, and Subalpine Fir Series ordered by values for three moisture variables. Each list orders the plant associations on a moisture gradient from dry to wet. An "*" indicates that potential soil moisture data are available for that association.

POTENTIAL SOIL MOISTURE [1]		TOPOGRAPHIC MOISTURE [2]		ENVIRONMENTAL ZONE [3]	
*ABAM/VAME/XETE	1.49	TSME/PHEM-VADE	2.8	ABLA2/LULA	11.5
*TSME/VAAL/ERMO	2.90	TSME/VAME/XETE	3.0	ABLA2/RHAL	11.0
*ABAM/XETE	2.96	ABLA2/JUCO4	3.2	ABLA2/JUCO4	10.4
*ABAM/POMU	3.24	ABLA2/LULA	3.6	ABLA2/VAME	9.8
*ABAM/VAAL/ERMO	3.79	*ABAM/VAME/XETE	3.6	ABAM/RHMA	9.1
*ABAM/VAAL/OXOR	3.80	ABAM/VAAL/XETE	3.7	TSME/RHAL-VAME	8.9
*ABAM/VAAL-BENE	4.54	ABLA2/RHAL	3.9	ABAM/VAAL-RHAL	8.8
*TSME/VAAL	4.66	*TSME/VAAL/ERMO	3.9	*ABAM/RHMA-VAAL	8.7
*ABAM/POMU-OXOR	4.74	*ABAM/VAAL/ERMO	4.1	ABAM/ACTR-TIUN	8.7
*ABAM/GASH/OXOR	5.46	ABAM/GASH	4.1	*ABAM/VAME/XETE	8.6
*ABAM/VAAL/CLUN	5.53	ABLA2/VAME	4.2	*ABAM/XETE	8.0
*ABAM/RHMA-VAAL	5.60	*ABAM/XETE	4.2	TSME/VAME/XETE	8.0
*ABAM/VAAL/TIUN	5.90	ABAM/VAAL-RHAL	4.3	ABAM/VAAL/LIBO2	7.8
*ABAM/GASH/BLSP	6.90	*ABAM/VAAL	4.4	ABAM/VAAL/XETE	7.6
*ABAM/VAAL	6.99	*TSME/VAAL	4.4	TSME/PHEM-VADE	7.0
*ABAM/OXOR	7.10	*ABAM/GASH/BLSP	4.4	ABAM/Dep	6.2
		TSME/VAAL/XETE	4.5	*ABAM/VAAL/TIUN	6.0
		ABAM/Dep	4.5	ABAM/GASH	5.9
		*ABAM/OXOR	4.5	ABAM/OPHO	5.9
		*ABAM/GASH/OXOR	4.6	*ABAM/VAAL-BENE	5.7
		*ABAM/VAAL/CLUN	4.6	*ABAM/POMU	5.5
		ABAM/RHMA	4.6	TSME/VAME/VAAL	5.3
		*ABAM/VAAL-BENE	4.7	*TSME/VAAL	5.3
		*ABAM/RHMA-VAAL	4.7	*ABAM/VAAL	4.8
		ABAM/VAAL/LIBO2	4.8	*ABAM/VAAL/CLUN	4.6
		TSME/RHAL-VAME	4.9	TSME/VAAL/XETE	4.3
		*ABAM/VAAL/OXOR	5.1	*ABAM/VAAL/ERMO	3.4
		*ABAM/POMU-OXOR	5.2	*ABAM/GASH/OXOR	2.9
		*ABAM/POMU	5.4	*ABAM/POMU-OXOR	2.7
		TSME/VAME-VAAL	5.5	*ABAM/OXOR	2.4
		*ABAM/VAAL/TIUN	5.7	*TSME/VAAL/ERMO	2.3
		ABAM/ACTR-TIUN	5.7	*ABAM/VAAL/OXOR	2.1
		ABAM/OPHO	6.5	*ABAM/GASH/BLSP	1.3
		ABAM/LYAM	8.0	ABAM/LYAM	1.0

[1]Potential Soil Moisture--percent available water based on soil texture (Brady 1974) of the effective rooting zone (root zone thickness: % of that thickness occupied by coarse fragments). Mean of all pits in type.

[2]Topographic Moisture--estimate of tendency for precipitation to be redistributed by topography. The scale is 1 - 9 with 1 the driest (steep, rocky ridge) and 9 aquatic.

[3]Environmental Zones are zones of roughly equivalent environments. Ranked from 0-12 with 0 the wettest and 12 the driest. Mean of all plots in type. Most types extend across several zones although as they do so moisture is compensated up or down by other factors including 1 and 2.

Table 159. Twenty centimeter soil temperature data by plant association. Temperature in degrees Celsius, n is number of plots.

PLANT ASSOCIATION	AVERAGE TEMP	SAMPLE PERIOD	n
PISI/POMU-OXOR	12.8	JUL,AUG	28
TSHE/XETE	10.2	JUN,AUG	2
TSHE/RHMA/XETE	9.3	JUL,AUG	3
TSHE/RHMA-BENE	11.9	JUN,AUG	6
TSHE/RHMA-GASH	10.5	JUN,JUL,AUG	44
TSHE/RHMA	9.5	JUN,JUL,AUG	19
TSHE/RHMA/POMU	10.1	JUN,JUL,AUG	6
TSHE/GASH/XETE	13.4	JUN	3
TSHE/GASH-HODI	11.9	JUL,AUG	8
TSHE/GASH	12.5	JUN,JUL	25
TSHE/BENE	10.4	JUL,AUG	7
TSHE/Dep	11.4	JUN,JUL,AUG	22
TSHE/GASH-VAOV2			
TSHE/GASH-BENE	12.2	JUN,JUL,AUG	15
TSHE/ACTR	11.6	JUN,JUL,AUG	8
TSHE/BENE/POMU	11.0	JUN,JUL	11
TSHE/GASH/POMU	12.3	JUN,JUL	35
TSHE/VAAL-GASH	12.4	JUN,JUL,AUG	9
TSHE/VAAL	10.1	JUN,JUL	5
TSHE/GASH/OXOR	14.3	JUL,AUG	4
TSHE/POMU-OXOR	12.2	JUN,JUL,AUG	7
TSHE/OXOR	13.2	JUL	12
TSHE/POMU-TITR	11.5	JUN,JUL,AUG	36
TSHE/VAAL/OXOR	12.5	JUN,JUL,AUG	7
TSHE/OPHO	11.9	JUN,JUL,AUG	9
TSHE/LYAM			
PSME/ARUV	13.2	JUL,AUG	4
PSME/HODI-ROGY	12.7	JUL,AUG	12
PSME/GASH	12.0	JUN,JUL	7
ABAM/XETE	9.9	JUN,AUG	4
ABAM/VAME/XETE	10.5	JUL,AUG	3
ABAM/RHMA	10.3	JUL,AUG	11
ABAM/RHMA-VAAL	9.3	JUN,JUL	4
ABAM/Dep	11.2	JUL	10
ABAM/GASH	11.9	JUN,JUL	3
ABAM/VAAL-RHAL	8.5	AUG	2
ABAM/VAAL/ERMO	9.2	JUN,JUL,AUG	8
ABAM/VAAL/XETE	7.8	JUN,AUG	2
ABAM/VAAL/LIBO2	11.3	JUL,AUG	4
ABAM/VAAL-BENE	10.0	JUN	2
ABAM/VAAL/CLUN	10.8	JUN,JUL	11
ABAM/VAAL	10.7	JUN,AUG	11
ABAM/GASH/OXOR	13.4	JUN,AUG	5
ABAM/POMU	11.7	JUN,JUL,AUG	5
ABAM/ACTR-TIUN	10.2	JUL,AUG	6
ABAM/POMU-OXOR	11.9	JUN,JUL	8
ABAM/OXOR	11.7	JUL	18
ABAM/GASH/BLSP	11.1	JUL,AUG	3
ABAM/VAAL/TIUN	10.6	JUN,JUL,AUG	7
ABAM/VAAL/OXOR	10.7	JUL	9
ABAM/OPHO	10.0	JUN,JUL,AUG	8
ABAM/LYAM			
TSME/PHEM-VADE	9.1	AUG	3
TSME/VAME/XETE			
TSME/VAME-VAAL	8.5	JUL,AUG	2
TSME/RHAL-VAME	8.1	JUL,AUG	10
TSME/VAAL/XETE			
TSME/VAAL	8.6	AUG	2
TSME/VAAL/ERMO	10.3	JUN,JUL,AUG	14
ABLA2/JUCO4	15.1	JUL,AUG	3
ABLA2/LULA	12.0	AUG	3
ABLA2/VAME	13.0	AUG	3
ABLA2/RHAL	10.0	AUG	7

Table 160. Summary of laboratory methods used for soil chemical analysis by Oregon State University Soil Testing Laboratory (Horneck et al. in press).

nutrient	method	unit	comments
pH	2:1 dilution	-log	
P	Bray P-1	ppm	soluble P
K	NH_4OAC 1 normal	ppm	extractable K
Ca	NH_4OAC 1 normal	meq/100g	extractable Ca
Mg	NH_4OAC 1 normal	meq/100g	extractable Mg
Na	NH_4OAC 1 normal	meq/100g	extractable Na
Zn	DTPA	ppm	
Cu	DTPA	ppm	
Mn	DTPA	ppm	
B	hot water extraction	ppm	
SO_4	KCl extraction	ppm	
N	Kjeldahl	%	total N
OM	Walkley black	%	total OM

APPENDIX 3

- Ecoclass Codes
- Distribution of Associations by District
- Plant Association Groups
- List of Plant Species
- Table of Mean Absolute Cover Values
- List of Birds

Table 161. Ecoclass codes for Plant Associations of the Olympic National Forest.

PLANT ASSOCIATION	ABBREVIATION	ECOCLASS CODE	COMPUTER CODE
DOUGLAS-FIR ASSOCIATIONS (PSME Series)			
1. Douglas-fir/Kinnikinnick	PSME/ARUV	CDS8 51	6141
2. Douglas-fir/Oceanspray-Baldhp Irose	PSME/HODI-ROGY	CDS2 21	6152
3. Douglas-fir/Salal	PSME/GASH	CDS2 55	6181
MOUNTAIN HEMLOCK ASSOCIATIONS (TSME Series)			
4. Mountain Hemlock/Alaska Huckleberry	TSME/VAAL	CMS2 41	4775
5. Mountain Hemlock/Alaska Huckleberry/Avalanche Lily	TSME/VAAL/ERMO	CMS2 42	4779
6. Mountain Hemlock/Alaska Huckleberry/Beargrass	TSME/VAAL/XETE	CMS2 43	4418
7. Mountain Hemlock/Big Huckleberry-Alaska Huckleberry	TSME/VAME-VAAL	CMS2 44	4414
8. Mountain Hemlock/Big Huckleberry/Beargrass	TSME/VAME/XETE	CMS2 45 (OLY)	4408
9. Mountain Hemlock/Red Heather-Blueleaf Huckleberry	TSME/PHEM-VADE	CMS3 11	4171
10. Mountain Hemlock/White Rhododendron-Big Huckleberry	TSME/RHAL-VAME	CMS3 12	4417
SILVER FIR ASSOCIATIONS (ABAM Series)			
11. Silver Fir/Alaska Huckleberry	ABAM/VAAL	CFS2 12 (OLY)	3718
12. Silver Fir/Alaska Huckleberry/Avalanche Lily	ABAM/VAAL/ERMO	CFS2 13	3450
13. Silver Fir/Alaska Huckleberry/Beargrass	ABAM/VAAL/XETE	CFS2 14	3522
14. Silver Fir/Alaska Huckleberry/Foamflower	ABAM/VAAL/TIUN	CFS2 15	3853
15. Silver Fir/Alaska Huckleberry/Oregongrape	ABAM/VAAL-BENE	CFS2 16	3526
16. Silver Fir/Alaska Huckleberry/Oxalis	ABAM/VAAL/OXOR	CFS2 17	3855
17. Silver Fir/Alaska Huckleberry/Queen's Cup	ABAM/VAAL/CLUN	CFS2 18	3715
18. Silver Fir/Alaska Huckleberry/Twinflower	ABAM/VAAL/LIBO2	CFS2 19	3524
19. Silver Fir/Alaska Huckleberry-White Rhododendron	ABAM/VAAL-RHAL	CFS2 20	3449
20. Silver Fir/Beargrass	ABAM/XETE	CFF3 11	3222
21. Silver Fir/Big Huckleberry/Beargrass	ABAM/VAME/XETE	CFS2 11 (OLY)	3224
22. Silver Fir/Depauperate	ABAM/Dep.	CFF9 11	3361
23. Silver Fir/Devil's Club	ABAM/OPHO	CFS3 11 (OLY)	3927
24. Silver Fir/Oxalis	ABAM/OXOR	CFF1 11 (OLY)	3758
25. Silver Fir/Rhododendron	ABAM/RHMA	CFS6 11 (OLY)	3315
26. Silver Fir/Rhododendron-Alaska Huckleberry	ABAM/RHMA-VAAL	CFS6 12	3317
27. Silver Fir/Salal	ABAM/GASH	CFS1 54 (OLY)	3365
28. Silver Fir/Salal/Deerfern	ABAM/GASH/BLSP	CFS1 55	3761
29. Silver Fir/Salal/Oxalis	ABAM/GASH/OXOR	CFS1 56	3750
30. Silver Fir/Skunkcabbage	ABAM/LYAM	CFM1 11	3961
31. Silver Fir/Swordfern	ABAM/POMU	CFF6 11	3753
32. Silver Fir/Swordfern-Oxalis	ABAM/POMU-OXOR	CFF6 12	3756
33. Silver Fir/Vanillaleaf-Foamflower	ABAM/ACTR-TIUN	CFF2 11	3755
SITKA SPRUCE ASSOCIATIONS (PISI Series)			
34. Sitka Spruce/Swordfern-Oxalis	PISI/POMU-OXOR	CSF1 11	1815
SUBALPINE FIR ASSOCIATIONS (ABLA2 Series)			
35. Subalpine Fir/Big Huckleberry	ABLA2/VAME	CES3 21 (OLY)	5233
36. Subalpine Fir/Common Juniper	ABLA2/JUCO4	CES6 21	5161
37. Subalpine Fir/Subalpine Lupine	ABLA2/LULA	CEF3 21	5231
38. Subalpine Fir/White Rhododendron	ABLA2/RHAL	CES2 12 (OLY)	5235
WESTERN HEMLOCK ASSOCIATIONS (TSHE Series)			
39. Western Hemlock/Alaska Huckleberry	TSHE/VAAL	CHS6 21	2638
40. Western Hemlock/Alaska Huckleberry/Beargrass	TSHE/VAAL/XETE	CHS6 22	2557
41. Western Hemlock/Alaska Huckleberry/Oxalis	TSHE/VAAL/OXOR	CHS6 23 (OLY)	2697
42. Western Hemlock/Alaska Huckleberry-Salal	TSHE/VAAL-GASH	CHS6 24 (OLY)	2637
43. Western Hemlock/Beargrass	TSHE/XETE	CHF5 11 (OLY)	2145
44. Western Hemlock/Depauperate	TSHE/Dep.	CHF9 11	2389
45. Western Hemlock/Devil's Club	TSHE/OPHO	CHS5 12 (OLY)	2920
46. Western Hemlock/Oregongrape	TSHE/BENE	CHS1 38 (OLY)	2387
47. Western Hemlock/Oregongrape/Swordfern	TSHE/BENE/POMU	CHS1 39 (OLY)	2632
48. Western Hemlock/Oxalis	TSHE/OXOR	CHF1 12 (OLY)	2695
49. Western Hemlock/Rhododendron	TSHE/RHMA	CHS3 31 (OLY)	2257
50. Western Hemlock/Rhododendron/Beargrass	TSHE/RHMA/XETE	CHS3 32 (OLY)	2253
51. Western Hemlock/Rhododendron-Oregongrape	TSHE/RHMA-BENE	CHS3 33 (OLY)	2254
52. Western Hemlock/Rhododendron-Salal	TSHE/RHMA-GASH	CHS3 34 (OLY)	2255
53. Western Hemlock/Rhododendron/Swordfern	TSHE/RHMA/POMU	CHS3 35 (OLY)	2258
54. Western Hemlock/Salal	TSHE/GASH	CHS1 31 (OLY)	2383
55. Western Hemlock/Salal/Beargrass	TSHE/GASH/XETE	CHS1 32	2271
56. Western Hemlock/Salal-Evergreen Huckleberry	TSHE/GASH/VAOV2	CHS1 33	2530
57. Western Hemlock/Salal-Oceanspray	TSHE/GASH-HODI	CHS1 34	2275
58. Western Hemlock/Salal-Oregongrape	TSHE/GASH-BENE	CHS1 35	2556
59. Western Hemlock/Salal/Oxalis	TSHE/GASH/OXOR	CHS1 36	2693
60. Western Hemlock/Salal/Swordfern	TSHE/GASH/POMU	CHS1 37	2635
61. Western Hemlock/Skunkcabbage	TSHE/LYAM	CHM1 11 (OLY)	2951
62. Western Hemlock/Swordfern-Foamflower	TSHE/POMU-TITR	CHF1 32	2696
63. Western Hemlock/Swordfern-Oxalis	TSHE/POMU-OXOR	CHF1 31 (OLY)	2694
64. Western Hemlock/Vanillaleaf	TSHE/ACTR	CHF2 11 (OLY)	2614

Table 162. Plot distribution by plant association and Ranger District.

PLANT ASSOCIATION	HOOD CANAL	QUILCENE	QUINAULT	SOLEDUCK
DOUGLAS-FIR ASSOCIATIONS				
Douglas-fir/Kinnikinnick	1	7		
Douglas-fir/Oceanspray-Baldhip Rose	2	23		
Douglas-fir/Salal	11	4		
MOUNTAIN HEMLOCK ASSOCIATIONS				
Mountain Hemlock/Alaska Huckleberry	7		4	
Mountain Hemlock/Alaska Huckleberry/Avalanche	8		7	
Mountain Hemlock/Alaska Huckleberry/Beargrass	2		2	
Mountain Hemlock/Big Huckleberry-Alaska Huckleberry		5		1
Mountain Hemlock/Big Huckleberry/Beargrass	4			
Mountain Hemlock/Red Heather-Blueleaf Huckleberry		5		1
Mountain Hemlock/White Rhododendron-Big Huckleberry		13	5	
SILVER FIR ASSOCIATIONS				
Silver Fir/Alaska Huckleberry	14	1	10	6
Silver Fir/Alaska Huckleberry/Avalanche Lily	9		6	2
Silver Fir/Alaska Huckleberry/Beargrass	13			
Silver Fir/Alaska Huckleberry/Foamflower	13	2	4	2
Silver Fir/Alaska Huckleberry-Oregongrape	7		1	1
Silver Fir/Alaska Huckleberry/Oxalis			28	10
Silver Fir/Alaska Huckleberry/Queen's Cup	18	3	15	5
Silver Fir/Alaska Huckleberry/Twinflower	7	4	1	4
Silver Fir/Alaska Huckleberry-White Rhododendron		3	1	
Silver Fir/Beargrass	6			
Silver Fir/Big Huckleberry/Beargrass	5	2		1
Silver Fir/Depauperate		4	4	14
Silver Fir/Devil's Club	8		3	9
Silver Fir/Oxalis			24	22
Silver Fir/Rhododendron	3	13		
Silver Fir/Rhododendron-Alaska Huckleberry	3	6		
Silver Fir/Salal	4	2	2	3
Silver Fir/Salal/Deerfern	2		10	3
Silver Fir/Salal/Oxalis			15	4
Silver Fir/Skunkcabbage			2	
Silver Fir/Swordfern	7	2	4	1
Silver Fir/Swordfern-Oxalis	1		23	7
Silver Fir/Vanillaleaf-Foamflower	4	6		2
SITKA SPRUCE ASSOCIATIONS				
Sitka Spruce/Swordfern-Oxalis			32	32
SUBALPINE FIR ASSOCIATIONS				
Subalpine Fir/Big Huckleberry	3	3		
Subalpine Fir/Common Juniper		4		1
Subalpine Fir/Subalpine Lupine		8		
Subalpine Fir/White Rhododendron		15		
WESTERN HEMLOCK ASSOCIATIONS				
Western Hemlock/Alaska Huckleberry	17		9	2
Western Hemlock/Alaska Huckleberry/Beargrass	3			
Western Hemlock/Alaska Huckleberry/Oxalis	2		16	2
Western Hemlock/Alaska Huckleberry-Salal	10		19	5
Western Hemlock/Beargrass	5			
Western Hemlock/Depauperate	5	12	5	11
Western Hemlock/Devil's Club	9	2		2
Western Hemlock/Oregongrape	8	6		1
Western Hemlock/Oregongrape/Swordfern	29	5	1	2
Western Hemlock/Oxalis	3		25	16
Western Hemlock/Rhododendron	3	26		
Western Hemlock/Rhododendron/Beargrass	5	1		
Western Hemlock/Rhododendron-Oregongrape	3	5		
Western Hemlock/Rhododendron-Salal	18	52		
Western Hemlock/Rhododendron/Swordfern	8	2		
Western Hemlock/Salal	22	9	4	15
Western Hemlock/Salal/Beargrass	31			
Western Hemlock/Salal-Evergreen Huckleberry	4			
Western Hemlock/Salal-Oceanspray	3	15		1
Western Hemlock/Salal-Oregongrape	44	4	3	3
Western Hemlock/Salal/Oxalis			9	2
Western Hemlock/Salal/Swordfern	71	16	9	3
Western Hemlock/Skunkcabbage		1	1	1
Western Hemlock/Swordfern-Foamflower	42	12	6	14
Western Hemlock/Swordfern-Oxalis	4		43	11
Western Hemlock/Vanillaleaf	6	5		2

Table 163. Olympic National Forest Plant Association groups for vegetation stratification for Integrated Resource Inventory.

DOUGLAS-FIR SERIES	
1. DOUGLAS-FIR/EVERGREEN SHRUB	(CDS5)
PSME/HODI-ROGY	CDS2 21
PSME/GASH	CDS2 55
2. DOUGLAS-FIR/BEARBERRY	(CDS0)
PSME/ARUV	CDS6 51
MOUNTAIN HEMLOCK SERIES	
3. MOUNTAIN HEMLOCK/BIG HUCKLEBERRY	(CMSC)
TSME/VAME/XETE (OLY)	CMS2 45
TSME/VAAL/XETE	CMS2 43
4. MOUNTAIN HEMLOCK SUBALPINE PARKS	(CAS2)
TSME/PHEM-VADE	CMS3 11
5. MOUNTAIN HEMLOCK/ALASKA HUCKLEBERRY	(CMSW)
TSME/VAAL	CMS2 41
TSME/VAAL/ERMO	CMS2 42
TSME/VAAL-VAME	CMS2 44
TSME/RHAL-VAME	CMS3 12
SILVER FIR SERIES	
6. SILVER FIR/SALAL-OREGONGRAPE	(CFS1)
ABAM/GASH (OLY)	CFS1 54
ABAM/Depauperate	CFF9 11
7. SILVER FIR/FORBS,WARM	CFFW)
ABAM/OXOR (OLY)	CFF1 11
ABAM/ACTR-TIUN	CFF2 11
ABAM/POMU	CFF6 11
ABAM/POMU-OXOR	CFF6 12
8. SILVER FIR/DEVIL'S CLUB	(CFS3)
ABAM/OPHO (OLY)	CFS3 11
ABAM/LYAM	CFM1 11
9. SILVER FIR/AZALEA-MENZIESIA	(CFS5)
ABAM/VAAL-RHAL	CFS2 20
ABAM/VAAL/TIUN	CFS2 15

Table 163 (cont.). Olympic National Forest Plant Association groups for vegetation stratification for Integrated Resource Inventory.

10. SILVER FIR/SHRUB-BEARGRASS	(CFF3)
ABAM/VAME/XETE	CFS2 11
ABAM/XETE	CFF3 11
11. SILVER FIR/RHODODENDRON	(CFS6)
ABAM/RHMA (OLY)	CFS6 11
ABAM/RHMA-VAAL	CFS6 12
12. SILVER FIR/COASTAL	(CFSF)
ABAM/GASH/BLSP	CFS1 55
ABAM/GASH/OXOR	CFS1 56
ABAM/VAAL/OXOR	CFS2 17
ABAM/VAAL/ERMO	CFS2 13
13. SILVER FIR/MOIST SHRUB	(CFSM)
ABAM/VAAL (OLY)	CFS2 12
ABAM/VAAL/CLUN	CFS2 18
14. SILVER FIR/SHRUB, COOL	(CFSC)
ABAM/VAAL-BENE	CFS2 16
ABAM/VAAL/LIBO2	CFS2 19
15. SILVER FIR/SHRUB, DRY	(CFSD)
ABAM/VAAL/XETE	CFS2 14
SITKA SPRUCE SERIES	
16. SITKA SPRUCE/SWORDFERN	(CSF1)
PISI/POMU-OXOR	CSF1 11
SUBALPINE FIR SERIES	
17.SUBALPINE FIR/AZALEA	(CES2)
ABLA2/RHAL (OLY)	CES2 12
ABLA2/JUCO4	CES6 21
18. SUBALPINE FIR/HUCKLEBERRY	(CES3)
ABLA2/VAME (OLY)	CES2 21
19. SUBALPINE FIR/DRY FORB	(CEFD)
ABLA2/LULA	CAG3

Table 163 (cont.). Olympic National Forest Plant Association groups for vegetation stratification for Integrated Resource Inventory.

WESTERN HEMLOCK SERIES

20. WESTERN HEMLOCK/MOIST SHRUBS	(CHS4)
TSHE/LYAM (OLY)	CHM1 11
TSHE/OPHO	CHS5 12
21. WESTERN HEMLOCK/SALAL-OREGONGRAPE	(CHS1)
TSHE/GASH-VAOV2CHSI 33	
TSHE/GASH/POMU	CHS1 37
TSHE/BENE/POMU	CHS1 39
TSHE/VAAL	CHS6 21
TSHE/VAAL-GASH	CHS6 24
22. WESTERN HEMLOCK/SWORDFERN-OXALIS	(CHF1)
TSHE/OXOR (OLY)	CHF1 12
TSHE/POMU-OXOR (OLY)	CHF1 31
TSHE/POMU-TITR	CHF1 32
23. WESTERN HEMLOCK/RHODODENDRON, COOL	(CHSC)
TSHE/RHMA/POMU	CHS3 35
24. WESTERN HEMLOCK/DRY FORBS	(CHF2)
TSHE/ACTR (OLY)	CHF2 11
25. WESTERN HEMLOCK/RHODODENDRON, WARM	(CHSW)
TSHE/XETE (OLY)	CHF5 11
TSHE/GASH/XETE	CHS1 32
TSHE/GASH-HODI	CHS1 34
TSHE/RHMA/XETE (OLY)	CHS3 32
TSHE/RHMA (OLY)	CHS3 31
TSHE/RHMA-BENE (OLY)	CHS3 33
TSHE/RHMA-GASH (OLY)	CHS3 34
TSHE/VAAL/XETE	CHS6 22
26. WESTERN HEMLOCK/SALAL-OREGONGRAPE, DRY	(CHSD)
TSHE/Depauperate	CHF9 11
TSHE/GASH (OLY)	CHS1 31
TSHE/GASH-BENE	CHS1 35
TSHE/BENE (OLY)	CHS1 38
27. WESTERN HEMLOCK/SHRUB-OXALIS	(CHSF)
TSHE/GASH/OXOR	CHS1 36
TSHE/VAAL/OXOR (OLY)	CHS6 23

Table 164. Vascular plant species encountered in sampling forest habitats.

ABAM	*Abies amabilis*
ABGR	*Abies grandis*
ABLA2	*Abies lasiocarpa*
ABPR	*Abies procera*
ACCI	*Acer circinatum*
ACGL	*Acer glabrum*
ACMA	*Acer macrophyllum*
ACMI	*Achillea millefolium*
ACTR	*Achlys triphylla*
ACRU	*Actaea rubra*
ADBI	*Adenocaulon bicolor*
ADPE	*Adiantum pedatum*
AGAU	*Agoseris aurantiaca*
AGGL	*Agoseris glauca*
AGGR	*Agoseris grandiflora*
AGAL	*Agrostis alba*
AGEX	*Agrostis exarata*
AGOR	*Agrostis oregonensis*
AGSC	*Agrostis scabra*
AGTE	*Agrostis tenuis*
AICA	*Aira caryophyllea*
ALAC	*Allium acuminatum*
ALCE	*Allium cernuum*
ALCR	*Allium crenulatum*
ALVI	*Allotropa virgata*
ALRU	*Alnus rubra*
ALSI	*Alnus sinuata*
AMAL	*Amelanchier alnifolia*
ANMA	*Anaphalis margaritacea*
ANDR	*Anemone drummondii*
ANLY2	*Anemone lyallii*
ANMU	*Anemone multifida*
ANOR	*Anemone oregana*
ANAR2	*Angelica arguta*
ANGE	*Angelica genuflexa*
ANAL	*Antennaria alpina*
ANLA	*Antennaria lanata*
ANMI2	*Antennaria microphylla*
ANNE2	*Antennaria neglecta*
ANRA	*Antennaria racemosa*
APAN	*Apocynum androsaemifolium*
AQFO	*Aquilegia formosa*
ARHI	*Arabis hirsuta*
ARLE	*Arabis lemmonii*
ARME	*Arbutus menziesii*
ARCA6	*Arceuthobium campylopodum* f. *tsugensis*
ARCO3	*Arctostaphylos columbiana*
ARNE	*Arctostaphylos nevadensis*
ARUV	*Arctostaphylos uva-ursi*
ARCA2	*Arenaria capillaris*
ARMA3	*Arenaria macrophylla*
AROB	*Arenaria obtusiloba*
ARCO	*Arnica cordifolia*
ARLA	*Arnica latifolia*
ARMO	*Arnica mollis*
ARSY	*Aruncus sylvester*
ASCA3	*Asarum caudatum*
ASDE	*Aspidotis densa*
ASTR	*Asplenium trichomanes*
ASRA	*Aster radulinus*
ATFI	*Athyrium filix-femina*
BENE	*Berberis nervosa*
BLSP	*Blechnum spicant*
BOHO	*Boschniakia hookeri*
BOLA	*Botrychium lanceolatum*
BOMU	*Botrychium multifidum*
BOVI	*Botrychium virginianum*
BOEL	*Boykinia elata*
BOMA	*Boykinia major*
BRCA	*Bromus carinatus*
BRCI	*Bromus ciliatus*
BRPA	*Bromus pacificus*
BRSI	*Bromus sitchensis*
BRVU	*Bromus vulgaris*
CACA	*Calamagrostis canadensis*
CABI	*Caltha biflora*
CABU2	*Calypso bulbosa*
CAPI	*Campanula piperi*
CARO3	*Campanula rotundifolia*
CASC2	*Campanula scouleri*
CAAN2	*Cardamine angulata*
CAOL	*Cardamine oligosperma*
CAPE4	*Cardamine pensylvanica*
CAAP3	*Carex aperta*
CABR6	*Carex brunnescens*
CACA2	*Carex californica*
CADE	*Carex deweyana*
CAHE	*Carex hendersoni*
CAIN5	*Carex interior*
CALA	*Carex laeviculmis*
CALE5	*Carex lenticularis*
CAME2	*Carex mertensii*
CAMU2	*Carex muricata*
CANI2	*Carex nigricans*
CAPA	*Carex pachystachya*
CAPE5	*Carex pensylvanica*
CAPH	*Carex phaeocephala*
CARO	*Carex rossii*
CASI3	*Carex sitchensis*
CASP	*Carex spectabilis*
CAVE	*Carex vesicaria*
CAME	*Cassiope mertensiana*
CAHI2	*Castilleja hispida*
CAMI2	*Castilleja miniata*
CAPA3	*Castilleja parviflora*
CESA	*Ceanothus sanguineus*
CEAR	*Cerastium arvense*
CENU	*Cerastium nutans*
CEVU	*Cerastium vulgatum*
CHNO	*Chamaecyparis nootkatensis*
CHME	*Chimaphila menziesii*
CHUM	*Chimaphila umbellata*
CHLE2	*Chrysanthemum leucanthemum*
CHGL	*Chrysosplenium glechomaefolium*
CILA2	*Cinna latifolia*
CIAL	*Circaea alpina*
CIAR	*Cirsium arvense*
CIED	*Cirsium edule*
CIVU	*Cirsium vulgare*
CLLA	*Claytonia lanceolata*

Table 164 (cont.). Vascular plant species encountered in sampling of forest habitats.

CLUN	*Clintonia uniflora*
COPA	*Collinsia parviflora*
COHE	*Collomia heterophylla*
COLA	*Coptis laciniata*
COMA3	*Corallorhiza maculata*
COME	*Corallorhiza mertensiana*
COCA	*Cornus canadensis*
CONU	*Cornus nuttallii*
COST	*Cornus stolonifera*
COSC	*Corydalis scouleri*
COCO2	*Corylus cornuta*
CRDO	*Crataegus douglasii*
CRCA	*Crepis capillaris*
CRCR	*Cryptogramma crispa*
CYFR	*Cystopteris fragilis*
DAGL	*Dactylis glomerata*
DACA	*Danthonia californica*
DAIN	*Danthonia intermedia*
DASP	*Danthonia spicata*
DEGL2	*Delphinium glareosum*
DEAT	*Deschampsia atropurpurea*
DECA	*Deschampsia caespitosa*
DEEL	*Deschampsia elongata*
DIFO	*Dicentra formosa*
DIPU	*Digitalis purpurea*
DIHO	*Disporum hookeri*
DISM	*Disporum smithii*
DOLA	*Douglasia laevigata*
DRAU2	*Dryopteris austriaca*
EBAU	*Eburophyton austiniae*
ELGL	*Elymus glaucus*
ELHI	*Elymus hirsutus*
EPAL	*Epilobium alpinum*
EPALL	*Epilobium alpinum lactiflorum*
EPAN	*Epilobium angustifolium*
EPGL	*Epilobium glaberrimum*
EPGL2	*Epilobium glandulosum*
EPLA	*Epilobium latifolium*
EPMI	*Epilobium minutum*
EPPA	*Epilobium paniculatum*
EQAR	*Equisetum arvense*
EQHY	*Equisetum hyemale*
ERFL2	*Erigeron flettii*
ERPE	*Erigeron peregrinus*
ERLA	*Eriophyllum lanatum*
ERGR	*Erythronium grandiflorum*
ERMO	*Erythronium montanum*
EROR	*Erythronium oregonum*
ERRE2	*Erythronium revolutum*
FEAR3	*Festuca arundinacea*
FEID	*Festuca idahoensis*
FEOC	*Festuca occidentalis*
FEOV	*Festuca ovina*
FEPR	*Festuca pratensis*
FERU	*Festuca rubra*
FESU	*Festuca subulata*
FESU2	*Festuca subuliflora*
FRVE	*Fragaria vesca*
FRVI	*Fragaria virginiana*
FRLA	*Fritillaria lanceolata*
GAAP	*Galium aparine*
GABI	*Galium bifolium*
GABO	*Galium boreale*
GAOR	*Galium oreganum*
GATR	*Galium triflorum*
GAOV	*Gaultheria ovatifolia*
GASH	*Gaultheria shallon*
GEMA	*Geum macrophyllum*
GLEL	*Glyceria elata*
GOOB	*Goodyera oblongifolia*
GYDR	*Gymnocarpium dryopteris*
HADI2	*Habenaria dilatata*
HAHY	*Habenaria hyperborea*
HAOR	*Habenaria orbiculata*
HASA	*Habenaria saccata*
HEOC	*Hedysarum occidentale*
HELA	*Heracleum lanatum*
HEGL2	*Heuchera glabra*
HEMI	*Heuchera micrantha*
HIAL	*Hieracium albiflorum*
HIGR	*Hieracium gracile*
HOLA	*Holcus lanatus*
HODI	*Holodiscus discolor*
HYTE	*Hydrophyllum tenuipes*
HYPE	*Hypericum perforatum*
HYRA	*Hypochaeris radicata*
HYMO	*Hypopitys monotropa*
ILAQ	*Ilex aquifolium*
JUEF	*Juncus effusus*
JUEN	*Juncus ensifolius*
JUPA	*Juncus parryi*
JUSU	*Juncus supiniformis*
JUCO4	*Juniperus communis*
JUSC	*Juniperus scopulorum*
LAMU	*Lactuca muralis*
LAPU2	*Lamium purpureum*
LANE	*Lathyrus nevadensis*
LEGR	*Ledum groenlandicum*
LEPY2	*Leptarrhena pyrolifolia*
LECO	*Lewisia columbiana*
LICA2	*Ligusticum canbyi*
LIGR	*Ligusticum grayi*
LICO4	*Lilium columbianum*
LIBO2	*Linnaea borealis*
LICA3	*Listera caurina*
LICO2	*Listera convallarioides*
LICO3	*Listera cordata*
LOPE2	*Lolium perenne*
LOMA2	*Lomatium martindalei*
LOCI	*Lonicera ciliosa*
LOHI	*Lonicera hispidula*
LOIN	*Lonicera involucrata*
LOUT2	*Lonicera utahensis*
LOCO3	*Lotus corniculatus*
LOMI	*Lotus micranthus*
LUPE	*Luetkea pectinata*
LUHY	*Luina hypoleuca*
LULA	*Lupinus latifolius*
LULE2	*Lupinus lepidus*
LURI	*Lupinus rivularis*
LUCA2	*Luzula campestris*

Table 164 (cont.). Vascular plants species encountered in sampling of forest habitats.

LUHI	*Luzula hitchcockii*
LUPA	*Luzula parviflora*
LUSP	*Luzula spicata*
LYAN	*Lycopodium annotinum*
LYCL	*Lycopodium clavatum*
LYCO2	*Lycopodium complanatum*
LYSE	*Lycopodium selago*
LYAM	*Lysichitum americanum*
MAEX	*Madia exigua*
MAMA	*Madia madioides*
MASA	*Madia sativa*
MADI2	*Maianthemum dilatatum*
MEFA	*Medicago falcata*
MESU	*Melica subulata*
MEAR3	*Mentha arvensis*
METR	*Menyanthes trifoliata*
MEFE	*Menziesia ferruginea*
MEPA	*Mertensia paniculata*
MIAL	*Mimulus alsinoides*
MIDE	*Mimulus dentatus*
MIGU	*Mimulus guttatus*
MILE	*Mimulus lewisii*
MIBR	*Mitella breweri*
MICA3	*Mitella caulescens*
MIOV	*Mitella ovalis*
MIPE	*Mitella pentandra*
MOUN2	*Monotropa uniflora*
MOPA	*Montia parvifolia*
MOSI	*Montia sibirica*
NEPA	*Nemophila parviflora*
NEPE	*Nemophila pedunculata*
NONE	*Nothochelone nemorosa*
NUPO	*Nuphar polysepala*
OECE	*Oemelaria cerasiformis*
OESA	*Oenanthe sarmentosa*
OPHO	*Oplopanax horridum*
OSCH	*Osmorhiza chilensis*
OSPU	*Osmorhiza purpurea*
OXOR	*Oxalis oregana*
PAMY	*Pachistima myrsinites*
PAFI	*Parnassia fimbriata*
PERA	*Pedicularis racemosa*
PEDA	*Penstemon davidsonii*
PEOV	*Penstemon ovatus*
PEPR	*Penstemon procerus*
PEFR2	*Petasites frigidus*
PEFRP	*Petasites frigidus palmatus*
PEHE	*Petrophytum hendersonii*
PHHE	*Phacelia heterophylla*
PHLE2	*Philadelphus lewisii*
PHAL	*Phleum alpinum*
PHPR	*Phleum pratense*
PHDI	*Phlox diffusa*
PHEM	*Phyllodoce empetriformis*
PISI	*Picea sitchensis*
PIAL	*Pinus albicaulis*
PICO	*Pinus contorta*
PIMO	*Pinus monticola*
PIPO	*Pinus ponderosa*
PITR	*Pityrogramma triangularis*
PLLA	*Plantago lanceolata*
PLRE	*Pleuropogon refractus*
POCU	*Poa cusickii*
POMA3	*Poa marcida*
POPA	*Poa palustris*
POPR	*Poa pratensis*
POTR3	*Poa trivialis*
POPU	*Polemonium pulcherrimum*
POBI	*Polygonum bistortoides*
POGL4	*Polypodium glycyrrhiza*
POHE2	*Polypodium hesperium*
POKR	*Polystichum kruckebergii*
POLO2	*Polystichum lonchitis*
POMU	*Polystichum munitum*
POTR2	*Populus trichocarpa*
POFR	*Potentilla fruticosa*
POGR	*Potentilla gracilis*
PRVU	*Prunella vulgaris*
PREM	*Prunus emarginata*
PSME	*Pseudotsuga menziesii*
PSPH	*Psoralea physodes*
PTAQ	*Pteridium aquilinum*
PTAN	*Pterospora andromedea*
PUPA	*Puccinellia pauciflora*
PYAS	*Pyrola asarifolia*
PYCH	*Pyrola chlorantha*
PYPI	*Pyrola picta*
PYSE	*Pyrola secunda*
PYUN	*Pyrola uniflora*
PYFU	*Pyrus fusca*
QUGA	*Quercus garryana*
RAPE	*Ranunculus pensylvanicus*
RARE	*Ranunculus repens*
RAUN2	*Ranunculus uncinatus*
RHPU	*Rhamnus purshiana*
RHAL	*Rhododendron albiflorum*
RHMA	*Rhododendron macrophyllum*
RIBR	*Ribes bracteosum*
RIHO	*Ribes howellii*
RILA	*Ribes lacustre*
RILO	*Ribes lobbii*
RISA	*Ribes sanguineum*
RITR	*Ribes triste*
RONA	*Rorippa nasturtium-aquaticum*
ROGY	*Rosa gymnocarpa*
RULA2	*Rubus laciniatus*
RULA	*Rubus lasiococcus*
RULE	*Rubus leucodermis*
RUNI	*Rubus nivalis*
RUPA	*Rubus parviflorus*
RUPE	*Rubus pedatus*
RUPR	*Rubus procerus*
RUSP	*Rubus spectabilis*
RUUR	*Rubus ursinus*
RUAC	*Rumex acetosella*
RUCR	*Rumex crispus*
RUOB	*Rumex obtusifolius*
RUOC2	*Rumex occidentalis*
SALA2	*Salix lasiandra*
SASC	*Salix scouleriana*

Table 164 (cont.). Vascular plant species encountered in sampling of forest habitats.

SACE	*Sambucus cerulea*
SARA	*Sambucus racemosa*
SAGR	*Sanicula graveolens*
SADO	*Satureja douglasii*
SAAR4	*Saxifraga arguta*
SABR	*Saxifraga bronchialis*
SAFE	*Saxifraga ferruginea*
SAME3	*Saxifraga mertensiana*
SAOC	*Saxifraga occidentalis*
SAPU	*Saxifraga punctata*
SCMI	*Scirpus microcarpus*
SEDI	*Sedum divergens*
SEOR2	*Sedum oreganum*
SESP	*Sedum spathulifolium*
SEDE3	*Selaginella densa*
SEOR	*Selaginella oregana*
SEWA2	*Selaginella wallacei*
SEFL2	*Senecio flettii*
SEJA	*Senecio jacobaea*
SELU2	*Senecio lugens*
SESY	*Senecio sylvaticus*
SETR	*Senecio triangularis*
SIPA	*Silene parryii*
SMRA	*Smilacina racemosa*
SMST	*Smilacina stellata*
SOMU	*Solidago multiradiata*
SOAU	*Sorbus aucuparia*
SOSI	*Sorbus sitchensis*
SPAN	*Sparganium angustifolium*
SPRU	*Spergularia rubra*
SPBE	*Spiraea betulifolia*
SPDO	*Spiraea douglasii*
STME2	*Stachys mexicana*
STCA2	*Stellaria calycantha*
STCR	*Stellaria crispa*
STME	*Stellaria media*
STOC2	*Stenanthium occidentale*
STOC	*Stipa occidentalis*
STAM	*Streptopus amplexifolius*
STRO	*Streptopus roseus*
STST	*Streptopus streptopoides*
SYAL	*Symphoricarpos albus*
SYMO	*Symphoricarpos mollis*
SYSC	*Synthyris schizantha*
TAOF	*Taraxacum officinale*
TABR	*Taxus brevifolia*
TEGR	*Tellima grandiflora*
THFE2	*Thalictrum fendleri*
THOC	*Thalictrum occidentale*
THPL	*Thuja plicata*
TITR	*Tiarella trifoliata*
TIUN	*Tiarella unifoliata*
TOGL	*Tofieldia glutinosa*
TOME	*Tolmiea menziesii*
TRCA3	*Trautvetteria caroliniensis*
TRLA2	*Trientalis latifolia*
TRRE	*Trifolium repens*
TROV	*Trillium ovatum*
TRCA	*Trisetum canescens*
TRCE	*Trisetum cernuum*
TRSP	*Trisetum spicatum*
TSHE	*Tsuga heterophylla*
TSME	*Tsuga mertensiana*
URDI	*Urtica dioica*
VAAL	*Vaccinium alaskaense*
VADE	*Vaccinium deliciosum*
VAME	*Vaccinium membranaceum*
VAOV	*Vaccinium ovalifolium*
VAOV2	*Vaccinium ovatum*
VAPA	*Vaccinium parvifolium*
VASI	*Valeriana sitchensis*
VEVI	*Veratrum viride*
VEAM	*Veronica americana*
VEAR	*Veronica arvensis*
VECH	*Veronica chamaedrys*
VECU	*Veronica cusickii*
VESC	*Veronica scutellata*
VIAM	*Vicia americana*
VIGI	*Vicia gigantea*
VISA	*Vicia sativa*
VIAD	*Viola adunca*
VIFL2	*Viola flettii*
VIGL	*Viola glabella*
VIHO	*Viola howellii*
VIOR2	*Viola orbiculata*
VISE	*Viola sempervirens*
XETE	*Xerophyllum tenax*
ZIEL	*Zigadenus elegans*

Table 165. Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Douglas-fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS		
		PSME/ ARUV	PSME/ HODI-ROGY	PSME/ GASH
ECOCLASS Code		CDS6 51	CDS2 21	CDS2 55
Number of plots		7	17	7
TREES				
ABGR	*Abies grandis*		2.2	
ABLA2	*Abies lasiocarpa*	0.1		
ACMA	*Acer macrophyllum*			
ARME	*Arbutus menziesii*		1.5	0.9
CONU	*Cornus nuttallii*			1.9
JUSC	*Juniperus scopulorum*	0.4	0.5	
PICO	*Pinus contorta*	12.6		
PIMO	*Pinus monticola*	0.3	0.1	1.0
PREM	*Prunus emarginata*	0.7		
PSME	*Pseudotsuga menziesii*	48.7	73.2	70.6
PYFU	*Pyrus fusca*		0.1	
QUGA	*Quercus garryana*		0.2	
RHPU	*Rhamnus purshiana*			
SASC	*Salix scouleriana*			0.4
TABR	*Taxus brevifolia*		0.4	
THPL	*Thuja plicata*		0.5	0.9
TSHE	*Tsuga heterophylla*	0.6	1.5	2.4
SHRUBS and HERBS				
ACCI	*Acer circinatum*			10.1
ACGL	*Acer glabrum*	0.7	3.4	1.1
ACMI	*Achillea millefolium*	0.4	0.9	0.1
ACTR	*Achlys triphylla*	0.1	3.2	0.1
ADBI	*Adenocaulon bicolor*		1.4	0.1
ALCE	*Allium cernuum*	0.1	0.2	
ALCR	*Allium crenulatum*	0.9		
ALVI	*Allotropa virgata*		0.1	0.1
AMAL	*Amelanchier alnifolia*	0.4	0.6	0.6
ANLY2	*Anemone lyallii*	0.3	0.1	
ANNE2	*Antennaria neglecta*	0.3		
ANRA	*Antennaria racemosa*		0.2	
ARCO3	*Arctostaphylos columbiana*	0.1	0.2	1.9
ARUV	*Arctostaphylos uva-ursi*	20.4	0.3	8.3
ARMA3	*Arenaria macrophylla*	0.6	1.4	0.3
ASRA	*Aster radulinus*	0.1	0.1	
BENE	*Berberis nervosa*	3.7	3.2	12.4
BRVU	*Bromus vulgaris*	0.6	6.8	0.1
CASC2	*Campanula scouleri*	0.4	1.6	0.6
CARO	*Carex rossii*		0.1	0.1
CAHI2	*Castilleja hispida*		0.1	0.1
CAMI2	*Castilleja miniata*	0.1	0.1	
CHME	*Chimaphila menziesii*		0.1	0.3
CHUM	*Chimaphila umbellata*	0.9	0.9	1.1
COPA	*Collinsia parviflora*	0.3	0.1	0.3
COHE	*Collomia heterophylla*		0.3	0.3
COME	*Corallorhiza mertensiana*		0.2	
COCO2	*Corylus cornuta*			0.3
ELGL	*Elymus glaucus*	0.9	1.2	
EPMI	*Epilobium minutum*	0.1	0.1	
ERLA	*Eriophyllum lanatum*	0.3	0.2	
EROR	*Erythronium oregonum*		0.1	
FEID	*Festuca idahoensis*	0.3	0.1	
FEOC	*Festuca occidentalis*	1.6	4.4	2.1
FRVE	*Fragaria vesca*	0.4	1.4	0.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 18 p. 95 for mean relative cover values.

Table 165 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Douglas-fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS		
		PSME/ ARUV	PSME/ HODI-ROGY	PSME/ GASH
ECOCLASS Code		CDS6 51	CDS2 21	CDS2 55
Number of plots		7	17	7
SHRUBS and HERBS (cont.)				
FRVI	*Fragaria virginiana*	0.1	0.7	
FRLA	*Fritillaria lanceolata*		0.1	0.1
GATR	*Galium triflorum*		0.4	
GASH	*Gaultheria shallon*		0.2	56.4
GOOB	*Goodyera oblongifolia*	0.1	0.5	0.6
HEGL2	*Heuchera glabra*		0.1	0.1
HEMI	*Heuchera micrantha*		0.1	
HIAL	*Hieracium albiflorum*	1.0	0.9	1.0
HODI	*Holodiscus discolor*	3.7	8.6	2.4
HYRA	*Hypochaeris radicata*		0.6	0.1
HYMO	*Hypopitys monotropa*		0.1	
JUCO4	*Juniperus communis*	0.6	0.5	
LAMU	*Lactuca muralis*		0.1	
LANE	*Lathyrus nevadensis*		0.5	
LICO4	*Lilium columbianum*		0.1	0.1
LIBO2	*Linnaea borealis*	0.1	0.3	1.6
LOMA2	*Lomatium martindalei*	1.3	0.1	0.1
LOCI	*Lonicera ciliosa*	0.3	0.5	0.1
LULA	*Lupinus latifolius*	2.9		
LUCA2	*Luzula campestris*		0.2	
LYAM	*Lysichitum americanum*			0.1
MAMA	*Madia madioides*		0.2	
MESU	*Melica subulata*		0.5	
MOPA	*Montia parvifolia*	0.1	0.4	0.1
NONE	*Nothochelone nemorosa*	0.4		0.4
OSCH	*Osmorhiza chilensis*		0.6	
PAMY	*Pachistima myrsinites*	0.9	0.8	0.1
PHLE2	*Philadelphus lewisii*		0.1	
POGL4	*Polypodium glycyrrhiza*		0.2	0.1
POHE2	*Polypodium hesperium*	0.1	0.1	
POMU	*Polystichum munitum*	0.1	0.6	2.7
PTAQ	*Pteridium aquilinum*		0.1	0.3
PYSE	*Pyrola secunda*	0.1		
RHMA	*Rhododendron macrophyllum*			1.9
RISA	*Ribes sanguineum*		0.1	0.1
ROGY	*Rosa gymnocarpa*	1.9	6.7	1.1
RUUR	*Rubus ursinus*		0.1	0.6
SADO	*Satureja douglasii*		0.1	
SESP	*Sedum spathulifolium*		0.1	
SEWA2	*Selaginella wallacei*	0.3		0.1
SYMO	*Symphoricarpos mollis*	1.0	4.2	0.7
TRLA2	*Trientalis latifolia*	0.4	1.1	1.1
TROV	*Trillium ovatum*			
TRCA	*Trisetum canescens*		0.2	
VAME	*Vaccinium membranaceum*		0.1	
VAPA	*Vaccinium parvifolium*	0.1	0.2	1.4
VIAM	*Vicia americana*		0.4	
VIAD	*Viola adunca*		0.2	
VISE	*Viola sempervirens*		0.1	0.1
XETE	*Xerophyllum tenax*			1.0

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 18 p. 95 for mean relative cover values.

Table 166. Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Mountain Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS						
		TSME/ VAAL	TSME/ VAAL/ERMO	TSME/ VAAL/XETE	TSME/ VAME-VAAL	TSME/ VAME/XETE	TSME/ PHEM-VADE	TSME/ RHAL-VAME
ECOCLASS Code		CMS2 41	CMS2 42	CMS2 43	CMS2 44	CMS2 45(OLY)	CMS3 11	CMS3 12
Number of plots		10	16	4	6	2	5	12
TREES								
ABAM	*Abies amabilis*	61.9	44.0	45.0	37.5	41.0	7.0	42.1
ABLA2	*Abies lasiocarpa*					7.5	4.6	5.6
CHNO	*Chamaecyparis nootkatensis*	4.9	9.1	14.0	9.0	15.0	5.8	16.8
PIAL	*Pinus albicaulis*							
PIMO	*Pinus monticola*				0.2			
PSME	*Pseudotsuga menziesii*		0.1	1.8	0.3	12.5		0.4
TABR	*Taxus brevifolia*		0.3		0.2			
THPL	*Thuja plicata*	0.6	0.6					
TSHE	*Tsuga heterophylla*	7.2	3.7	5.8	2.7	5.0		8.7
TSME	*Tsuga mertensiana*	30.0	33.7	53.5	24.2	17.5	25.0	37.9
SHRUBS and HERBS								
ACCI	*Acer circinatum*		0.3					
ACMI	*Achillea millefolium*						0.4	
ACTR	*Achlys triphylla*	0.1	0.1			1.5		
ALSI	*Alnus sinuata*		0.8		0.2			1.6
ANAL	*Antennaria alpina*						0.2	
ARUV	*Arctostaphylos uva-ursi*					0.5		0.2
ARCA6	*Arceuthobium campylopodum* f. *tsugensis*		0.1					
ARLA	*Arnica latifolia*						0.6	1.0
ARSY	*Aruncus sylvester*	0.1	0.1					
ATFI	*Athyrium filix-femina*	0.3		0.3				0.1
BENE	*Berberis nervosa*					1.0		
BLSP	*Blechnum spicant*	0.7	1.8	1.0	0.2			
CABI	*Caltha biflora*	0.3		0.3			0.2	
CARO3	*Campanula rotundifolia*						0.2	0.1
CAIN5	*Carex interior*		0.1	0.3				
CANI2	*Carex nigricans*						0.4	
CAME	*Cassiope mertensiana*	0.1					3.8	0.5
CAPA3	*Castilleja parviflora*						0.4	
CHME	*Chimaphila menziesii*		0.1			0.5		
CHUM	*Chimaphila umbellata*					0.5		0.1
CLUN	*Clintonia uniflora*	3.0	0.1	6.5		1.0		0.3
COME	*Corallorhiza mertensiana*	0.2	0.1					
COCA	*Cornus canadensis*	0.3	0.2	1.3				
CRCR	*Cryptogramma crispa*		0.1				0.4	0.1
OEAT	*Deschampsia atropurpurea*						0.4	
ORAU2	*Dryopteris austriaca*	0.1	0.1					
ERFL2	*Erigeron flettii*							
ERPE	*Erigeron peregrinus*						0.2	0.1
ERMO	*Erythronium montanum*	0.8	13.6	0.5	1.0		2.2	0.9
FEID	*Festuca idahoensis*						0.6	
FEOC	*Festuca occidentalis*							0.1
GAOV	*Gaultheria ovatifolia*		0.3	0.3	0.3	0.5		
GASH	*Gaultheria shallon*				0.2			
GOOB	*Goodyera oblongifolia*	0.1	0.4	0.3	0.3			0.3
GYDR	*Gymnocarpium dryopteris*	0.1	0.1					0.1
HYMO	*Hypopitys monotropa*	0.1	0.1		0.3			0.2
JUPA	*Juncus parryi*						1.2	
JUCO4	*Juniperus communis*							0.2

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 26 p. 115 for mean relative cover values.

Table 166 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Mountain Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS						
		TSME/ VAAL	TSME/ VAAL/ERMO	TSME/ VAAL/XETE	TSME/ VAME-VAAL	TSME/ VAME/XETE	TSME/ PHEM-VADE	TSME/ RHAL-VAME
ECOCLASS Code		CMS2 41	CMS2 42	CMS2 43	CMS2 44	CMS2 45	CMS3 11	CMS3 12
Number of plots		10	16	4	6	2	5	12
SHRUBS and HERBS (cont.)								
LICO4	*Lilium columbianum*	0.1						0.1
LIBO2	*Linnaea borealis*	0.1	0.1	0.3				0.1
LICA3	*Listera caurina*		0.1					0.2
LICO2	*Listera convallarioides*		0.2	0.3				
LICO3	*Listera cordala*		0.1	0.3	0.2			0.1
LOMA2	*Lomalium martindalei*						0.6	0.1
LUPE	*Luetkea peclinala*	0.1	0.1				0.4	0.3
LUPA	*Luzula parviflora*	0.1	0.1	0.3			0.4	0.2
LYCL	*Lycopodium clavatum*			0.8	0.2			
LYSE	*Lycopodium selago*	0.1						
LYAM	*Lysichitum americanum*			1.0				
MADI2	*Maianthemum dilalatum*	0.5	0.1	0.8				
MEFE	*Menziesia ferruginea*	2.1	1.9	4.3	4.2		0.4	2.8
NONE	*Nolhochelone nemorosa*		0.1			0.5	0.2	0.2
OPHO	*Oplopanax horridum*	0.4						
PAMY	*Pachistima myrsiniles*		0.1				1.2	
PERA	*Pedicularis racemosa*						0.6	0.2
PHDI	*Phlox diffusa*						1.0	0.1
PHEM	*Phyllodoce empetriformis*		1.1		1.3		34.8	1.7
POPU	*Polemonium pulcherrimum*							0.1
POLO2	*Polyslichum lonchitis*	0.1						0.1
POMU	*Polyslichum munitum*	0.1	0.3					0.1
PUPA	*Puccinellia pauciflora*	0.1		0.3				
PYAS	*Pyrola asarifolia*		0.1					0.1
PYSE	*Pyrola secunda*	0.5	0.1	0.3	0.2	1.5		0.8
RHAL	*Rhododendron albiflorum*	1.3	3.9		1.3		0.2	22.1
RIBR	*Ribes bracteosum*	0.1	0.1					
RIHO	*Ribes howellii*	0.1	0.1					0.1
ROGY	*Rosa gymnocarpa*							0.1
RULA	*Rubus lasiococcus*	0.6	0.4	0.3	0.5		0.4	1.3
RUPE	*Rubus pedatus*	14.6	5.3	4.3	1.0		0.6	4.3
RUSP	*Rubus speclabilis*	0.6	0.1	0.3				
SAFE	*Saxifraga ferruginea*		0.1				0.4	0.1
SMRA	*Smilacina racemosa*	0.1	0.1	0.3				
SMST	*Smilacina slellala*	0.1						
SOSI	*Sorbus sitchensis*	0.4	0.6	0.5	0.7	0.5		0.4
STAM	*Slreplopus amplexifolius*		0.1	0.3				
STRO	*Streplopus roseus*	0.7	0.2	0.3				0.1
SYSC	*Synthyris schizantha*		0.1					
TITR	*Tiarella lrifoliala*		0.3	0.3				
TIUN	*Tiarella unifoliala*	0.7	0.4					0.1
TRCA3	*Trautvetteria caroliniensis*		0.1	0.5				
TROV	*Trillium ovatum*	0.2	0.1					
VAAL	*Vaccinium alaskaense*	45.0	44.7	39.2	25.8	4.0	0.4	1.0
VADE	*Vaccinium deliciosum*				0.8		22.0	0.2
VAME	*Vaccinium membranaceum*	1.1	1.6	0.8	31.7	37.5	8.2	14.1
VAOV	*Vaccinium ovalifolium*	7.3	8.1	8.0	18.8		4.0	4.5
VASI	*Valeriana silchensis*	0.6	0.1				1.0	1.3
VEVI	*Veralrum viride*	0.3	0.1	0.3				0.6
VIFL2	*Viola flettii*						0.2	
VISE	*Viola sempervirens*		0.2					0.3
XETE	*Xerophyllum lenax*	0.3	2.9	14.5	6.5	22.5	9.8	2.0

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 26 p. 115 for mean relative cover values.

Table 167. Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ VAAL	ABAM/ VAAL/ERMO	ABAM/ VAAL/XETE	ABAM/ VAAL/TIUN	ABAM/ VAAL-BENE	ABAM/ VAAL/OXOR
ECOCLASS Code		CFS2 12 (OLY)	CFS2 13	CFS2 14	CFS2 15	CFS2 16	CFS2 17
Number of plots		18	15	10	19	8	29
TREES							
ABAM	*Abies amabilis*	50.4	64.7	38.8	52.6	39.5	46.5
ABLA2	*Abies lasiocarpa*						
ACMA	*Acer macrophyllum*						
ALRU	*Alnus rubra*				0.3		
CHNO	*Chamaecyparis nootkatensis*	0.3	5.5	4.7	0.6		
CONU	*Cornus nuttallii*						
PISI	*Picea sitchensis*						0.2
PIMO	*Pinus monticola*						
PSME	*Pseudotsuga menziesii*	9.4		14.5	1.8	8.9	0.1
TABR	*Taxus brevifolia*	0.8	0.3	0.2			
THPL	*Thuja plicata*	3.1	1.4	4.4	1.9	1.3	1.4
TSHE	*Tsuga heterophylla*	49.4	25.3	46.3	50.7	56.0	72.3
TSME	*Tsuga mertensiana*	1.1	2.5	0.8	0.1		
SHRUBS and HERBS							
ACCI	*Acer circinatum*	1.0	0.3	8.5	1.7	22.9	0.3
ACTR	*Achlys triphylla*	0.2	0.5	0.4	1.8	3.3	0.5
ACRU	*Actaea rubra*	0.1	0.1				
ADBI	*Adenocaulon bicolor*	0.1			0.2		
ADPE	*Adiantum pedatum*	0.1	0.1		0.1		
ALSI	*Alnus sinuata*				0.3		
ARCA6	*Arceuthobium campylopodum* f. *tsugensis*					0.1	0.1
ARSY	*Aruncus sylvester*	0.1	0.1				
ASCA3	*Asarum caudatum*		0.1		0.1		
ATFI	*Athyrium filix-femina*	0.1	0.5		1.6		1.1
BENE	*Berberis nervosa*	0.1	0.1	1.2		15.1	0.3
BLSP	*Blechnum spicant*	0.5	1.5		2.6	0.8	2.7
BOEL	*Boykinia elata*				0.1		0.2
BRVU	*Bromus vulgaris*						
CABI	*Caltha biflora*		0.3		0.5		
CADE	*Carex deweyana*				0.1		
CHME	*Chimaphila menziesii*	0.2	0.1	0.1	0.1	0.5	
CHUM	*Chimaphila umbellata*	0.1		0.7	0.1	0.8	
CIAL	*Circaea alpina*				0.1		
CLUN	*Clintonia uniflora*	0.8	2.1	1.8	2.3	0.8	0.8
COLA	*Coptis laciniata*	0.3	1.6		2.4	0.9	2.5
COMA3	*Corallorhiza maculata*	0.1				0.1	
COME	*Corallorhiza mertensiana*	0.2	0.1	0.5	0.1	0.3	0.1
COCA	*Cornus canadensis*	0.5	0.4	0.7	1.1	0.4	
DIHO	*Disporum hookeri*	0.1	0.1	0.4	0.9	0.4	0.3
DISM	*Disporum smithii*				0.1		0.2
DRAU2	*Dryopteris austriaca*				0.3		
EBAU	*Eburophyton austiniae*	0.1					
EPAN	*Epilobium angustifolium*				0.1		
EPGL	*Epilobium glaberrimum*				0.1		
ERMO	*Erythronium montanum*		2.4	0.1			
ERRE2	*Erythronium revolutum*						
GAAP	*Galium aparine*						
GAOR	*Galium oreganum*		0.1				
GATR	*Galium triflorum*		0.1		0.5		0.1
GAOV	*Gaultheria ovatifolia*		0.1	1.0			
GASH	*Gaultheria shallon*	0.3		3.0	0.3	1.5	0.7
GOOB	*Goodyera oblongifolia*	0.1	0.3		0.1	0.1	
GYDR	*Gymnocarpium dryopteris*	0.1	0.3		1.9		0.3
HIAL	*Hieracium albiflorum*				0.1		0.1
HYTE	*Hydrophyllum tenuipes*				0.1		
HYMO	*Hypopitys monotropa*	0.1		0.3	0.1	0.1	
LAMU	*Lactuca muralis*			0.1			0.1
LICO4	*Lilium columbianum*		0.1	1.1			

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ VAAL	ABAM/ VAAL/ERMO	ABAM/ VAAL/XETE	ABAM/ VAAL/TIUN	ABAM/ VAAL-BENE	ABAM/ VAAL/OXOR
ECOCLASS Code		CFS2 12 (OLY)	CFS2 13	CFS2 14	CFS2 15	CFS2 16	CFS2 17
Number of plots		18	15	10	19	8	29
SHRUBS and HERBS (cont.)							
LIBO2	*Linnaea borealis*	0.5	0.1		0.3	1.3	0.1
LICA3	*Listera caurina*	0.1			0.1		0.1
LICO2	*Listera convallarioides*	0.1	0.1				0.2
LICO3	*Listera cordata*	0.1	0.1	0.3	0.2		
LULA	*Lupinus latifolius*						
LUPA	*Luzula parviflora*	0.1	0.1		0.4		0.3
LYCL	*Lycopodium clavatum*	0.1	0.1	0.1	0.1		0.3
LYAM	*Lysichitum americanum*						0.1
MADI2	*Maianthemum dilatatum*	0.3	0.9	0.1	3.7		2.6
MEFE	*Menziesia ferruginea*	0.8	1.3	1.2	1.1	0.1	1.5
MIBR	*Mitella breweri*		0.1		0.1		
MIOV	*Mitella ovalis*		0.1		0.1		
MOSI	*Montia sibirica*				0.2		0.1
OPHO	*Oplopanax horridum*	0.1	0.1		0.7		0.4
OSCH	*Osmorhiza chilensis*		0.2		0.2		0.1
OSPU	*Osmorhiza purpurea*						
OXOR	*Oxalis oregana*	0.2	0.1		0.1		25.7
PERA	*Pedicularis racemosa*						
POGL4	*Polypodium glycyrrhiza*				0.1		
POMU	*Polystichum munitum*	0.3	0.2	0.2	1.5	2.6	1.8
PTAQ	*Pteridium aquilinum*				0.1		
PYAS	*Pyrola asarifolia*						
PYPI	*Pyrola picta*	0.3				0.4	0.1
PYSE	*Pyrola secunda*	0.4	0.2	0.2	0.4	0.1	
PYUN	*Pyrola uniflora*	0.2	0.1				0.4
RHAL	*Rhododendron albiflorum*						
RHMA	*Rhododendron macrophyllum*				0.1		
RIBR	*Ribes bracteosum*		0.1		0.1		0.3
RILA	*Ribes lacustre*				0.3		
ROGY	*Rosa gymnocarpa*		0.1		0.1	0.1	
RULA	*Rubus lasiococcus*	0.1	0.1	0.8	0.7		
RUPA	*Rubus parviflorus*				0.1		
RUPE	*Rubus pedatus*	0.4	6.1	1.3	4.7		4.6
RUSP	*Rubus spectabilis*	0.1	0.2		2.5	0.1	4.5
RUUR	*Rubus ursinus*				0.2	0.1	0.2
SARA	*Sambucus racemosa*		0.1		0.1		0.1
SEOR	*Selaginella oregana*						
SMRA	*Smilacina racemosa*					0.1	0.1
SMST	*Smilacina stellata*	0.1	0.2	0.3	1.2	0.5	0.1
SOSI	*Sorbus sitchensis*		0.1	0.2	0.1		
STME2	*Stachys mexicana*				0.1		
STAM	*Streptopus amplexifolius*	0.1	0.1		0.4	0.3	0.2
STRO	*Streptopus roseus*	0.3	1.1		2.7	0.3	0.9
STST	*Streptopus streptopoides*				0.1		
SYSC	*Synthyris schizantha*				0.1		
TITR	*Tiarella trifoliata*	0.1	0.5	0.1	4.0	0.4	1.8
TIUN	*Tiarella unifoliata*	0.1	0.7	0.1	1.4	0.3	
TOME	*Tolmiea menziesii*				0.1		
TRLA2	*Trientalis latifolia*	0.1	0.1	0.1	0.1	0.1	0.1
TROV	*Trillium ovatum*	0.4	0.3	0.4	0.5	0.8	0.5
TRCA	*Trisetum canescens*				0.1		0.1
TRCE	*Trisetum cernuum*				0.2		0.4
VAAL	*Vaccinium alaskaense*	35.3	57.9	41.5	39.4	11.0	23.0
VAME	*Vaccinium membranaceum*	0.1	0.7	1.2		0.1	
VAOV	*Vaccinium ovalifolium*	0.8	3.3	1.5	1.7		0.2
VAPA	*Vaccinium parvifolium*	2.6	0.1	1.4	1.6	11.9	6.1
VASI	*Valeriana sitchensis*		0.5	0.2	0.1		
VEVI	*Veratrum viride*		0.1	0.1	0.3		
VIGL	*Viola glabella*		0.5		0.4		
VIOR2	*Viola orbiculata*						
VISE	*Viola sempervirens*	0.1		0.4	0.5	0.3	0.4
XETE	*Xerophyllum tenax*	0.2	0.1	19.6		0.5	

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ VAAL/CLUN	ABAM/ VAAL/LIBO2	ABAM/ VAAL-RHAL	ABAM/ XETE	ABAM/ VAME/XETE	ABAM/ Dep.
ECOCLASS Code		CFS2 18	CFS2 19	CFS2 20	CFF3 11	CFS2 11 (OLY)	CFF9 11
Number of plots		31	11	4	5	2	14
TREES							
ABAM	*Abies amabilis*	56.8	41.9	43.7	12.6	50.0	61.0
ABLA2	*Abies lasiocarpa*					2.5	0.1
ACMA	*Acer macrophyllum*		0.1				
ALRU	*Alnus rubra*						
CHNO	*Chamaecyparis nootkatensis*	1.6	1.8	8.3			
CONU	*Cornus nuttallii*						
PISI	*Picea sitchensis*						
PREM	*Prunus emarginata*						
PSME	*Pseudotsuga menziesii*	1.7	14.2	1.3	36.0	12.5	8.7
TABR	*Taxus brevifolia*	0.7	1.4				0.6
THPL	*Thuja plicata*	1.5	10.9	1.3	0.4	5.0	0.9
TSHE	*Tsuga heterophylla*	56.8	43.1	47.5	68.0	42.5	63.9
TSME	*Tsuga mertensiana*	0.9	0.9	2.8	0.2	7.5	
SHRUBS and HERBS							
ACCI	*Acer circinatum*	3.6	5.1		4.4		0.1
ACTR	*Achlys triphylla*	1.1	1.6	0.5	8.4		0.3
ACRU	*Actaea rubra*						
ADBI	*Adenocaulon bicolor*				0.2		
ADPE	*Adiantum pedatum*						
ALSI	*Alnus sinuata*						
ARCA6	*Arceuthobium campylopodum* f. *tsugensis*	0.3					
ARSY	*Aruncus sylvester*		0.2				
ASCA3	*Asarum caudatum*		0.1				0.1
ATFI	*Athyrium filix-femina*	0.1	0.2	0.5	0.2		0.1
BENE	*Berberis nervosa*	0.4	0.6	0.3	6.0		0.3
BLSP	*Blechnum spicant*	2.5	1.0	0.3			0.7
BOEL	*Boykinia elata*		0.2				
BRVU	*Bromus vulgaris*						
CABI	*Caltha biflora*						
CADE	*Carex deweyana*						
CHME	*Chimaphila menziesii*	0.2	0.3	0.3	0.6		0.1
CHUM	*Chimaphila umbellata*	0.1	0.5		0.4		0.1
CIAL	*Circaea alpina*						
CLUN	*Clintonia uniflora*	3.4	3.0	2.0	1.0		0.3
COLA	*Coptis laciniata*	0.2	0.2				
COMA3	*Corallorhiza maculata*						
COME	*Corallorhiza mertensiana*	0.2	0.2		0.2		0.1
COCA	*Cornus canadensis*	1.3	0.8	0.8	0.6		0.1
DIHO	*Disporum hookeri*	0.1	0.4				
DISM	*Disporum smithii*	0.1	0.1				
DRAU2	*Dryopteris austriaca*						
EBAU	*Eburophyton austiniae*						
EPAN	*Epilobium angustifolium*			0.3			
EPGL	*Epilobium glaberrimum*						
ERMO	*Erythronium montanum*						
ERRE2	*Erythronium revolutum*						
GAAP	*Galium aparine*						
GAOR	*Galium oreganum*						
GATR	*Galium triflorum*	0.1					0.1
GAOV	*Gaultheria ovatifolia*			0.3			
GASH	*Gaultheria shallon*	0.3	0.9	0.8			0.2
GOOB	*Goodyera oblongifolia*	0.1	0.2				0.1
GYDR	*Gymnocarpium dryopteris*	0.1	0.2	0.8			
HIAL	*Hieracium albiflorum*		0.3	0.3	0.2		0.1
HYTE	*Hydrophyllum tenuipes*						
HYMO	*Hypopitys monotropa*	0.1	0.1		0.4		
LAMU	*Lactuca muralis*		0.1				
LICO4	*Lilium columbianum*				0.4		

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ VAAL/CLUN	ABAM/ VAAL/LIBO2	ABAM/ VAAL-RHAL	ABAM/ XETE	ABAM/ VAME/XETE	ABAM/ Dep.
ECOCLASS Code		CFS2 18	CFS2 19	CFS2 20	CFF3 11	CFS2 11 (OLY)	CFF9 11
Number of plots		31	11	4	5	2	14
SHRUBS and HERBS (cont.)							
LIBO2	*Linnaea borealis*	0.4	16.9	2.0	0.6		0.4
LICA3	*Listera caurina*	0.2	0.3				0.1
LICO2	*Listera convallarioides*		0.1				0.1
LICO3	*Listera cordata*		0.2				
LULA	*Lupinus latifolius*						
LUPA	*Luzula parviflora*	0.1	0.1	0.3			0.1
LYCL	*Lycopodium clavatum*						0.1
LYAM	*Lysichitum americanum*						
MADI2	*Maianthemum dilatatum*	1.0	0.2				0.4
MEFE	*Menziesia ferruginea*	1.0	0.7	3.5	0.2	2.5	0.4
MIBR	*Mitella breweri*						
MIOV	*Mitella ovalis*						
MOSI	*Montia sibirica*						
OPHO	*Oplopanax horridum*	0.2	0.3				0.3
OSCH	*Osmorhiza chilensis*			0.3			
OSPU	*Osmorhiza purpurea*						
OXOR	*Oxalis oregana*	0.2					0.1
PERA	*Pedicularis racemosa*			0.3	0.4		
POGL4	*Polypodium glycyrrhiza*	0.1					0.1
POMU	*Polystichum munitum*	0.4	1.5	0.3	1.0		0.4
PTAQ	*Pteridium aquilinum*				0.2		
PYAS	*Pyrola asarifolia*	0.1	0.3	0.3			
PYPI	*Pyrola picta*	0.2			0.2		0.1
PYSE	*Pyrola secunda*	0.4	0.5	1.3	0.8	1.0	0.3
PYUN	*Pyrola uniflora*	0.2	0.1	0.3			0.6
RHAL	*Rhododendron albiflorum*		0.1	18.2		0.5	0.1
RHMA	*Rhododendron macrophyllum*	0.1	0.3	3.8	1.4		0.2
RIBR	*Ribes bracteosum*						
RILA	*Ribes lacustre*		0.1	0.3			
ROGY	*Rosa gymnocarpa*		0.1		0.8		
RULA	*Rubus lasiococcus*	0.4	0.5	2.5	0.2	1.0	0.1
RUPA	*Rubus parviflorus*						
RUPE	*Rubus pedatus*	2.4	4.5	6.5			0.4
RUSP	*Rubus spectabilis*	0.4	0.3	0.3			0.1
RUUR	*Rubus ursinus*	0.3	0.1		0.2		0.1
SARA	*Sambucus racemosa*	0.1		0.3			0.1
SEOR	*Selaginella oregana*						
SMRA	*Smilacina racemosa*				0.2		
SMST	*Smilacina stellata*	0.2	0.1		1.0		
SOSI	*Sorbus sitchensis*	0.1			0.2	0.5	
STME2	*Stachys mexicana*						
STAM	*Streptopus amplexifolius*	0.1		0.3			
STRO	*Streptopus roseus*	0.5	0.4	1.0	0.2		0.4
STST	*Streptopus streptopoides*						
SYSC	*Synthyris schizantha*						
TITR	*Tiarella trifoliata*	0.4	1.6	0.3	0.2		0.6
TIUN	*Tiarella unifoliata*	0.2	0.4	1.3	0.2		0.1
TOME	*Tolmiea menziesii*						
TRLA2	*Trientalis latifolia*	0.1					0.1
TROV	*Trillium ovatum*	0.3	0.6	0.3	0.4		0.7
TRCA	*Trisetum canescens*						
TRCE	*Trisetum cernuum*			0.3			
VAAL	*Vaccinium alaskaense*	39.7	17.5	14.5	1.2	1.0	0.9
VAME	*Vaccinium membranaceum*	0.4	0.8	2.0	0.8	10.5	0.1
VAOV	*Vaccinium ovalifolium*	1.7	0.4	11.2	0.2		0.1
VAPA	*Vaccinium parvifolium*	4.7	9.8	0.5	0.6		0.7
VASI	*Valeriana sitchensis*	0.3		0.5			0.1
VEVI	*Veratrum viride*		0.1	0.8	0.4		0.1
VIGL	*Viola glabella*				0.2		
VIOR2	*Viola orbiculata*		0.1	0.3			
VISE	*Viola sempervirens*	0.3	0.4	0.8	0.4		0.1
XETE	*Xerophyllum tenax*	0.1	0.3	2.0	20.6	20.5	0.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ OPHO	ABAM/ OXOR	ABAM/ RHMA	ABAM/ RHMA-VAAL	ABAM/ GASH	ABAM GASH/BLSP
ECOCLASS Code		CFS3 11 (OLY)	CFF1 11 (OLY)	CFS6 11 (OLY)	CFS6 12	CFS1 54 (OLY)	CFS1 55
Number of plots		15	19	9	5	8	13
TREES							
ABAM	*Abies amabilis*	46.7	51.1	24.6	33.0	30.7	54.2
ABLA2	*Abies lasiocarpa*						
ACMA	*Acer macrophyllum*						0.1
CHNO	*Chamaecyparis nootkatensis*	0.5		0.7			
CONU	*Cornus nuttallii*						0.1
PISI	*Picea sitchensis*		0.1				0.6
PIMO	*Pinus monticola*			0.1			
PSME	*Pseudotsuga menziesii*	2.8	0.3	17.3	22.2	14.4	0.1
TABR	*Taxus brevifolia*	0.3	0.3	1.0	1.0	3.1	0.3
THPL	*Thuja plicata*	2.5	4.4	7.6	20.2	15.6	5.8
TSHE	*Tsuga heterophylla*	46.5	52.7	69.4	67.0	46.9	60.0
TSME	*Tsuga mertensiana*	0.5					
SHRUBS and HERBS							
ACCI	*Acer circinatum*	0.5	3.4	0.8		5.4	1.3
ACTR	*Achlys triphylla*	0.9	1.3	0.3	0.6	0.1	0.3
ACRU	*Actaea rubra*	0.1		0.1	0.2		
ADBI	*Adenocaulon bicolor*	0.2	0.1			0.1	
ADPE	*Adiantum pedatum*	0.9	0.1				0.1
ALSI	*Alnus sinuata*						
ARCA6	*Arceuthobium campylopodum f. tsugensis*		0.6	0.1			0.9
ARSY	*Aruncus sylvester*	0.2					0.2
ASCA3	*Asarum caudatum*	0.3					
ATFI	*Athyrium filix-femina*	1.8	0.6		0.2		0.2
BENE	*Berberis nervosa*	0.2	0.5	1.1	2.6	4.8	1.4
BLSP	*Blechnum spicant*	2.1	1.9	0.1	0.2	0.3	4.2
BOEL	*Boykinia elata*	0.1	0.2				
BRVU	*Bromus vulgaris*						
CABI	*Caltha biflora*						
CADE	*Carex deweyana*		0.1				
CHME	*Chimaphila menziesii*	0.1	0.1	0.3	0.8	0.3	0.2
CHUM	*Chimaphila umbellata*	0.1		0.6	0.2	0.8	
CIAL	*Circaea alpina*		0.2				
CLUN	*Clintonia uniflora*	1.1	0.6	0.3	0.8		1.2
COLA	*Coptis laciniata*	0.1	0.4			0.1	0.2
COMA3	*Corallorhiza maculata*						
COME	*Corallorhiza mertensiana*	0.1	0.1	0.6	0.6	0.1	
COCA	*Cornus canadensis*	0.5	0.1	0.7	1.8	0.1	4.8
DIHO	*Disporum hookeri*	0.3	0.2				0.1
DISM	*Disporum smithii*	0.4	0.4				
DRAU2	*Dryopteris austriaca*	0.2	0.2				
EBAU	*Eburophyton austiniae*						
EPAN	*Epilobium angustifolium*	0.1					0.1
EPGL	*Epilobium glaberrimum*	0.1					
ERMO	*Erythronium montanum*						
ERRE2	*Erythronium revolutum*		0.1				0.8
GAAP	*Galium aparine*				0.2		
GAOR	*Galium oreganum*	0.3					
GATR	*Galium triflorum*	0.7	0.1			0.1	0.1
GAOV	*Gaultheria ovatifolia*	0.1					
GASH	*Gaultheria shallon*	0.3	0.5	0.3	0.6	46.9	22.8
GOOB	*Goodyera oblongifolia*		0.2		0.2	0.3	0.2
GYDR	*Gymnocarpium dryopteris*	1.3	0.1				
HIAL	*Hieracium albiflorum*	0.1	0.1		0.2	0.1	0.2
HODI	*Holodiscus discolor*			0.1			
HYTE	*Hydrophyllum tenuipes*	0.1					
HYRA	*Hypochaeris radicata*		0.1				
HYMO	*Hypopitys monotropa*	0.1	0.1	0.3	0.2		
LAMU	*Lactuca muralis*	0.1	0.1				0.2
LICO4	*Lilium columbianum*			0.2	0.4		

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		ABAM/ OPHO	ABAM/ OXOR	ABAM/ RHMA	ABAM/ RHMA-VAAL	ABAM/ GASH	ABAM GASH/BLSP
ECOCLASS Code		CFS3 11 (OLY)	CFF1 11 (OLY)	CFS6 11 (OLY)	CFS6 12	CFS1 54 (OLY)	CFS1 55
Number of plots		15	19	9	5	8	13
SHRUBS and HERBS (cont.)							
LIBO2	*Linnaea borealis*	0.1	0.3	2.0	8.0	4.6	0.9
LICA3	*Listera caurina*	0.1		0.1	0.2	0.1	0.1
LICO2	*Listera convallarioides*	0.1	0.1				0.2
LICO3	*Listera cordata*	0.1	0.1			0.4	0.4
LULA	*Lupinus latifolius*						
LUPA	*Luzula parviflora*	0.2	0.2				0.1
LYCL	*Lycopodium clavatum*	1.0	0.1	0.1	0.4		0.4
LYAM	*Lysichitum americanum*		0.1				0.1
MADI2	*Maianthemum dilatatum*	1.3	3.2				2.2
MEFE	*Menziesia ferruginea*	0.8	0.5	0.1		0.3	1.1
MIBR	*Mitella breweri*	0.1	0.3				
MIOV	*Mitella ovalis*						
MOSI	*Montia sibirica*	0.5	0.6				0.1
OPHO	*Oplopanax horridum*	11.7	0.4		0.4	0.4	0.2
OSCH	*Osmorhiza chilensis*	0.1	0.1				
OSPU	*Osmorhiza purpurea*	0.1	0.1				
OXOR	*Oxalis oregana*	7.3	42.6				0.3
PERA	*Pedicularis racemosa*						
POGL4	*Polypodium glycyrrhiza*						0.2
POMU	*Polystichum munitum*	1.3	2.1	0.3	0.4	1.3	0.9
PTAQ	*Pteridium aquilinum*						
PYAS	*Pyrola asarifolia*	0.1	0.1	0.4	0.8	0.1	
PYPI	*Pyrola picta*	0.1	0.1	0.2			0.2
PYSE	*Pyrola secunda*	0.2	0.1	0.4	0.2	0.3	
PYUN	*Pyrola uniflora*	0.2	0.3			0.3	0.3
RHAL	*Rhododendron albiflorum*						
RHMA	*Rhododendron macrophyllum*			43.8	25.6		
RIBR	*Ribes bracteosum*	1.7	0.1				
RILA	*Ribes lacustre*	0.3		0.1	0.2		
ROGY	*Rosa gymnocarpa*	0.1		0.3		0.1	0.1
RULA	*Rubus lasiococcus*	0.1		0.6	0.4		
RUPA	*Rubus parviflorus*	0.1					0.1
RUPE	*Rubus pedatus*	1.1	0.3	0.2	3.6		1.3
RUSP	*Rubus spectabilis*	3.1	1.4		0.2	0.3	0.4
RUUR	*Rubus ursinus*	0.1	0.2	0.1		0.1	0.2
SARA	*Sambucus racemosa*	2.3	0.2		0.2		
SEOR	*Selaginella oregana*						
SMRA	*Smilacina racemosa*	0.2		0.1	0.2		0.1
SMST	*Smilacina stellata*	0.4	0.2	0.2		0.1	0.1
SOSI	*Sorbus sitchensis*	0.1					
STME2	*Stachys mexicana*		0.1				
STAM	*Streptopus amplexifolius*	0.6	0.1				0.1
STRO	*Streptopus roseus*	0.5	0.2	0.2			0.2
STST	*Streptopus streptopoides*	0.1					
SYSC	*Synthyris schizantha*						
TITR	*Tiarella trifoliata*	3.8	1.1	0.1	0.8	0.3	0.5
TIUN	*Tiarella unifoliata*	0.2					
TOME	*Tolmiea menziesii*						
TRLA2	*Trientalis latifolia*	0.1	0.1	0.2	0.2		0.2
TROV	*Trillium ovatum*	0.5	0.8	0.3	0.4	0.1	0.2
TRCA	*Trisetum canescens*						0.2
TRCE	*Trisetum cernuum*		0.3				
VAAL	*Vaccinium alaskaense*	18.1	1.8	1.0	18.0	2.1	19.3
VAME	*Vaccinium membranaceum*			0.3	0.4		
VAOV	*Vaccinium ovalifolium*	4.0	0.1	0.1	0.2		0.9
VAPA	*Vaccinium parvifolium*	1.2	2.1	0.8	7.4	9.1	10.6
VASI	*Valeriana sitchensis*	0.3					
VEVI	*Veratrum viride*						
VIGL	*Viola glabella*	0.6	2.1				
VIOR2	*Viola orbiculata*	0.1					
VISE	*Viola sempervirens*	0.4	0.4	0.6	0.2	0.3	0.2
XETE	*Xerophyllum tenax*			0.8	3.0	0.8	2.3

1 Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series.Cover values based on plots 150 years and older.

		ASSOCIATIONS				
		ABAM/ GASH/OXOR	ABAM/ LYAM	ABAM/ POMU	ABAM/ POMU-OXOR	ABAM/ ACTR-TIUN
ECOCLASS Code		CFS1 56	CFM1 11	CFF6 11	CFF6 12	CFF2 11
Number of plots		7	2	8	24	7
TREES						
ABAM	*Abies amabilis*	22.1	20.5	36.7	26.2	47.6
ABLA2	*Abies lasiocarpa*					
ACMA	*Acer macrophyllum*					
ALRU	*Alnus rubra*		11.5			
CHNO	*Chamaecyparis nootkatensis*					0.1
CONU	*Cornus nuttallii*					
PISI	*Picea sitchensis*	0.6				
PIMO	*Pinus monticola*					
PSME	*Pseudotsuga menziesii*			10.5	1.0	12.7
TABR	*Taxus brevifolia*	0.3	2.5	1.4		
THPL	*Thuja plicata*	19.3	48.5	22.1	3.2	3.6
TSHE	*Tsuga heterophylla*	84.7	51.0	62.1	74.7	39.6
TSME	*Tsuga mertensiana*					0.9
SHRUBS and HERBS						
ACCI	*Acer circinatum*			1.5	0.8	0.3
ACTR	*Achlys triphylla*	0.1		6.3	2.5	12.3
ACRU	*Actaea rubra*					0.1
ADBI	*Adenocaulon bicolor*					0.3
ADPE	*Adiantum pedatum*			0.4		0.1
ALSI	*Alnus sinuata*					
ARCA6	*Arceuthobium campylopodum* f.tsugensis	1.3		0.1	0.3	0.6
ARSY	*Aruncus sylvester*					0.1
ASCA3	*Asarum caudatum*			0.3		
ATFI	*Athyrium filix-femina*	0.3	0.5	0.5	0.7	1.4
BENE	*Berberis nervosa*	10.0		2.3	1.0	1.1
BLSP	*Blechnum spicant*	4.9	2.5	4.0	2.0	0.3
BOEL	*Boykinia elata*	0.1			0.1	
BRVU	*Bromus vulgaris*		0.5			
CABI	*Caltha biflora*					
CADE	*Carex deweyana*		0.5			
CHME	*Chimaphila menziesii*			0.1		0.1
CHUM	*Chimaphila umbellata*			0.4		0.3
CIAL	*Circaea alpina*		1.0		0.1	0.1
CLUN	*Clintonia uniflora*	0.4	1.0	1.3	0.3	5.1
COLA	*Coptis laciniata*	2.0	3.0	0.3	0.6	
COMA3	*Corallorhiza maculata*					
COME	*Corallorhiza mertensiana*					0.1
COCA	*Cornus canadensis*	0.1	1.5	1.5	0.1	1.9
DIHO	*Disporum hookeri*	0.6		0.3	0.4	
DISM	*Disporum smithii*			0.3	0.3	0.4
DRAU2	*Dryopteris austriaca*			0.1	0.3	0.1
EBAU	*Eburophyton austiniae*					
EPAN	*Epilobium angustifolium*					0.3
EPGL	*Epilobium glaberrimum*					
ERMO	*Erythronium montanum*		0.5			
ERRE2	*Erythronium revolutum*					
GAAP	*Galium aparine*				0.1	
GAOR	*Galium oreganum*					
GATR	*Galium triflorum*			0.3		0.3
GAOV	*Gaultheria ovatifolia*					
GASH	*Gaultheria shallon*	19.4	14.5	1.5	0.9	0.1
GOOB	*Goodyera oblongifolia*	0.1		0.3		
GYDR	*Gymnocarpium dryopteris*				0.1	3.0
HIAL	*Hieracium albiflorum*			0.1		0.1
HYTE	*Hydrophyllum tenuipes*	0.3				
HYMO	*Hypopitys monotropa*	0.1				
LAMU	*Lactuca muralis*			0.3		
LICO4	*Lilium columbianum*	0.1				

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 167 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Silver Fir Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS				
		ABAM/ GASH/OXOR	ABAM/ LYAM	ABAM/ POMU	ABAM/ POMU-OXOR	ABAM/ ACTR-TIUN
ECOCLASS Code		CFS1 56	CFM1 12	CFF6 11	CFF6 12	CFF2 11
Number of plots		7	2	6	24	7
SHRUBS and HERBS (cont.)						
LIBO2	*Linnaea borealis*	0.1	1.0	4.6		4.1
LICA3	*Listera caurina*			0.3		0.1
LICO2	*Listera convallarioides*		0.5			
LICO3	*Listera cordata*	0.1	0.5	0.1		0.1
LULA	*Lupinus latifolius*					0.1
LUPA	*Luzula parviflora*	0.3	0.5	0.1	0.5	0.4
LYCL	*Lycopodium clavatum*	0.1			0.2	
LYAM	*Lysichitum americanum*	0.4	10.5			
MADI2	*Maianthemum dilatatum*	5.4	2.5	0.5	0.9	0.1
MEFE	*Menziesia ferruginea*	2.6	4.5	0.3	0.4	0.1
MIBR	*Mitella breweri*		0.5			0.1
MIOV	*Mitella ovalis*				0.1	
MOSI	*Montia sibirica*	0.1	0.5		0.5	0.1
OPHO	*Oplopanax horridum*	0.3		0.9	0.5	1.0
OSCH	*Osmorhiza chilensis*		0.5		0.1	0.3
OSPU	*Osmorhiza purpurea*					
OXOR	*Oxalis oregana*	36.0		0.1	38.7	
PERA	*Pedicularis racemosa*					
POGL4	*Polypodium glycyrrhiza*	0.1	1.0			
POMU	*Polystichum munitum*	4.6	0.5	13.0	18.2	1.0
PTAQ	*Pteridium aquilinum*					
PYAS	*Pyrola asarifolia*					0.3
PYPI	*Pyrola picta*	0.1			0.1	0.1
PYSE	*Pyrola secunda*					0.6
PYUN	*Pyrola uniflora*	0.1	0.5	0.1	0.2	0.3
RHAL	*Rhododendron albiflorum*					0.9
RHMA	*Rhododendron macrophyllum*			0.1		
RIBR	*Ribes bracteosum*					0.3
RILA	*Ribes lacustre*					0.3
ROGY	*Rosa gymnocarpa*					0.3
RULA	*Rubus lasiococcus*					0.7
RUPA	*Rubus parviflorus*					0.1
RUPE	*Rubus pedatus*	0.3	2.5	0.1	0.3	3.7
RUSP	*Rubus spectabilis*	1.3	1.0	0.1	1.0	0.4
RUUR	*Rubus ursinus*	0.6		0.5	0.3	
SARA	*Sambucus racemosa*			0.1	0.2	0.6
SEOR	*Selaginella oregana*		1.0			
SMRA	*Smilacina racemosa*					0.1
SMST	*Smilacina stellata*	0.4		0.3		2.6
SOSI	*Sorbus sitchensis*					0.1
STME2	*Stachys mexicana*					
STAM	*Streptopus amplexifolius*		1.0	0.3	0.1	0.1
STRO	*Streptopus roseus*		1.5	0.9	0.2	2.7
STST	*Streptopus streptopoides*					
SYSC	*Synthyris schizantha*					
TITR	*Tiarella trifoliata*	0.9	0.5	2.3	1.3	3.7
TIUN	*Tiarella unifoliata*			0.4		3.1
TOME	*Tolmiea menziesii*				0.1	
TRLA2	*Trientalis latifolia*				0.1	0.1
TROV	*Trillium ovatum*	0.7		0.6	0.6	0.7
TRCA	*Trisetum canescens*					
TRCE	*Trisetum cernuum*		0.5		0.2	0.1
VAAL	*Vaccinium alaskaense*	6.6	17.5	1.3	2.7	0.9
VAME	*Vaccinium membranaceum*			0.1	0.1	1.0
VAOV	*Vaccinium ovalifolium*	0.1	5.0			1.1
VAPA	*Vaccinium parvifolium*	12.3	0.5	3.0	2.5	0.7
VASI	*Valeriana sitchensis*					0.1
VEVI	*Veratrum viride*					0.3
VIGL	*Viola glabella*					
VIOR2	*Viola orbiculata*					
VISE	*Viola sempervirens*	1.7		0.9	0.6	1.0
XETE	*Xerophyllum tenax*		2.5			0.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 36 p. 148 for mean relative cover values.

Table 168. Mean absolute cover[1] values of trees, shrubs and herbs for the Sitka Spruce/Swordfern-Oxalis Association. Cover values based on plots 150 years and older.

ECOCLASS Code Number of plots		CSF1 11 26
TREES		
ABAM	*Abies amabilis*	0.5
ACMA	*Acer macrophyllum*	1.5
ALRU	*Alnus rubra*	4.0
PISI	*Picea sitchensis*	28.5
PSME	*Pseudotsuga menziesii*	0.4
RHPU	*Rhamnus purshiana*	0.9
THPL	*Thuja plicata*	1.2
TSHE	*Tsuga heterophylla*	60.5
SHRUBS and HERBS		
ACCI	*Acer circinatum*	8.1
ADBI	*Adenocaulon bicolor*	0.1
ARCA6	*Arceuthobium campylopodum* f. *tsugensis*	0.4
ATFI	*Athyrium filix-femina*	1.6
BLSP	*Blechnum spicant*	4.1
CADE	*Carex deweyana*	0.2
CHGL	*Chrysosplenium glechomaefolium*	0.2
CIAL	*Circaea alpina*	2.0
CLUN	*Clintonia uniflora*	0.4
DIHO	*Disporum hookeri*	0.1
DRAU2	*Dryopteris austriaca*	0.7
GATR	*Galium triflorum*	0.7
GASH	*Gaultheria shallon*	1.0
GYDR	*Gymnocarpium dryopteris*	0.2
HYTE	*Hydrophyllum tenuipes*	0.5
LICO3	*Listera cordata*	0.1
LUPA	*Luzula parviflora*	0.7
LYAM	*Lysichitum americanum*	0.1
MADI2	*Maianthemum dilatatum*	1.4
MEFE	*Menziesia ferruginea*	1.2
MOSI	*Montia sibirica*	0.7
OPHO	*Oplopanax horridum*	0.3
OSCH	*Osmorhiza chilensis*	0.1
OXOR	*Oxalis oregana*	44.8
POGL4	*Polypodium glycyrrhiza*	0.2
POMU	*Polystichum munitum*	18.3
PYSE	*Pyrola secunda*	0.1
PYUN	*Pyrola uniflora*	0.2
RARE	*Ranunculus repens*	0.2
RIBR	*Ribes bracteosum*	0.1
RUPE	*Rubus pedatus*	5.6
RUSP	*Rubus spectabilis*	14.5
RUUR	*Rubus ursinus*	0.2
SARA	*Sambucus racemosa*	0.3
SEOR	*Selaginella oregana*	1.3
SMST	*Smilacina stellata*	0.1
STME2	*Stachys mexicana*	0.3
TITR	*Tiarella trifoliata*	7.2
TOME	*Tolmiea menziesii*	1.5
TROV	*Trillium ovatum*	0.2
TRCA	*Trisetum canescens*	0.3
TRCE	*Trisetum cernuum*	0.2
VAAL	*Vaccinium alaskaense*	7.5
VAOV	*Vaccinium ovalifolium*	1.4
VAPA	*Vaccinium parvifolium*	3.2
VIGL	*Viola glabella*	0.2
VISE	*Viola sempervirens*	0.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean.
See Table 79 p. 247 for mean relative cover values.

Table 169. Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Subalpine Fir Series. Cover values based on plots 80 years and older.

		ASSOCIATIONS		
		ABLA2/ JUCO4	ABLA2/ LULA	ABLA2/ RHAL
ECOCLASS Code		CES6 21	CEF3 21	CES2 12 (OLY)
Number of plots		3	8	10
TREES				
ABAM	Abies amabilis	1.7		
ABLA2	Abies lasiocarpa	18.7	22.1	47.9
CHNO	Chamaecyparis nootkatensis		0.6	3.0
PIAL	Pinus albicaulis		0.8	
PICO	Pinus contorta	41.7	31.4	18.1
PIMO	Pinus monticola		0.5	0.1
PSME	Pseudotsuga menziesii	13.3	9.8	12.3
TSHE	Tsuga heterophylla	0.3	0.8	1.6
TSME	Tsuga mertensiana			2.5
SHRUBS and HERBS				
ACGL	*Acer glabrum*			0.1
ACMI	*Achillea millefolium*	1.0	0.3	0.3
ACTR	*Achlys triphylla*		0.3	1.2
ALCR	*Allium crenulatum*	0.3	0.4	
ALSI	*Alnus sinuata*			0.3
ANMA	*Anaphalis margaritacea*		0.1	
ANLY2	*Anemone lyallii*	0.7	0.4	0.2
ANRA	*Antennaria racemosa*	0.7	0.3	0.3
AQFO	*Aquilegia formosa*		0.3	0.1
ARUV	*Arctostaphylos uva-ursi*	1.0	4.8	
ARCA2	*Arenaria capillaris*		0.1	
ARMA3	*Arenaria macrophylla*	0.3	0.5	
ARCO	*Arnica cordifolia*	0.3	3.1	1.2
ARLA	*Arnica latifolia*		0.5	2.7
BENE	*Berberis nervosa*		0.3	0.2
CAPI	*Campanula piperi*	0.3		
CARO3	*Campanula rotundifolia*	0.3	0.3	
CASC2	*Campanula scouleri*	0.3	0.5	0.1
CARO	*Carex rossii*	0.3	0.3	0.1
CAME	*Cassiope mertensiana*			0.4
CAMI2	*Castilleja miniata*		0.1	0.1
CHME	*Chimaphila menziesii*	0.3		
CHUM	*Chimaphila umbellata*	0.3	1.6	
CLUN	*Clintonia uniflora*		0.1	0.3
COCA	*Cornus canadensis*			0.4
EPAN	*Epilobium angustifolium*		0.1	0.2
ERFL2	*Erigeron flettii*	0.7	0.3	
FEID	*Festuca idahoensis*	0.3		
FEOC	*Festuca occidentalis*		0.8	0.4
FEOV	*Festuca ovina*	0.3	0.1	
FRVE	*Fragaria vesca*		0.4	
FRVI	*Fragaria virginiana*	0.3	0.1	0.1
GATR	*Galium triflorum*		0.1	
GAOV	*Gaultheria ovatifolia*		0.1	0.4
GASH	*Gaultheria shallon*			0.1
HEOC	*Hedysarum occidentale*	0.7	0.1	0.2
HELA	*Heracleum lanatum*		0.4	0.2
HIAL	*Hieracium albiflorum*	0.7	0.6	0.4
HYMO	*Hypopitys monotropa*		0.1	
JUCO4	*Juniperus communis*	11.7	2.9	0.1
LICO4	*Lilium columbianum*		0.1	0.1
LIBO2	*Linnaea borealis*		2.0	1.7
LOMA2	*Lomatium martindalei*	1.0	0.8	0.3
LOCI	*Lonicera ciliosa*			0.5
LOUT2	*Lonicera utahensis*	0.3	0.4	0.3
LUPE	*Luetkea pectinata*			0.5
LULA	*Lupinus latifolius*		14.9	0.9
MEFE	*Menziesia ferruginea*			0.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 83 p. 259 for mean relative cover values.

Table 169 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Subalpine Fir Series. Cover values based on plots 80 years and older.

		ASSOCIATIONS		
		ABLA2/ JUCO4	ABLA2/ LULA	ABLA2/ RHAL
ECOCLASS Code		CES6 21	CEF3 21	CES2 12 (OLY)
Number of plots		3	8	10
SHRUBS and HERBS (cont.)				
NONE	*Nothochelone nemorosa*	0.3	0.3	0.2
OSCH	*Osmorhiza chilensis*		0.8	
PAMY	*Pachistima myrsinites*	1.3	0.9	1.0
PERA	*Pedicularis racemosa*	0.3	0.4	0.4
PEDA	*Penstemon davidsonii*	0.3		
PEPR	*Penstemon procerus*	0.7	0.4	
PHDI	*Phlox diffusa*	1.7	0.4	0.1
PHEM	*Phyllodoce empetriformis*			1.0
POPU	*Polemonium pulcherrimum*		1.3	0.2
PYAS	*Pyrola asarifolia*			0.4
PYSE	*Pyrola secunda*	1.0	0.8	0.9
RHAL	*Rhododendron albiflorum*	0.3	0.1	41.5
RHMA	*Rhododendron macrophyllum*			0.9
RIHO	*Ribes howellii*			0.1
RILA	*Ribes lacustre*		0.1	0.1
ROGY	*Rosa gymnocarpa*		0.6	0.1
RULA	*Rubus lasiococcus*	0.3		4.8
RUPE	*Rubus pedatus*			1.1
SEDI	*Sedum divergens*	0.3	0.1	
SEFL2	*Senecio flettii*	1.0	0.3	0.3
SELU2	*Senecio lugens*	0.3	0.1	0.2
SIPA	*Silene parryi*		0.4	0.1
SMST	*Smilacina stellata*			0.2
SOMU	*Solidago multiradiata*	0.3	0.1	
SOSI	*Sorbus sitchensis*			0.3
SYMO	*Symphoricarpos mollis*	0.7	0.4	0.3
THFE2	*Thalictrum fendleri*		3.3	0.2
TITR	*Tiarella trifoliata*			0.1
TRLA2	*Trientalis latifolia*		0.1	
TROV	*Trillium ovatum*		0.1	
TRCA	*Trisetum canescens*			
TRCE	*Trisetum cernuum*		0.1	
TRSP	*Trisetum spicatum*		0.1	
VAME	*Vaccinium membranaceum*		0.3	6.6
VASI	*Valeriana sitchensis*	0.3	0.5	0.9
VEVI	*Veratrum viride*			0.4
VIOR2	*Viola orbiculata*	0.3		0.6
VISE	*Viola sempervirens*		0.1	0.3
XETE	*Xerophyllum tenax*			3.9

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 83 p. 259 for mean relative cover values.

Table 170. Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS						
		TSHE/ VAAL	TSHE/ VAAL/XETE	TSHE/ VAAL/OXOR	TSHE/ VAAL-GASH	TSHE/ XETE	TSHE/ Dep.	TSHE/ OPHO
ECOCLASS Code		CHS6 21	CHS6 22	CHS6 23 (OLY)	CHS6 24 (OLY)	CHF5 11 (OLY)	CHF9 11	CHS5 12 (OLY)
Number of plots		17	3	15	21	3	12	4
TREES								
ABAM	*Abies amabilis*	3.5	3.0	2.7	1.7		1.3	0.5
ABGR	*Abies grandis*	0.1					2.5	
ACMA	*Acer macrophyllum*					0.2	1.5	
ALRU	*Alnus rubra*				0.5		4.7	0.8
CHNO	*Chamaecyparis nootkatensis*	0.6						
CONU	*Cornus nuttallii*							0.3
PISI	*Picea sitchensis*	0.1		0.1	0.1		0.1	
PICO	*Pinus contorta*							
PIMO	*Pinus monticola*							
PSME	*Pseudotsuga menziesii*	15.9	29.0	2.3	15.3	55.0	28.8	45.0
PYFU	*Pyrus fusca*				0.7			
RHPU	*Rhamnus purshiana*	0.3		0.3	0.5			
TABR	*Taxus brevifolia*	0.5			0.9		1.2	0.5
THPL	*Thuja plicata*	3.9	6.7	2.4	12.6		3.2	11.5
TSHE	*Tsuga heterophylla*	79.4	62.7	88.0	70.0	49.0	72.8	37.5
TSME	*Tsuga mertensiana*					0.7		
SHRUBS and HERBS								
ACCI	*Acer circinatum*	6.6	18.3	1.7	8.8	11.3	0.7	21.2
ACGL	*Acer glabrum*					1.0		
ACTR	*Achlys triphylla*	1.4	0.7	0.2	0.3	1.7	0.3	2.8
ADBI	*Adenocaulon bicolor*	0.1		0.1	0.1			1.3
ADPE	*Adiantum pedatum*	0.1						0.3
ALVI	*Allotropa virgata*					0.3		
ARCA6	*Arceuthobium campylopodum* f. *tsugensis*	0.6	2.0	0.7	0.4			
ARUV	*Arctostaphylos uva-ursi*							
ARMA3	*Arenaria macrophylla*							
ASCA3	*Asarum caudatum*							0.5
ATFI	*Athyrium filix-femina*	0.4		0.6	0.2			3.5
BENE	*Berberis nervosa*	1.2	3.7		2.1	12.0	1.2	0.5
BLSP	*Blechnum spicant*	2.9	0.3	5.0	4.5		0.3	1.5
BOEL	*Boykinia elata*	0.1		0.3				
BRPA	*Bromus pacificus*							0.3
CASC2	*Campanula scouleri*					0.3		
CADE	*Carex deweyana*							
CHME	*Chimaphila menziesii*	0.2	0.7		0.1	1.0	0.3	
CHUM	*Chimaphila umbellata*	0.2	0.7		0.4	0.3	0.1	
CIAL	*Circaea alpina*			0.1			5.0	
CLUN	*Clintonia uniflora*	1.6	0.7	0.5	0.2		0.3	0.8
COLA	*Coptis laciniata*	0.9		0.7	0.2			
COMA3	*Corallorhiza maculata*		0.3					
COME	*Corallorhiza mertensiana*	0.1	0.3		0.1	0.3	0.1	
COCA	*Cornus canadensis*	0.8	0.7	1.6	1.8		0.1	0.
DIHO	*Disporum hookeri*	0.1		0.1				0.8
DISM	*Disporum smithii*	0.3		0.1	0.1			0.3
DRAU2	*Dryopteris austriaca*	0.5		0.6	0.2		0.3	0.8
RMO	*Erythronium montanum*							
FEOC	*Festuca occidentalis*							
FESU	*Festuca subulata*						0.3	
GAAP	*Galium aparine*							
GATR	*Galium triflorum*			0.1				1.8
GAOV	*Gaultheria ovatifolia*	0.1				0.3		1.5
GASH	*Gaultheria shallon*	1.4	2.0	1.4	30.0	2.7	0.3	
GOOB	*Goodyera oblongifolia*		0.3	0.1	0.3	0.3		
GYDR	*Gymnocarpium dryopteris*	0.1		0.3				2.0
HIAL	*Hieracium albiflorum*	0.1				0.3	0.1	0.5
HODI	*Holodiscus discolor*							
HYMO	*Hypopitys monotropa*	0.1	0.7		0.1	0.7	0.2	
LAMU	*Lactuca muralis*	0.1		0.1				
LICO4	*Lilium columbianum*	0.3						

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 286 for mean relative cover values.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

					ASSOCIATIONS			
		TSHE/ VAAL	TSHE/ VAAL/XETE	TSHE/ VAAL/OXOR	TSHE/ VAAL-GASH	TSHE/ XETE	TSHE/ Dep.	TSHE/ OPHO
ECOCLASS Code		CHS6 21	CHS6 22	CHS6 23 (OLY)	CHS6 24 (OLY)	CHF5 11 (OLY)	CHF9 11	CHS5 12 (OLY)
Number of plots		17	3	15	21	3	12	4
SHRUBS and HERBS (cont.)								
LIBO2	*Linnaea borealis*	5.8		1.1	2.4		0.3	0.8
LICA3	*Listera caurina*	0.1						0.5
LICO2	*Listera convallarioides*							
LICO3	*Listera cordata*	0.3	0.1					
LUPA	*Luzula parviflora*	0.2		0.3	0.1		0.1	0.5
LYCL	*Lycopodium clavatum*			0.1				
LYAM	*Lysichitum americanum*	0.1			0.1			
MADI2	*Maianthemum dilatatum*	0.5		1.5	0.3		0.1	3.8
MEFE	*Menziesia ferruginea*	0.9	2.3	2.3	1.3			
MOSI	*Montia sibirica*			0.1				
NONE	*Nothochelone nemorosa*						0.1	
OPHO	*Oplopanax horridum*	0.1		0.1	0.2			10.7
OSCH	*Osmorhiza chilensis*	0.1						0.5
OXOR	*Oxalis oregana*	0.1		24.1	0.1			
PAMY	*Pachistima myrsinites*		0.3			0.3		
POGL4	*Polypodium glycyrrhiza*							0.3
POMU	*Polystichum munitum*	2.2		3.6	1.4	0.3	1.2	24.2
PTAQ	*Pteridium aquilinum*	0.1			0.4		0.2	0.5
PTAN	*Pterospora andromedea*							
PYAS	*Pyrola asarifolia*	0.1					0.2	
PYPI	*Pyrola picta*			0.1				
PYSE	*Pyrola secunda*	0.2	0.3	0.1	0.1	0.7	0.2	
PYUN	*Pyrola uniflora*			0.2	0.2		0.1	
RHAL	*Rhododendron albiflorum*							
RHMA	*Rhododendron macrophyllum*	0.2	0.3				0.1	
RIBR	*Ribes bracteosum*							2.3
RILA	*Ribes lacustre*						0.2	
ROGY	*Rosa gymnocarpa*	0.1	0.3		0.1	0.7	0.2	
RULA	*Rubus lasiococcus*	0.1	0.7		0.1			
RULE	*Rubus leucodermis*							
RUNI	*Rubus nivalis*						0.1	
RUPA	*Rubus parviflorus*	0.1						0.3
RUPE	*Rubus pedatus*	1.8		1.1	1.3			0.3
RUSP	*Rubus spectabilis*	1.9		3.4	2.1		0.1	1.3
RUUR	*Rubus ursinus*	0.6		0.2	0.4		0.3	1.0
SARA	*Sambucus racemosa*	0.1		0.3				
SEOR	Selaginella oregana			0.1	1.9			
SMRA	*Smilacina racemosa*	0.1					0.1	
SMST	*Smilacina stellata*	0.4		0.2	0.2	0.3	0.1	4.0
SOSI	*Sorbus sitchensis*		0.3					
STME2	*Stachys mexicana*			0.1				
STAM	*Streptopus amplexifolius*	0.2		0.2	0.2		0.1	0.5
STRO	*Streptopus roseus*	0.5	0.3	0.2				1.0
STST	*Streptopus streptopoides*							
SYAL	*Symphoricarpos albus*						0.1	
SYMO	*Symphoricarpos mollis*						0.1	
TITR	*Tiarella trifoliata*	1.8		1.1	0.7		0.1	5.0
TIUN	*Tiarella unifoliata*	0.1					0.1	1.8
TOME	*Tolmiea menziesii*							0.3
TRLA2	*Trientalis latifolia*	0.1	0.3	0.1	0.1	0.3	0.3	0.8
TROV	*Trillium ovatum*	0.4	0.3	0.5	0.3	0.3	0.3	0.8
TRCE	*Trisetum cernuum*	0.1		0.1	0.1		0.1	
VAAL	*Vaccinium alaskaense*	22.3	31.7	29.8	24.0	0.7	0.3	1.0
VAME	*Vaccinium membranaceum*	0.1	0.3			0.3		
VAOV	*Vaccinium ovalifolium*	0.8	0.3	1.2	1.4		0.1	0.5
VAOV2	*Vaccinium ovatum*							
VAPA	*Vaccinium parvifolium*	12.6	7.7	4.0	9.7	1.3	0.6	3.0
VIAM	*Vicia americana*							
VIGL	*Viola glabella*			0.1	0.1			1.5
VIOR2	*Viola orbiculata*							
VISE	*Viola sempervirens*	0.3	0.3	0.2	0.2	1.3	0.3	0.3
XETE	*Xerophyllum tenax*	0.1	7.3		1.3	33.3	0.1	

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 286 for mean relative cover values.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS						
		TSHE/ BENE	TSHE/ BENE/POMU	TSHE/ OXOR	TSHE/ RHMA	TSHE/ RHMA/XETE	TSHE/ RHMA-BENE	TSHE/ RHMA-GASH
ECOCLASS Code		CHS1 38	CHS1 39	CHF1 12(OLY)	CHS3 31 (OLY)	CHS3 32(OLY)	CHS2 33(OLY	CHS3 34(OLY)
Number of plots		3	9	8	13	5	5	34
TREES								
ABAM	*Abies amabilis*	2.3		0.6	1.8	1.2	1.4	0.5
ABGR	*Abies grandis*		0.1		0.5			0.1
ACMA	*Acer macrophyllum*		2.9					
ALRU	*Alnus rubra*		0.4	2.0				0.1
CHNO	*Chamaecyparis nootkatensis*	1.7			1.3			0.7
CONU	*Cornus nuttallii*		0.1					
PISI	*Picea sitchensis*			1.0				
PICO	*Pinus contorta*							
PIMO	*Pinus monticola*					0.8	0.2	0.2
PSME	*Pseudotsuga menziesii*	76.7	29.2	16.9	38.5	38.0	37.8	46.5
PYFU	*Pyrus fusca*							
RHPU	*Rhamnus purshiana*			0.3				
TABR	*Taxus brevifolia*	3.3	0.2		3.6	0.6	2.0	1.9
THPL	*Thuja plicata*	10.0	8.0	0.1	11.0	15.0	7.8	18.8
TSHE	*Tsuga heterophylla*	33.3	62.4	92.1	70.8	63.0	68.0	45.7
TSME	*Tsuga mertensiana*							
SHRUBS and HERBS								
ACCI	*Acer circinatum*	28.3	13.3	4.8	0.3	0.4	7.0	3.5
ACGL	*Acer glabrum*							0.1
ACTR	*Achlys triphylla*	0.3	3.7	1.3	0.4		0.6	0.2
ADBI	*Adenocaulon bicolor*		0.2	0.1	0.1			0.1
ADPE	*Adiantum pedatum*				0.1			
ALVI	*Allotropa virgata*				0.1			
ARCA6	*Arceuthobium campylopodum f.tsugensis*			0.9				0.1
ARUV	*Arctostaphylos uva-ursi*					0.2		0.1
ARMA3	*Arenaria macrophylla*							0.1
ASCA3	*Asarum caudatum*							
ATFI	*Athyrium filix-femina*			0.5				
BENE	*Berberis nervosa*	17.0	16.9	0.4	1.5	4.0	12.6	4.4
BLSP	*Blechnum spicant*		0.1	1.6			0.2	
BOEL	*Boykinia elata*							
BRPA	*Bromus pacificus*							
CASC2	*Campanula scouleri*				0.2			0.1
CADE	*Carex deweyana*							
CHME	*Chimaphila menziesii*	0.7	0.2		0.4	0.2		0.3
CHUM	*Chimaphila umbellata*	0.7	0.1		0.6	0.6	2.4	1.1
CIAL	*Circaea alpina*		0.3					
CLUN	*Clintonia uniflora*	0.3	0.2	0.3	0.4		0.4	0.1
COLA	*Coptis laciniata*			0.8				
COMA3	*Corallorhiza maculata*							0.1
COME	*Corallorhiza mertensiana*			0.1	0.3	0.2	0.2	0.1
COCA	*Cornus canadensis*		0.1	0.4	0.2	0.2	0.8	0.4
DIHO	*Disporum hookeri*		0.6	0.1	0.1			
DISM	*Disporum smithii*			0.5				
DRAU2	*Dryopteris austriaca*		0.1	0.1				
ERMO	*Erythronium montanum*							
FEOC	*Festuca occidentalis*	0.3			0.1			0.2
FESU	*Festuca subulata*							
GAAP	*Galium aparine*							0.1
GATR	*Galium triflorum*		0.9	0.1	0.1			
GAOV	*Gaultheria ovatifolia*					0.4		
GASH	*Gaultheria shallon*	0.7	2.0	0.8	0.4	25.6	1.4	44.6
GOOB	*Goodyera oblongifolia*	0.7	0.3		0.2	0.2		0.3
GYDR	*Gymnocarpium dryopteris*		0.1	0.4				
HIAL	*Hieracium albiflorum*	0.3			0.2	0.2		0.3
HODI	*Holodiscus discolor*	0.3						1.1
HYMO	*Hypopitys monotropa*	0.3		0.1	0.4	0.2	0.2	0.1
LAMU	*Lactuca muralis*		0.1	0.1	0.1			
LICO4	*Lilium columbianum*				0.2	0.6		0.2

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 286 for mean relative cover values.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS						
		TSHE/ BENE	TSHE/ BENE/POMU	TSHE/ OXOR	TSHE/ RHMA	TSHE/ RHMA/XETE	TSHE/ RHMA-BENE	TSHE/ RHMA-GASH
ECOCLASS Code		CHS1 38	CHS1 39	CHF1 12(OLY)	CHS3 31(OLY)	CHS3 32(OLY)	CHS3 33(OLY)	CHS3 34(OLY)
Number of plots		3	9	8	13	5	5	34
SHRUBS and HERBS (cont.)								
LIBO2	*Linnaea borealis*	2.0	1.3	2.6	1.1	0.8	3.2	4.0
LICA3	*Listera caurina*							
LICO2	*Listera convallarioides*						0.2	0.1
LICO3	*Listera cordata*				0.2	0.2		0.1
LUPA	*Luzula parviflora*			0.3				
LYCL	*Lycopodium clavatum*							
LYAM	*Lysichitum americanum*							
MADI2	*Maianthemum dilatatum*			1.3				
MEFE	*Menziesia ferruginea*			0.6	0.2	0.2	0.2	0.1
MOSI	*Montia sibirica*		0.2					
NONE	*Nothochelone nemorosa*	0.3			0.2			0.1
OPHO	*Oplopanax horridum*			0.1				
OSCH	*Osmorhiza chilensis*		0.1		0.2			
OXOR	*Oxalis oregana*			29.7				
PAMY	*Pachistima myrsinites*	0.7			0.2	0.2		0.2
POGL4	*Polypodium glycyrrhiza*			0.1				0.1
POMU	*Polystichum munitum*	1.0	25.2	2.3	0.8		1.4	0.6
PTAQ	*Pteridium aquilinum*		0.1	2.5				
PTAN	*Pterospora andromedea*				0.2			
PYAS	*Pyrola asarifolia*				0.2	0.2	0.4	0.2
PYPI	*Pyrola picta*	0.3			0.1		0.2	
PYSE	*Pyrola secunda*	0.7			0.7	0.6	0.4	0.1
PYUN	*Pyrola uniflora*			0.1				
RHAL	*Rhododendron albiflorum*						0.2	
RHMA	*Rhododendron macrophyllum*	1.3			48.5	44.6	26.4	39.3
RIBR	*Ribes bracteosum*							
RILA	*Ribes lacustre*			0.1	0.1			
ROGY	*Rosa gymnocarpa*	0.3	0.2		0.1	0.2	0.8	0.4
RULA	*Rubus lasiococcus*	0.3			0.3	0.2		
RULE	*Rubus leucodermis*							
RUNI	*Rubus nivalis*							
RUPA	*Rubus parviflorus*			0.1				
RUPE	*Rubus pedatus*		0.1	1.4	0.1			
RUSP	*Rubus spectabilis*			5.0				
RUUR	*Rubus ursinus*		0.4	1.3	0.1	0.2	0.2	0.2
SARA	*Sambucus racemosa*			0.3				
SEOR	*Selaginella oregana*							
SMRA	*Smilacina racemosa*	0.7						0.1
SMST	*Smilacina stellata*			0.1	0.2			
SOSI	*Sorbus sitchensis*							
STME2	*Stachys mexicana*			0.1				
STAM	*Streptopus amplexifolius*			0.1				
STRO	*Streptopus roseus*				0.1			
STST	*Streptopus streptopoides*							
SYAL	*Symphoricarpos albus*		0.1	0.1				
SYMO	*Symphoricarpos mollis*	1.0			0.2		0.4	0.1
TITR	*Tiarella trifoliata*		0.3	1.6	0.3			0.1
TIUN	*Tiarella unifoliata*				0.2			
TOME	*Tolmiea menziesii*							
TRLA2	*Trientalis latifolia*	1.7	0.4	0.1	0.4			0.4
TROV	*Trillium ovatum*		0.7	0.6	0.4		0.2	0.4
TRCE	*Trisetum cernuum*		0.1	0.1				0.1
VAAL	*Vaccinium alaskaense*		0.6	3.0	0.3	1.4	0.4	0.4
VAME	*Vaccinium membranaceum*	0.3			0.2	0.4	0.2	
VAOV	*Vaccinium ovalifolium*			0.1				0.1
VAOV2	*Vaccinium ovatum*	0.7						
VAPA	*Vaccinium parvifolium*	1.0	2.8	2.1	0.5	4.4	1.4	3.3
VIAM	*Vicia americana*	1.3						
VIGL	*Viola glabella*			0.1				
VIOR2	*Viola orbiculata*				0.2			
VISE	*Viola sempervirens*		0.3	0.6	0.4	0.4	0.6	0.3
XETE	*Xerophyllum tenax*		0.8		0.2	8.6	0.2	1.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 288 for mean relative cover values.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		TSHE/ RHMA/POMU	TSHE/ GASH	TSHE/ GASH/XETE	TSHE/ GASH-VAOV2	TSHE/ GASH-HODI	TSHE/ GASH-BENE
ECOCLASS Code		CHS3 35 (OLY)	CHS1 31 (OLY)	CHS1 32	CHS1 33	CHS1 34	CHS1 35
Number of plots		3	12	21	4	5	16
TREES							
ABAM	*Abies amabilis*	1.3	0.7	1.1			0.3
ABGR	*Abies grandis*				0.1	6.0	0.1
ACMA	*Acer macrophyllum*				2.8		
ALRU	*Alnus rubra*				0.3		0.1
CHNO	*Chamaecyparis nootkatensis*						
CONU	*Cornus nuttallii*			0.9			
PISI	*Picea sitchensis*						
PICO	*Pinus contorta*						
PIMO	*Pinus monticola*			0.1		0.2	0.3
PSME	*Pseudotsuga menziesii*	40.0	26.2	39.4	69.7	60.0	50.6
PYFU	*Pyrus fusca*		0.2				
RHPU	*Rhamnus purshiana*			0.1			
TABR	*Taxus brevifolia*		0.7	2.1		4.0	0.9
THPL	*Thuja plicata*	33.3	15.3	7.1	30.0	6.0	5.0
TSHE	*Tsuga heterophylla*	53.3	53.4	54.5	14.7	24.0	45.6
TSME	*Tsuga mertensiana*						
SHRUBS and HERBS							
ACCI	*Acer circinatum*	0.3	1.3	18.7	5.0	0.4	6.3
ACGL	*Acer glabrum*					0.4	0.1
ACTR	*Achlys triphylla*	0.3	0.4	0.7	0.3	1.8	1.8
ADBI	*Adenocaulon bicolor*		0.1			0.4	
ADPE	*Adiantum pedatum*						
ALVI	*Allotropa virgata*						
ARCA6	*Arceuthobium campylopodum* f.*tsugensis*	0.3					0.2
ARUV	*Arctostaphylos uva-ursi*						
ARMA3	*Arenaria macrophylla*		0.1				
ASCA3	*Asarum caudatum*						
ATFI	*Athyrium filix-femina*						0.1
BENE	*Berberis nervosa*	11.0	1.1	6.1	2.8	13.6	9.9
BLSP	*Blechnum spicant*		1.8	0.1			0.5
BOEL	*Boykinia elata*						
BRPA	*Bromus pacificus*						
CASC2	*Campanula scouleri*	0.3	0.1			0.8	
CADE	*Carex deweyana*						0.1
CHME	*Chimaphila menziesii*	0.7	0.3	0.6			0.4
CHUM	*Chimaphila umbellata*	0.3	0.3	1.1		1.2	0.4
CIAL	*Circaea alpina*						
CLUN	*Clintonia uniflora*	0.7	0.1			0.4	0.4
COLA	*Coptis laciniata*		0.3	0.2			0.2
COMA3	*Corallorhiza maculata*						0.1
COME	*Corallorhiza mertensiana*	0.3		0.1			0.1
COCA	*Cornus canadensis*	0.3	0.2	0.6		0.2	0.4
DIHO	*Disporum hookeri*		0.1				0.1
DISM	*Disporum smithii*		0.1				0.1
DRAU2	*Dryopteris austriaca*						
ERMO	*Erythronium montanum*						
FEOC	*Festuca occidentalis*		0.1			0.2	0.1
FESU	*Festuca subulata*						0.1
GATR	*Galium triflorum*				0.3		0.1
GAOV	*Gaultheria ovatifolia*						
GASH	*Gaultheria shallon*	36.7	64.2	50.7	67.5	62.0	63.4
GOOB	*Goodyera oblongifolia*	0.3	0.3	0.3	0.3	0.8	0.6
GYDR	*Gymnocarpium dryopteris*	1.3				0.4	0.1
HIAL	*Hieracium albiflorum*		0.1			0.4	0.5
HODI	*Holodiscus discolor*				1.5	3.0	
HYMO	*Hypopitys monotropa*		0.1	0.1		0.2	0.1
LAMU	*Lactuca muralis*						0.1
LICO4	*Lilium columbianum*		0.1	0.1		0.2	0.1

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 288 for mean relative cover values.

[2] Stand ages for the Tshe/Gash-Vaov2 Association ranged between 55 and 98 years.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		TSHE/ RHMA/POMU	TSHE/ GASH	TSHE/ GASH/XETE	TSHE/ GASH-VAOV2	TSHE/ GASH-HODI	TSHE/ GASH-BENE
ECOCLASS Code		CHS3 35 (OLY)	CHS1 31 (OLY)	CHS1 32	CHS1 33	CHS1 34	CHS1 35
Number of plots		3	12	21	4	5	1
SHRUBS and HERBS (cont.)							
LIBO2	*Linnaea borealis*	1.7	1.3	1.8	1.5	2.0	11.4
LICA3	*Listera caurina*			0.1			
LICO2	*Listera convallarioides*				0.3		0.1
LICO3	*Listera cordata*		0.1			0.2	0.4
LUPA	*Luzula parviflora*	0.3					
LYCL	*Lycopodium clavatum*		0.1				0.1
LYAM	*Lysichitum americanum*		0.3				
MADI2	*Maianthemum dilatatum*		0.1				0.1
MEFE	*Menziesia ferruginea*	0.3	0.9	0.4			0.1
MOSI	*Montia sibirica*						
NONE	*Nothochelone nemorosa*						
OPHO	*Oplopanax horridum*						0.1
OSCH	*Osmorhiza chilensis*						0.1
OXOR	*Oxalis oregana*						
PAMY	*Pachistima myrsinites*					0.6	
POMU	*Polystichum munitum*	8.7	0.5	1.3	4.0	1.4	0.9
PTAQ	*Pteridium aquilinum*		0.8	0.1	0.5	0.4	0.3
PTAN	*Pterospora andromedea*			0.1		0.2	
PYAS	*Pyrola asarifolia*		0.1	0.1		0.2	0.1
PYPI	*Pyrola picta*						0.1
PYSE	*Pyrola secunda*	0.3		0.1		0.2	0.1
PYUN	*Pyrola uniflora*		0.2				0.1
RHAL	*Rhododendron albiflorum*						
RHMA	*Rhododendron macrophyllum*	24.7	0.2	0.1	4.3		0.1
RIBR	*Ribes bracteosum*						
RILA	*Ribes lacustre*						0.1
ROGY	*Rosa gymnocarpa*		0.2	0.2	0.3	2.6	0.4
RULA	*Rubus lasiococcus*						
RULE	*Rubus leucodermis*						
RUNI	*Rubus nivalis*		0.1				0.1
RUPA	*Rubus parviflorus*						
RUPE	*Rubus pedatus*	0.3	0.1				0.1
RUSP	*Rubus spectabilis*		0.8				0.1
RUUR	*Rubus ursinus*		0.1	0.1	0.8	0.4	0.7
SARA	*Sambucus racemosa*						0.1
SEOR	*Selaginella oregana*						0.1
SMRA	*Smilacina racemosa*						0.1
SMST	*Smilacina stellata*	0.3					0.4
SOSI	*Sorbus sitchensis*		0.2				
STME2	*Stachys mexicana*						
STAM	*Streptopus amplexifolius*						0.1
STRO	*Streptopus roseus*	0.3					
STST	*Streptopus streptopoides*	0.3					
SYAL	*Symphoricarpos albus*				0.3		
SYMO	*Symphoricarpos mollis*					1.0	
TITR	*Tiarella trifoliata*	0.7				0.2	0.3
TIUN	*Tiarella unifoliata*	0.3					
TOME	*Tolmiea menziesii*						
TRLA2	*Trientalis latifolia*		0.3	0.4	0.3	0.8	0.4
TROV	*Trillium ovatum*	0.3	0.3	0.2		0.2	0.6
TRCE	*Trisetum cernuum*					0.2	0.1
VAAL	*Vaccinium alaskaense*	0.7	1.9	1.0			1.1
VAME	*Vaccinium membranaceum*					0.2	0.1
VAOV	*Vaccinium ovalifolium*	0.3	0.6				0.4
VAOV2	*Vaccinium ovatum*				8.8		
VAPA	*Vaccinium parvifolium*	4.0	4.7	4.2	3.3	1.2	10.7
VIAM	*Vicia americana*						
VIGL	*Viola glabella*						
VIOR2	*Viola orbiculata*						
VISE	*Viola sempervirens*	0.7	0.2	0.3		0.4	0.9
XETE	*Xerophyllum tenax*		0.3	12.0			0.2

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 286 for mean relative cover values.
[2] Stand ages for the Tshe/Gash-Vaov2 Association ranged between 55 and 98 years.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for Associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		TSHE/ GASH/OXOR	TSHE/ GASH/POMU	TSHE/ LYAM	TSHE/ POMU-TITR	TSHE/ POMU-OXOR	TSHE/ ACTR
ECOCLASS Code		CHS1 36	CHS1 37	CHM1 11 (OLY)	CHF1 32	CHF1 31 (OLY)	CHF2 11 (OLY)
Number of plots		4	34	1	17	25	10
TREES							
ABAM	*Abies amabilis*	1.8	0.2		1.2	1.8	0.7
ABGR	*Abies grandis*				0.2		
ACMA	*Acer macrophyllum*		1.4		3.4	0.2	
ALRU	*Alnus rubra*	6.3	0.2			0.1	
CHNO	*Chamaecyparis nootkatensis*						
CONU	*Cornus nuttallii*		1.1		0.1		
PISI	*Picea sitchensis*					1.0	
PICO	*Pinus contorta*						
PIMO	*Pinus monticola*		0.1				
PSME	*Pseudotsuga menziesii*		41.5		38.8	6.9	45.5
PYFU	*Pyrus fusca*						
RHPU	*Rhamnus purshiana*		0.2	4.0	0.2	1.6	
TABR	*Taxus brevifolia*		1.5		0.1	0.2	0.2
THPL	*Thuja plicata*	4.5	11.6	21.0	15.5	7.0	10.5
TSHE	*Tsuga heterophylla*	90.0	47.8	45.0	53.4	80.8	53.6
TSME	*Tsuga mertensiana*						
SHRUBS and HERBS							
ACCI	*Acer circinatum*	1.5	22.9	5.0	9.4	3.7	10.1
ACGL	*Acer glabrum*						
ACTR	*Achlys triphylla*		1.7		3.6	0.6	14.7
ADBI	*Adenocaulon bicolor*				0.2	0.1	0.3
ADPE	*Adiantum pedatum*		0.1		0.4	0.1	0.1
ALVI	*Allotropa virgata*						
ARCA6	*Arceuthobium campylopodum f.tsugensis*	0.8			0.4		
ARUV	*Arctostaphylos uva-ursi*						
ARMA3	*Arenaria macrophylla*						
ASCA3	*Asarum caudatum*				0.2		0.1
ATFI	*Athyrium filix-femina*	0.3	0.4	1.0	2.3	0.8	0.2
BENE	*Berberis nervosa*	5.3	11.8		1.1	0.3	6.1
BLSP	*Blechnum spicant*	2.3	0.9		2.6	5.4	0.3
BOEL	*Boykinia elata*					0.2	
BRPA	*Bromus pacificus*						
CASC2	*Campanula scouleri*						0.1
CADE	*Carex deweyana*						
CHME	*Chimaphila menziesii*		0.4		0.2		0.6
CHUM	*Chimaphila umbellata*		0.6		0.1		1.2
CIAL	*Circaea alpina*		0.1		0.1	0.2	0.2
CLUN	*Clintonia uniflora*		0.1		0.5	0.2	1.8
COLA	*Coptis laciniata*	0.5			0.1	0.2	
COMA3	*Corallorhiza maculata*				0.1		0.1
COME	*Corallorhiza mertensiana*				0.1		0.3
COCA	*Cornus canadensis*		0.1		0.1	0.1	1.8
DIHO	*Disporum hookeri*	0.3	0.2		0.5	0.2	0.3
DISM	*Disporum smithii*	0.3	0.1		0.5	0.3	0.2
DRAU2	*Dryopteris austriaca*				0.2	0.4	0.1
ERMO	*Erythronium montanum*						
FEOC	*Festuca occidentalis*						
FESU	*Festuca subulata*						0.1
GAAP	*Galium aparine*					0.1	0.1
GATR	*Galium triflorum*		0.3		1.6	0.5	0.1
GAOV	*Gaultheria ovatifolia*						
GASH	*Gaultheria shallon*	17.5	45.3	1.0	1.2	1.6	0.7
GOOB	*Goodyera oblongifolia*		0.4		0.4		0.4
GYDR	*Gymnocarpium dryopteris*		0.2		0.8	0.6	
HIAL	*Hieracium albiflorum*		0.1		0.1		0.2
HODI	*Holodiscus discolor*		0.1				
HYMO	*Hypopitys monotropa*		0.1				0.1
LAMU	*Lactuca muralis*		0.2		0.3		
LICO4	*Lilium columbianum*		0.1				0.2

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 286 for mean relative cover values.

Table 170 (cont.). Mean absolute cover[1] values of trees, shrubs and herbs for associations in the Western Hemlock Series. Cover values based on plots 150 years and older.

		ASSOCIATIONS					
		TSHE/ GASH/OXOR	TSHE/ GASH/POMU	TSHE/ LYAM	TSHE/ POMU-TITR	TSHE/ POMU-OXOR	TSHE/ ACTR
ECOCLASS Code		CHS1 36	CHS1 37	CHM1 11 (OLY)	CHF1 32	CHF1 31 (OLY)	CHF2 11 (OLY)
Number of plots		4	34	1	17	25	10
SHRUBS and HERBS (cont.)							
LIBO2	*Linnaea borealis*		3.5		5.0	0.4	3.7
LICA3	*Listera caurina*						
LICO2	*Listera convallarioides*				0.1		0.6
LICO3	*Listera cordata*	0.3					0.2
LUPA	*Luzula parviflora*	0.3	0.1		0.3	0.5	0.1
LYCL	*Lycopodium clavatum*						0.1
LYAM	*Lysichitum americanum*			15.0			
MADI2	*Maianthemum dilatatum*	0.8		1.0	0.4	0.5	0.1
MEFE	*Menziesia ferruginea*	1.0	0.2	1.0	0.3	1.7	0.3
MOSI	*Montia sibirica*				0.2	0.2	0.1
NONE	*Nothochelone nemorosa*				0.1		0.1
OPHO	*Oplopanax horridum*		0.2		0.5	0.2	0.2
OSCH	*Osmorhiza chilensis*				0.1		0.3
OXOR	*Oxalis oregana*	16.2				36.4	
PAMY	*Pachistima myrsinites*		0.1				0.1
POGL4	*Polypodium glycyrrhiza*		0.1		0.1	0.1	0.1
POMU	*Polystichum munitum*	3.5	19.4	1.0	32.9	24.5	1.7
PTAQ	*Pteridium aquilinum*		0.3		0.1		
PTAN	*Pterospora andromedea*						0.1
PYAS	*Pyrola asarifolia*		0.1		0.1		0.2
PYPI	*Pyrola picta*		0.1		0.1		0.3
PYSE	*Pyrola secunda*						0.7
PYUN	*Pyrola uniflora*					0.2	0.1
RHAL	*Rhododendron albiflorum*						
RHMA	*Rhododendron macrophyllum*		0.3		0.3		1.3
RIBR	*Ribes bracteosum*				0.1	0.1	
RILA	*Ribes lacustre*						0.2
ROGY	*Rosa gymnocarpa*		0.6		0.1		0.7
RULA	*Rubus lasiococcus*				0.1	0.1	
RULE	*Rubus leucodermis*						
RUNI	*Rubus nivalis*		0.1		0.1		0.1
RUPA	*Rubus parviflorus*		0.1		0.1		
RUPE	*Rubus pedatus*			1.0	0.4	1.3	0.2
RUSP	*Rubus spectabilis*	2.0	0.5	45.0	0.6	4.7	
RUUR	*Rubus ursinus*		0.8		1.7	0.4	0.2
SARA	*Sambucus racemosa*		0.2		0.1	0.2	
SEOR	*Selaginella oregana*		0.2			0.2	
SMRA	*Smilacina racemosa*		0.1		0.1	0.1	0.1
SMST	*Smilacina stellata*		0.1		0.5	0.2	6.9
SOSI	*Sorbus sitchensis*						
STME2	*Stachys mexicana*						
STAM	*Streptopus amplexifolius*	0.3			0.2	0.4	0.2
STRO	*Streptopus roseus*				0.1	0.1	0.8
STST	*Streptopus streptopoides*						0.1
SYAL	*Symphoricarpos albus*						
SYMO	*Symphoricarpos mollis*		0.1				0.1
TITR	*Tiarella trifoliata*	0.3	1.8	3.0	5.7	1.8	2.9
TIUN	*Tiarella unifoliata*				0.4		0.3
TOME	*Tolmiea menziesii*				0.1		
TRLA2	*Trientalis latifolia*		0.8		0.7	0.3	0.4
TROV	*Trillium ovatum*	1.0	0.6		0.8	0.6	0.6
TRCE	*Trisetum cernuum*				0.1	0.1	0.1
VAAL	*Vaccinium alaskaense*	3.3	1.0	10.0	0.9	4.8	0.8
VAME	*Vaccinium membranaceum*						0.4
VAOV	*Vaccinium ovalifolium*		0.1		0.1	0.2	0.2
VAOV2	*Vaccinium ovatum*						
VAPA	*Vaccinium parvifolium*	6.5	8.8	1.0	3.1	4.9	3.1
VIAM	*Vicia americana*						
VIGL	*Viola glabella*					0.1	0.1
VIOR2	*Viola orbiculata*						
VISE	*Viola sempervirens*	0.5	0.9		0.5	0.4	1.2
XETE	*Xerophyllum tenax*		0.1				1.7

[1] Mean absolute cover are values where zeroes are included in the calculation of the mean. See Table 93 p. 286 for mean relative cover values.

Table 171. Birds of the Olympic National Forest (Current American Ornithologist Union nomenclature), (modified from Guenther and Kucera 1978).

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE AND SEASONALITY
Common Loon	*Gavia immer*	RS
Pied-billed Grebe	*Podilymbus podiceps*	UP
Horned Grebe	*Podiceps auritus*	RS
Western Grebe	*Aechmophrus occidentalis*	RS
Double-crested cormorant	*Phalacrocorax auritus*	?W
American Bittern	*Botaurus lentiginosus*	?P
Great Blue Heron	*Ardea herodias*	UP
Green-backed Heron	*Butorides striatus*	RS
Tundra Swan	*Cygnus columbianus*	?M
Trumpeter Swan	*Cygnus buccinator*	RW
Great White-fronted Goose	*Anser albifrons*	?M
Snow Goose	*Chen caerulescens*	?M
Canada Goose	*Branta canadensis*	UW
Wood Duck	*Aix sponsa*	US
Green-winged Teal	*Anas crecca*	UW
Mallard	*Anas platyrhynchos*	UP
Northern Pintail	*Anas acuta*	RM
Blue-winged Teal	*Anas discors*	?M
Cinnamon Teal	*Anas cyanoptera*	?M
Northern Shoveler	*Anas clypeata*	?W
Gadwall	*Anas strepera*	RW
American Wigeon	*Anas americana*	UW
Canvasback	*Aythya valisineria*	RM
Redhead	*Aythya americana*	?M
Ring-necked Duck	*Aythya collaris*	UW
Greater Scaup	*Aythya marila*	?W
Lesser Scaup	*Aythya affinis*	UW
Harlequin Duck	*Histrionicus histrionicus*	US
Common Goldeneye	*Bucephala clangula*	UW
Barrow's Goldeneye	*Bucephala islandica*	?M
Bufflehead	*Bucephala albeola*	UW
Hooded Merganser	*Lophodytes cucullatus*	UP
Common Merganser	*Mergus merganser*	UP
Red-breasted Merganser	*Mergus serrator*	?M
Ruddy Duck	*Oxyura jamaicensis*	RW
Turkey Vulture	*Cathartes aura*	RS
Osprey	*Pandion haliaetus*	US
Bald Eagle	*Haliaeetus leucocephalus*	UP
Northern Harrier	*Circus cyaneus*	UM
Sharp-shinned Hawk	*Accipiter striatus*	CP
Cooper's Hawk	*Accipiter cooperi*	UP
Northern Goshawk	*Accipiter gentilis*	UP
Swainson's Hawk	*Buteo swainsoni*	?M
Red-tailed Hawk	*Buteo jamaicensis*	CS,UW
Golden Eagle	*Aquila chrysaetos*	RP
American Kestrel	*Falco sparverius*	US,RW
Merlin	*Falco columbarius*	RP
Peregrine Falcon	*Falco peregrinus*	RP
Gyrfalcon	*Falco rusticolus*	RW

Table 171. (cont.) Birds of the Olympic National Forest (Current American Ornitholigist Union nomenclature), (modified from Guenther and Kucera 1978).

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE AND SEASONALITY
Ring-necked Pheasant	*Phasianus colchicus*	?
Blue Grouse	*Dendragapus obscurus*	CP
Ruffed Grouse	*Bonasa umbellus*	CP
California Quail	*Callipepla californica*	?
Mountain Quail	*Oreortyx pictus*	?
Virginia Rail	*Rallus limicola*	RS
Sora	*Porzana carolina*	?S
American Coot	*Fulica americana*	UW
Sandhill Crane	*Grus canadensis*	?M
Killdeer	*Charadrius vociferus*	US,RW
Greater Yellowlegs	*Tringa melanoleuca*	RM
Lesser Yellowlegs	*Tringa flavipes*	?M
Solitary Sandpiper	*Tringa solitaria*	RM
Spotted Sandpiper	*Actitis macularia*	US
Western Sandpiper	*Calidris mauri*	RM
Least Sandpiper	*Calidris minutilla*	RM
Dunlin	*Calidris alpina*	?M
Long-billed Dowitcher	*Limnodromus scolopaceus*	?M
Common Snipe	*Gallinago gallinago*	RP
Bonaparte's Gull	*Larus philadelphia*	RM
Ring-billed Gull	*Larus delawarensis*	RM
California Gull	*Larus californicus*	RM
Glaucous-winged Gull	*Larus glaucescens*	RW
Marbled Murrelet	*Brachyramphus marmoratus*	RS
Rock Dove	*Columba livia*	?P
Band-tailed Pigeon	*Columba fasciata*	CS,RW
Mourning Dove	*Zenaida macroura*	RS
Common Barn-Owl	*Tyto alba*	?P
Western Screech-Owl	*Otus kennicottii*	CP
Great Horned Owl	*Bubo virginianus*	UP
Northern Pygmy-Owl	*Glaucidium gnoma*	UP
Spotted Owl	*Strix occidentalis*	RP
Barred Owl	*Strix varia*	RP
Great Gray Owl	*Strix nebulosa*	?
Short-eared Owl	*Asio flammeus*	?W
Northern Saw-whet Owl	*Aegolius acadicus*	UP
Common Nighthawk	*Chordeiles minor*	US
Black Swift	*Cypseloides niger*	US
Vaux's Smith	*Chaetura vauxi*	CS
Anna's Hummingbird	*Calypte anna*	?W
Rufous Hummingbird	*Selasphorus rufus*	CS
Belted Kingfisher	*Ceryle alcyon*	UP
Red-Breasted Sapsucker	*Sphyrapicus ruber*	UP
Downy Woodpecker	*Picoides pubescens*	UP
Hairy Woodpecker	*Picoides villosus*	CP
Three-toed Woodpecker	*Picoides tridactylus*	RP
Northern Flicker	*Colaptes auratus*	CS,UW
Pileated Woodpecker	*Dryocopus pileatus*	UP
Olive-sided Flycatcher	*Contopus borealis*	CS
Western Wood-Pewee	*Contopus sordidulus*	US
Willow Flycatcher	*Empidonax trailii*	CS

Table 171. (cont.) Birds of the Olympic National Forest (Current American Ornitholigist Union nomenclature), (modified from Guenther and Kucera 1978).

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE AND SEASONALITY
Hammond's Flycatcher	*Empidonax hammondii*	CS
Dusky Flycatcher	*Empidonax oberholseri*	RS
Western Flycatcher	*Empidonax difficilis*	AS
Horned Lark	*Eremophila alpestris*	US
Purple Martin	*Progne subis*	?S
Tree Swallow	*Tachycineta bicolor*	US
Violet-green Swallow	*Tachycineta thalassina*	US
Northern Rough-winged swallow	*Stelgidopteryx serripennis*	US
Cliff Swallow	*Hirunda pyrrhonota*	RS
Barn Swallow	*Hirunda rustica*	US
Gray Jay	*Perisoreus canadensis*	CP
Steller's Jay	*Cyanocitta stelleri*	CP
Clark's Nutcracker	*Nucifraga columbiana*	RP
American Crow	*Corvus brachyrhynchos*	UP
Northwestern Crow	*Corvus caurinus*	RP
Common Raven	*Corvus corax*	CP
Black-capped Chickadee	*Parus atricapillus*	UP
Mountain Chickadee	*Parus gambeli*	RP
Chestnut-backed Chickadee	*Parus rufescens*	AP
Bushtit	*Psaltriparus minimus*	UP
Red-breasted Nuthatch	*Sitta canadensis*	CP
Brown Creeper	*Certhia americana*	CP
Bewick's Wren	*Thryomanes bewickii*	UP
House Wren	*Troglodytes aedon*	RS
Winter Wren	*Troglodytes troglodytes*	AS
Marsh Wren	*Cistothorus palustris*	RS
American Dipper	*Cinclus mexicanus*	UP
Golden-crowned Kinglet	*Regulus satrapa*	AP
Ruby-crowned Kinglet	*Regulus calendula*	UW,RS
Western Bluebird	*Sialia mexicana*	RM
Mountain Bluebird	*Sialia currucoides*	RS
Townsend's Solitaire	*Myadestes townsendi*	US
Swainson's Thrush	*Catharus ustulatus*	CS
Hermit Thrush	*Catharus guttatus*	CS,RW
American Robin	*Turdus migratorius*	CS,UW
Varied Thrush	*Ixoreus naevius*	AP
Water Pipit	*Anthus spinoletta*	US
Bohemian Waxwing	*Bombycilla garrulus*	?W
Cedar Waxwing	*Bombycilla cedrorum*	UP
Northern Shrike	*Lanius excubitor*	?W
European Starling	*Sturnus vulgaris*	RP
Solitary vireo	*Vireo solitarius*	US
Hutton's vireo	*Vireo huttoni*	UP
Warbling vireo	*Vireo gilvus*	CS
Red-eyed vireo	*Vireo olivaceus*	?S
Orange-crowned Warbler	*Vermivora celata*	US
Nashville Warbler	*Vermivora ruficapilla*	RM
Yellow Warbler	*Dendroica petechia*	US
Yellow-rumped Warbler	*Dendroica coronata*	CS,RW
Black-throated Gray Warbler	*Dendroica nigrescens*	CS

Table 171. (cont.) Birds of the Olympic National Forest (Current American Ornitholigist Union nomenclature), (modified from Guenther and Kucera 1978).

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE AND SEASONALITY
Townsend's Warbler	*Dindroica townsendi*	CS,RW
Hermit Warbler	*Dendroica occidentali*	CS
MacGillivray's Warbler	*Oporonis tolmiei*	US
Common Yellowthroat	*Geothlypis trichas*	RS
Wilson's Warbler	*Wilsonia pusilla*	CS
Western Tanager	*Piranga ludoviciana*	US
Black-headed Grosbeak	*Pheucticus melanocephalus*	US
Rufous-sided Towhee	*Pipilo erythrophthalmus*	UP
Chipping Sparrow	*Spizella passerina*	US
Vesper Sparrow	*Pooecetes gramineus*	RM
Savannah Sparrow	*Passerculus sandwichensis*	RS,UM
Fox Sparrow	*Passerella iliaca*	UP
Song Sparrow	*Melospiza melodia*	CP
Lincoln's Sparrow	*Melospiza lincolnii*	RM
Golden-crowned Sparrow	*Zonotrichia atricapilla*	UM,RW
White-crowned Sparrow	*Zonotrichia leucophrys*	US,RW
Dark-eyed Junco	*Junco hyemalis*	AS,UW
Red-winged Blackbird	*Agelaius phoeniceus*	US,RW
Western Meadowlark	*Sturnella neglecta*	RM
Brewer's Blackbird	*Euphagus cyanocephalus*	RP
Brown-headed Cowbird	*Molothrus ater*	US
Rosy Finch	*Leucosticte arctoa*	UP
Pine Grosbeak	*Pinicola enucleator*	RP
Purple Finch	*Carpodacus purpureus*	UP
Cassin's Finch	*Carpodacus cassinii*	?S
House Finch	*Carpodacus mexicanus*	?
Red Crossbill	*Loxia curvirostra*	CP
White-winged Crossbill	*Loxia leucoptera*	RP
Common Redpoll	*Carduelis flammea*	?W
Pine Siskin	*Carduelis pinus*	CP
American Goldfinch	*Carduelis tristis*	US,RW
Evening Grosbeak	*Coccothraustes vespertina*	CP
House Sparrow	*Passer domesticus*	?

Saltwater species likely to occur off Seal Rock in addition to the above species.

Red-throated Loon	*Gavia stellata*
Pacific Loon	*Gavia pacifica*
Yellow-billed Loon	*Gavia adamsii*
Red-necked Grebe	*Podiceps grisegena*
Eared Grebe	*Podiceps nigricollis*
Brandt's Cormorant	*Phalacrocorax penicillatus*
Pelagic Cormorant	*Phalacrocorax pelagicus*
Brant	*Branta bernicla*
Eurasian Wigeon	*Anas penelope*
Oldsquaw	*Clangula hyemalis*
Black Scoter	*Melanitta nigra*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*

Table 171. (cont.) Birds of the Olympic National Forest (Current American Ornitholigist Union nomenclature), (modified from Guenther and Kucera 1978).

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE AND SEASONALITY
Black-bellied Plover	*Pluvialis squatarola*	
Semipalmated Plover	*Charadrius semipalmatus*	
Ruddy Turnstone	*Arenaria interpres*	
Black Turnstone	*Arenaria melanocephala*	
Sanderling	*Calidris alba*	
Short-billed Dowitcher	*Limnodromus griseus*	
Red-necked Phalarope	*Phalaropus lobatus*	
Parasitic Jaeger	*Stercorarius parasiticus*	
Heermann's Gull	*Larus heermanni*	
Mew Gull	*Larus canus*	
Herring Gull	*Larus argentatus*	
Thayer's Gull	*Larus thayeri*	
Western Gull	*Larus occidentalis*	
Caspian Tern	*Sterna caspia*	
Common Tern	*Sterna hirundo*	
Common Murre	*Uria aalge*	
Pigeon Guillemot	*Cepphus columba*	
Ancient Murrelet	*Synthliboramphus antiquus*	
Rhinoceros Auklet	Cerorhinca monocerata	

Abundance and Seasonality Codes

A = abundant. Very numerous in habitats present over much of the Forest. Always present in appropriate habitat.
C = common. Numerous in a widespead habitat. Nearly always present in appropriate habitat, but less numerous than A.
U = uncommon. Usually present in small numbers in a widespread habitat and therefore only encountered at times in appropriate habitat, or present in a habitat that is very limited in distribution, e.g. lakes, alpine.
R = rare. Rarely encountered in a widespread habitat where it is present in very small numbers, or very sporadic in occurrence, or sometimes present in small numbers in a habitat that is very limited in distribution.
? = questionable. Species may occur on the Forest, but no known records and if so, rare.
P = permanent resident or year-round visitor
S = summer resident or visitor
W = winter resident or visitor
M = migrant present only in spring and/or fall.

These lists were compiled by Chris Chappell based on a review of the literature, including bird sightings reported in *American Birds* and his personal field experience of many years in western Washington. Paul Meehan-Martin made valuable comments and suggestions based on his field experience. These are working lists, by no means absolutely complete or accurate. There are still many gaps in our knowledge of Olympic bird distribution.

APPENDIX 4

- Height Curves for Tree Species
- Height Curve Equations
- Site Index Equations
- Mean Annual Increment Curves
- Empirical Volume and MAI Curves
- List of Oldest and Biggest Trees

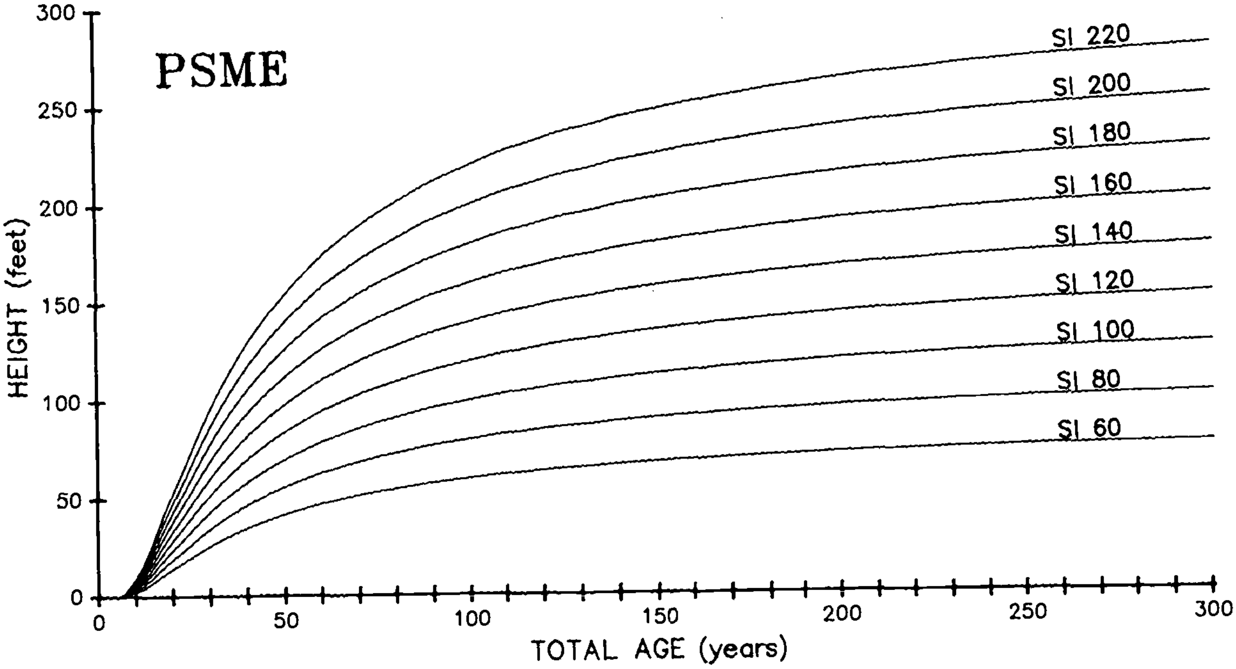

Figure 175. Height growth curves for Douglas-fir (McArdle and Meyer 1930).

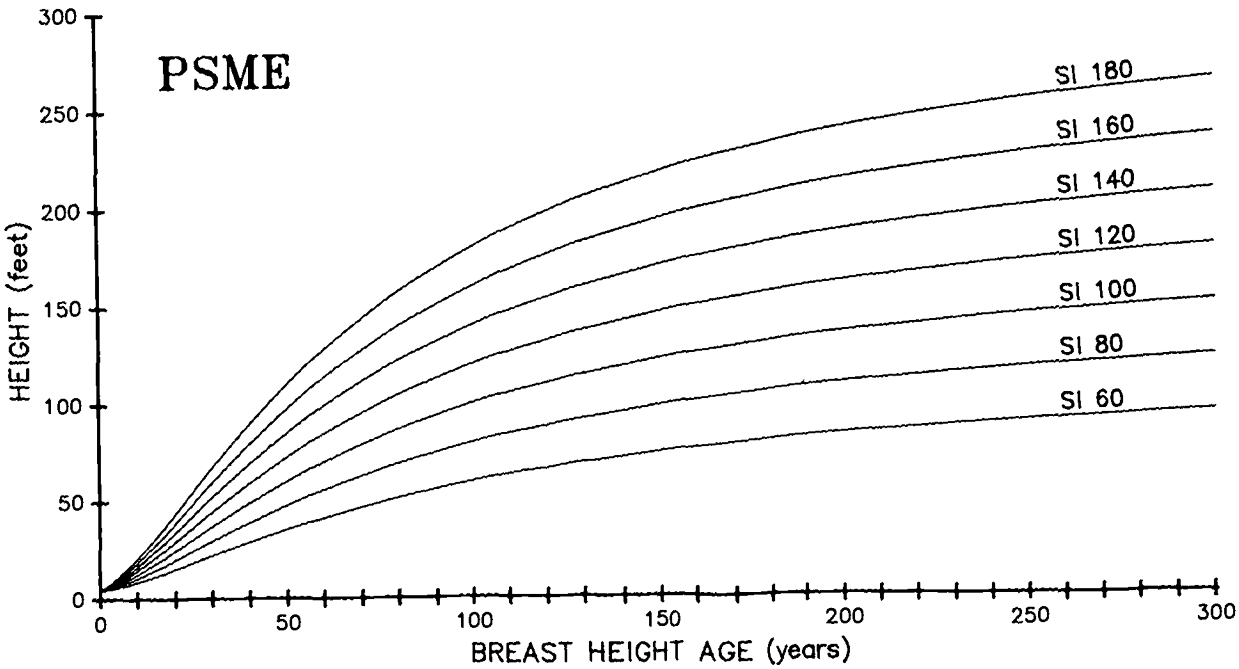

Figure 176. Height growth curves for Douglas-fir (Curtis *et al.* 1974).

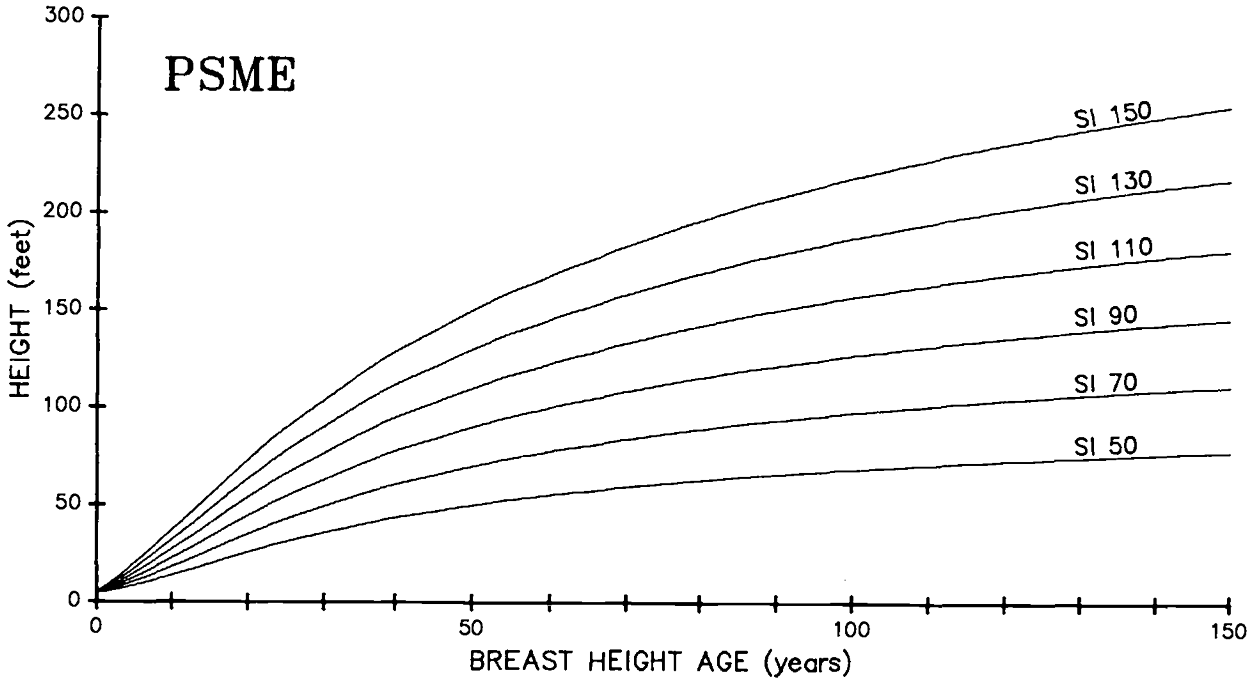

Figure 177. Height growth curves for Douglas-fir (King 1966).

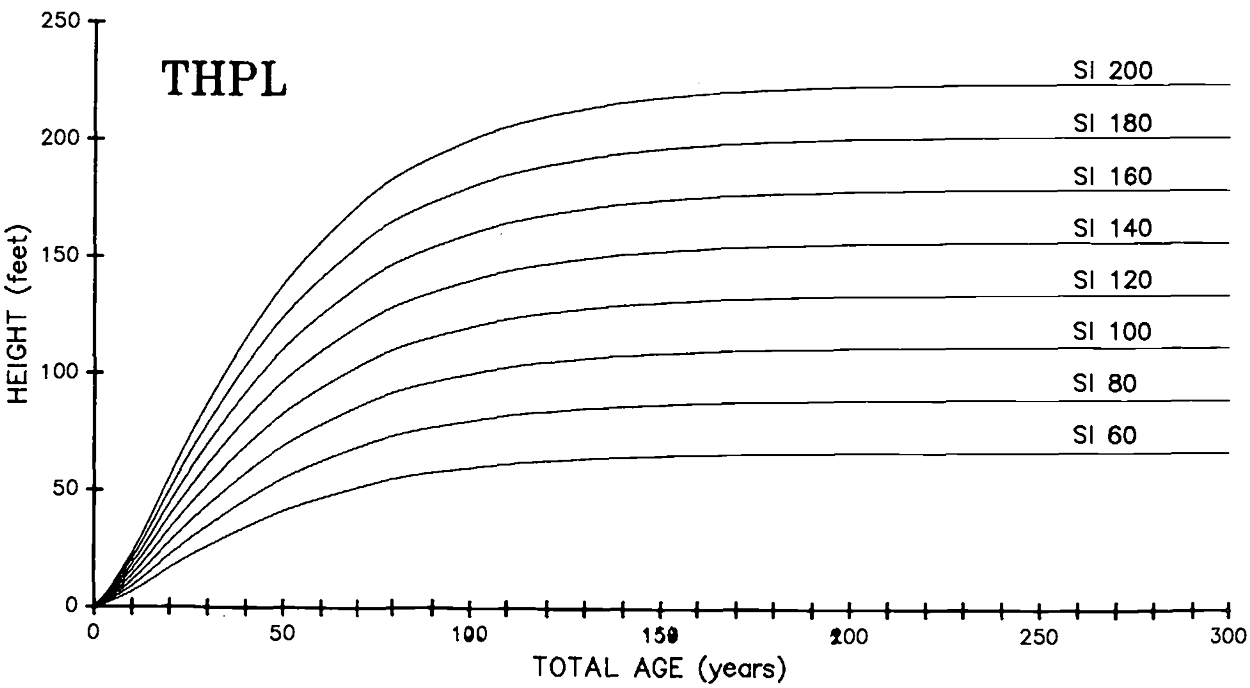

Figure 178. Height growth curves for western redcedar (Hegyi *et al.* 1979).

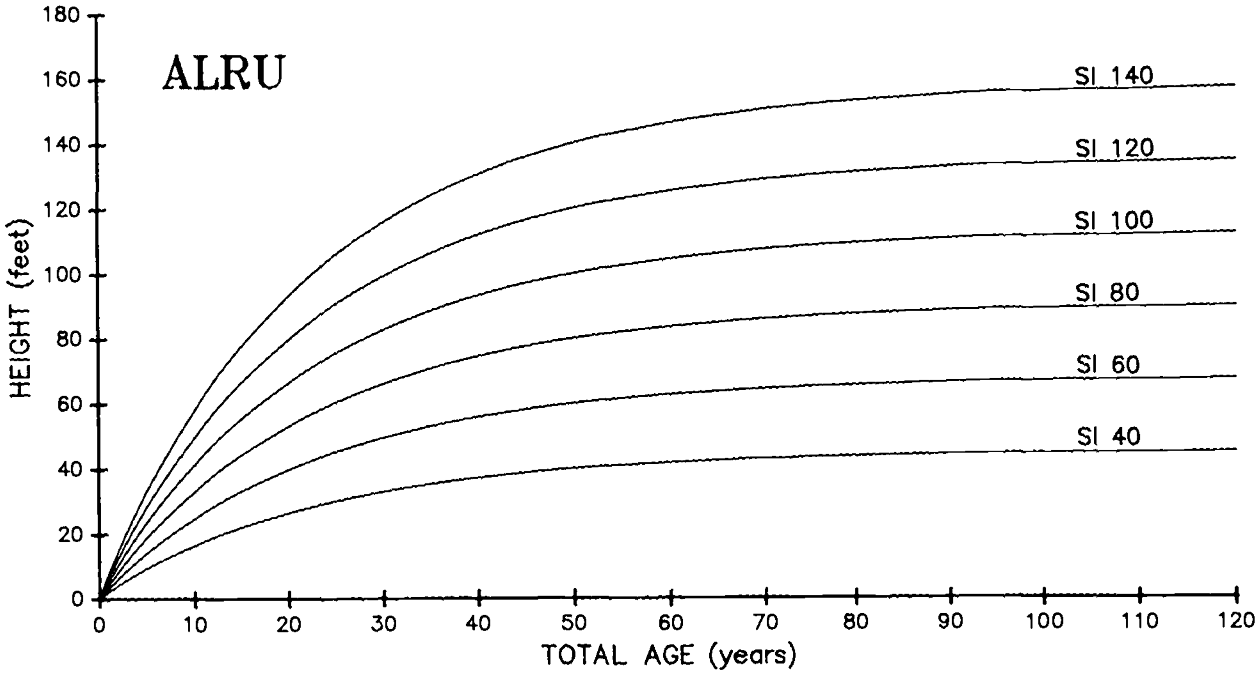

Figure 179. Height growth curves for red alder (Hegyi *et al.* 1979).

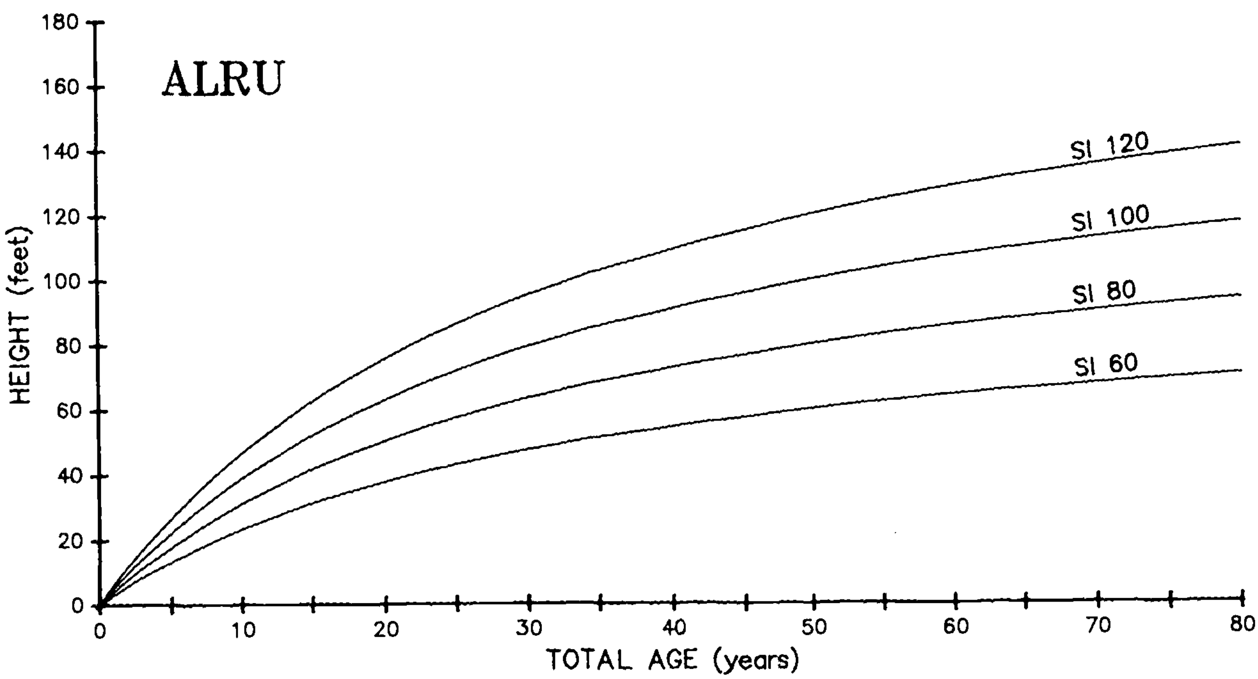

Figure 180. Height growth curves for red alder (Worthington *et al.* 1960).

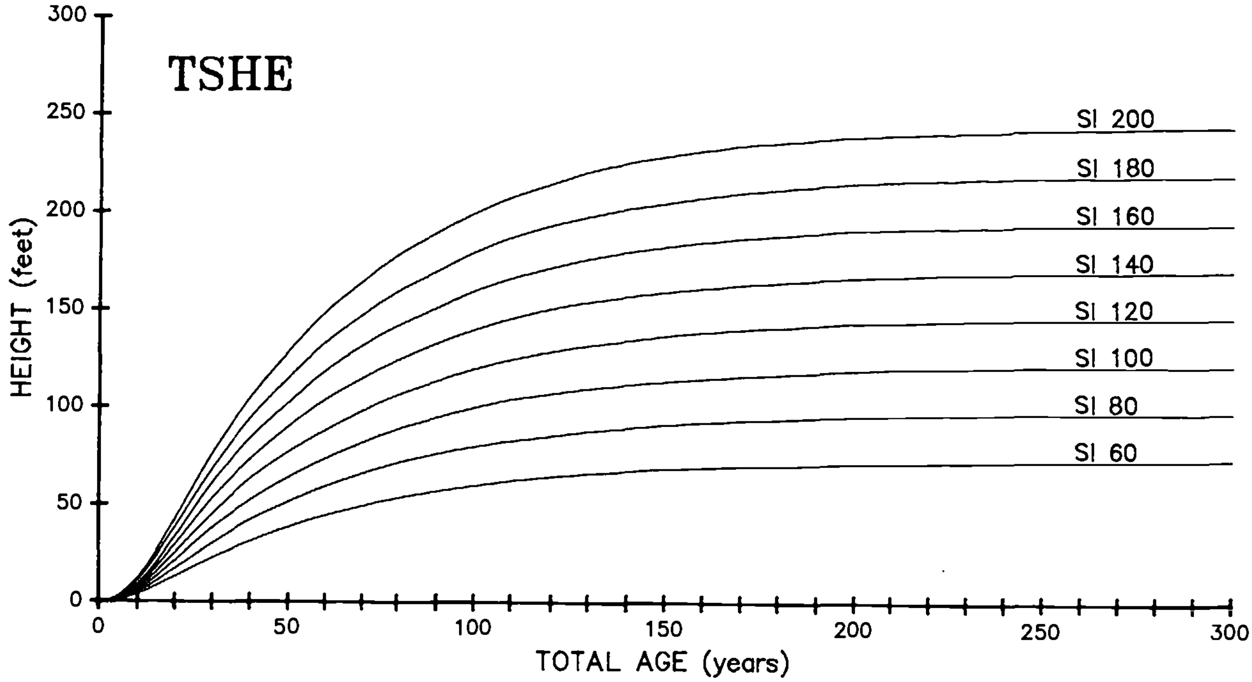

Figure 181. Height growth curves for western hemlock (Barnes 1962).

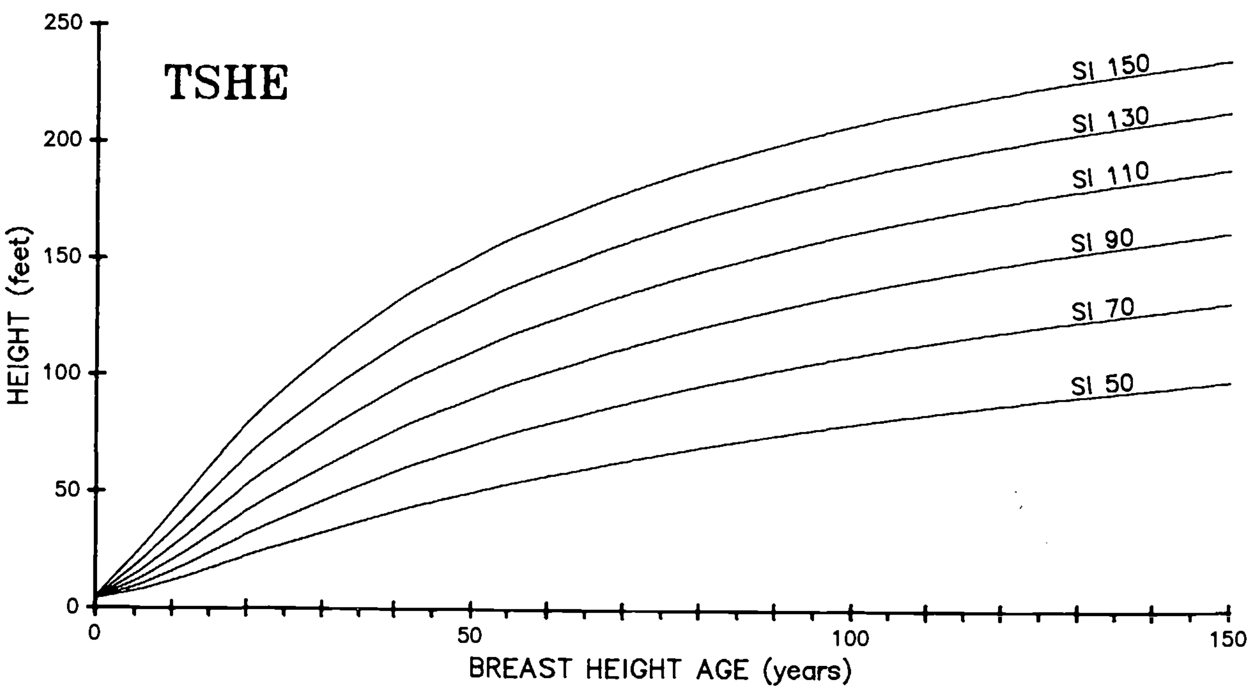

Figure 182. Height growth curves for western hemlock (Wiley 1978a).

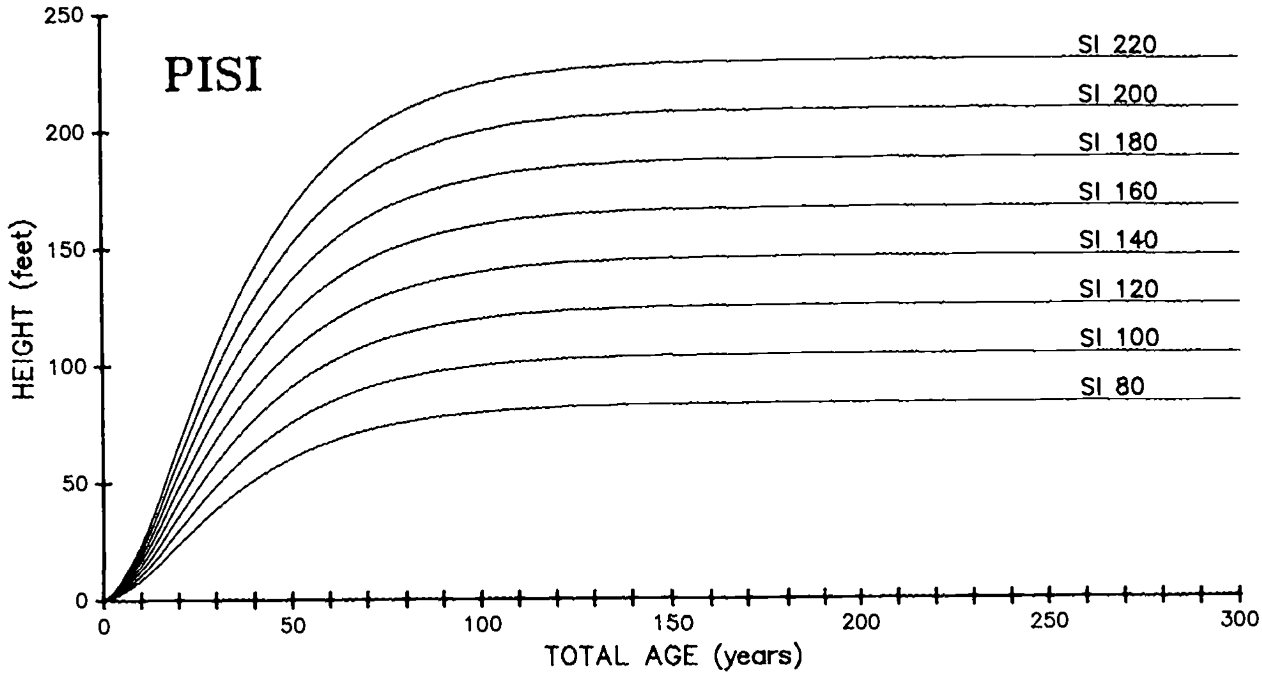

Figure 183. Height growth curves for Sitka spruce (Hegyi *et al.* 1979).

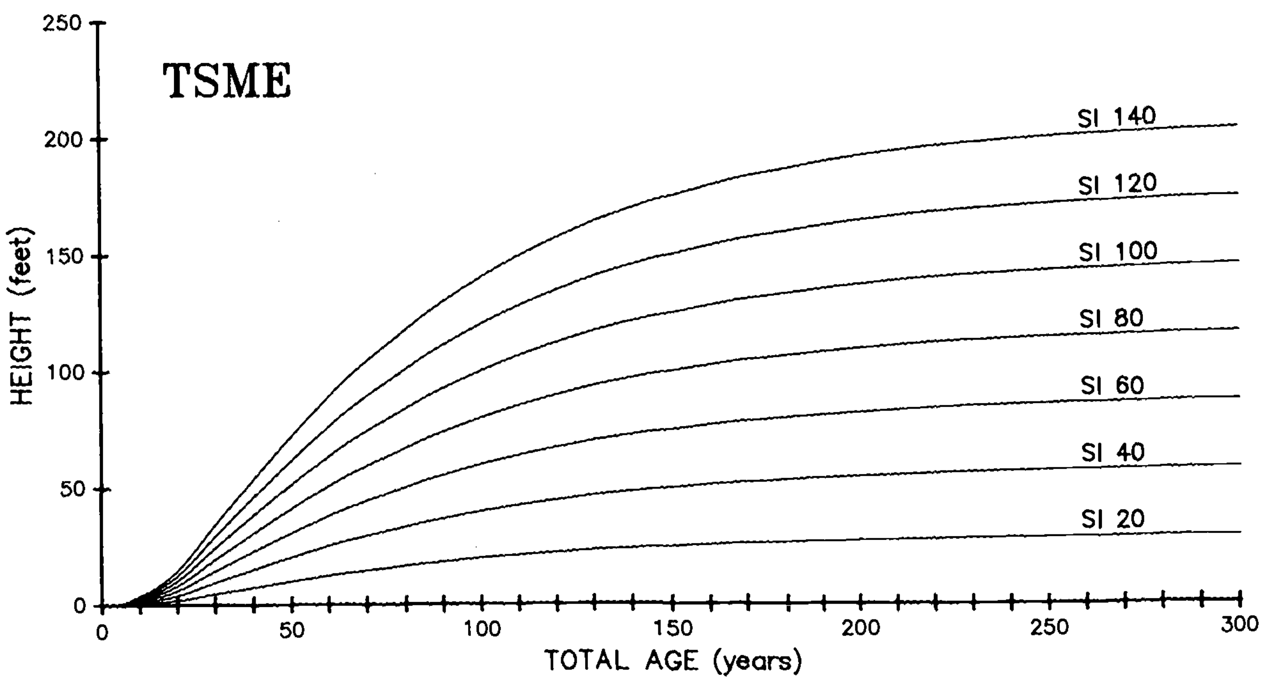

Figure 184. Height growth curves for mountain hemlock (Adapted from Hegyi *et al.* 1979).

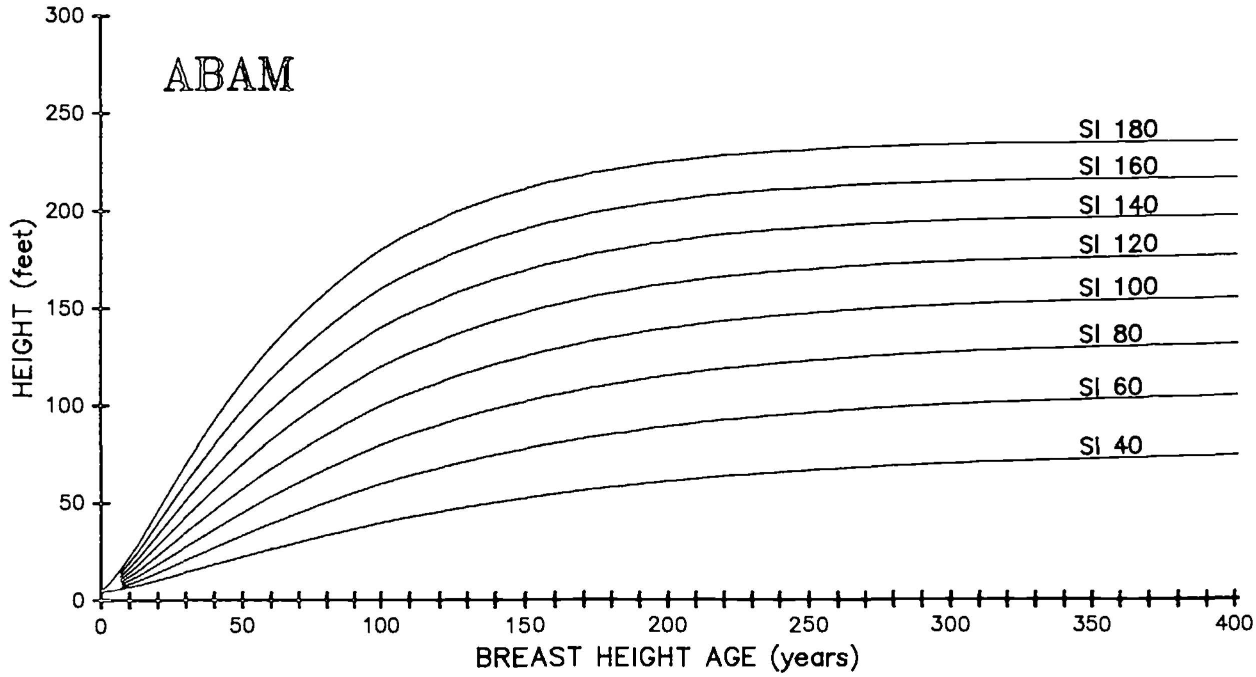

Figure 185. Height growth curves for silver fir (Hoyer and Herman in press).

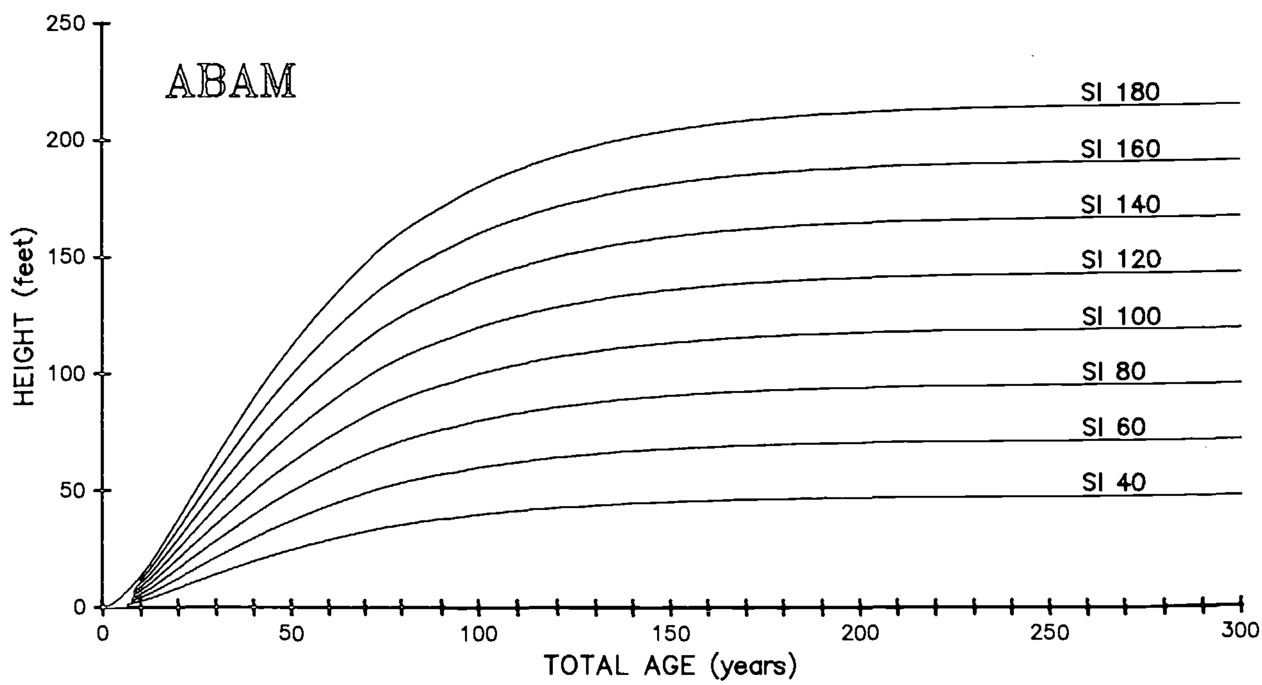

Figure 186. Height growth curves for silver fir (Hegyi *et al.* 1979).

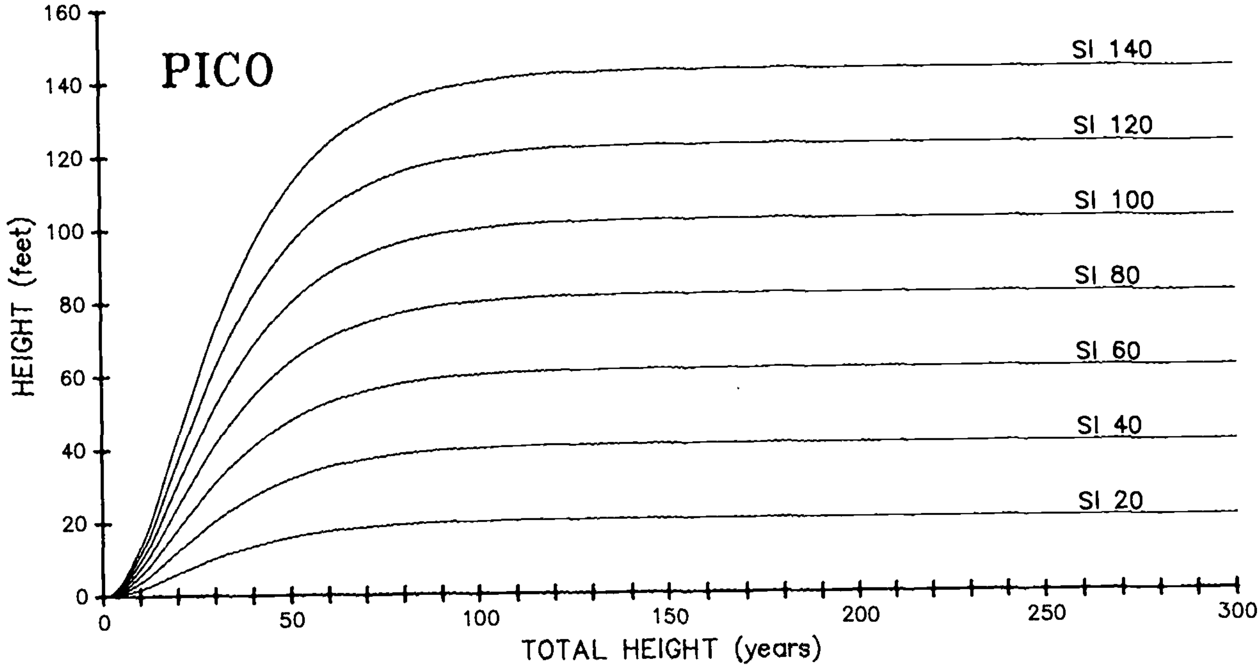

Figure 187. Height growth curves for lodgepole pine (Hegyi *et al.* 1979).

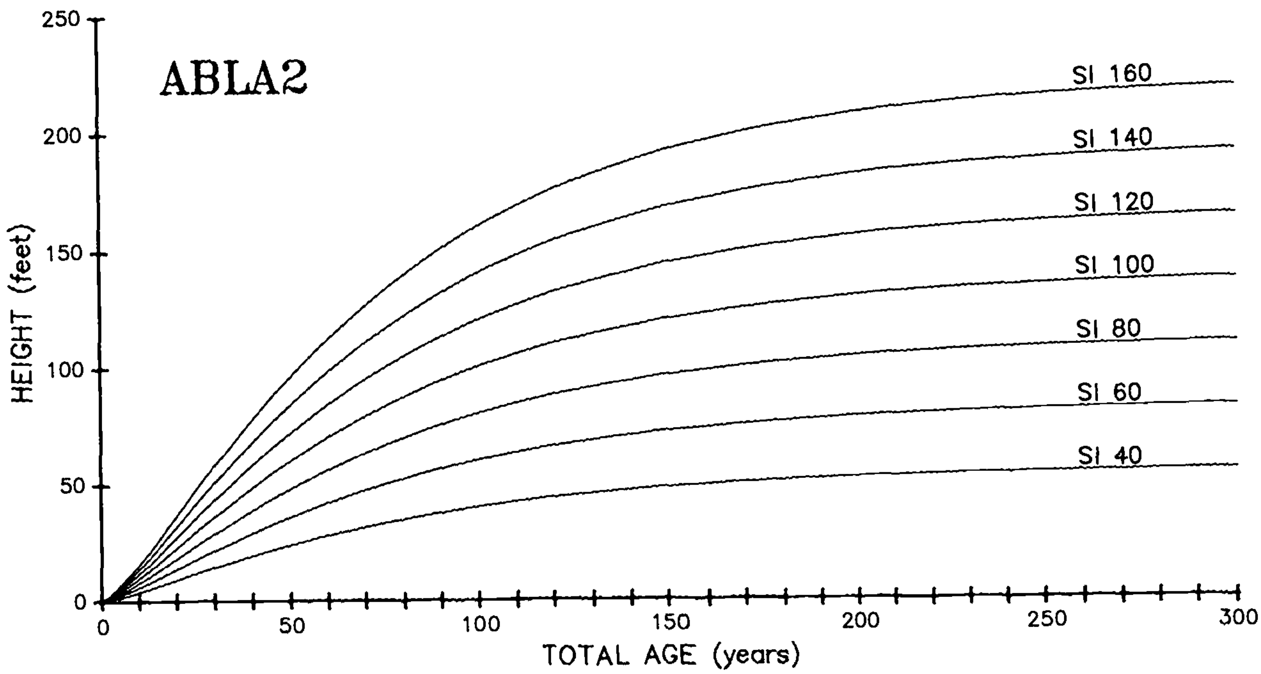

Figure 188. Height growth curves for subalpine fir (Hegyi *et al.* 1979).

Table 172. Height curve equations for major trees on the Olympic National Forest.

The following equations describe the height growth curves for common trees on the Forest. They take the form of "classic" site index curves, however height, not site index, is the dependent variable. Site index can be derived mechanically from these curves when they are displayed in graphical form (see the classical "site index curves" of McArdle and Meyer (1930) or Barnes (1962). These curves are presented in their graphical form in Appendix 4. The equations in Table 173 give site index as the dependent variable. All cases are given in English measurements.

1. DOUGLAS-FIR (Bruce et al. 1977, adapted from McArdle and Meyer 1930)

$$Ht = SI_{100} * (10^{[.1567 - (15.67/TAge]})$$

2. DOUGLAS-FIR (Curtis et al. 1974)

$$Ht = 4.5 + (SI_{100} - 4.5)/[0.6192 - 5.3394(SI_{100}-4.5)^{-1} + 240.29(BHAge^{-1.4}) + 3368.9\ (SI_{100}-4.5)^{-1}\ (BHAge^{-1.4})]$$

3. DOUGLAS-FIR (King 1966)

$$Ht = 4.5 + BHAge2/\{-0.954038 + 0.109757\ (2500/[SI_{50}-4.5]) +0.0558178 + 0.00792236\ (2500/[SI_{50}-4.5])\ (BHAge) -0.000733819 + 0.00019769\ (2500/[SI_{50}-4.5])\ (BHAge^2)\}$$

4. WESTERN HEMLOCK (Wiley 1978a)

$$Ht = 4.5 + BHAge^2/\ \{-1.7307 + 0.1394\ (2500/[SI_{50}-4.5]) - 0.0616 + 0.0137\ (2500/[SI_{50}-4.5])\ (BHAge) + 0.00192 + 0.00007\ (2500/[SI_{50}-4.5])\ (BHAge^2)\}$$

5. WESTERN HEMLOCK (Barnes 1962)

$$Ht = (SI_{100} /(0.7409 + 12.96258/TAge + 1348.904/TAge^2)$$

6. MOUNTAIN HEMLOCK (Adapted from Hegyi et al. 1979)

$$Ht = SI_{100} * 1.3832\ [1-e^{(-0.0155\ TAge)}]^{1.3597}$$

Table 172 (cont.). Height curve equations for major trees on the Olympic National Forest.

7. WESTERN REDCEDAR (Hegyi et al. 1979)

$$Ht = SI_{100} * 1.1243\ [1\text{-}e^{(-0.0263 * TAge)}]^{1.5662}$$

8. SITKA SPRUCE (Hegyi et al. 1979)

$$Ht = SI_{100} * 1.0458\ [1\text{-}e^{(-0.038 * TAge)}]^{1.9804}$$

9. SILVER FIR (Hoyer and Herman in press)

$$Ht = 4.5 + [SI_{100}\ 1\text{-}e^{(a+\{b*si*BHAge\}]}\ ]^{c} / [1\text{-}e^{(a+b*SI*100)}\ ]^{c}$$

where: a= -0.0071839
b= +0.0000571
c= 1.39005

10. SILVER FIR (Hegyi et al. 1979)

$$Ht = SI_{100} * 1.1945\ [1\text{-}e^{(-0.0236 * TAge)}]^{1.7918}$$

11. RED ALDER (Hegyi et al. 1979)

$$Ht = SI_{50} * 1.1302\ [1\text{-}e^{(-0.0421 * TAge)}]^{.9422}$$

12. RED ALDER (Worthington et al. 1960)

$$Ht = SI_{50} / 0.60924 + (19.538/TAge)$$

13. LODGEPOLE PINE (Hegyi et al. 1979)

$$Ht = SI_{100} * 1.0236\ [1\text{-}e^{(-0.0465 * TAge)}]^{2.4269}$$

14. SUBALPINE FIR (Hegyi et al. 1979)

$$Ht = SI_{100} * 1.3832\ [1\text{-}e^{(-0.0155 * TAge)}]^{1.3597}$$

Table 173. Site Index equations for trees on the Olympic National Forest.

The following equations are presented with site index as the dependent variable, and were used for computing site index values for individual trees in our data base. Related height curves, with tree height as the dependent variable are given in Table 172 and are graphed in Appendix 4. Information given here includes the species the curve was built for, the base age (either 50 or 100), whether total or breast height age was used, the reference for the site index curves, and in some cases the original source of the data. All cases are given in English measurements.

1. DOUGLAS-FIR (Bruce et al. 1977, adapted from McArdle and Meyer 1930) Base age = 100, Total age

$$SI = Ht / 10^{[.1567-(15.67/TAge)]}$$

2. DOUGLAS-FIR (Curtis et al. 1974) Base age = 100, Breast height age

For Breast height age < 100

$$SI = 4.5 + [0.010006 (100\text{-}BHAge)^2] + [1.0 + 0.00549779 (100\text{-}BHAge) + (1.46842 * 10^{-14})*(100\text{-}BHAge)^7] * [Ht - 4.5]$$

For Breast height age > 100

$$SI = 4.5 + 7.66772 [e^{-0.95 (100/BHAge-100)\ **2}] + [1.0 - 0.730948 (\log BHAge-2.0)^{.80}] * [Ht-4.5]$$

3. DOUGLAS-FIR (King 1966) Base age = 100, Breast height age for ages < 120 years

$$SI = 4.5 + 2500 *[(Ht-4.5) * (0.109757 + 0.0079223 * BHAge + 0.00019769 * BHAge^2)] / (BHAge^2 - (Ht-4.5) * (-0.954038 + 0.0558178 * BHAge - 0.00073382 * (BHAge)^2)]$$

4. WESTERN HEMLOCK (Wiley 1978) Base age = 50, Breast height age for ages < 120 years

$$SI = 4.5 + 2500 * [(Ht-4.5) * (0.1394 + 0.0137 * BHAge + 0.00007 * BHAge^2)] / [BHAge^2 - (Ht-4.5) * (-1.7307 - 0.0616 * BHAge + 0.00192 * BHAge^2)]$$

5. WESTERN HEMLOCK (Barnes 1962) base age = 100, total age for ages 30-400.

$$SI = Ht * (0.7409 + 12.96258/TAge + 1348.904/TAge^2)$$

Table 173 (cont.) Site Index equations for trees on the Olympic National Forest.

6. MOUNTAIN HEMLOCK (Adapted from Hegyi et al. 1979) Base Age = 100, Total age

$$SI = Ht / 1.278 [1-e^{(-.0155 * TAge)}]^{1.3597}$$

7. WESTERN REDCEDAR (Hegyi et al. 1979) Base Age = 100, Total age

$$SI = Ht / 1.1243 [1-e^{(-.0263 * TAge)}]^{1.5662}$$

8. SITKA SPRUCE (Hegyi et al. 1979) Base age = 100, Total age

$$SI = Ht / 1.0458 [1-e^{(-0.0380 * TAge)}]^{1.9804}$$

9. SILVER FIR (Hoyer and Herman in press) Base age = 100, Breast height age

$$SI = Ht * 10^{a+b+c+d+e}$$

where:
$a = -0.0268797(BHAge-100)/BHAge$
$b = +0.0046259(BHAge-100)^2/100$
$c = -0.0015862(BHAge-100)^3/10000$
$d = -0.0761453(BHAge-100)/Ht^{1/2}$
$e = +0.0891105(BHAge-100)/Ht$

10. SILVER FIR (Hegyi et al. 1979) Base Age = 100, Total age

$$SI = Ht / 1.1945 [1-e^{(-0.0236 TAge)}]^{1.7918}$$

11. RED ALDER (Hegyi et al. 1979) Base age = 50, Total age

$$SI = Ht / 1.1302 [1-e^{(-0.0421 TAge)}]^{.9422}$$

12. LODGEPOLE PINE (Hegyi et al. 1979) Base age = 100, Total age

$$SI = Ht / 1.236 [1-e^{(-0.0465 TAge)}]^{2.4269}$$

13. SUBALPINE FIR (Hegyi et al. 1979) Base age = 100, Total age

$$SI = Ht / 1.3832 [1-e^{(-0.0155 TAge)}]^{1.3597}$$

Table 174. Other equations used to calculate tree, stand and productivity values.

Many equations were used in calculating tree, stand and productivity values. Equations, other than site index or height equations are given here.

1. Stand Density Index (Reineke 1933, Daniel et al. 1979). This equation gives Reineke's Stand Density Index (SDI) in terms of trees per acre (N) at a stocking level where the diameter of the tree of average basal area or Quadratic Mean Diameter (QMD) is 10 inches.

$$SDI = N/(10/QMD)^{1.6}$$

2. Quadratic Mean Diameter (QMD). Quadratic Mean Diameter is the diameter of the tree of average basal area and can be calculated using the following formula where BA is basal area in square feet per acre and N is trees per acre.

$$QMD = [(BA * 144/N)/\ \text{"pi"}]^{1/2}$$

3. Curtis' Relative Density (CRD) (Curtis et al. 1981). Another index of stand density was developed by R.O. Curtis and is used in the Douglas-fir growth simulator DFSIM (Curtis et al. 1981). It usually varies from 30 to 100 and is intended to be applied to even-aged stands. BA is stand basal area in square feet per acre and QMD is the diameter of the tree of average basal area.

$$CRD = BA / QMD^{1/2}$$

4. Hall's Growth Basal Area (GBA) (Hall 1983, 1987). Growth Basal Area is the basal area which will yield a diameter increment per decade of 1 inch. It is expressed by the following equations which have been calibrated for western Washington conditions. The relationship is expressed by two equations, one for stand age less than 100 years and the other for stand age 100 years or more. Where BA is stand basal area in square feet per acre and RI is the 10-year radial increment of 5 dominant and codominant trees in 20th of an inch.

for age < 100 years:

$$GBA = (0.415 + 0.128 \ln Age)\ (BA)\ (0.5351 e^{0.0623\ RI})$$

for age > 100 years:

$$GBA = (-0.343 + 0.293 \ln Age)\ (BA)\ (0.5351 e^{0.0623\ RI})$$

5. Tree Height. Tree height can be estimated from Diameter Breast Height (DBH) using the following equations:

$$Ht = 4.5 + e^{C0 + C1\ (1/[DBH + 1])}$$

where C0 varies from 4.6217 for lodgepole pine and 5.1999 for western white pine and Douglas-fir is 4.8152; and C1 varies from -5.3248 for lodgepole pine to -9.3174 for mountain hemlock and Douglas-fir is -7.2931 (see Wykoff et al. 1982, p. 52).

or $\log Ht = a + b\ DBH\text{-}1$ (Curtis 1967)

or $\ln (Ht\text{-}4.5) = a + b\ (DBH)c$ (Curtis et al. 1981)

Table 174 (cont.). Other equations used to calculate tree, stand and productivity values.

6. Tree Volume. Many different ways are available to estimate tree volume based on DBH and Height where volume is expressed in cubic feet including stump and top. Three are used here:

a. **Vol = b1 (DBH)2 * Ht + b2 * DBH * Ht** (Wykoff et al. 1982, p. 81)

where:	b1	b2	species
	.00171	.00386	Douglas-fir
	.00219	0	western hemlock
	.00205	0	western redcedar

b. **Vol = .00278 (DBH)1.0941 * Ht1.0488** (Wykoff et al. 1982) lodgepole pine, red alder

c. **Vol = b1 + b2 log DBH + b3 log Ht** (Browne 1962)

where:	b1	b2	b3	species
	-2.6580	1.7399	1.1332	Douglas-fir<140 years
	-2.7122	1.6590	1.1957	Douglas-fir > 80 years
	-2.3796	1.6823	1.0397	western redcedar
	-2.6638	1.7902	1.1249	western hemlock
	-2.5756	1.8068	1.0947	silver fir
	-2.7006	1.7542	1.1645	Sitka spruce
	-2.4543	1.7410	1.0584	Alaska yellowcedar
	-2.6156	1.8475	1.0858	lodgepole pine
	-2.9450	- 1.8040	1.2386	black cottonwood
	-2.6728	1.9206	1.0740	red alder
	-2.7703	1.8858	1.1190	bigleaf maple

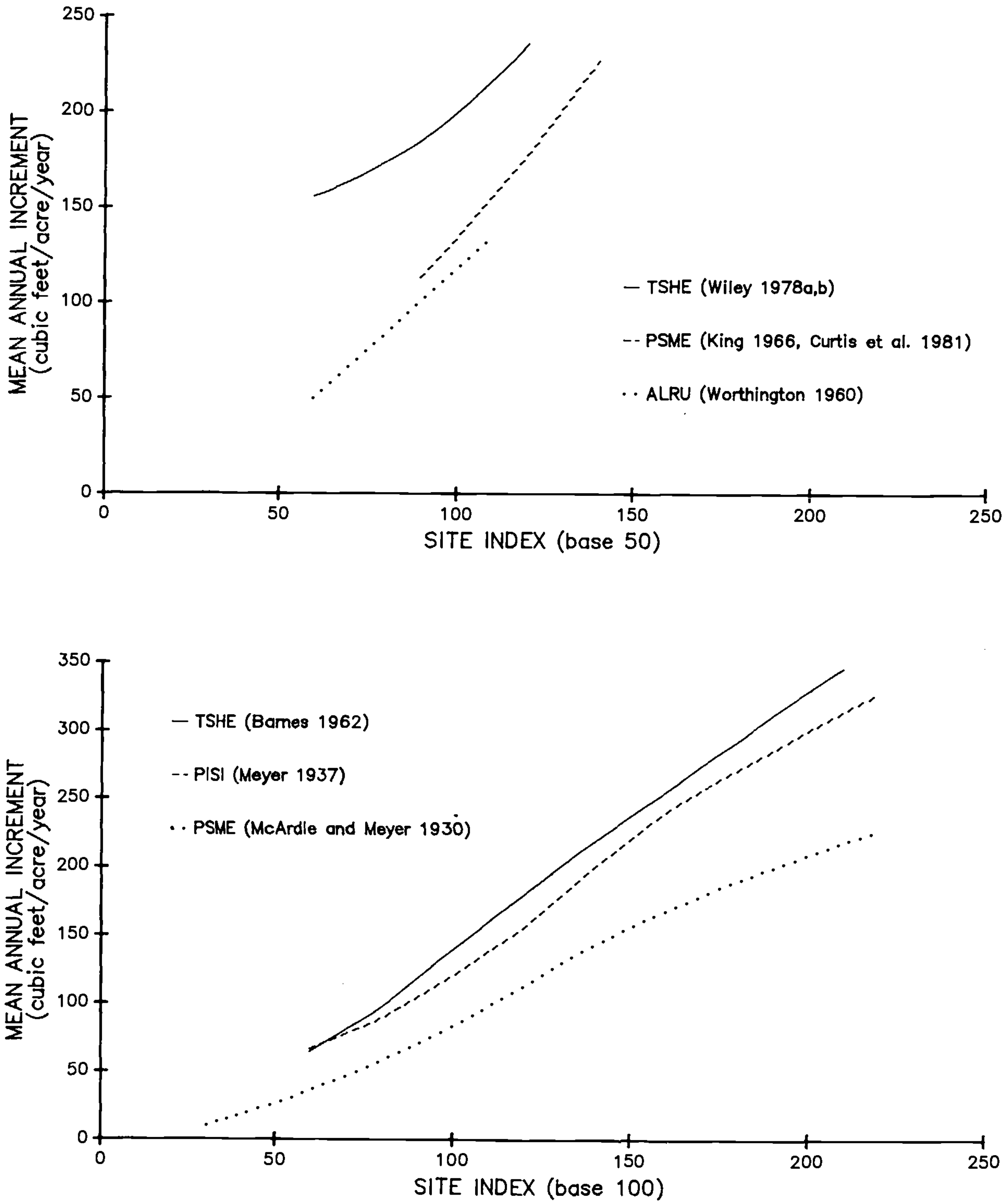

Figure 189. Culmination of mean annual increment curves for Douglas-fir, western hemlock, Sitka spruce and red alder.

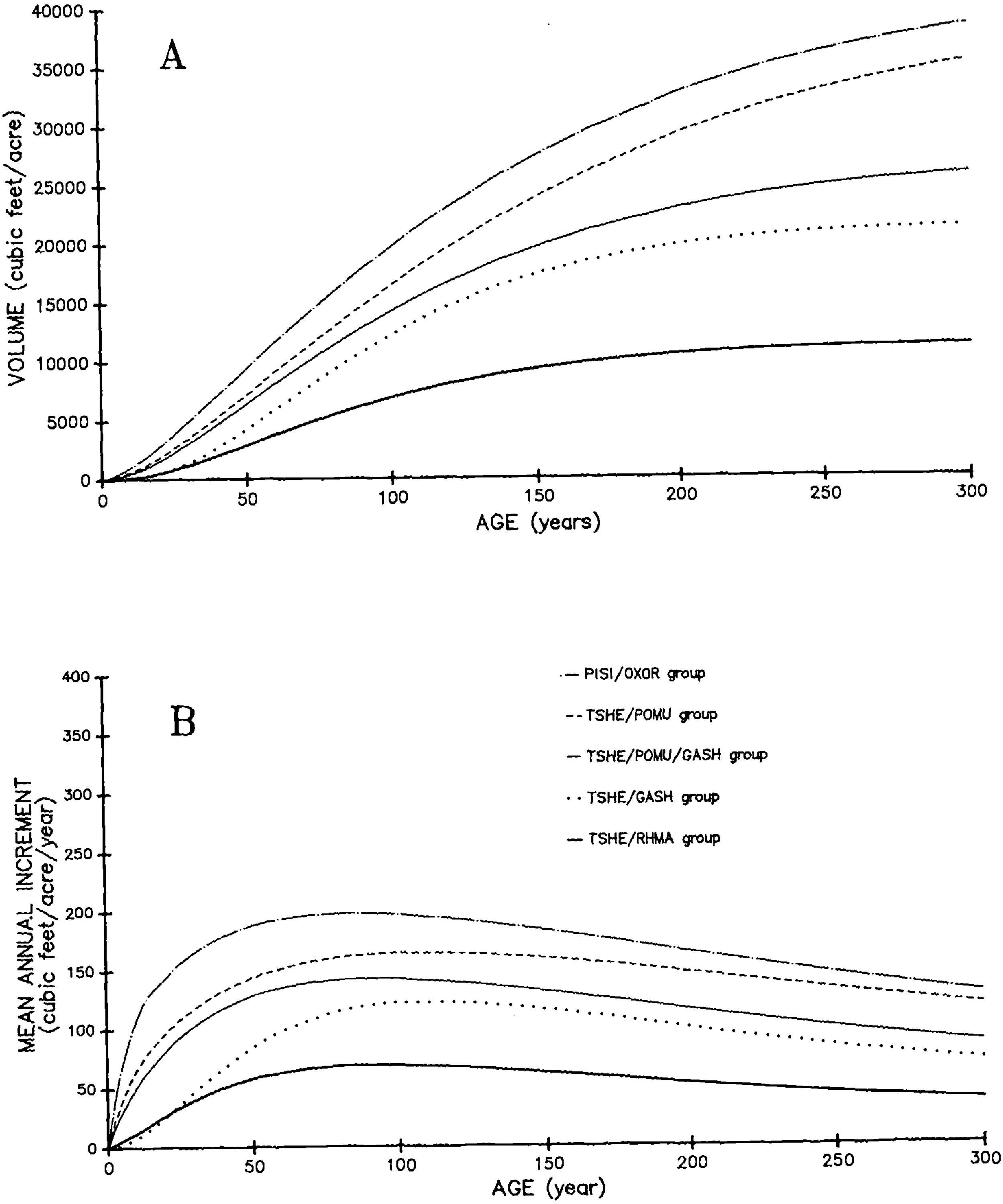

Figure 190. Empirical volume (A) and mean annual increment (B) curves for the Western Hemlock and Sitka Spruce Series.

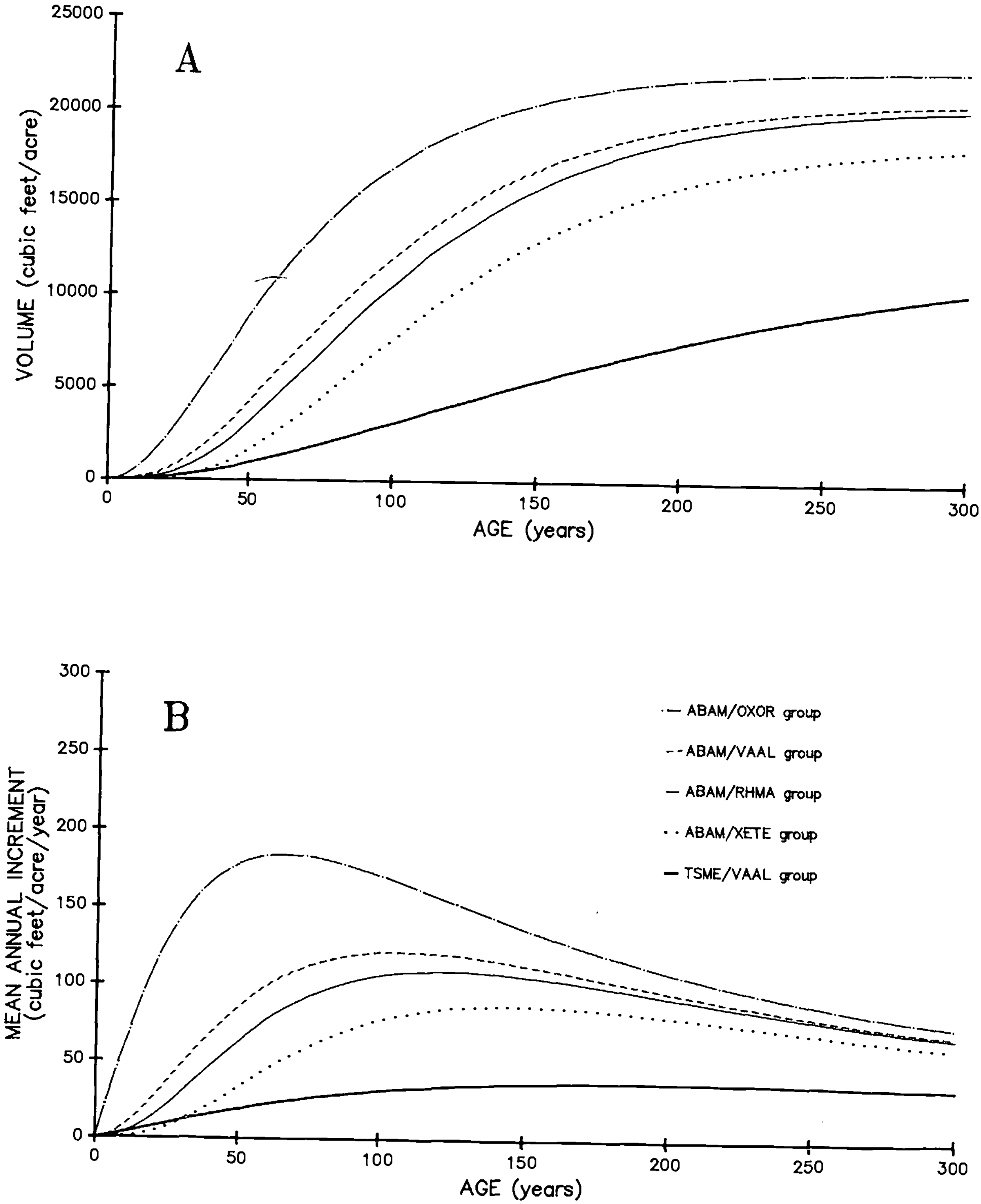

Figure 191. Empirical volume (A) and mean annual increment (B) curves for the Silver Fir and Mountain Hemlock Series.

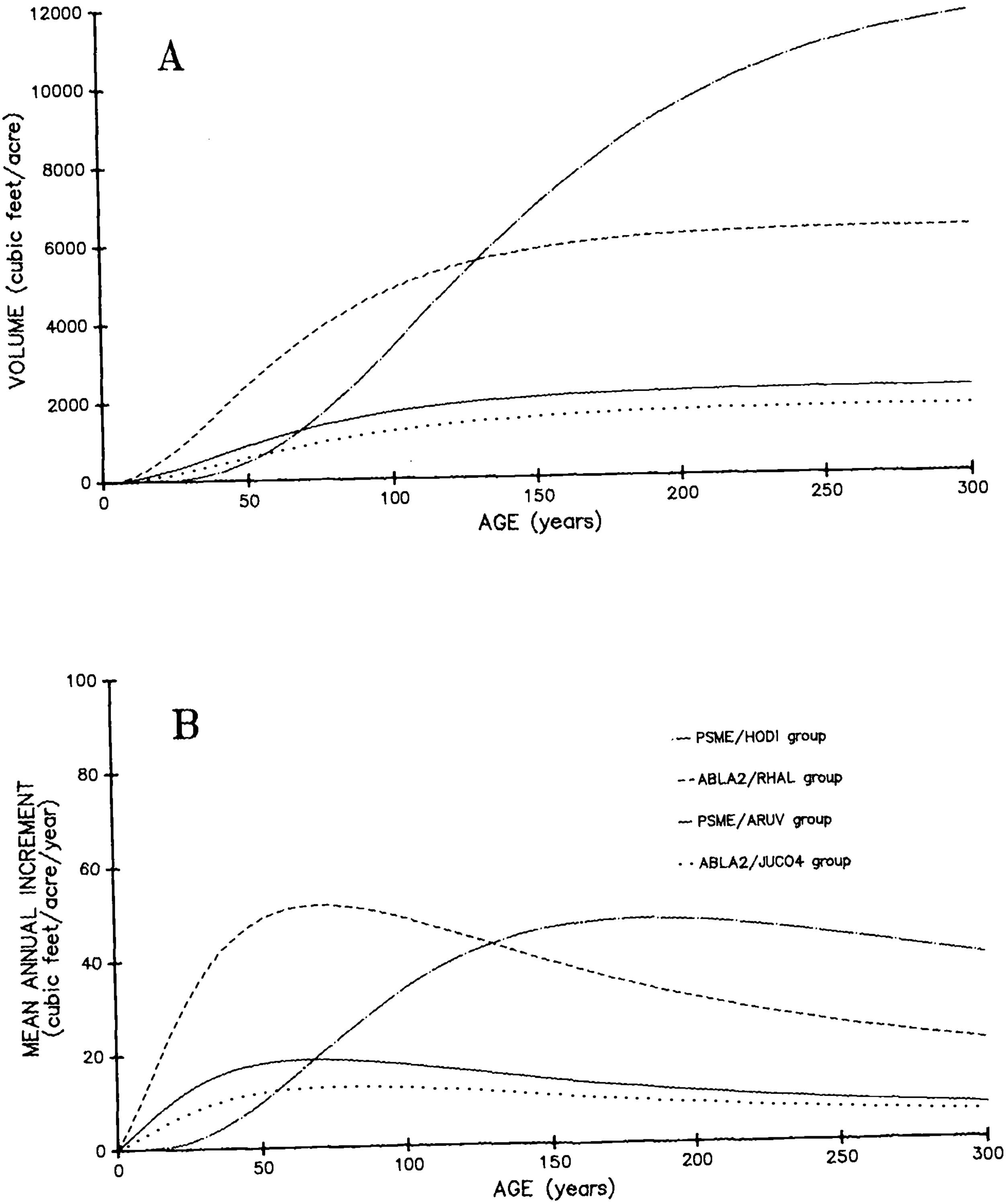

Figure 192. Empirical volume (A) and mean annual increment (B) curves for the Douglas-fir and Subalpine Fir Series.

Table 175. Oldest and biggest trees encountered in ecology plot sampling.

SPECIES	DBH (inches)	Height (feet)	Core Age	Stump Age	Plot No.	Plant Association	Location
Alaska yellowcedar	102.0	stump		1508	1338	ABAM/VAAL/ERMO	Three Peaks
	34.9	135			1631	ABAM/VAAL/RHAL	Tunnel Cr.
	66.6	115	1060		1706	TSME/VAAL/ERMO	Three Peaks
Bigleaf maple	43.8	96			1701	PISI/POMU-OXOR	W. Fk. Humptulips
	33.0	130			1431	ACMA/ACCI	Dosewallips
	27.8	118	159		1681	ACMA/ACCI	Brown Cr.
Black cottonwood	50.8	stump		103	1431	ACMA/ACCI	Dosewallips
	46.0	173	46		182	TSHE/POMU	Wynoochee
	31.3	157	53		1441	TSHE/POMU-TITR	Hamma Hamma
Douglas-fir	118.0	stump		920	722	TSHE/POMU-OXOR	Rugged Ridge
	80.0	279	700		132	TSHE/POMU-TITR	Satsop
Lodgepole pine	20.8	61	257		1637	PSME/ARUV	Mt. Townsend
	20.0	108	222		1259	ABLA2/LULA	Dungeness R.
Madrone	14.0	52			1188	unrecognised	Cabin Cr.
	8.0	88			1798	TSHE/GASH-VAOV2	Seal Rock
	8.2	26	85		1901	QUGA/FEID?	S. Fk. Skokomish
Mountain hemlock	60.9	stump		802	1721	TSME/VAAL	Mt. Tebo
	27.0	160	439		1754	TSME/VAAL/ERMO	Pine Mt.
	48.5	147	875		1887	TSME/VAAL	Moonlight Dome
Pacific yew	8.0	30			133	TSHE/GASH/XETE	Anderson Butte
	5.8	42	286		1796	TSHE/RHMA/GASH	Tunnel Cr.
Red alder	28.0	111	101		1431	ACMA/ACCI	Dosewallips
	15.9	136	54		1441	TSHE/POMU-TITR	Hamma Hamma
Rocky Mtn. juniper	7.8	33	120		1729	PSME/HODI-ROGY	Dungeness R.
	4.0	16	183		1830	PSME/HODI-ROGY	Dungeness R.
Silver fir	76.8	217	340		1338	ABAM/VAAL/ERMO	Three Peaks
	55.0	236	273		377	ABAM/VAAL/MADI2	E. Fk. Humptulips
	27.8	94	651		1838	ABAM/VAAL/CLUN	Moonlight Dome
	44.0	stump		455	452	ABAM/ACTR	Four Stream
Sitka spruce	124.0	stump		486	350	TSHE/VAAL/OXOR	Rainbow Cr.
	45.7	279	280		1357	PISI/POMU-OXOR	Prairie Cr.
Subalpine fir	27.0	stump		173	1275	ABLA2/LULA	Tubal Cain
	23.0	69	195		1273	TSME/RHAL-VAME	Buckhorn
	14.0	102	175		1241	ABLA2/VASI	Mt. Townsend
	7.0	27	249		1811	ABLA2/JUCO4	Goat Lk.
Western hemlock	108.0	stump		433	376	ABAM/VAAL/OXOR	Humptulips Ridge
	41.0	203	256		420	ABAM/POMU	Flat Bottom Cr.
	72.0	stump		821	77	ABAM/VAAL	Humptulips R.
Western redcedar	118.0	stump		1215	80	ABAM/VAAL/CLUN	U. Wynoochee R.
	100.8	194	1460		1359	TSHE/POMU-OXOR	Canoe Cr.

KEY TO FOREST SERIES AND PLANT ASSOCIATIONS OF THE OLYMPIC NATIONAL FOREST

This key to Forest Series applies to climax or stable state vegetation. Read the first line of the key. If the statement is true relative to the stand in question (i.e., if there is more than or equal to 10 percent cover of mountain hemlock in the stand) then it is Mountain Hemlock Series. If not then go to line 2 and repeat.

Series Key

Mountain Hemlock ≥ 10% cover	Mountain Hemlock Series (TSME)	p. 109
Silver Fir ≥ 10% cover	Silver Fir Series (ABAM)	p. 139
Sitka Spruce ≥ 10% cover	Sitka Spruce Series (PISI)	p. 243
Western Hemlock and/or Western Redcedar ≥ 10% cover	Western Hemlock Series (TSHE)	p. 277
Douglas-fir ≥ 10% cover	Douglas-fir Series (PSME)	p. 89
Subalpine Fir ≥ 10% cover	Subalpine Fir Series (ABLA2)	p. 253

The following key is used to identify the forested plant associations on the Olympic National Forest once the series is known.

Mountain Hemlock Series

Red Heather ≥10%, Blueleaf Huckleberry ≥10%	TSME/PHEM-VADE	p. 132
Avalanche Lily ≥5%, Alaska Huckleberry ≥10%	TSME/VAAL/ERMO	p. 120
Big Huckleberry ≥5%		
White Rhododendron ≥5%	TSME/RHAL-VAME	p. 136
Alaska Huckleberry ≥ 5%	TSME/VAME-VAAL	p. 126
Beargrass ≥5%	TSME/VAME/XETE	p. 130
Alaska Huckleberry ≥10%		
Beargrass ≥5%	TSME/VAAL/XETE	p. 124
Beargrass ≤5%	TSME/VAAL	p. 116

Silver Fir Series

Skunkcabbage ≥5%	ABAM/LYAM	p. 226
Devil's Club ≥5%	ABAM/OPHO	p. 198
White Rhododendron ≥5% and Alaska Huckleberry ≥10%	ABAM/VAAL-RHAL	p. 184
Rhododendron ≥10%		
Alaska Huckleberry ≥5%	ABAM/RHMA-VAAL	p. 210
Alaska Huckleberry ≤5%	ABAM/RHMA	p. 206
Big Huckleberry ≥10% and Beargrass ≥5%	ABAM/VAME/XETE	p. 190
Oxalis ≥10%		
Salal ≥10%	ABAM/GASH-OXOR	p. 222
Swordfern ≥10%	ABAM/POMU-OXOR	p. 234
Alaska Huckleberry ≥5%	ABAM/VAAL/OXOR	p. 172
Alaska Huckleberry ≤5%	ABAM/OXOR	p. 202
Alaska Huckleberry ≥10%		
Oxalis ≥5%	ABAM/VAAL/OXOR	p. 172
Salal ≥5% and Deerfern ≥1%	ABAM/GASH/BLSP	p. 218
Beargrass ≥5%	ABAM/VAAL/XETE	p. 160
Avalanche Lily ≥1%	ABAM/VAAL/ERMO	p. 156
Oregongrape ≥5%	ABAM/VAAL-BENE	p. 168
Twinflower ≥3%	ABAM/VAAL/LIBO2	p. 180
Foamflower plus Rosy Twisted-stalk ≥3%	ABAM/VAAL/TIUN	p. 164
Queen's Cup, Bunchberry, Five-leaved Bramble and/or Deerfern ≥3%	ABAM/VAAL/CLUN	p. 176
Not as above	ABAM/VAAL	p. 152
Swordfern ≥10%	ABAM/POMU	p. 230
Salal ≥10%		
Deerfern ≥2%, Alaska Huckleberry or Red Huckleberry present	ABAM/GASH/BLSP	p. 218
Deerfern ≤2%	ABAM/GASH	p. 214
Beargrass ≥5%	ABAM/XETE	p. 186
Vanillaleaf plus Foamflower ≥5%, Rosy Twisted-stalk and/or Queen's cup usually present	ABAM/ACTR-TIUN	p. 238
Ground Cover ≤10%	ABAM/Dep.	p. 194

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KEY TO FOREST SERIES AND PLANT ASSOCIATIONS OF THE OLYMPIC NATIONAL FOREST (Continued)

Western Hemlock Series

Skunkcabbage ≥5%	TSHE/LYAM	p. 378
Devil's Club ≥5%	TSHE/OPHO	p. 314
Rhododendron ≥10%		
Beargrass ≥5%	TSHE/RHMA/XETE	p. 334
Swordfern ≥5%	TSHE/RHMA/POMU	p. 346
Salal ≥10%	TSHE/RHMA-GASH	p. 342
Oregongrape ≥5%	TSHE/RHMA-BENE	p. 338
Oregongrape ≤5%	TSHE/RHMA	p. 330
Oxalis ≥10%		
Swordfern ≥10%	TSHE/POMU-OXOR	p. 386
Alaska Huckleberry ≥10%	TSHE/VAAL/OXOR	p. 298
Salal ≥5%	TSHE/GASH/OXOR	p. 370
Salal ≤5%	TSHE/OXOR	p. 326
Alaska Huckleberry ≥10%		
Beargrass ≥5%	TSHE/VAAL/XETE	p. 294
Salal ≥5%	TSHE/VAAL-GASH	p. 302
Salal ≤5%	TSHE/VAAL	p. 290
Swordfern ≥10%		
Salal ≥5%	TSHE/GASH/POMU	p. 374
Oregongrape ≥5%	TSHE/BENE/POMU	p. 322
Oxalis ≥5%	TSHE/POMU-OXOR	p. 386
Foamflower, Fragrant Bedstraw usually present	TSHE/POMU-TITR	p. 382
Salal ≥10%		
Rhododendron ≥5%	TSHE/RHMA-GASH	p. 342
Oxalis ≥5%	TSHE/GASH/OXOR	p. 370
Evergreen Huckleberry ≥4%	TSHE/GASH-VAOV2	p. 358
Oceanspray ≥2%	TSHE/GASH-HODI	p. 362
Beargrass ≥2%	TSHE/GASH/XETE	p. 354
Swordfern ≥3%	TSHE/GASH/POMU	p. 374
Oregongrape ≥2%, Red Huckleberry and/or Vine Maple present	TSHE/GASH-BENE	p. 366
Not as above	TSHE/GASH	p. 350
Vanillaleaf and Star-flowered Solomon's Seal ≥5% and Oregongrape often present	TSHE/ACTR	p. 390
Oregongrape ≥5%		
Swordfern ≥4%	TSHE/BENE/POMU	p. 322
Swordfern ≤4%	TSHE/BENE	p. 318
Beargrass ≥5%	TSHE/XETE	p. 306
Ground Cover ≤10% (except Vine Maple)	TSHE/Dep.	p. 310

Sitka Spruce Series

Oxalis ≥10%, Swordfern ≥5%	PISI/POMU-OXOR	p. 250

Douglas-fir Series

Salal ≥5%	PSME/GASH	p. 104
Kinnikinnick ≥5%	PSME/ARUV	p. 96
Oceanspray and Baldhip Rose ≥5%, Western Fescue ≥1%	PSME/HODI-ROGY	p. 100

Subalpine Fir Series

White Rhododendron ≥10%	ABLA2/RHAL	p. 272
Big Huckleberry >5%	ABLA2/VAME	p. 260
Subalpine Lupine ≥3%	ABLA2/LULA	p. 268
Common Juniper ≥3%	ABLA2/JUCO4	p. 264