Board of Natural Resources

Old-Growth and Older Forests Discussion

Reference Materials

May 2021

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F. Multispecies Conservation Strategy for Unlisted Species in the Five West-side Planning Units

Introduction

The multispecies conservation strategy for the five west-side planning units is directed at providing habitat for animal species of concern and other unlisted animal species and at special landscape features identified as uncommon habitats or habitat elements. For the purposes of this HCP, species of concern are federally listed, state-listed, federal candidate, and state candidate animal species. (See Table III.7 for the federally listed species and Table III.13 for the other species of concern excluding anadromous salmonids and bull trout. Those are named in Table III.10.) Other unlisted species include other animal species that may use the types of habitat found within the five west-side planning units and that may become listed or candidates for listing in the future. For the purposes of this HCP, uncommon habitats on DNR-managed lands are talus fields, caves, cliffs, oak woodlands, large snags, balds, mineral springs, and large, structurally unique trees.

Under this HCP, multispecies conservation strategies shall be implemented on DNR-managed lands in the five west-side planning units and the Olympic Experimental State Forest (OESF). The multispecies conservation strategy for the OESF is discussed in Section E of this chapter. Briefly, the OESF strategy differs somewhat from that for the five west-side planning units because:

(1) the emphasis in the OESF on research and systematic application and refinement of knowledge gained to achieve effective and efficient integration of commodity production and conservation will likely lead to changes in conservation strategies over time; and

(2) the conservation strategies for salmonids and the northern spotted owl, which are the foundation of the multispecies conservation strategies, are different for the OESF. (See Section E of this chapter for a complete discussion of the OESF conservation strategies.)

Neither multispecies conservation strategy will be applied in the east-side planning units. But all DNR management activities there will still comply with state Forest Practices Rules and applicable state wildlife regulations and will be consistent with the policies set forth by the Board of Natural Resources.

DNR will continue to participate in watershed analysis according to state Forest Practices Rules (WFPB 1994). If watershed analysis indicates that public resources require a greater level of protection than that specified by the HCP, the prescriptions developed through watershed analysis to provide this additional protection shall be implemented. However, because (as of the writing of this HCP) watershed analysis does not address wildlife, the HCP multispecies conservation strategy shall continue to apply to DNR-managed lands in Watershed Administrative Units (WAU) for which watershed analysis has been conducted, unless stated otherwise elsewhere in this HCP.

For uncommon habitats and certain species of concern, the multispecies conservation strategy specifies special management prescriptions and/or additional mitigation. The management prescriptions and mitigation are intended to be straightforward ways to provide a standard level of protection. In some instances, these will not be the most efficient means available to provide effective wildlife conservation. Therefore, in places where DNR believes that effective conservation can be provided in a more efficient way, DNR through cooperation with the U.S. Fish and Wildlife Service, may develop a site-specific management plan that provides adequate protection for the species or habitat occurring at that site. When a management plan approved by the U.S. Fish and Wildlife Service is in place, the special management prescriptions and/or additional mitigation specified in this HCP shall be waived.

If, however, DNR discovers some active nesting, denning, or roosting sites in the course of forest management activities, or through voluntary surveys, or such sites are documented by the Washington Department of Fish and Wildlife on DNR-managed lands, DNR shall provide the special protection described in the subsection titled Species by Species Conservation. At the time a new species is proposed for listing, and a written request to add that species to the permit is made by DNR, DNR will evaluate and consider additional protection measures such as seasonal restrictions and protection of nesting/denning sites.

Within the five west-side planning units, 62 animal species are considered species of concern because information indicates they face some risk of extinction: nine are federally listed, two, including the bull trout, are federal candidates, 23 are federal species of concern, two are listed by the state but have no special federal status, 12 are state candidates with no special federal status, seven are sensitive species, and seven species of anadromous salmonids have been or are under review by the federal government for listing. (The federally listed species are shown in Table III.8, the salmonids in Table III.11, and the other species in Table III.14.) Other species will probably be added to this list in the coming decades, but it is difficult to predict which species are at the brink of "at risk."

Federal guidelines (e.g., spotted owl circles) and state rules (WAC 232-12-292, WAC 222-16-080) place species-specific constraints on forest practices for the benefit of federally listed and state-listed species. But, given the large and probably expanding array of listed and candidate species, species-specific forest practices have become an inefficient and impractical means of attaining wildlife conservation objectives and providing income to the trusts. Within the confines of a managed forest, the most effective means for the conservation of wildlife is to provide functional habitat. Under this HCP, DNR will contribute to the survival of species of concern and other unlisted species through forest management that provides a variety of well-distributed, interconnected habitats.

The multispecies strategy discusses the objectives for conservation of habitat for unlisted species of concern and other unlisted species. Then the benefits to habitat of unlisted species through the other HCP conservation strategies are described, followed by a discussion of protection of uncommon habitats. The strategy closes with a description of conservation for habitat of specific unlisted species of concern and a summary of habitat types provided on DNR-managed lands in the five west-side planning units.

Conservation Objectives

DNR had identified three conservation objectives for its multispecies strategy on DNR-managed lands in the five west-side planning units to provide habitat that:

(1) helps maintain the geographic distribution of unlisted species that have small annual or breeding-season home range areas;

(2) contributes to demographic support of populations of unlisted species with large home ranges on federal forest reserves (National Parks, National Forest Wilderness Areas, National Forest Late successional Reserves, etc.); and

(3) facilitates the dispersal of these wide-ranging species among federal forest reserves.

Maintenance of geographic distribution means supporting the continued presence of the species, or its habitat, over as much of its historic range as possible. Therefore, objective (1) requires that habitat supporting the life needs of unlisted species with small ranges be provided throughout the range of the species on DNR-managed lands in the five west-side planning units. Demographic support refers to the continued viability of populations through the reproductive contribution of individuals. Therefore, objective (2) requires that habitat capable of supporting the successful reproduction of wide-ranging unlisted species be provided on DNR-managed lands in the five west-side planning units near federal reserves. Dispersal entails the movement of individuals from one subpopulation to another. Therefore, objective (3) requires that foraging and resting habitat of wide-ranging unlisted species be provided on DNR-managed lands in the five west-side planning units between blocks of federal reserves.

The habitats most critical for the conservation of unlisted species on DNR-managed lands in the five west-side planning units contain elements of late successional coniferous forest, riparian areas and wetlands, or both. The aggregate landscape-level effects of the HCP riparian, spotted owl, and marbled murrelet conservation strategies, as described below, are expected to provide habitat for most unlisted species. However, some unlisted species require special landscape features or habitat elements that may not be adequately conserved by the species-specific strategies. Thus, the special protection of talus fields, caves, cliffs, oak woodlands, and very large old trees are considered necessary to provide conservation for these species. Furthermore, some unlisted species are known or thought to be highly sensitive to human disturbance, and therefore, in the context of a managed forest, special management to reduce human disturbance is warranted.

Conservation Strategy

The HCP multispecies conservation strategy is built upon conservation measures directed at providing habitat for three taxa: salmonids (the riparian strategy), the northern spotted owl, and the marbled murrelet. (See Sections C, A, and B, respectively, of this chapter for more detail on each strategy.) The aggregate effect of this species-specific conservation is the creation of landscapes containing interconnected patches of late successional forest. Late successional forests consist of both mature (80-200 years old) and old-growth (greater than 200 years old) forest age classes (Thomas et al. 1993; FEMAT 1993; Spies and Franklin 1991). In addition, the other managed forests will provide early and mid-seral stage forest habitat.

RIPARIAN CONSERVATION STRATEGY

This strategy benefits nearly all aquatic, wetland, riparian obligate, and upland species that may occupy DNR-managed lands. The riparian management zones established along all Types 1, 2, 3, and 4 waters should provide suitable habitat for aquatic and riparian obligate species. Wetland species will be protected through DNR's continued commitment to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p. 36). For upland species, the long-term benefit of salmonid conservation is a network of riparian corridors connecting upland patches of late successional forest on unstable hillslopes.

The riparian buffer of the riparian management zone is estimated to occupy 69,000 acres along Types 1, 2, 3, and 4 waters (6 percent of DNR-managed forest lands in the five west-side planning units). The riparian management zone will be managed to maintain or restore salmonid habitat. Given this objective, most of the no-harvest and minimal-harvest areas (58,000 acres) in the riparian management zone will likely develop into forest that has old-growth characteristics. The low-harvest area (11,000 acres) is managed according to the same objective, but its distance from water may permit more management activities, and therefore, in most places, the low-harvest area will likely eventually contain forests with a range of late successional characteristics. Unstable hillslopes are estimated to occupy an additional 5 to 10 percent of DNR-managed forest land outside the riparian management zone. Unstable areas will be managed to minimize the risk of mass wasting, and it is likely that little harvest will occur there. Unstable hillslopes should add another 60,000 to 120,000 acres of late successional forest, with some portion being old growth.

Overall, salmonid and riparian conservation is expected to result in the maintenance or restoration of 129,000 to 189,000 acres of forest with mature and old-growth characteristics (11 to 16 percent of the five west-side planning units). However, natural disturbances will cause the amount to vary over time. Approximately 9 percent of these areas are currently in a late successional stage, and 84 percent are expected to be in a late successional stage by the year 2195. The ubiquity of streams, particularly Type 4 waters and Type 5 waters on unstable hillslopes, will ensure connectivity among patches of late successional forest.

Management within the wind buffers of the riparian management zone will be largely experimental, and therefore, the forest conditions within the wind buffer cannot be accurately predicted. Wind buffers may occupy up to 1 percent (10,000 acres) of DNR-managed forest land in the five west-side planning units.

MARBLED MURRELET CONSERVATION STRATEGY

Landscape conditions outside riparian areas and not on unstable hillslopes will be enhanced by management for marbled murrelets. Preliminary estimates of marbled murrelet habitat suggest that between 47,000 and 108,000 acres of habitat exists outside riparian management zones and not on unstable hillslopes — another 4 to 9 percent of the west-side planning units. The long-term murrelet conservation strategy is not yet developed, but it will quite likely entail the preservation of some marbled murrelet nesting habitat, and this will increase the amount of late successional forest available to other species.

NORTHERN SPOTTED OWL CONSERVATION STRATEGY

In the five west-side planning units, the spotted owl strategy designates 163,000 acres to be managed as nesting, roosting, and foraging (NRF) habitat for the spotted owl. There will be two 300-acre nest patches per 5,000 acres of managed forest in NRF management areas, for a total of approximately 20,000 acres. These nest patches will consist of high quality spotted owl nesting habitat with old-growth forest characteristics. The nest patches will occur within a larger, contiguous 500-acre area, of which the remaining 200 acres shall be sub-mature forest (as defined in Hanson et al. 1993) or higher quality habitat. At least 50 percent of the designated NRF management area in each WAU (including the nest patches) will be sub-mature forest or higher quality habitat.

The riparian conservation strategy will result in 11 to 16 percent of the NRF management area in a late successional condition. High-quality spotted owl nesting habitat in nest patches will occupy 12 percent of NRF management areas, but portions of the nests patches will be in riparian areas or on unstable hillslopes. The nest patches are estimated to occupy 10 percent of the NRF management area outside those areas protected by the riparian conservation strategy. The marbled murrelet strategy will contribute additional late successional forest, but an accurate estimate of amount cannot be made at this time. Nest patches and the riparian conservation strategy will result in late successional forest over 21 to 26 percent of designated NRF management areas. Therefore, on average, another 24 to 29 percent of the area designated for NRF management in each WAU will need to be submature forest or better to meet the 50 percent requirement for each WAU with designated NRF habitat.

A working hypothesis of the spotted owl conservation strategy is that the development of spotted owl habitat may be accelerated through special forest management. The calculation of harvest rotations are based on the assumption that managed forests can attain sub-mature characteristics at approximately age 70 years. Designated NRF management areas may be managed under an even-aged regulated forest system, and under such management, the 50 percent sub-mature forest prescription would require a harvest rotation of at least 100 years. Consequently, an additional 14 to 21 percent of the area designated for NRF management in each WAU will be mature forest (i.e., more than 80 years old). On average, 40 to 42 percent of the designated NRF management area in each WAU will be late successional forest, with some portion possessing old-growth characteristics.

In the five west-side planning units, the spotted owl strategy designates 117,000 acres to be managed as spotted owl dispersal habitat, which supports the movement of juvenile spotted owls among sub-populations on federal reserves. Dispersal habitat must provide foraging and roosting opportunities in amounts adequate to promote the survival of spotted owls. At least 50 percent of the designated dispersal management areas in each WAU will meet the minimum specifications for dispersal habitat.

Using the average site productivity of DNR-managed forests on the west side, dispersal habitat characteristics are estimated to be attained at approximately 40 years of age. Dispersal habitat areas will be managed under an even-aged regulated forest system, and therefore, the 50 percent prescription will require a harvest rotation greater than 40 years. The riparian conservation strategy will result in 11 to 16 percent of the land base in a late successional forest. The marbled murrelet strategy will contribute additional late successional forest, but an accurate estimate of amount cannot be made at this time. To meet the 50 percent prescription, another 34 to 39 percent of the land base must be dispersal or higher quality owl habitat, and therefore, a harvest rotation between 65 and 70 years is necessary.

OTHER MANAGED FORESTS

In conjunction with the conservation strategies described for spotted owls, marbled murrelets, riparian ecosystems (salmonids), and uncommon habitats, DNR will continue with a wide range of forest land management activities. (See Section H of this chapter, titled Forest Land Management Activities, for more discussion.) Typically, even-aged management is based on either an economic rotation or a maximum volume rotation. Currently, the most widely used harvest age is based on the economic rotation, which is approximately 50 to 60 years in west-side forests. Maximum volume rotations are approximately 80 to 100 years, the age at which stands reach maturity.

After a natural disturbance, such as fire, a stand regenerates and develops through a succession of seral stages. Managed forests often follow a similar, yet altered, pattern of sucession after a clearcut timber harvest. Various systems have been used to describe forest succession. The system used by Brown (1985) is based on the structural condition of the stand and identifies six stages: grass/forb, shrub, open sapling/pole, closed sapling/pole/sawtimber, large sawtimber, and old growth. Large saw timber is approximately equivalent to mature forest. Mature and old-growth forests are considered to be late successional (Thomas et al. 1993). Conifer forest stands develop closed sapling/pole/sawtimber structural conditions at approximately 30 to 80 years of age (Brown 1985), and stands exhibiting such conditions are generally considered to be young forest (Spies and Franklin 1991). Forests managed on an economic or maximum volume rotation should provide suitable habitat for species that utilize grass/forb, shrub, open sapling/pole, and closed sapling/pole/sawtimber stages of forest succession.

Benefits of the Species-Specific Strategies to Unlisted Species

A population's extinction risk, or conversely, its viability, is primarily a function of population size. Larger populations are more resilient to adverse environmental changes, whether such changes are natural or human-caused. Reductions in a species' habitat quality or quantity are necessarily followed by a decrease in population size, and a substantial decrease in population size increases the risk of extinction. Improving habitat quality or quantity should, in theory, lead to a larger population and decreased risk of extinction.

Geographic distribution is also a factor in risk of extinction. Maintaining a species over a large geographic area decreases the risk of extinction caused by environmental change. Over a sufficiently large area, it is unlikely that catastrophic disturbances (e.g., forest fires), harsh weather, or disease will directly affect all sub-populations. Ecological distribution may also play a role in long-term population viability. Exposing sub-populations to a range of ecological conditions maintains the genetic variation in a population. Genetic variation at the population level is essential for adaptation to changing environmental conditions.

DNR-managed forests on the west side are distributed from the Canadian border to the Columbia River Gorge and from the Cascade crest to the Pacific Coast. The five west-side planning units include portions of five physiographic provinces (Northern Cascades, Southern Washington Cascades, Puget Trough, Olympic Peninsula, and the Coast Ranges — see Map III.1), three major vegetational zones (Sitka spruce, western hemlock, and silver fir — see discussion in the section of Chapter I titled Land Covered by the HCP), and a range of climatic conditions (Franklin and Dyrness 1973; see also section of Chapter I titled Land Covered). This mix of soils, vegetation, and climate exposes sub-populations to a range of ecological conditions. The large geographic area covered by the five west-side planning units and the range of ecological conditions within them will contribute to the long-term viability of unlisted species populations.

The conservation strategies for salmonids and marbled murrelets should serve to reduce the risk of extinction for many unlisted species, in particular those that have small home ranges and depend on riparian/wetland ecosystems or late successional forests. The riparian (salmonid) strategy will maintain or restore the quantity, quality, and geographic distribution of riparian/wetland habitats. The murrelet strategy is expected to result in the retention of a significant amount of late successional forest. Even-aged forest management will provide habitat for species that utilize young forests. Some unlisted species depend on special landscape features or habitat elements that have yet to be addressed. The conservation measures for talus fields, caves, cliffs, oak woodlands, large snags, balds, mineral springs, and large, structurally unique trees described later in this section are intended to provide habitat for these species.

The spotted owl conservation strategy positions large landscapes of mature and old-growth forest within 2 miles of federal reserves (National Parks, National Forest Wilderness Areas, National Forest Late successional Reserves, etc.). For wide-ranging species (northern goshawk, Pacific fisher, California wolverine, grizzly bear, gray wolf), the conservation benefits of this HCP are seen as adjunct to those provided by federal reserves. Wildlife populations on federal lands will benefit from the proximity of additional riparian and late successional forests on DNR-managed lands. The HCP conservation strategies will broaden the geographic distribution of late successional forest and improve connectivity between noncontiguous blocks of federal land. For those unlisted species sensitive to human disturbance, special management as described below will enhance the reproductive success of individuals.

Protection of Uncommon Habitats

The conservation strategies for salmonids, spotted owls, and marbled murrelets protect habitat for many unlisted species, particularly those associated with late successional forests or riparian ecosystems. For species that rely on uncommon habitats or habitat elements, additional measures are necessary to meet the conservation objectives of the HCP. These measures specifically address talus, caves, cliffs, oak woodlands, large snags, and large, structurally unique trees. The protection of talus, caves, cliffs, and oak woodlands is important because once altered or destroyed, these habitats are difficult to restore or recreate. Large snags and large, structurally unique trees are essential habitat elements that are generally scarce in managed forest

TALUS

Talus has been designated a priority habitat by the Washington Department of Fish and Wildlife (WDFW 1995). It is a homogenous area of rock rubble ranging in size from 1 inch to 6.5 feet (WDFW 1995a; Herrington and Larsen 1985). Naturally occurring talus fields often develop at the base of cliffs or steep hillslopes as gravitational forces act upon disintegrating rock. As more rock accumulates, talus fields expand into adjacent areas of vegetation. Organic soils and pioneering vegetation may also begin to appear in some portions of talus fields in the primary stage of forest succession.

The Larch Mountain salamander requires talus in upland areas (Leonard et al. 1993). Dunn's and Van Dyke's salamanders are also known to inhabit the moist spaces between and under the rocks in talus fields (WDW 1991). Several bat species of concern use rock crevices in large talus for solitary roosts (Christy and West 1993; Holroyd et al. 1994). The microclimatic conditions and shelter provided in the spaces between and under rocks are the elements that make talus an important habitat. Because talus with a high soil content lacks such spaces, it is less important as habitat.

The rock rubble that forms talus fields accumulates where the slope is less than the angle of repose. Although talus provides habitat for some species, the talus fields are also used as road beds and the rocks are used to build roads. (Forty-seven percent is the average angle of repose for unconsolidated materials). The stability of these areas, as evidenced by these accumulations, often make them highly suitable for road beds. Routing roads around all talus fields to preserve them as habitat would mean building on less stable parts of a hillslope, creating the potential for mass wasting and sedimentation. This would be contrary to the riparian conservation strategy, which seeks to reduce the adverse impacts of roads on salmonid habitat.

Much talus is composed of hard rock, which may be suitable material for road construction. Mining talus fields for road construction can result in both short-term and long-term minimization of adverse impacts to salmonid habitat. Heavy trucks hauling construction materials can cause a short-term increase in road erosion and stream sediment concentrations, which can be lessened by using rocks from nearby talus fields (Cederholm et al. 1981). In addition, the use of construction materials inferior to hard rock talus can lead to increased risk of road failure and long-term increases in stream sedimentation caused by surface erosion. Therefore, the protection of all talus fields would conflict with the riparian conservation strategy, which requires that the adverse affects of upland management activities on salmonid habitat be minimized. Besides which, the hauling of materials to a road construction site can be prohibitively expensive compared to the mining of talus.

The conservation objectives for the talus habitat are to maintain its physical integrity and minimize microclimatic change. To meet these objectives, avoid conflict with the conservation of salmonid habitat, and promote cost effective forest management, naturally occurring talus fields shall be protected as follows:

(1) Nonforested Talus - defined as exposed talus with 30 percent or less canopy closure.

- No timber harvest will occur in talus fields greater than or equal to 1 acre.

- No timber harvest will occur in talus fields greater than 1/4 acre in spotted owl NRF and dispersal habitat management areas in the Columbia Planning Unit, except for the western half of the Siouxon Block and 2 isolated sections near Highway 12 where no timber harvest will occur in talus fields greater than 1 acre.

- A 100-foot-wide timber buffer will be applied around talus fields identified above. The buffer will be measured from the edge of the nonforested talus field, i.e. where canopy closure first exceeds 30 percent.

- Timber harvest in the buffer must retain at least 60 percent canopy closure. Any yarding within the buffer will protect the integrity of the talus field.

(2) Forested Talus - defined as exposed talus with greater than 30 percent canopy closure.

- Timber harvest may not remove more than one-third of standing timber volume each harvest rotation from forested talus not located in talus buffers.

(3) Nonforested and Forested Talus

- Road construction through talus fields and buffers will be avoided, provided that the routing of roads will be accomplished in a practicable and economically feasible manner, that is consistent with other objectives of a comprehensive landscape-based road network planning process.

- The mining of rock from talus fields and buffers for road construction will be avoided, provided construction materials can be acquired in a practicable manner, consistent with other objectives of a comprehensive road network planning process.

If a functional relationship between relative density and canopy closure can be demonstrated, then relative density can be substituted for canopy closure in the above definitions of talus.

CAVES

The Washington Department of Fish and Wildlife (1995) defines cave as "a naturally occurring cavity, recess, void, or system of interconnected passages which occurs under the earth in soils, rock, ice, or other geological formations, and is large enough to contain a human." This landscape feature has been designated a priority habitat by the Washington Department of Fish and Wildlife (1995a). Caves possess unique microclimates: constant high humidity levels, low evaporation rates, stable temperatures, and an absence of light. The archetypal cave possesses three zones: entrance zone, twilight zone, and dark zone. The entrance zone receives direct light and commonly has a vegetative component. The twilight and dark zones lie beyond the entrance zone in cave passages, i.e., the corridors and chambers that constitute a cave. The twilight zone receives no direct light, but light is detectable. Shade tolerant plants may inhabit this zone. The dark zone is devoid of light and photosynthetic plant life. In terms of species richness, the cave ecosystem is relatively simple, and therefore it is more vulnerable to environmental disturbances.

Species associated with caves in western Washington include the Larch Mountain salamander (WDW 1991), Townsend's big-eared bat (WDW 1991), long-legged myotis, long-eared myotis, fringed myotis, and Yuma myotis (Christy and West 1993). Only six caves are known on DNR-managed land (WDFW Priority Habitats Database 1995). Most caves in western Washington are lava tubes, which are long passages typically close to the surface.

The Washington Department of Fish and Wildlife definition of a cave is extraordinarily broad, and it is unlikely that all geomorphological features that fit this definition are important to wildlife. Under this HCP, when a cave is found, DNR shall determine, in cooperation with the the U.S. Fish and Wildlife Service, whether it is important to wildlife habitat, and only those caves identified as important habitat shall be protected. The conservation objectives for such caves are to:

(1) maintain the microclimate at the cave entrance;

(2) maintain the physical integrity of cave passages; and

(3) minimize human disturbance to bat hibernacula and maternity colonies.

Caves and cave passages that have been identified as important wildlife habitat shall be protected as follows:

- A 250-foot-wide buffer shall be established around cave entrances. No disturbance of soils or vegetation shall occur within these buffers.
- Where surface activities may disturb a cave passage, a 100-foot-wide buffer shall be established on both sides of the cave passage. No disturbance of soils or vegetation shall occur within these buffers.
- Roads shall not be constructed within 0.25 mile of a cave entrance, provided that the routing of roads around caves can be accomplished in a practicable manner, consistent with other objectives of a comprehensive landscape-based road network planning process.
- Where surface activities may disturb a cave passage, roads shall not be constructed within 300 feet of the cave passage, provided that the routing of roads around caves can be accomplished in a practicable manner, consistent with other objectives of a comprehensive landscape-based road network planning process.
- Newly discovered caves shall be explored and mapped before forest management activities in their vicinity may commence. Explorations will be timed to avoid active maternity colonies or hibernacula.
- The location of caves will be kept confidential by DNR, to the extent permitted by law.

CLIFFS

Cliffs are steep, vertical, or overhanging rock faces; those greater than 25 feet tall and below 5,000 feet in elevation are considered a priority habitat by Washington Department of Fish and Wildlife (1995a). Ledges provide important nesting sites for peregrine falcons. Fissures and overhanging rock provide roosting and hibernation sites for several unlisted bat species of concern (Sarell et al. 1993).

Cliffs are often composed of hard rock that is suitable for road construction. The occasional proximity of cliffs to road construction reduces the hauling distance of road construction materials. The use of construction materials inferior to hard rock can lead to increased risk of road failure and long-term increases in stream sedimentation caused by surface erosion. Furthermore, the acquisition and hauling of materials to a road construction site can be prohibitively expensive compared to the mining of cliffs.

The conservation objectives for cliff habitat are to minimize disturbance to geomorphic features and to protect species that inhabit cliffs. However, few management practices have been specifically developed for cliffs in managed forests. Therefore, management prescriptions to meet these objectives shall be developed on a site-specific basis with consideration given to the following:

(1) During planning for harvest activities around cliffs greater than 25 feet tall and below 5,000 feet in elevation, DNR shall evaluate the cliff to determine if use by wildlife is likely (e.g., are fissures/overhangs present suitable for bats, are ledges/perch trees present suitable for nesting raptors, etc.) and, if so, provide adequate protection measures including, but not limited to:

   a. protection of integrity of cliffs judged suitable and likely for wildlife use (e.g., during felling/yarding, logs should not be allowed to disturb cliff face);

   b. retention of trees on cliff benches and along the base and top of cliffs judged suitable for nesting raptors, especially perch trees along the top of cliffs; and

   c. avoidance of damage to significant cavities, fissures, and ledges.

(2) All cliffs in excess of 150 feet in height will be evaluated for peregrine falcon use as described elsewhere in this HCP (see Minimization and Mitigation for Other Federally Listed Species in All Planning Units)

(3) All cliffs with known peregrine falcon aeries will be protected according to Forest Practice regulations and the commitments contained in this HCP for peregrines (see Minimization and Mitigation for Other Federally Listed Species in All HCP Planning Units).

The mining of rock from cliffs for road construction shall be avoided, provided construction materials can be acquired in a practicable manner, and is consistent with other objectives of a comprehensive landscape-based road-network planning process.

OAK WOODLANDS

Oak woodlands have been designated a priority habitat by the Washington Department of Fish and Wildlife (1995a). Oregon white oak (*Quercus garryana*) is the only native oak in Washington. The center of its range is the Willamette Valley of Oregon; the northern limit of its range is along the lower east slopes of the central Washington Cascades. Scattered Oregon white oak woodlands occur in the Puget Trough, the Columbia Gorge, and along the east slope of the southern Washington Cascades (Franklin and Dyrness 1973). Oregon white oak is also an important component of some ponderosa pine stands along the east slope of the southern and central Washington Cascades (Franklin and Dyrness 1973). In the area covered by the HCP, DNR manages about 4,000 acres of oak woodland (e.g., where oak is the primary tree species) and an additional 7,000 acres of mostly ponderosa pine stands in which oak is a significant associate (e.g., where oak is a secondary or tertiary tree species), but only about 500 acres of oak woodland are in the five west-side planning units (DNR GIS 1995).

Fire is believed to have had a crucial role in the maintenance of oak woodlands by limiting and reducing the number of encroaching conifers. Fire may also stimulate sprouting in Oregon white oaks and enhance the growth of seedlings by removing competing herbaceous vegetation. Without natural wildfires or managed periodic burns, the vegetative composition of the woodland changes. Douglas fir becomes established, and within three to four decades, the rapidly growing conifer overtops the oak, at which point the plant community may be irreversibly altered.

Oak woodlands are a rare plant community in Washington and provide important habitat for several high priority species, including Lewis' woodpecker and the western gray squirrel, which is listed by the state as threatened. Species that find significant habitat in these areas are primarily those that are at the center of their ranges farther south.

The conservation objectives for this habitat are to:

(1) maintain the current quality and distribution of oak habitat to the extent possible considering air quality, fire management, and other constraints; and

(2) restore the quality and distribution of oak habitat where consistent with the above constraints.

Oak woodlands shall be managed as follows:

(1) Partial harvest may occur in oak woodlands. Such harvest will:

- retain all very large dominant oaks (greater than 20 inches dbh);
- maintain 25 to 50 percent canopy cover;
- remove encroaching conifers, except western white pine; and
- retain standing dead and dying oak trees.

(2) Prescribed underburns shall be conducted where appropriate.

(3) Road construction through oak woodlands shall be avoided, provided that the routing of roads around oak woodlands can be accomplished in a practicable manner, consistent with other objectives of a comprehensive landscape-based road network planning process.

LARGE, STRUCTURALLY UNIQUE TREES

Very large trees with certain structural characteristics are important habitat elements in conifer forests of western Washington. Individual trees most valuable for wildlife possess large strong limbs, open crowns, large hollow trunks, and broken tops or limbs. Many live trees that exhibit such characteristics are described by foresters as "deformed" or "defective". These trees provide important, perhaps essential, nesting and/or roosting habitat for two listed species, the marbled murrelet and bald eagle, and several bird species of concern including Vaux's swift, and the pileated woodpecker, as well as forest bats. In western Washington, three species of trees attain enormous size, are very long-lived, and are generally quite wind-firm persisting through numerous disturbances — Sitka spruce (*Picea sitchensis*), Douglas fir (*Pseudotsuga menziesii*), and western redcedar (*Thuja plicata*). According to Waring and Franklin (1979), on "better sites" in the Pacific Northwest, Douglas fir, Sitka spruce, and western redcedar can attain typically large diameters, from 60 to 87 inches, 70 to 90 inches, and 60 to 118 inches, respectively. In a managed forest, the largest examples of such trees are sometimes referred to as old-growth remnants.

The conservation objectives for this habitat element are to:

(1) retain very large trees with certain structural characteristics important to wildlife, and

(2) retain large trees that may develop these structural characteristics.

Research on animal species using large, structurally unique trees provides guidance for retention criteria. In western Washington, the mean diameter of Douglas fir used for nesting by bald eagles was 50 inches dbh (n = 70) and ranged from 24 to 90 inches dbh (Anthony et al. 1982). Bald eagles used Sitka spruce that ranged from 41 to 109 inches dbh and averaged 75 inches dbh (n = 17) (Anthony et al. 1982). Raley et al. (1994) found more than two-thirds of the roost trees used by radio-tagged pileated woodpeckers were large hollow western redcedars (mean diameter = 81 inches dbh). Vaux's swifts have been found roosting and nesting in hollow western redcedars similar to those used by pileated woodpeckers. Hamer and Nelson (1995) found that in Washington, marbled murrelets nest in trees that average 60 inches dbh (n = 6) and range in size from 35 to 87 inches dbh.

DNR shall conserve the habitat elements provided by large, structurally unique trees as follows:

- When selecting trees for retention, a preference shall be shown for large trees with structural characteristics important to wildlife, or those considered to be old-growth remnants.

- At least 1 tree per acre selected for retention shall belong to the largest diameter class of living trees in the management unit before harvest (by 2-inch increments). At least 1 other tree per acre shall belong to the dominant crown class.

- The trees selected for retention will be left in the harvest unit where practicable, and may be clumped to improve wildlife habitat, protect trees from severe weather, or facilitate operational efficiency, but where practicable, the density of clumps may not be less than 1 clump per 5 acres.

- Trees selected for retention will pose no hazard to workers during harvest operations per the safety standards of the Washington Department of Labor and Industries (WAC 296-54).

SNAGS

DNR shall conserve the habitat elements provided by large snags as follows:

- At least three snags shall be retained for each acre harvested, on average. DNR will try to leave all snags where safe and practical.

- If available, snags retained will be at least 15 inches dbh and 30 feet tall. DNR will try to leave all snags where safe and practical.

- Priority for retention will be given to large hollow snags, hard snags with bark, and snags that are at least 20 inches dbh and 40 feet tall.

- At least five live trees shall be retained permanently for each acre harvested, on average. Two of these trees will be as described in the section on large, structurally unique trees. The other three trees per acre will belong to the dominant, codominant, or intermediate crown classes, and, when available, will have at least one-third of their height in live crown.

- Priority for retention will be given to tree species which have a propensity to develop cavities (e.g., maple), but the stand tree species diversity after harvest should be generally representative of the tree species diversity prior to harvest.

- If fewer than three snags per acre are available prior to harvest, or if fewer than three snags can be left because of safety concerns, additional live trees will be retained so that the total number of stems per acre retained after harvest is, on average, at least 8 per acre. If additional live trees belong to the co-dominant or intermediate crown classes, and when available, will have at least one-third of their height in live crown. If intermediate crown-class trees are retained, shade-tolerant species with at least one-third of their height in live crown will be selected.

- Snags and trees selected for retention within the harvest units may be clumped to improve wildlife habitat, protect trees from severe weather, or facilitate operational efficiency, but where practicable, the density of clumps may not be less than one clump per five acres.

- Snags and trees selected for retention will pose no hazard to workers during harvest operations per safety standards of the Washington Department of Labor and Industries (WAC 296-54).

BALDS

Road construction through balds shall be avoided, provided that the routing of roads around balds can be accomplished in a practicable manner and is consistent with other objectives of a comprehensive landscape-based road network planning process.

MINERAL SPRINGS

Mineral springs provide important resources for certain animal species, e.g., the band-tailed pigeon (*Columbia fasciata).* To prevent or reduce adverse impacts to this landscape feature and the wildlife species associated with it, DNR will cooperate with the U.S. Fish and Wildlife Service in planning management activities within 200 feet of known mineral springs. Such activities will be designed to: (1) retain adequate trees for perching; and (2) maintain berry, fruit, and mast producing shrubs and trees, particularly in openings near mineral springs. Trees harvested near mineral springs will be felled away from the spring. DNR will avoid crossing mineral springs with yarding equipment and will prohibit the crossing of mineral springs by ground-based logging equipment. Residual large green trees and snags within 25 feet of mineral springs will be left, and either clumped or scattered depending upon operational feasibility. In addition, DNR will continue to minimize the use of herbicides as directed by Forest Resource Plan Policy No. 33.

Species by Species Conservation for Unlisted Species of Concern

Habitat for these species will be protected through the conservation strategies for the northern spotted owl and the marbled murrelet, and particularly through the riparian conservation strategy. Please refer to the full descriptions of these strategies as discussed in Sections A, B, and C, respectively, of this chapter for more details.

MOLLUSKS

Newcomb's Littorine Snail

DNR manages several parcels of land near the southern shores of Grays Harbor. The riparian conservation strategy of the HCP is expected to provide protection of the estuarine and wetland habitats considered important to the Newcomb's littorine snail. This protection will be achieved primarily through:

(1) the application of the riparian management zone to estuaries, all of which are shorelines of the state (RCW 90.58.030) and therefore Type 1 waters; and

(2) riparian buffers along Types 1, 2, 3, and 4 waters. Riparian buffers will mediate the delivery of sediment, detrital nutrients, and large woody debris from inland areas to estuaries.

Furthermore, although no specific HCP strategies have been designed for the protection of estuarine areas, some additional protection is expected through DNR's compliance with the Shoreline Management Act (RCW 90.58) and the guidelines for forest management practices promulgated under this Act (WAC 173-16-060).

California Floater and Great Columbia River Spire Snail

DNR expects the riparian conservation strategy of the HCP to protect the rivers and large streams (Types 1, 2 and 3 waters) considered important to the California floater and the great Columbia River spire snail.

ARTHROPODS

Beller's Ground Beetle, Long-horned Leaf Beetle, and Hatch's Click Beetle

DNR expects the riparian conservation strategy of the HCP to protect the sphagnum bog habitat in which these three species of beetles occur through a commitment to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p 36). Sphagnum bogs associated with low-elevation lakes will be provided further protection when the lake is a Type 1, 2, or 3 water.

Fender's Soliperlan Stonefly and Lynn's Clubtail

DNR expects the riparian conservation strategy of the HCP to protect the aquatic habitats considered important to the Fender's soliperlan stonefly and Lynn's clubtail. The riparian conservation strategy should facilitate the redevelopment of riparian plant communities and the natural variability of the aquatic environment. The natural mix of conifer and deciduous species within the riparian buffer should occur through ecosystem restoration. Also, natural disturbances, such as floods and channel migration will continue to create the silty waters that Lynn's clubtail uses for breeding.

FISH

Olympic Mudminnow

The riparian conservation strategy is expected to protect the spawning and rearing habitats of the Olympic mudminnow through:

(1) committing to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p. 36);

(2) protecting lakes and ponds classifies as Types 1, 2, and 3 waters;

(3) protecting Types 1, 2, 3, and 4 rivers and streams; and

(4) treating Type 4 and 5 waters documented to contain fish that are proposed candidates for federal listing as Type 3 waters, if appropriate.

Additional protection of aquatic habitat will occur through the prohibition of timber harvest on unstable hillslopes and road network management that minimizes adverse impacts to salmonid habitat.

Pacific Lamprey and River Lamprey

The riparian conservation strategy as described above for the Olympic mudminnow should protect the spawning and rearing habitats of the Pacific and river lampreys.

Green Sturgeon

Green sturgeon spawning and juvenile rearing habitats are not known to occur in Washington, and thus are out of the bounds of the area covered by the HCP. However, some adult habitat occurs in Grays Harbor, Willapa Bay, and along the Columbia River and its estuaries. This habitat would receive some protection through the riparian conservation strategy as described above for Newcomb's littorine snail.

AMPHIBIANS

Larch Mountain Salamander

This species is strongly associated with talus. Talus fields that are 1 acre or larger in size will be protected as previously described in the subsection titled Protection of Uncommon Habitats. Also, DNR expects the riparian conservation strategy to protect talus fields within or immediately below unstable areas because no harvest will occur on hillslopes with a high risk of mass wasting. In addition, the riparian management zone along Types 1, 2, 3, and 4 waters may encompass some talus fields.

Dunn's and Van Dyke's Salamanders and the Tailed Frog

The riparian conservation strategy is expected to protect the breeding, foraging, and resting habitats of Dunn's and Van Dyke's salamanders and the tailed frog. Riparian buffers along Types 1, 2, and 3 waters will be approximately equal to the site potential height of trees in a mature conifer stand, or 100 feet, whichever is greater. A riparian buffer 100 feet wide will be applied to both sides of Type 4 waters. Management of the no-harvest and minimal-harvest areas of the riparian buffer is anticipated to maintain or restore forests with mature or old-growth characteristics.

Some seeps will be protected through Type 5 stream protection. Type 5 waters that flow through an area with a high risk for mass wasting will be protected under the riparian conservation strategy, and other Type 5 waters will be protected where necessary for key nontimber resources, such as water quality, fish, wildlife habitat, and sensitive plant species (DNR 1992 p. 35).

Dunn's and Van Dyke's salamanders are occasionally found in upland talus (WDW 1991). Talus fields that are 1 acre or larger will be protected as described previously in the subsection titled Uncommon Habitats.

Northern Red-legged Frog, Cascades Frog, and Spotted Frog

The riparian conservation strategy is expected to protect the breeding, foraging, and resting habitats of the northern red-legged, Cascades, and spotted frogs through:

(1) committing to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p. 36);

(2) protecting lakes and ponds classified as Types 1, 2, or 3 waters; and

(3) protecting Types 1, 2, 3, and 4 rivers and streams.

The riparian conservation strategy should facilitate the redevelopment of riparian plant communities and the natural variability of the aquatic environment. The natural mix of conifer and deciduous species within the riparian buffer should occur through ecosystem restoration.

REPTILES

Northwestern Pond Turtle

The riparian conservation strategy is expected to protect the breeding, foraging, and resting habitats of the northwestern pond turtle through:

(1) committing to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p. 36);

(2) protecting lakes and ponds classified as Types 1, 2, or 3 waters; and

(3) protecting Types 1, 2, 3, and 4 rivers and streams.

In addition, under WAC 222-16-080 of the state Forest Practices Rules, harvesting, road construction, aerial application of pesticides, or site preparation within 0.25 mile of a known individual occurrence, documented by the Washington Department of Fish and Wildlife, of a northwestern pond turtle are Class IV-Special forest practices and require an environmental checklist in compliance with the State Environmental Policy Act. The environmental checklist may indicate a need for further protection of the species' critical wildlife habitat.

California Mountain Kingsnake

The California mountain kingsnake occupies oak and pine forests. Oak woodlands have been designated a priority habitat by the Washington Department of Fish and Wildlife (1995a). Oak woodlands will be protected as described previously in the subsection titled Protection of Uncommon Habitats.

The riparian conservation strategy is expected to provide protection of the habitat of the California mountain kingsnake. No harvest will occur on hillslopes with a high risk of mass wasting, and some oak forest exists within unstable areas. The riparian management zone along Types 1, 2, 3, and 4 waters may also encompass some oak forest.

BIRDS

Harlequin Duck

The riparian conservation strategy is expected to protect the breeding, foraging, and resting habitats of the harlequin duck. Buffers along Types 1, 2, and 3 waters will be approximately equal to the site potential height of trees in a mature conifer stand, or 100 feet, whichever is greater. A riparian buffer 100 feet wide will be applied to both sides of Type 4 waters. Management of the no-harvest and minimal-harvest areas of the riparian buffer is anticipated to maintain or restore forests with mature or old-growth characteristics.

Forest management in the riparian buffer must maintain or restore the quality of salmonid habitat, and the resulting conditions should also be conducive to natural densities of aquatic macro-invertebrates upon which the Harlequin duck feeds. The adverse impacts of human disturbance will be minimized by the riparian buffer, which is estimated to have an average width of 150 to 160 feet. Human disturbance will be further reduced by the wind buffer that will be placed where needed along the windward side of many reaches of Types 1, 2, and 3 waters.

ADDITIONAL MITIGATION

DNR shall place restrictions in its contracts for sales of timber and other valuable materials, as well as in its grants of rights of way and easements, to prohibit activities within 165 feet of a known active harlequin duck nest site between May 1 and September 1 where such activities would appreciably reduce the likelihood of nesting success.

Northern Goshawk

The combination of the riparian, spotted owl, and marbled murrelet conservation strategies is expected to provide forest conditions suitable for northern goshawk breeding, foraging, and resting habitat. In concert, these three strategies ensure the development of large landscapes of mature and old-growth forest. In spotted owl NRF management areas, there will be two 300-acre nest patches per 5,000 acres of managed forest. These nest patches will consist of high quality spotted owl nesting habitat that has old-growth characteristics. The nest patches will occur within a larger, contiguous 500-acre area, of which the remaining 200 acres shall be sub-mature forest or higher quality habitat. At least 50 percent of the designated NRF management areas in each WAU (including the nest patches) will be sub-mature forest (as defined in Hanson et al. 1993) or higher quality habitat. On average, 40 to 42 percent of the designated NRF management area in each WAU will be mature or old-growth forest. The landscape conditions in the NRF management areas will meet or exceed the habitat recommendations made by Reynolds et al. (1992) for northern goshawks.

In the five west-side planning units, the spotted owl strategy designates 117,000 acres to be managed as spotted owl dispersal habitat, which supports the movement of juvenile spotted owls among sub-populations on federal reserves. It is likely the availability of this habitat will enhance the survival of dispersing juvenile goshawks as well. At least 50 percent of the designated dispersal management areas in each WAU will meet the minimum specifications for spotted owl dispersal habitat.

Outside the spotted owl NRF management areas, the riparian and murrelet conservation strategies will protect goshawk breeding, foraging, and resting habitat. Management within the riparian buffer, particularly in the no-harvest and minimal-harvest areas, should eventually result in forests with mature and old-growth characteristics. Mature and old-growth forests will also exist on hillslopes with a high risk of mass wasting. The long-term murrelet conservation strategy is not yet developed, but it will quite likely entail the preservation of some late successional forest. Consistent with RCW 77.16.120, outside NRF management areas, trees or snags that are known to contain active goshawk nests will not be harvested.

To meet the objective of providing habitat for demographic support of goshawk populations on federal forest reserves, additional mitigation is necessary to ensure the reproductive success of goshawk breeding pairs in

DNR-managed forests. In particular, special management is necessary to minimize human disturbance around active nest sites.

ADDITIONAL MITIGATION

DNR shall place restrictions in its contracts for sales of timber and other valuable materials, as well as in its grants of rights of way and easements, to prohibit activities within 0.55 mile of a known active northern goshawk nest site located in a NRF management area between April 1 and August 31 where such activities would appreciably reduce the likelihood of nesting success. A circle of radius 0.55 mile will circumscribe the entire post-fledgling family area (600 acres).

Sandhill Crane and Black Tern

The riparian conservation strategy is expected to protect the wetland habitats of the sandhill crane and black tern through: (1) committing to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p. 36), and (2) protecting lakes and ponds classified as Types 1, 2, or 3 waters.

In addition, under WAC 222-16-080 of the state Forest Practices Rules, harvesting, road construction, aerial application of pesticides, or site preparation within 0.25 mile of a known active nesting area, documented by the Washington Department of Fish and Wildlife, of a sandhill crane are Class IV-Special forest practices and require an environmental checklist in compliance with the State Environmental Policy Act. The environmental checklist may indicate a need for further protection of the species' critical wildlife habitat.

Olive-sided Flycatcher

The combination of the riparian, spotted owl, and marbled murrelet conservation strategies should provide forest conditions suitable for olive-sided flycatcher breeding, foraging, and resting habitat. In concert, these three strategies ensure the development of large contiguous landscapes of mature and old-growth forest. At least 50 percent of the designated NRF management areas in each WAU (including the spotted owl nest patches) will be sub-mature forest (as defined in Hanson et al. 1993) or higher quality habitat. On average, 40 to 42 percent of the designated NRF management area in each WAU will be mature or old-growth forest.

Outside spotted owl NRF management areas, the riparian and murrelet conservation strategies will protect breeding, foraging, and resting habitat. Management within the riparian buffer, particularly in the no-harvest and minimal-harvest areas, should eventually result in forests with mature and old-growth characteristics. Mature and old-growth forests will also exist on hillslopes with a high risk of mass wasting. The long-term murrelet conservation strategy is not yet developed, but it will quite likely entail the preservation of some late successional forest.

Little Willow Flycatcher

The riparian conservation strategy and forest management in the five west-side planning units are expected to provide breeding, foraging, and resting habitat for the little willow flycatcher. Buffers along Types 1, 2, and 3 waters will be approximately equal to the site potential height of trees in a mature conifer stand, or 100 feet, whichever is greater. A riparian buffer 100 feet wide will be applied to both sides of Type 4 waters. The natural mix of conifer and deciduous species should occur through ecosystem restoration. Also, natural disturbances such as floods, and channel migration will continue to create the alder and willow riparian habitat preferred by this species.

Even-aged forest management throughout the five west-side planning units will continue to provide shrubby habitats in regenerating clearcuts and sapling stands.

Common Loon

The riparian conservation strategy is expected to protect the loon's lake habitat. The adverse impacts of human disturbance will be minimized by the riparian buffer, which is estimated to have an average width of 150 to 160 feet and will be applied along the shoreline of Types 1, 2, and 3 lakes and ponds. Human disturbance will be further reduced by the wind buffer that will be placed where needed along the riparian buffer on the windward side of Types 1, 2, and 3 waters. In order to meet the conservation objectives, further mitigation is required to reduce the adverse affects of human disturbance.

ADDITIONAL MITIGATION

DNR shall place restrictions in its contracts for sales of timber and other valuable materials, as well as in its grants of rights of way and easements, to prohibit activities within 500 feet of a known active common loon nest site between April 1 and September 1 where such activities would appreciably reduce the likelihood of nesting success.

Golden Eagle

Golden eagles nest in large trees or on cliffs. These uncommon habitats and habitat elements will be protected as described earlier in this section. The combination of the riparian conservation strategy and forest management in the five west-side planning units should provide breeding, foraging, and resting habitat for the golden eagle. Many forests on unstable hillslopes will not be harvested and some of these areas will contain large trees. Buffers along Types 1, 2, and 3 waters will be approximately equal to the site potential height of trees in a mature conifer stand, or 100 feet, whichever is greater. A riparian buffer 100 feet wide will be applied to both sides of Type 4 waters. Management within the riparian buffer is expected to result in the development of late successional forest containing large live trees. Even-aged forest management throughout the five west-side planning units will continue to provide openings for foraging habitat.

Golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668, Revised 1978). Under this Act, it is unlawful to molest or disturb golden eagles and their nests. RCW 77.16.120 of the Wildlife Code of Washington prohibits destroying the nests of protected wildlife. Consistent with these regulations, trees or snags that contain known active golden eagle nests shall not be harvested.

Vaux's Swift

The combination of the riparian, spotted owl, and marbled murrelet conservation strategies is expected to provide forest conditions suitable for Vaux's swift breeding, foraging, and resting habitat. In concert, these three strategies ensure the development of large contiguous landscapes of mature and old-growth forests containing large live tree and snags. In spotted owl NRF management areas, there will be two 300-acre nest patches per 5,000 acres of managed forest. These nest patches will consist of high quality spotted owl nesting habitat, which will have old-growth forest characteristics. The nest patches will occur within a larger, contiguous 500-acre area, of which the remaining 200 acres shall be sub-mature forest or higher quality habitat. At least 50 percent of the designated NRF management areas in each WAU (including the nest patches) will be sub-mature forest or higher quality habitat.

Even-aged forest management will provide a full range of seral stages for foraging. No harvest will occur on unstable hillslopes with a high risk of mass wasting, and some of these areas will contain large live trees and large snags. Management activities within the riparian buffer are expected to result in the development of late successional forest containing large live trees.

Outside the NRF management areas, the riparian and murrelet conservation strategies will protect breeding and resting habitat. Management within the riparian buffer, particularly in the no-harvest and minimal-harvest areas, should eventually result in forests with mature and old-growth characteristics. Mature and old-growth forests will also exist on hillslopes with a high risk of mass wasting. The long-term murrelet conservation strategy is not yet developed, but it will quite likely entail the preservation of some late successional forest.

Large, structurally unique trees and large hollow snags will be protected as described previously in the subsection titled Protection of Uncommon Habitat. In addition, consistent with RCW 77.16.120, trees or snags that are known to contain active Vaux's swift nests shall not be harvested. Green tree and snag retention are subject to the safety standards of the Department of Labor and Industries (WAC 296-54).

ADDITIONAL MITIGATION

Live trees or snags that are known to be used by Vaux's swifts as night roosts shall not be harvested. Green tree and snag retention are subject to the safety standards of the Department of Labor and Industries (WAC 296-54).

Lewis' Woodpecker

Oak woodlands are used for breeding, foraging, and resting habitat by Lewis' woodpecker. Oak woodlands have been designated a priority habitat by the Washington Department of Fish and Wildlife (1995a) and will be protected as described previously in the subsection titled Protection of Uncommon Habitats. The riparian conservation strategy is expected to guarantee some protection of this habitat within unstable areas because no harvest will occur on hillslopes with a high risk of mass wasting areas. The riparian management zone along Types 1, 2, 3, and 4 waters may also encompass some oak forests.

The riparian conservation strategy should protect some deciduous riparian habitat. Buffers along Types 1, 2, and 3 waters will be approximately equal to the site potential height of trees in a mature conifer stand. A riparian buffer 100 feet wide will be applied to both sides of Type 4 waters. DNR expects this management to result in the development of late successional forest containing large snags. The natural mix of conifer and deciduous species should occur through ecosystem restoration, and natural disturbances, such as floods, and channel migration will continue to create the cottonwood riparian habitat preferred by this species.

Pileated Woodpecker

The combination of the riparian, spotted owl, and marbled murrelet conservation strategies is expected to provide forest conditions suitable for pileated woodpecker breeding, foraging, and resting habitat. In concert, these three strategies ensure the development of large contiguous landscapes of mature and old-growth forest containing large live tree and snags. At least 50 percent of the NRF management area in each WAU will be submature forest (as defined in Hanson et al. 1993) or higher quality. There will be two 300-acre nest patches per 5,000 acres of managed forest in NRF management areas. These nest patches will consist of high quality spotted owl nesting habitat, which has old-growth forest characteristics. The nest patches will occur within a larger, contiguous 500-acre area, of which the remaining 200 acres shall be sub-mature forest or higher quality habitat. On average, 40 to 42 percent of the designated NRF management area in each WAU will be mature or old-growth forest.

Outside of spotted owl NRF management areas, the riparian and murrelet conservation strategies will protect breeding and resting habitat. Management within the riparian buffer, particularly in the no-harvest and minimal-harvest areas, should eventually result in forests with mature and old-growth characteristics. Mature and old-growth forests will also exist on hillslopes with a high risk of mass wasting. The long-term murrelet conservation strategy is not yet developed, but it will quite likely entail the preservation of some late successional forest.

Snags will be retained according to state Forest Practices Rules. Under WAC 222-30-020(11), three wildlife reserve trees (typically snags) are left for each acre harvested in western Washington. The wildlife reserve trees must be 10 or more feet in height and 12 or more inches dbh. These minimum sizes do not guarantee that wildlife trees suitable for pileated woodpeckers will be retained. The retention of large, structurally unique trees, as described previously in the subsection titled Protection of Uncommon Habitats, will provide a source for large snags.

Conservation measures for large snags and large, structurally unique trees will retain structural elements required by pileated woodpeckers for nesting and roosting. Additional conservation measures for snags will increase the density of snags, and consequently, opportunities for foraging.

Consistent with RCW 77.16.120, trees or snags that are known to contain active pileated woodpecker nests will not be harvested. In addition, trees or snags that are known to have been used by pileated woodpeckers for nesting will not be harvested. Green tree and snag retention are subject to the safety standards of the Department of Labor and Industries (WAC 296-54).

Purple Martin

The riparian conservation strategy is expected to protect the open riparian/wetland habitat of purple martins through:

(1) committing to "no overall net loss of naturally occurring wetland acreage and function" (DNR 1992 p. 36); and

(2) the protection of lakes and ponds classified as Types 1, 2, or 3 waters.

Conservation measures for large snags and large, structurally unique trees will retain structural elements required by purple martins for nesting.

In addition, consistent with RCW 77.16.120, trees or snags that are known to contain active purple martin nests will not be harvested. Green tree and snag retention are subject to the safety standards of the Department of Labor and Industries (WAC 296-54).

Western Bluebird

Even-aged forest management throughout the five west-side planning units will continue to provide openings suitable for breeding, foraging, and resting habitat. Conservation measures for large snags and large, structurally unique trees will retain structural elements required by western bluebirds for nesting.

In addition, consistent with RCW 77.16.120, trees or snags that are known to contain active western bluebird nests will not be harvested. Green tree and snag retention are subject to the safety standards of the Department of Labor and Industries (WAC 296-54).

MAMMALS

Myotis Bats

The combination of the riparian, spotted owl, and marbled murrelet conservation strategies should provide forest conditions suitable for myotis bat breeding, foraging, and resting habitat. In concert, these three strategies ensure the development of large contiguous landscapes of mature and old-growth forest. On average, 40 to 42 percent of the designated NRF management area in each WAU will be mature or old-growth forest.

Outside of spotted owl NRF management areas, the riparian and murrelet conservation strategies will protect breeding and resting habitat. Management within the riparian buffer, particularly in the no-harvest and minimal-harvest areas, should eventually result in forests with mature and old-growth characteristics. Mature and old-growth forests will also exist on hillslopes with a high risk of mass wasting. The long-term murrelet conservation strategy is not yet developed, but it will quite likely entail the preservation of some late successional forest.

Talus fields, cliffs, and caves will be protected as described previously in the subsection titled Protection of Uncommon Habitats, and DNR will also protect large, structurally unique trees and large snags as described in the same subsection.

ADDITIONAL MITIGATION

Live trees or snags that are known to be used by myotis bat species as communal roosts or maternity colonies shall not be harvested. Green tree and snag retention are subject to the safety standards of the Department of Labor and Industries (WAC 296-54).

Townsend's Big-eared Bat

Caves will be protected as described previously in the subsection titled Protection of Uncommon Habitats.

California Wolverine

There is very little montane forest on DNR-managed lands. But some parcels of DNR-managed forest are positioned adjacent to federal wilderness areas and federal Late successional Reserves that may serve as refugia for wolverines. Therefore, it is possible that wolverines could now or in the future be present in DNR-managed forests. The combination of the riparian, spotted owl, and marbled murrelet conservation strategies is expected to provide forest conditions suitable for wolverine breeding, foraging, and resting habitat. In concert, these three strategies should ensure the development of large landscapes of mature and old-growth forest. Forest management will create a range of habitat types from grass-forb to late-successional forest.

To meet the objective of providing habitat for demographic support of populations on federal forest reserves additional mitigation is necessary to ensure the reproductive success of breeding adults in DNR-managed forests. In particular, special management is necessary to minimize human disturbance around active den sites and eliminate trapping mortality.

DNR-managed roads are routinely closed for cost-effective forest management and protection of public resources, including wildlife (DNR 1992 p. 41). Road closures benefit the wolverine population by limiting human disturbance and reducing the likelihood of accidental trapping. Road closures will continue on DNR-managed lands and will be consistent with cost-effective forest management and policies set forth by the Board of Natural Resources.

ADDITIONAL MITIGATION

DNR shall place restrictions in its contracts for sales of timber and other valuable materials, as well as in its grants of rights of way and easements, to prohibit activities within 0.5 mile of a known active wolverine den site located in a spotted owl NRF management area between January 1 and July 31 where such activities would appreciably reduce the likelihood of denning success.

Pacific Fisher

The combination of the riparian, spotted owl, and marbled murrelet conservation strategies is expected to provide forest conditions suitable for fisher breeding, foraging, and resting habitat. In concert, these three strategies ensure the development of large landscapes of mature and old-growth forest. At least 50 percent of the designated NRF management areas in each WAU (inclusive of the nest patches) will be sub-mature forest (as defined in Hanson et al. 1993) or higher quality habitat. The high-quality owl nesting habitat in nest patches will have old-growth forest characteristics. On average, 40 to 42 percent of the designated NRF management area in each WAU will be mature or old-growth forest.

In the five west-side planning units, the spotted owl strategy designates 117,000 acres to be managed as spotted owl dispersal habitat. At least 50 percent of the designated dispersal management area in each WAU will meet the minimum specifications for spotted dispersal habitat. The purpose of dispersal habitat is to support the movement of juvenile spotted owls between sub-populations on federal reserves, and it is likely the availability of this habitat may also enhance the survival of dispersing juvenile fishers.

The geographical distribution of areas managed for spotted owl breeding habitat will maintain some of the elevational range of fisher habitat. DNR-managed forests are generally located at a lower elevation than federal lands. To meet the objective of providing habitat for demographic support of populations on federal forest reserves, additional mitigation is necessary to ensure the reproductive success of breeding adults in DNR-managed forests. In particular, special management is necessary to minimize human disturbance around active den sites and eliminate trapping mortality.

DNR-managed roads are routinely closed for cost-effective forest management and protection of public resources including wildlife (DNR 1992 p. 41). Road closures benefit the fisher population by limiting human disturbance and reducing the likelihood of accidental trapping. Road closures will continue on DNR-managed lands and will be consistent with cost-effective forest management and policies set forth by the Board of Natural Resources.

Conservation measures for large snags and large, structurally unique trees will retain structural elements required by fishers for denning and resting.

ADDITIONAL MITIGATION

DNR shall place restrictions in its contracts for sales of timber and other valuable materials, as well as in its grants of rights of way and easements, to prohibit activities within 0.5 mile of a known active fisher den site located in a spotted owl NRF management area between February 1 and July 31 where such activities would appreciably reduce the likelihood of denning success.

Western Gray Squirrel

Oak woodlands are the breeding, foraging, and resting habitat of the western gray squirrel. Oak woodlands have been designated a priority habitat by the Washington Department of Fish and Wildlife (1995a), and will be protected as described previously in the subsection titled Protection of Uncommon Habitats.

The riparian conservation strategy is expected to provide some protection of the breeding, foraging, and resting habitat of the western gray squirrel. No harvest will occur on hillslopes with a high risk of mass wasting, and some oak forest will exist within unstable areas. The riparian management zone along Types 1, 2, 3, and 4 waters may also encompass some oak forest.

In addition, under WAC 222-16-080 of the state Forest Practices Rules, the Forest Practices Board may adopt rules pertaining to management activities which impact western gray squirrels. These rules would provide further protection of the species' critical wildlife habitat.

Lynx

Although the lynx may potentially occur in the area covered by the HCP, it is not known to occur in the five west-side planning units. Therefore, it is not discussed in this section.

California Bighorn Sheep

Although the California bighorn sheep may potentially occur in the area covered by the HCP, it is not known to occur in the five west-side planning units. Therefore, it is not discussed in this section.

Summary of Habitat Types Provided on DNR-managed Lands in the Five West-Side Planning Units

The type and distribution of habitat available during the term of this HCP will be the result of commitments under the HCP, natural events, forest management policies of the Board of Natural Resources and DNR, technological developments that influence management practices, and land transactions.

HABITATS TO BE MAINTAINED OR RESTORED UNDER THE HCP

Spotted Owl Nesting, Roosting, and Foraging (NRF) Areas

Two types of habitat are required within designated NRF areas:

(1) high quality nesting habitat; and

(2) areas that, at a minimum, meet the sub-mature habitat definition.

In every 5,000 acres, there shall be two 300-acre nest patches of high quality spotted owl nesting habitat that has old-growth characteristics. These nest patches will occur within a larger, contiguous 500-acre area, of which the remaining 200 acres shall be sub-mature forest or higher quality habitat. At least 50 percent of the designated NRF management areas in each WAU (Watershed Administrative Unit) shall be sub-mature, including the nest patches.

See Section A of Chapter IV on spotted owl mitigation for a full description of these habitats, their distribution, and the amount required. The definitions of these habitats are summarized below:

- High quality nesting habitat (average condition over a 300-acre nesting habitat patch)
  - at least 31 trees per acre greater than or equal to 21 inches dbh with at least 15 trees per acre greater than or equal to 31 inches dbh;
  - at least three trees from the above group of 31 trees have broken tops;
  - at least 12 snags per acre larger than 21 inches dbh;
  - a minimum of 70 percent canopy closure; and
  - a minimum of 5 percent ground cover of large woody debris.
- Sub-mature habitat (applied as average stand conditions)
  - forest community dominated by conifers or in mixed conifer/hardwood forest, the community is composed of at least 30 percent conifers (measured as stems per acre dominant, co-dominant, and intermediate trees);
  - at least 70 percent canopy closure;
  - tree density of between 115 and 280 trees per acre greater than 4 inches dbh;

- dominant and co-dominant trees at least 85 feet tall;
- at least three snags or cavity trees per acre that are at least 20 inches dbh; and
- a minimum of 5 percent ground cover of large down woody debris.

Spotted Owl Dispersal Areas

Within designated spotted owl dispersal areas, 50 percent of the area shall be maintained in stands that meet the dispersal habitat definition. See Section A of Chapter IV on spotted owl mitigation for a full description of this habitat. The definition of dispersal habitat is summarized below:

- canopy cover of at least 70 percent;
- quadratic mean diameter of at least 11 inches dbh for the 100 largest trees in a stand;
- top height of at least 85 feet; and
- at least four trees per acre from the largest size class retained for future snag and cavity trees.

Marbled Murrelet Habitat Blocks

The interim conservation strategy for the marbled murrelet calls for deferring harvest on suitable habitat blocks while studies are conducted to provide information for developing a long-term conservation strategy. The amount of habitat required for murrelets in the long-term strategy is expected to be less than is identified using the current definition. See Section B of Chapter IV for a complete discussion of the mitigation for marbled murrelets. Suitable marbled murrelet habitat that will be used for identifying blocks to be deferred is defined as a contiguous forested area meeting all of the following three criteria:

- at least five acres in size;
- containing an average of at least two potential nesting platforms per acre; and
- within 50 miles of marine waters.

Riparian Management Zones

Management activities allowed within riparian management zones will influence the type of habitat provided. The requirements for no harvest within the first 25 feet of the active channel margin and minimal harvest in the next 75 feet will tend to leave, or develop over time, timber stands with a range of mature to old-growth characteristics. Through restoration efforts consistent with the riparian conservation objective of maintaining or restoring salmonid freshwater habitat on DNR-managed lands, most riparian management zones will be coniferous with minor hardwood components. Hardwoods will be maintained on sites that are not environmentally suited to conifers. See Section D of Chapter IV for a detailed discussion of riparian management zones.

Wetlands

DNR will allow no overall net loss of naturally occurring wetland acreage or function. This applies to nonforested and forested wetlands. See Section D of Chapter IV on the riparian conservation strategy for a detailed discussion of wetland management activities and habitat. For forested wetlands and buffers of nonforested wetlands, timber harvests shall be designed to maintain the perpetuate stands that:

- are as wind-firm as possible;
- have large root systems to maintain the uptake and transpiration of ground water; and
- have a minimum basal area of 120 square feet per acre.

Uncommon Habitats

See Section F of Chapter IV on the multispecies conservation strategy for a discussion of uncommon habitats on DNR-managed lands. The following uncommon habitats will be identified and protected:

- cliffs;
- caves and cave passages that have been identified as important wildlife habitat;
- oak woodlands

  (Oak woodlands are very limited in the five west-side planning units. Where they occur, they will be managed to maintain the current quality and distribution of the habitat to the extent possible considering air quality, fire management, and other constraints and to restore the quality and distribution of this habitat where consistent with these constraints.); and
- talus fields that are one acre or larger.

HABITATS PROVIDED ON DNR-MANAGED LANDS

After a natural disturbance, such as fire, a stand regenerates and develops through a succession of seral stages. Managed forests follow a similar pattern of succession following clearcut timber harvest. A variety of wildlife habitats on DNR-managed lands will occur in the different seral stages (Brown 1985) described below:

- Grass/forb

  Grass/forb-dominated areas develop quickly on cleared lands and are common for a few years after harvest or site preparation activities. In cases where a significant shrub layer existed under the timber that was harvested, a grass/forb condition frequently will not develop. Generally, a grass/forb condition exists at the time sites are planted or develops shortly after planting.
- Shrub

  Shrubs develop on a site following harvests, including thinnings, or start developing at the same time as grasses and forbs. However, shrubs generally take a few years to develop to the point of dominating a site. The length of time shrubs dominate an area depends primarily on the development of trees. Tree seedlings are generally present on these sites but are not tall enough to impact the shrubs.

- Open sapling/pole
  In the open sapling/pole condition, shrubs are frequently the dominant vegetation, but trees are tall enough to prevent being suppressed by shrubs.

- Closed sapling/pole/sawtimber
  This condition is marked by very dense tree canopies which limit all ground vegetation. Thinning commonly opens the canopy sufficiently to allow shrubs to redevelop.

- Large sawtimber
  Large sawtimber is frequently defined as stands with an average diameter greater than 21 inches. In managed stands, trees often have a relatively uniform size and may approach the tree sizes found in old-growth stands. However, these stands generally lack characteristics such as snags, down woody debris, and the two or more canopy layers that are found in old-growth stands.

- Old growth
  Old-growth stands are characterized by the presence of snags, down woody debris, and two or more canopy layers that develop as a result of the mortality of overstory trees. Stand diameters may be similar to or larger than large sawtimber stands.

Table IV.13 lists the types of habitat expected to be provided under the HCP on DNR-managed lands in the five west-side planning units. Examples of representative species that might use that habitat type, management activities that may be conducted, potential negative impacts that may result from the management activities, and benefits expected to accrue from the HCP are given for each habitat type. Additional details regarding the management activities are included in Section H (Forest Land Management Activities) of this chapter.

Table IV.13: Habitats and representative wildlife species covered by this HCP for the west-side planning units

(Source: Brown 1985, Thomas et al. (1993), Parsons et al. (1991), and Pyle (1989)).

Type of habitat	Representative species that can use these habitat types
Spotted owl high quality nesting habitat	dusky shrew, long-eared myotis, northern flying squirrel, Pacific fisher, wood duck, northern goshawk, barred owl, pileated woodpecker, olive-sided flycatcher, northern spotted owl, hoary bat, bushy-tailed woodrat, red tree vole, harlequin duck, marbled murrelet, Vaux's swift, red-breasted nuthatch, Dunn's salamander, Larch Mountain salamander, Van Dyke's salamander, tailed frog, pine white butterfly, Johnson's hairstreak butterfly, *Acalypta saudersi* (a lace bug), *Cychrus tuberculatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle)
Spotted owl sub-mature habitat	dusky shrew, long-legged myotis, northern flying squirrel, Pacific fisher, wood duck, hairy woodpecker, northern goshawk, barred owl, olive-sided flycatcher, northern spotted owl, hoary bat, bushy-tailed woodrat, red tree vole, red-breasted nuthatch, Dunn's salamander, northwestern salamander, Van Dyke's salamander, tailed frog, northern alligator lizard, pine white butterfly, coral hairstreak butterfly, California hairstreak butterfly, *Cychrus tuberculatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle)
Spotted owl dispersal habitat	Douglas' squirrel, sharp-shinned hawk, Swainson's thrush, evening grosbeak, dusky shrew, northern spotted owl, long-legged myotis, mountain beaver, creeping vole, bobcat, elk, Vaux's swift, orange-crowned vireo, northern alligator lizard, rubber boa, long-toed salamander,

Table IV.13: Habitats and representative wildlife species covered by this HCP for the west-side planning units *(continued)*

Type of habitat	**Representative species that can use these habitat types**
Spotted owl dispersal habitat *(continued)*	*Cychrus tuberculatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle)
Marbled murrelet habitat	dusky shrew, long-legged myotis, northern flying squirrel, Pacific fisher, wood duck, northern goshawk, barred owl, hairy woodpecker, Oliver-sided flycatcher, marbled murrelet, hoary bat, bushy-tailed woodrat, red tree vole, harlequin duck, Vaux's swift, red-breasted nuthatch, Dunn's salamander, Larch Mountain salamander, Van Dyke's salamander, tailed frog, pine white butterfly, Johnson's hair-streak butterfly, *Acalypta saudersi* (a lace bug), *Cychrus tuberculatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle)
Conifer-dominated riparian ecosystems	long-legged myotis, Pacific fisher, mink, wood duck, sharp-shinned hawk, ruffed grouse, olive-sided flycatcher, purple martin, Dunn's salamander, Van Dyke's salamander, salamander, tailed frog, dusky shrew, Trowbridge's shrew, southern red-backed vole, river otter, Barrow's goldeneye, band-tailed pigeon, long-eared owl, red-breasted sapsucker, hermit thrush, evening grosbeak, Cascade frog, bull trout, coho salmon, steelhead salmon, mayflies, stoneflies, caddisflies, midges, arborvitae hair-streak butterfly
Hardwood-dominated riparian ecosystems	long-legged myotis, mink, wood duck, purple martin, northwestern pond turtle, common garter snake, Dunn's salamander, northern red-legged frog, ruffed grouse, dusky shrew, shrew mole, yellowpine chimunk, river otter,

Table IV.13: Habitats and representative wildlife species covered by this HCP for the west-side planning units *(continued)*

Type of habitat	Representative species that can use these habitat types
Hardwood-dominated riparian ecosystem *(continued)*	Barrow's goldeneye, Cooper's hawk, band-tailed pigeon, downy woodpecker, black-headed grosbeak, Olympic salamander, Olympic mudminnow, mayflies, stoneflies, caddisflies, dreamy duskywing butterfly, western tiger swallowtail
Nonforested wetland	northern harrier, common snipe, northwestern pond turtle, northern red-legged frog, spotted frog, Beller's ground beetle, long-horned leaf beetle, Hatch's click beetle, mallard, mink, dusky shrew, Pacific shrew, coast mole, Yuma myotis, long-tailed vole, American bittern, little willow flycatcher, common loon, sandhill crane, black tern, coho salmon, Olympic mudminnow, dragonflies, damselflies, sonora skipper butterfly
Forested wetland	long-legged myotis, Pacific fisher, ruffed grouse, sharp-shinned hawk, barred owl, olive-sided flycatcher, purple martin, Van Dyke's salamander, northern red-legged frog, mink, spotted frog, dusky shrew, water shrew, bushy-tailed woodrat, common merganser, band-tailed pigeon, northern saw-whet owl, red-breasted sapsucker, western toad, dragonflies, flies, cad-disflies, pale tiger swallowtail butterfly
Cliffs	fringed myotis, long-legged myotis, Yuma myotis, mountain goat, peregrine falcon, turkey vulture, black swift, cliff swallow, western fence lizard, bushy-tailed woodrat, golden eagle, wasps, shorttailed black swallowtail butterfly

Table IV.13: Habitats and representative wildlife species covered by this HCP for the west-side planning units *(continued)*

Type of habitat	Representative species that can use these habitat types
Caves	Townsend's big-eared bat, fringed myotis, long-legged myotis, Yuma myotis, coyote, California wolverine, mountain lion, bobcat, black swift, Larch Mountain salamander, crickets
Oak woodland	western gray squirrel, Lewis' woodpecker, California mountain kingsnake, Propertius' duskywing butterfly, Oregon green hairstreak butterfly
Talus	Cascade golden-mantled ground squirrel, mountain goat, Pacific fisher, California wolverine, bobcat, white-tailed ptarmigan, common nighthawk, rosy finch, western fence lizard, Larch Mountain salamander, Dunn's salamander, Van Dyke's salamander, wolf spiders, jumping spiders, small-footed myotis
Grass/forb forest stage	coast mole, vagrant shrew, Townsend's vole, coyote, long-tailed weasel, black-tailed deer, common nighthawk, white-crowned sparrow, northwestern garter snake, western fence lizard, northwestern salamander, western bluebird, wolf spiders, grasshoppers, mariposa copper butterfly, silvery blue butterfly, Blackmore's blue butterfly, western meadow fritillary butterfly, *Oncocnemis dunbari* (a moth), *Formica neorufibarbis* (an ant)
Shrub forest stage	coast mole, Townsend's vole, mountain beaver, coyote, long-tailed weasel, black-tailed deer, common nighthawk, blue grouse, rufous hummingbird, hermit thrush, white-crowned sparrow, rufous-sided towhee, northwestern garter snake, western fence lizard,

Table IV.13: Habitats and representative wildlife species covered by this HCP for the west-side planning units *(continued)*

Type of habitat	**Representative species that can use these habitat types**
Shrub forest stage *(continued)*	northwestern salamander, western bluebird, Pacuvius' duskywing butterfly, satyr anglewing butterfly
Open sapling/pole forest stage	coast mole, Douglas' squirrel, mountain beaver, black-tailed deer, long-tailed weasel, coyote, blue grouse, rufous hummingbird, American robin, hermit thrush, rufous-sided towhee, western fence lizard, western bluebird, Phoebus parnassian butterfly, golden hairstreak butterfly, western tailed blue butterfly, bobcat, snowshoe hare
Closed sapling/pole/sawtimber forest stage	Douglas' squirrel, sharp-shinned hawk, Swainson's thrush, evening grosbeak, dusky shrew, long-legged myotis, mountain beaver, creeping vole, bobcat, elk, Vaux's swift, orange-crowned vireo, northern alligator lizard, rubber boa, long-toed salamander, *Cychrustuber-culatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle)
Large sawtimber forest stage	dusky shrew, long-legged myotis, northern flying squirrel, Pacific fisher, wood duck, hairy woodpecker, northern goshawk, barred owl, olive-sided flycatcher, hoary bat, bushy-tailed woodrat, red tree vole, red-breasted nuthatch, Dunn's salamander, northwestern salamander, Van Dyke's salamander, tailed frog, northern alligator lizard, coral hairstreak butterfly, pine white butterfly, California hairstreak butterfly, *Cychrus tuberculatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle)

Table IV.13: Habitats and representative wildlife species covered by this HCP for the west-side planning units *(continued)*

Type of habitat	Representative species that can use these habitat types
Old-growth forest stage	Johnson's hairstreak butterfly, pine white butterfly, *Acalypta saudersi* (a lace bug), *Cychrus tuberculatus* (a carabid beetle), *Lobosoma horridum* (a weevil), *Omus dejeani* (a tiger beetle); and see list for spotted owl high quality nesting habitat

Provision of a Range of Forest Types Across the HCP Landscape

DNR management activities that will occur under the HCP will ensure a range of forest types in adequate amounts to provide for multi-species conservation across the landscape covered by the HCP. DNR has modeled the age-class distribution that will likely result from expected management under the HCP and existing policies. Results from this modeling have been used to develop a table (see Table IV.14) of expected percentages of each of several forest habitat/structural types, using age-class as a surrogate, that would likely exist 100 years following implementation of such management.

Table IV.14: DNR HCP stand structure objectives at year 100 (in percent of land area)

Stand Stage[1]	West-side Planning Units Excluding the OESF	OESF Planning Unit
Open (0-10 Years)[2]	5-10	5-15
Regeneration (10-20 years)[2]	5-15	5-15
Pole (20-40 years)[2]	15-25	5-15
Closed (40-70 years)[2]	25-35	5-15
Complex (at least 70 years)[2]	25-35	60-70
Fully Functional	(At least 150 years)	(At least 200 years)
(Subset of Complex)	10-15	10-15

[1]Stand stages are defined as:
Open- earliest seral stage; overstory has been removed; dominated by herbs and shrubs with some young conifer and deciduous trees present.

Regeneration-shrubs and saplings; branches beginning to intertwine; dense canopies from ground-level upwards.

Pole - early stages of stem exclusion; stems closely spaced and numerous; little understory; limited self-pruning; and insufficient canopy lift to allow larger birds to penetrate.

Closed - have undergone some stem exclusion and competition mortality; have achieved some canopy lift from self-pruning; have well-developed, deep canopies; and lacking complex structural characteristics of older types.

Complex - stocked with large trees with a variety of diameters and heights evident; mortality within the stand (or residual trees, snags, and logs) provides cavities in standing snags, downed logs, deformities in standing live trees; large horizontal branches; and a complex canopy with conifer establishment occurring under opening in the canopy.

Fully Functional - a subset of complex forests but more mature and structurally complex.

[2]Age-classes shown are a surrogate for stand structure. If and when it can be shown that appropriate structure can be obtained at a different age, different age classes may be used.

The information in the above table was derived from modeling that contained assumptions based on the Forest Resource Plan policies. These assumptions are described in Appendix 5 of the Final EIS (available from DNR). The FRP states that the goal for average rotation age for west-side conifer dominated forests will be 60 years. At present, DNR expects to continue this policy and information regarding the average rotation age will be provided to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service at scheduled inter-agency HCP reviews. However, as long as DNR can show that reaching the stand structure objectives is likely, other rotation ages may be used. Additionally, DNR maintains the flexibility to harvest specific stands at an earlier age to address specific silvicultural situations (i.e., a 30- to 35-year old stand that was not thinned at an appropriate age may be more quickly converted into a healthy, productive stand by clear-cutting the stand and "starting over").

Subsequent to the modeling exercise, DNR, the U.S. Fish & Wildlife Service and the National Marine Fisheries Service negotiated a 70-year term for this HCP, with provisions for up to three, 10-year extensions. (See the Implementation Agreement in Appendix B of this document.) Such extensions could occur at DNR's option if commitments of the HCP are met at year 70, or at the U.S. Fish and Wildlife Service's option if commitments have not been met at year 70. Currently no projections are available for the forest structure expected at year 70. However, during the first year following approval of the HCP, additional modeling will be conducted by DNR. The modeling will be by decade and the results will be provided to the U.S. Fish and Wildlife Service at, or by, the first annual review. These decadal projections will be used by DNR as part of its monitoring process.

The projections for year 70 will be a part of the U.S. Fish and Wildlife Service's evaluation of whether DNR has met the commitments of the HCP at year 70. In that evaluation, the U.S. Fish and Wildlife Service will also review DNR's progress in meeting the conservation objectives included in Chapter IV of this HCP. DNR's HCP provides for the conservation of both listed and unlisted species. Detailed, specific conservation measures are described elsewhere in this chapter for the northern spotted owl and a long-term strategy will be developed for the marbled murrelet. Additional important, but more limited, measures will be described for certain other listed species. Conservation measures affecting the unlisted species include those undertaken for listed species with additional measures described for certain important habitat types. The most important conservation measures affecting unlisted species are those associated with the riparian conservation strategy.

Of the HCP's three primary conservation components (spotted owl conservation strategy, marbled murrelet conservation strategy, and riparian conservation strategy), the marbled murrelet strategy is the only one that is interim in nature. A long-term strategy will not be developed for a number of years. An adequate and appropriate means of evaluating commitments for the marbled murrelet at year 70 cannot be described, at this time, except in terms of compliance with the strategy described in Chapter IV.

The riparian conservation strategy will be implemented in the five west-side planning units and the OESF. DNR's compliance and effectiveness monitoring plan for the riparian areas should provide sufficient information for the U.S. Fish and Wildlife Service to determine whether commitments in this area have been met at year 70.

The spotted owl conservation strategy sets specific goals for developing and maintaining NRF and dispersal habitat in specific amounts and locations (by WAU). Approximately 200,000 acres are designated for a NRF habitat role and 125,000 of those acres (62.5 percent) are in WAUs that are already at or above the goals set in this HCP. The conditions in the WAUs that are not currently at or above the goal, will be reviewed by the U.S. Fish and Wildlife Service at year 70, when evaluating whether DNR has met its obligations under the HCP.

As described above, the 70 year term should be sufficient for all species based upon the anticipated habitats resulting from the HCP management strategies. Riparian areas and uncommon/special habitats (e.g., talus, caves, wetlands) are expected to provide improved wildlife habitat over the life of the plan. Older stand structures (i.e., structurally complex forests and fully functional forests) increase or remain constant when comparing the current conditions with those anticipated at the end of the permit period. Healthy riparian systems, mature forest with structure, and uncommon/special habitats comprise the major concerns regarding adequacy of habitats. Younger forests (between 40 and 70 years) will continue to be provided as a result of timber management. In addition, the long-term plan for murrelets will be developed in consideration of the 70-year permit term to ensure its adequacy. Finally, as mentioned above in this section, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service will review DNR's progress in meeting the conservation objectives and may require an extension of the HCP if it can be demonstrated that DNR failed to achieve the commitments of the HCP.

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STATE OF WASHINGTON

DEPARTMENT OF NATURAL RESOURCES

BOARD OF NATURAL RESOURCES

RESOLUTION NO. 1110

A **RESOLUTION** authorizing the Department of Natural Resources to prepare the Final Environmental Impact Statement for Sustainable Forest Management of State Trust Lands in Western Washington.

BE IT RESOLVED BY THE BOARD OF NATURAL RESOURCES, DEPARTMENT OF NATURAL RESOURCES, STATE OF WASHINGTON, THAT THE FOLLOWING PRINCIPLES SHALL BE INCORPORATED INTO THE PREFERRED ALTERNATIVE:

SECTION 1. State law (formerly RCW 79.68, recodified at Laws of 2003, Ch. 334, sec. 555(3)) directs the DNR to apply "sustained yield" management to state trust forestlands. The law requires the DNR to periodically adjust acreages designated for inclusion in the sustained yield management program, and calculate a sustainable forestry harvest level.

SECTION 2. The "sustainable harvest level" means the volume of timber to be scheduled for sale from state-owned lands during a planning decade. This is part of DNR's strategic plan for sustainable forest management. It provides for sustainable harvesting on a continuing basis without major prolonged curtailment or cessation of harvest, as required by state law.

SECTION 3. A draft environmental impact statement (DEIS) was issued, November 2003. The DEIS identified six alternatives without identifying a preferred alternative. Scoping comments, multiple public meetings, extensive written comments on the DEIS, direct public comments to the Board of Natural Resources, special Board Sustainable Forestry Workshops, comments from the Sustainable Forestry Technical Committee, outputs from the *Options* policy simulation model, and the DEIS itself, all have provided important information that has led to the development of the preferred alternative.

SECTION 4. The Preferred Alternative shall be analyzed in the Final Environmental Impact Statement (FEIS). The DNR shall publish the FEIS and present its findings to the Board of Natural Resources and the public during May 2004. The Preferred Alternative shall be based upon the following statements and the documents referenced in Section 6:

A. Inter-decadal sales variability shall be limited to +/- 25%, based on volume.

B. The model calculation will be based on value. Operational management will also use volume to make stand-level decisions to capture forest value growth while managing the total inventory.

C. Sustainable harvest calculation groups shall be twenty (17 Forest Board Counties, Capital Forest, Olympic Experimental Forest (OESF) and all federal grants and Forest Board Purchased as a single group).

D. Actively manage the land base consistent with our fiduciary and Habitat Conservation Plan responsibilities.

E. Maturity criteria that reflect forest health and value-based considerations will be used by the DNR to provide professional management of the forested trust assets.

F. Bio-diversity pathways will be used to simultaneously increase the production of trust revenue and complex forest habitat with a priority for habitat areas, and across the landscape as appropriate.

G. Old Growth Research Areas continue to be deferred. Over time, target 10-15% of each westside HCP planning units for the development of older forests as defined by structural characteristics provided that existing old growth (as defined by the HCP) and older stands will be a priority focus in developing HCP planning unit targets.

H. The "50/25" strategy is removed and cumulative effects will be addressed through other SEPA processes.

I. The HCP directions shall replace the current legacy & reserve tree requirements.

J. For northern spotted owls:

   a. Nesting/roosting/foraging and Dispersal Management: implement the HCP strategy for 50% habitat targets.

   b. Prior to 2007, protect circles identified in Owl Memo #1.

   c. Prior to 2007, protect Stat 1-R circles outside of the OESF.

   d. Prior to 2006, protect SW owl circles other than those above.

   e. Prior to 2005, protect owl circles in the OESF.

K. Riparian management shall be consistent with the HCP requirements and agreement with the federal services.

L. The Department shall annually report to the Board of Natural Resources its assessment of the environmental and economic results of implementing the Preferred Alternative. The Department shall employ a structured monitoring and reporting program.

SECTION 5. The Department shall present an analysis to the Board of Natural Resources during the May 2004 meeting that identifies hiring, implementation timelines and cash flow necessary to transition to the Preferred Alternative management practices and associated harvest levels. The Department is directed to prepare a Preferred Alternative that shall meet an average annual harvest target of 636mmbf as soon as possible.

SECTION 6. The FEIS shall take guidance from the following documents in the preparation of the FEIS and its Preferred Alternative: Document One (Management Principles and Objectives, February 3, 2004 as amended by the Board February 17, 2004). Document Two (The description of the Preferred Alternative as presented and amended by the Board on February 17, 2004).

APPROVED AND ADOPTED by the Board of Natural Resources, Department of Natural Resources, State of Washington, this _second_____ day of _March_______, 2004.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the official seal of the Commissioner of Public Lands.

DOUG SUTHERLAND
Commissioner of Public Lands

Approved as to form,
March 2, 2004

Phil Ferester, AAG

Washington State
Board of Natural Resources

FILE COPY

Resolution 1110 – Document 1. **February 17, 2004**

Sustainable Harvest Calculation Management Principles and Objectives

These principles and objectives were first introduced in a memo to the Board of Natural Resources (Board) by Board member Terry Bergeson, Superintendent of Public Instruction, at the January 2004 Board meeting. The memo was discussed and amended January 8th, February 3rd, and February 17th.

The objectives below provide a broad level of direction by the Board of Natural Resources to the Department of Natural Resources in modeling the sustainable harvest calculation and subsequent implementation of the preferred alternative, focusing on:

- Our fiduciary responsibilities;
- A flexible framework for DNR staff to work within;
- Phasing in management strategies to maximize net revenue within reasonable expenditures;
- Utilizing innovative forestry techniques to maintain a diverse, healthy forest system and to protect sensitive areas and habitats, and;
- Requiring monitoring and, at a minimum, annual reporting by DNR to the Board of efforts and results in an outcome-based format so that the Board can respond in a timely manner to policy and implementation issues.

The Board must ensure all decisions meet our fiduciary responsibilities and legal obligations. From the court ruling in *Skamania:* "The state's fiduciary duty of undivided loyalty prevents it from using state trust lands to accomplish public purposes other than those which benefit the trust beneficiaries." Each decision needs to be weighed in terms of:

- Being prudent;
- Assuring intergenerational equity; and
- Maintaining asset productivity in perpetuity.

With these principles in mind, the following objectives reflect the discussion of the Board members for the Sustainable Harvest Calculation and DNR management to meet:

1. The first objective is to have financial performance measured by net present value, a valuable tool to help assure optimum returns to all generations.
2. The second objective is to align all department-created policies, procedures and tasks with Board approved policies to ensure flexibility, optimize the net present value, and achieve other asset management objectives in support of our fiduciary responsibilities.
3. A third objective is to direct the DNR to provide professional management of the assets through active stewardship of as much of the landscape as allowable by law (including the HCP), opening up the landscape to on-base activities.
4. A fourth objective is for the Sustainable Harvest Calculation to reflect a flexible framework within which DNR may, year to year and stand by stand, use professional judgment, best

available science and sound field forestry to achieve excellence in our public stewardship. Timber sales should be regulated through a combined value and volume approach. Decadal target volumes should be managed to effectively market timber so as to increase the value of each timber sale, allowing for intra-decadal variability.

5. A fifth objective is to phase in innovative and more intensive silviculture activities such as improvements to planting stock, site preparation, fertilization, and thinnings that are appropriate for local stand conditions as cash flow is available, e.g., from improved timber sales marketing and reductions in regulatory or administrative constraints, living within present expenditure limits (referring to the 25 percent management fee) in the near-term.
6. A sixth objective is to actively manage the land base in such a manner as to complement our fiduciary responsibilities and still achieve a mosaic that includes a diverse forest structure and provides for broader economic, conservation, aesthetic, recreational and other public benefits. To this end, such innovative activities might include different types of variable density harvests, contract harvesting in sensitive areas, intentionally managing for snags and woody debris, rotating harvest ages, and the development of biological pathways – all in appropriately designated areas.
7. A seventh objective is to employ a structured monitoring and reporting program, providing, at a minimum, annual reporting by DNR to the Board on efforts and results. The report shall include short- and long-term costs and benefits and foreseeable changes needed in statutes, Board approved policies, management fees, or departmental practices.
8. An eighth objective is to identify those trust lands that are inefficient or unsuitable for meeting the trust mandate or fiduciary responsibility but appear to provide ecosystem and/or public benefits. Partnering with communities and other interest groups, DNR should identify and prioritize parcels no longer suited for trust land management and look at creative ways to remove those lands from the trust inventory, such that the trusts are fully compensated. (One example that might receive priority for communities is old natural forests, areas of old growth that have never been harvested or managed for harvest (estimated at 2,000 to 2,500 acres in total).)

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Resolution 1110 - Document 2. **February 17, 2004**

Description of Proposed Policy and Procedural Changes in Potential Preferred Alternative

PROPOSED POLICY CHANGES

Sustainable, Even-flow Timber Harvest – Forest Resource Plan Policy #4

CURRENT POLICY

Timber harvest "even-flow" assures that about the same amount of timber is available now and continues for future generations in perpetuity. The current policy for sustainable even-flow timber harvest is defined in Forest Resource Plan Policy No. 4. The policy states, "The department will manage state [trust] forest lands to produce a sustainable, even flow harvest of timber, subject to economic, environmental and regulatory considerations."

In application, the term "even flow" means that roughly the same amount of timber is offered for sale by the department on an ongoing basis. It refers to the amount of variability from the sustainable forestry level that will be entered into the computer model. Different interpretations of sustainable even-flow will result in different harvest levels.

As previously stated, the definition for sustained yield contained in the Revised Code of Washington (formerly RCW 79.68.030, recodified at Laws of 2003, Ch. 334, sec. 555(3)) requires "management of the forest to provide harvesting on a continuing basis without major prolonged curtailment or cessation of harvest." This concept of sustained or sustainable even-flow can be characterized in several ways.

Under current policy even-flow is managed as a narrow band of variation allowing the harvest level to vary by as much as 25 percent above and below the long-term harvest level.

CHANGE IN PROPOSED PREFERRED ALTERNATIVE

The Preferred Alternative proposes a policy objective of allowing timber harvest flows, measured by volume, to not vary from a previous decade by more than +/-25%.

TIMBER HARVEST LEVELS - FOREST RESOURCE PLAN POLICY #5

CURRENT POLICY

The method of calculating the sustainable forestry levels is central to the management of state trust forestlands. Sustainable harvest can be regulated by several means, including volume, acreage, and economic value. Current Board policy uses timber volume.

When harvest is calculated by volume, as current policy dictates in Forest Resource Plan Policy No. 5, the objective is to determine the maximum volume that can be sustained over a planning period, subject to a large number of legal and policy constraints. Timber volume is expressed in terms of millions of board feet of timber.

Change in proposed Preferred Alternative

Change the calculation method from maximization of volume to maximization of value subject to policy objectives and resource constraints.

Ownerships Groups (or Sustainable harvest units) Forest Resource Plan Policy #6

Current Policy

The sustainable harvest calculation is based on "ownership groups." Ownership groups include the Forest Board Transfer lands (calculated by individual counties (17 total in western Washington), Federal Grant lands and Forest Board Purchase (calculated by department administrative regions (of which there are 5 in western Washington), Capitol State Forest and Olympic Experimental State Forest (separate groups). Current policy on ownership groupings is defined in the 1992 Forest Resource Plan under Policy No. 6 (western Washington Ownership Groups). In all, there are 24 ownership groups.

Change in proposed Preferred Alternative

Federal Grant lands and Forest Board Purchase lands are placed in one ownership group from five. This reduces the overall number of groups from the current 24 to 20.

Name of the policy would be changed to from Ownership groups to **Sustainable Harvest Units**

Managing On-base lands - Forest Resource Plan Policy No. 11

Update the current policy discussion to include direction for the department to strive to maintain as much trust land on-base as allowable by law (including the HCP). Forest land in the on-base category will be managed under differing intensities of silviculture depending upon specific policy objectives (e.g. northern spotted owl demographic support management area) and/or land resource limitations (e.g. the degree of slope instability). The discussion will also direct the department to demonstrate how it is employing innovative management techniques that seek to combine resource protection, sensitivity to cultural and local issues, and revenue generation activities across DNR managed landscapes.

Forest conditions for determining when stands are regenerated

Current Policy

In western Washington, DNR's current average minimum regeneration age is 60 years (per discussion under Forest Resource Plan Policy No. 4). To meet specific objectives such as stand diversity, the department may cut some stands as early as 45 years and other stands only when trees reach 100 years (Forest Resource Plan Policy No. 4). Forest Resource Plan Policy No. 11 sets out the decision criteria that guide the determination of regeneration age of a forest stand.

Change in proposed Preferred Alternative

The policy discussions under FRP Policy No. 4 and No. 11 will be amended to update the discussion of suitable forest condition criteria for designing forest and stand-level silvicultural prescriptions. The amendment will focus on updating the use of a sole decision criterion of stand age to criteria that reflect forest health (structure) and value-based considerations. This amendment will assist in aligning this policy direction of with that of Forest Resource Policy No. 5.

Policy on biodiversity pathways - Forest Resource Plan Policy No. 30 & 31

CURRENT POLICY

Current policies do reflect a specific position on the use of silviculture to create, develop, enhance or maintain forest biodiversity and health.

CHANGE IN PROPOSED PREFERRED ALTERNATIVE

Changes would propose an update to the policies discussion to reflect the use of silviculture to create, develop, enhance or maintain forest biodiversity and health. The objective of using innovative silviculture based on Carey et al. (1996) biodiversity pathways principles for simultaneous increases in production of both habitat and income.

Older Forest – update to Forest Resource Plan Policy No. 14 (Old Growth Research Areas)

CURRENT POLICY

The Old Growth Research Area deferrals (Forest Resource Plan Policy No. 14) are maintained deferred from harvest. The purpose of these deferrals is to maintain DNR's ability to do research and collect data that may assist management elsewhere and benefit the trusts in the long run.

CHANGE IN PROPOSED PREFERRED ALTERNATIVE

The proposed Preferred Alternative would target 10 to 15 percent of each westside HCP Planning Unit as older forests based on structural characteristics. The desired structural characteristics are represented by stand development classes understory development through old natural forests (as described in the Sustainable Forest Management DEIS)Proposed changes to Procedure and Tasks

Maintaining mature forest components – DNR Task 14-001-010

CURRENT PROCEDURE/TASK

Where DNR manages at least 5 percent of the total watershed, DNR will maintain at least 50 percent of its forested land in trees 25 years old or older (Task 14-001-010, Maintain Mature Forest Components). This so-called "50/25" strategy stipulates that until 50 percent of a watershed meets the forest maturity criterion, no regeneration harvest is allowed in that watershed.

CHANGE IN PROPOSED PREFERRED ALTERNATIVE

The "50/25 WAU strategy" is removed.

Northern Spotted Owl Conservation Management - Procedure #14-004-120

CURRENT PROCEDURE/TASK

The Preferred Alternative does not proposes changes to the nesting, roosting, foraging and dispersal habitat strategies outlined in the Habitat Conservation Plan (page IV.3).

Northern spotted owl management is represented by a suite of policy, procedural, and implementation strategies. These are currently specified in the Habitat Conservation Plan and Procedure 14-004-120.

Northern spotted owl habitat circle management is currently applied to three types of owl circles listed in Procedure 14-004-120. As specified in the Implementation Agreement Memorandum 1 of the Habitat Conservation Plan, no timber harvest is allowed within certain spotted owl circles prior to 2007, and harvest is allowed only within non-habitat areas of several other circles. These areas are identified as "Memorandum 1" (Memo 1) owl circles.

Two other groups of owl circles—"Status 1 – Reproductive" (Stat. 1-R) and "Southwest Washington" (SW Washington)—receive explicit consideration in Procedure 14-004-120. Timber harvest activities are allowed only in the non-habitat portions of four SW Washington owl circles, and only habitat enhancement activities are allowed in the non-habitat portion of all Stat 1-R owl circles throughout the planning area. The Washington Department of Fish and Wildlife defined both Status 1 Reproductive and SW Washington owl circles.

Under current procedure, when the area designated for nesting, roosting, foraging or dispersal management within a Watershed Administrative Unit (based on 2000 Watershed Administrative Unit delineations and referred to in this document as "watershed") is below 50 percent of the desired habitat, regeneration harvests are not allowed. Regeneration harvests are allowed when the threshold is reached or exceeded (Habitat Conservation Plan, page IV.4). If less than 50 percent of designated nesting, roosting, and foraging or dispersal management areas in a watershed meets the habitat requirements, then only habitat enhancement activities may be conducted, even in the non-habitat portion of that watershed. Habitat enhancement includes thinnings that accelerate tree growth and encourage understory development.

Low-impact access development and maintenance (including stream crossings and yarding corridors) is allowed in watersheds below the 50 percent habitat requirement.

The current procedure for nesting, roosting, foraging and dispersal management strategies are implemented as a constraint, whereby if conditions are not met, management is restricted.

CHANGE IN PROPOSED PREFERRED ALTERNATIVE

Management of Memo 1 owl circles remains the stipulated in the current procedure (i.e. deferred from harvest activities until 2007).

Management of Stat. 1-R and SW Washington circles outside the Olympic Experimental State Forest are deferred from harvest until 2007.

Deferrals of timber harvests in Stat. 1-R owl circles in the Olympic Experimental State Forest would cease in 2004.

In the Preferred Alternative, a target of 50 percent desirable habitat is established for designated nesting, roosting, and foraging, or dispersal management areas within a watershed. Unlike the current procedure, thinning, variable density thinning under biodiversity pathways principles (Carey et al., 1996) is available as a strategy to create and maintain nesting, roosting, and foraging management area objectives. In addition, regeneration harvests and thinnings (both commercial thinnings and variable density thinnings) are allowed in non-habitat areas in the rest of the watershed even if the watershed currently has less than 50 percent habitat.

Adoption of the Preferred Alternative or variant would require a change in Procedure 14-004-120 but no amendment to the Habitat Conservation Plan would be required.

Riparian Management - Procedure #14-004-150

Current Procedure/Task

The Habitat Conservation Plan specified an interim set of management procedures to be used until permanent procedures could be developed by DNR, then reviewed and approved by the Federal Services (Habitat Conservation Plan page IV.61). Once implementation began according to the plan, DNR agreed not to conduct activities in riparian management zones—other than limited road development and maintenance—until a permanent procedure had been agreed upon. Current management of these sensitive areas follows the plan's guidelines and are identified in Procedure 14-004-150 (Identifying and Protecting Riparian and Wetland Management Zones in westside Habitat Conservation Plan Planning units, Excluding the Olympic Experimental State Forest Planning Unit). As stated in the plan, riparian management zones are to be developed on stream types 1, 2, 3, and 4, and wetland management zones are to be developed for wetlands greater in size than 0.25 acre.

Currently, no harvest activities are conducted within designated riparian management zones, except road and yarding corridor crossings.

The Habitat Conservation Plan management strategies for the Olympic Experimental State Forest are designed to effectively maintain key physical and biological functions until streams recover sufficiently from past disturbances. Recovery allows greater integration of commodity production and conservation. Combined with the current forest conditions and experimental objectives, the Olympic Experimental State Forest riparian strategies are different from the westside HCP Planning Units (page IV.132). For the purposes of modeling, canopy closure is maintained (relative density of 33 or greater) over 67 percent of the riparian management area in the Olympic Experimental State Forest under all Alternatives.

Change in proposed Preferred Alternative

The Preferred Alternative does not propose a new riparian procedure, as this is current under negotiation with the Federal Services (at time of publication). The Preferred Alternative, states only a policy position that the DNR should attempt to reach agreement on a riparian procedure with the Federal Services and actively manage the designated riparian management zones to create and maintain healthy, structurally complex forest, while generating revenue opportunities for the trust beneficiaries.

To model the Preferred Alternative, DNR has developed some modeling that consider the restoration and silvicultural activities that may be allowed under the final riparian procedure in the Westside HCP units, excluding the OESF. Ecosystem restoration encompasses a range of activities that must be site-specific and tailored to the physical and biological conditions at a particular site.

As defined in the Habitat Conservation Plan (page IV.62), disturbance of areas of potential slope instability within riparian areas and wetlands is minimized to light access development and maintenance (road and yarding corridors).

In the Preferred Alternative, biodiversity pathways management (Carey et al. 1996) is used to achieve desired structural components of a complex riparian forest stand. It is assumed for modeling purposes that activities in the Preferred Alternative would maintain canopy closure over 90 percent of the riparian management area.

Legacy and Reserve Tree Levels For Regeneration Harvest Units - Procedure #14-006-090

Current Procedure/Task

Procedure 14-006-090 implements the protection of structurally unique trees and snags described in the Habitat Conservation Plan (pages IV.156-157) by requiring retention of 7 percent of the trees in regeneration harvest units

Change in proposed Preferred Alternative

Under the Preferred Alternative, this legacy and reserve tree procedure would change from the current procedure requiring retention of 7 percent of the trees in regeneration harvest units to the Habitat Conservation Plan strategy of retaining a minimum of 8 trees per acre.

Updates to other Procedures and Tasks

The Preferred Alternative would require revisions to DNR Procedure 14-001-010 (Determining Harvest Levels and Completing the Five-Year Action and Development Plan) and Forestry Handbook Task 14-001-020 (Developing the Draft Five-Year Action and Development Plan) that direct DNR region staff in the implementation of Policy changes to Forest Resource Policies No. 4 and No. 5.

Resolution 1134

STATE OF WASHINGTON

DEPARTMENT OF NATURAL RESOURCES

BOARD OF NATURAL RESOURCES

FILE COPY

RESOLUTION NO. 1134

A **RESOLUTION** establishing the Sustainable Forest Management Harvest level for the planning decade for State Trust Lands in Western Washington, and establishing policies, procedures and tasks consistent therewith. The planning decade is fiscal year 2005 through fiscal year 2014.

BE IT RESOLVED BY THE BOARD OF NATURAL RESOURCES, STATE OF WASHINGTON, THAT:

SECTION 1. RCW 79.10.320 directs the Department of Natural Resources to apply "sustained yield" management to state owned forest lands under its jurisdiction. The law requires the Department to periodically adjust acreages designated for inclusion in the sustained yield management program, and calculate a sustainable harvest level. The "sustainable harvest level" means the volume of timber to be scheduled for sale from state-owned lands during a planning decade. This is part of the Department's strategic plan for sustainable forest management. RCW 79.10.310 provides for sustainable harvesting on a continuing basis without major prolonged curtailment or cessation of harvest, as required by state law.

SECTION 2. RCW 43.30.215 authorizes the Board to establish policies concerning the management of forest lands within the Department's jurisdiction. The Board has adopted a number of forest land policies and compiled them in a document entitled the "Forest Resource Plan". In addition, the Department has adopted procedures and tasks to implement the Board's policies and manage the forest land.

SECTION 3. In 2000, the Board and the Department began the process of re-examining the Western Washington sustainable harvest level and associated policies, procedures and tasks. In beginning this process, the Board set overall goals to provide for sustainable stewardship of state forest lands, revenue for schools and other beneficiaries, healthy forest ecosystems and productivity, and benefits for all the people of Washington. From 2000 to the present, the Board and the Department have reviewed enormous amounts of data and information pertaining to the environmental, societal, and economic implications of various harvest levels and amendments to Forest Resource Plan policies and procedures. The sources of information included:

- An Environmental Impact Statement,
- Extensive public input,
- DNR staff analyses and computer simulations,
- Expert opinions from the Sustainable Forestry Technical Committee, and
- Independent review by the members of the Board of Natural Resources.

SECTION 4. The Department issued a draft environmental impact statement (DEIS) in November 2003. The DEIS identified six alternatives without identifying a preferred alternative. Scoping comments, multiple public meetings, extensive written comments on the DEIS, direct public comments to the Board of Natural Resources, special Board Sustainable Forestry Workshops, comments from the Sustainable Forestry Technical Committee, outputs from the ***Options*** policy simulation model, and the DEIS itself, all have provided important information that led to the development of a preferred alternative. At its March 2004 meeting, the Board adopted Resolution 1110, which provided direction to the Department on how to develop and implement the Preferred Alternative. The Preferred Alternative was analyzed in the Final Environmental Impact Statement (FEIS), issued July 30, 2004. The Board reviewed the FEIS. At the August and September 2004 Board meetings, the Board conducted further discussions regarding the sustainable harvest level, and the associated policies, procedures and tasks.

SECTION 5. The Board and the Department have carefully and fully considered the economic effects on trust assets of the various proposed sustainable harvest levels and associated policies, procedures and tasks. The Board and the Department have also carefully considered the Environmental Impact Statement and the social effects associated with their decisions. Accordingly, the Board and the Department find as follows:

A. The environmental impacts that may result from the implementation of the chosen policies, procedures and tasks, and of harvesting at a mean annual level of 597 million board feet per year over the planning decade are within the range of impacts evaluated in the FEIS.

B. The choices in the FEIS's Preferred Alternative provide for a stable and sustainable flow of revenue for each trust, while allowing sufficient annual and inter-decadal variation to capitalize on market trends and available timber inventory. This enables the Department and the Board to focus more on optimizing the value of future timber sales, in addition to providing a predictable flow of timber volume.

C. In selecting the Preferred Alternative, the Board and the Department considered how their choices affect the trust asset base and trust asset production both from a short-term and a long-term perspective. The Preferred Alternative's suite of choices reflects an appropriate balance between the interests of the current beneficiaries and the interests of future beneficiaries.

D. In adopting the sustainable harvest level, the Board and the Department will use innovative silvicultural practices (referred to as "biodiversity pathways") to address forest health concerns by creating more structurally diverse forests, with a priority for habitat, across the landscape as appropriate, while simultaneously increasing the production of trust revenue. Use of these silvicultural practices will also help meet the habitat goals of the Department's federally approved Habitat Conservation Plan more quickly and thus increase management flexibility over the long term, to the benefit of the trusts.

E. Adoption of the policies, procedures and tasks embodied in the Preferred Alternative, and the adoption of a mean annual sustainable harvest level of 597 million board feet per year, enables a net economic benefit to each of the trusts, while providing an appropriate level of income stability over time.

SECTION 6.

A. The Board hereby adopts the Western Washington sustainable harvest level of 597 million board feet per year for the planning decade of fiscal year 2005 through fiscal year 2014. The Department is directed to implement this resolution by preparing sales that are consistent with this sustainable harvest level and all policies adopted by the Board. The Department shall employ a structured monitoring and reporting program. The Department shall present an annual sales plan to the Board on or about April of each year.

B. The Department shall annually report to the Board of Natural Resources its assessment of the economic, ecological, and social results of implementing the Board's adopted sustainable harvest level. The Department shall provide a report on its efforts to implement "biological pathways" and other innovative silvicultural practices in connection with implementing the sustainable harvest level. Consistent with Policy A in Attachment One of this resolution, the Department shall report to the Board any significant new information or changing circumstances bearing substantially on its achievement of the sustainable harvest level.

SECTION 7. The Board hereby adopts the policies identified in Attachment One to this Resolution (*Sustainable Forestry Policy Changes*). The Department hereby adopts the procedures and tasks identified in Appendix F.4 of the FEIS. Attachment One and the procedures and tasks in Appendix F.4 are incorporated herein by reference.

APPROVED AND ADOPTED by the Board of Natural Resources, Department of Natural Resources, State of Washington, this seventh day of September, 2004.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the official seal of the Commissioner of Public Lands.

DOUG SUTHERLAND
Commissioner of Public Lands

BOB NICHOLS
Governor's Office

TERRY BERGESON
Superintendent of Public Instruction

DR. R. JAMES COOK
Dean, College of Agriculture and
Home Economics

DR. BRUCE BARE
Dean, College of Forest Resources

GLEN HUNTINGFORD
Jefferson County Commissioner

Approved as to form:

Assistant Attorney General

Date: September 7, 2004

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Resolution 1134 - Attachment One **September 07, 2004**

Sustainable Forestry Policy Changes

Board of Natural Resources Policy Changes

A. **CIRCUMSTANCES TRIGGERING THE NEED FOR A RECALCULATION OF THE SUSTAINABLE HARVEST LEVEL**

DISCUSSION

State law requires that the Department shall manage the state-owned lands under its jurisdiction, which are primarily valuable for the purpose of growing forest crops on a sustained yield basis. "To this end, the Department shall periodically adjust the acreages designated for inclusion in the sustained yield management program and calculate a sustainable harvest level." (RCW 79.10.320). State law also defines sustainable harvest level as, "Sustainable harvest level means the volume of timber scheduled for sale from state-owned lands during a planning decade as calculated by the department and approved by the board."(RCW 79.10.300(5)).

The legislature envisioned that the sustainable harvest level is likely to need adjustment from time to time, based on the quantity, quality, growth, and availability of the timber resource on state lands. At the time the statute was enacted, the suitable time period was thought to be one decade, with the average annual sustainable harvest level remaining constant during the decade.

Currently, the factors affecting a stable long-term sustainable harvest calculation remain dynamic. Regulatory requirements are in flux, and information about the resource base continues to improve. In addition, new more powerful and flexible computer models have emerged, making it feasible to adjust the harvest level as circumstance changes. At the same time, the fundamental trust obligations and statutory requirements continue to be the foundation of policy.

POLICY

The department, with board approval, will recalculate the statewide sustainable harvest level, for board adoption no less frequently than every ten years.

The department will adjust the calculation and recommend adoption by the board when the department determines changing circumstances within the planning decade suggest

that an adjusted harvest level would be prudent. Such circumstances may include major changes in legal requirements, significant new policy direction from the board, new information about the resource base available for harvest, or changes in technology.

B. DEFINITION OF SUSTAINABILITY FOR THE SUSTAINABLE HARVEST CALCULATION

DISCUSSION

State law defines "sustained yield" as "management of the forest to provide harvesting on a continuing basis without major prolonged curtailment or cessation of harvest." (RCW 79.10.310). A common law duty of the state as trustee is to not favor either present or future trust beneficiaries over each other. Sustained yield management helps accomplish this duty.

Within that broad statutory direction, various interpretations of sustained yield management are possible. Differences in interpretation may relate to the size of areas subject to separate calculations of sustainable yield of timber, for example, either the state trust ownership as a whole or smaller areas; the degree of variability of timber harvest over time; and the aspect of forest management to be the primary focus of sustainability, such as area or volume of timber harvested or retained, or revenue earned.

In the past, the department has divided the forest land base into separate sustainable harvest units based on county boundaries, the department's administrative regions, and several separately treated areas. In addition, the department has set the variability of harvest over time based on a non-declining even-flow objective. The department has calculated sustainable yield based on timber volume. The Board of Natural Resources has expressed a desire for a more flexible system as the basis for the sustainable harvest calculation.

(Lands formerly know as Forest Board Transfer and Forest Board Purchase are now defined in RCW 79.02.010(10) as "State Forest Lands." For purposes of this policy, former Forest Board Transfer lands will be called "State Forest Trust Lands," and former Forest Board Purchase Lands will be called "State Forest Purchase Lands.")

POLICY

For Western Washington the department will calculate, and the Board will adopt, a separate long-term decadal sustainable harvest level, expressed as mean annual timber volume for a planning decade, for twenty distinct sustainable harvest units, as follows: Each of the seventeen county beneficiaries of State Forest Trust lands separately, and all of the federally granted trusts and State Forest Purchase lands in Western Washington together, with the exception that the Olympic Experimental State Forest and the Capitol State Forest shall each have a separate calculation regardless of trust.

In order to ensure intergenerational equity among beneficiaries, within each sustainable harvest unit, the department shall calculate an estimated multi-decade harvest level such

that the mean annual timber volume for any decade should not vary up or down more than 25% from the level of the preceding decade, except that all State Forest Trust lands outside Capital State Forest and Olympic Experimental State Forest shall be treated as a single sustainable harvest unit for purposes of achieving the allowable variation between decadal timber harvest levels. In order to take advantage of shorter term operational or market opportunities, the harvest level for any year within the planning decade may also fluctuate up to 25% plus or minus from the mean annual harvest level adopted by the Board, as long as the decadal mean is sustained over the decade.

Subject to all applicable legal and policy direction, the department will analyze the financial characteristics of forest stands in order to optimize the economic value of forest stands and timber production over time, in calculating the sustainable harvest level, in planning and scheduling timber harvests, in making investments in forest growth, and in searching for the least-cost methods of achieving other forest management objectives.

C. GENERAL SILVICULTURAL STRATEGY APPLIED TO THE TIMBER RESOURCE BASE AVAILABLE FOR SUSTAINABLE HARVEST IN WESTERN WASHINGTON

DISCUSSION

The department defines silviculture as the art and science of cultivating forests to achieve objectives. The department uses a flexible, site-by-site approach for evaluating and implementing silvicultural treatments, based on site specific, rotational or long term analysis incorporating return on investment, variable biological conditions, and physical limitations. Site-specific silvicultural prescriptions include intensive activities such as improved planting stock, site preparation, fertilization, and thinning, as budgets allow at the time prescribed activities come due. Innovative silvicultural treatments may be used to create, develop, enhance, or maintain forest biodiversity and health. For example, the objective of the "biodiversity pathways" approach to silviculture, presented by Carey et al (1996) is for simultaneous increases in production of both habitat and income. This approach may be used to create complex, multi-aged stand structures that sustain key forest stand elements to replicate vital ecological functions at the stand and landscape levels.

All silviculture strategies are applied within a context of specific stand-level or larger area objectives to achieve long-term sustainable flow of forest products, services and other relevant values. Stands whose progress toward objectives is below potential are generally chosen for management intervention. Stands selected for regeneration harvests include but are not limited to those that have a low possibility for a positive response to partial harvest regimes.

POLICY

The department will follow legal requirements in maintaining the greatest possible portion of the trust forest lands as on-base.

The department will provide professional management of forestlands through active stewardship of on-base lands. Active management of the land base will be carried out as an integral part of the department's fiduciary responsibilities to achieve, on a landscape basis, a combination of forest structures that over time provide for broad and balanced economic,

STATE OF WASHINGTON

DEPARTMENT OF NATURAL RESOURCES

BOARD OF NATURAL RESOURCES

RESOLUTION NO. 1239

A **RESOLUTION** adjusting the decadal Sustainable Forest Management Harvest Level for forested State Trust lands in Western Washington, consistent with the policy on Recalculation of the Sustainable Harvest Level as adopted by the Board of Natural Resources (Board) in Resolution 1134 and the Policy for Sustainable Forests (Dec. 2006). The planning decade is fiscal year 2005 through fiscal year 2014.

GIVEN THESE FACTS:

SECTION 1. RCW 79.10.320 directs the state Department of Natural Resources (Department) to periodically adjust acreages to be included in a sustainable yield management program and calculate a sustainable harvest level. RCW 79.10.300 (5) defines sustainable harvest level as, "...the volume of timber scheduled for sale from state-owned lands during a planning decade as calculated by the Department and approved by the Board".

SECTION 2. At the time the statute was enacted, the suitable time period was thought to be one decade, with the harvest level remaining constant during the decade. Today's policies require multiple objectives and the science and knowledge around those objectives is often very fluid. With the more powerful and dynamic computer models that exist today it is feasible to analyze and adjust the Sustainable Harvest Calculation (SHC) as circumstances change.

SECTION 3. The Board adopted a two-part policy, one part to address the establishment of the decadal sustainable harvest and a second part to anticipate possible changes within the decade. The second part of the policy reads, "The Department will adjust the calculation and recommend adoption by the Board of Natural Resources when the Department determines changing circumstances within the planning decade suggest that an adjusted harvest level would be prudent. Such circumstances may include major changes in legal requirements, significant new policy direction from the Board of Natural Resources, new information about the resource base available for harvest, or changes in technology".

SECTION 4. In 2000, the Board and the Department began a process to set a new decadal sustainable harvest level for Western Washington. In November of 2003 the Department issued a draft Environmental Impact Statement (Draft EIS) with six management alternatives. In March 2004 the Board adopted Resolution 1110 which directed the Department to proceed with the development of the preferred management alternative given specific guidance and criteria in the resolution.

SECTION 5. In September of 2004 the Board, in Resolution 1134, adopted the current Westside decadal sustainable harvest for fiscal year 2005 through fiscal year 2014 — along with specific policies, procedures, and tasks to implement it.

SECTION 6. The desired objectives of the 2004 Sustainable Harvest Calculation have not changed. However, within this planning decade there have been some changing circumstances of the magnitude that suggest an adjustment to the sustainable harvest volume would be prudent.

SECTION 7. When the Sustainable Harvest Calculation was adopted in 2004, it incorporated the Riparian Strategy from the 1997 trust lands Habitat Conservation Plan (HCP), but the implementation procedure had not been finalized and riparian areas were being deferred from harvest. As a consequence, while the Department had modeled 9 percent of the volume coming from the riparian areas in the harvest calculation, there was no volume actually being harvested. Subsequently, in April 2006, the Department negotiated with the federal services and adopted Implementation Procedures for the Habitat Conservation Plan Riparian Forest Restoration Strategy that is being implemented and is anticipated to contribute approximately 5 percent of the total volume over the decade. This change is estimated to result in a 4 percent reduction in the modeled Sustainable Harvest Calculation volume estimate of 597 billion board feet for the planning decade.

SECTION 8. After the adoption of the Sustainable Harvest Calculation in March of 2004 the Washington Environmental Council (WEC) filed litigation (Oct 2004) seeking a declaration that Resolution 1134 was invalid on the grounds that it was adopted without proper compliance with the State Environmental Policy Act (SEPA). In October 2005 Judge Armstrong rendered a memorandum opinion that the Final EIS, which provided the basis for SEPA compliance for Resolution 1134, was inadequate as to impacts on the northern spotted owl, riparian management, and the alternatives analyzed. If reduced to final order, this memorandum opinion would have vacated Resolution 1134 and the Department's ability to implement the sustainable Westside harvest volume anticipated to be 5.97 billion board feet over the planning decade. As a consequence the Department estimated it would harvest less than 400 million board feet per year until a legal remedy and/or an administrative remedy could be achieved which could take from two to four years.

SECTION 9. To avoid this potential loss in revenue to the beneficiaries and delay in meeting several Habitat Conservation Plan objectives, the Department entered into settlement negotiations with the plaintiffs and interveners in November 2005. In March 2006 all parties signed a settlement agreement that required the Department to manage some habitat differently for the planning decade but restored Resolution 1134. This settlement avoided a costly and uncertain future for the trust beneficiaries but is estimated to result in a 4 percent reduction in the sustainable harvest volume estimate over the planning decade.

BE IT RESOLVED BY THE BOARD OF NATURAL RESOURCES, DEPARTMENT OF NATURAL RESOURCES, STATE OF WASHINGTON, THAT:

SECTION 1. After careful review and analysis presented by the Department, the Board has determined that the riparian strategy and the lawsuit are two circumstances with impacts that were unknown at the time Resolution 1134 was adopted, and that an adjustment to the decadal harvest level adopted with Resolution 1134 would be prudent.

SECTION 2. Therefore, the Sustainable Forest Management Harvest Level for forested State Trust Lands and Western Washington for the planning decade of fiscal year 2005 through fiscal year 2014 is adjusted to 5.5 billion board feet over the planning decade.

SECTION 3. The Board recognizes that there will be other anticipated and unanticipated changing circumstances within the planning decade, such as: the science regarding endangered species, modeling techniques and sophistication, and more information from forest land planning that is underway. Therefore, the Board directs the Department to continue to refine and adjust the calculation to reflect these circumstances and recommend prudent changes to the Board in the future. Further, the Board directs the Department to continue to look for and implement effective and efficient strategies to reach the desired habitat and income objectives modeled in the Sustainable Harvest Calculation.

SECTION 4. The Board directs the Department, in its annual report to the Board, to give a general accounting of the activities and investments made to reach the objectives and outcomes modeled in the Sustainable Harvest Calculation and the status of the current and anticipated results of those activities and investments, including any indication that the Board should consider an adjustment of the decadal harvest level.

APPROVED AND ADOPTED by the Board of Natural Resources, Department of Natural Resources, State of Washington, this 3rd day of July, 2007.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the official seal of the Commissioner of Public Lands.

DOUG SUTHERLAND
Commissioner of Public Lands

Approved as to form this 3rd day of July, 2007.

Christa Thompson, AAG

N A T U R A L R E S O U R C E S

Definition and Inventory of Old Growth Forests on DNR-Managed State Lands

June 2005

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

WASHINGTON STATE DEPARTMENT OF
Natural Resources

DOUG SUTHERLAND
Commissioner of Public Lands

June 30, 2005

Dear Reader,

Old growth is revered by many as invaluable remnants of the forests that used to exist across Washington. It is a scarce but very important component of forested landscapes managed by the Washington State Department of Natural Resources (DNR), providing unique and crucial habitat that performs specialized ecological functions.

Recognizing the importance of old growth to society and DNR, the 2004 Legislature directed DNR to conduct an inventory of old-growth forest stands on state lands as defined by a panel of scientists. In February of this year, DNR convened this independent Old Growth Definition Committee. We were fortunate to recruit for this committee three of the foremost forest ecologists with expertise in the characterization of Pacific Northwest old growth — Dr. Jerry Franklin, Dr. Tom Spies, and Dr. Bob Van Pelt. As required by ESHB 2573, Section 905, in addition to the three scholars, the panel included a representative from the Washington Department of Fish and Wildlife, and a representative from DNR.

I am pleased to inform you that the Old Growth Definition Committee has completed its work. This two-part report includes their report on the results of their efforts, and DNR's report on the old growth inventory, as directed by the legislation.

The Definition Committee employed the "Weighted Old Growth Habitat Index," a screening tool that uses data from DNR's Forest Resource Inventory System (FRIS) to compare the structure of stands on DNR-managed land with a reference condition from known old growth stands in Western Washington.

It is the intention of the DNR to identify old growth stands east of the Cascade Crest during the agency's Eastside Sustainable Harvest Calculation; which is scheduled to begin next biennium. DNR does not currently have sufficient inventory data on the reference condition for old growth forests east of the Cascade Crest. Additionally, adequate old-growth definitions do not currently exist for eastside forest types. Consequently, the committee's definition pertains to Western Washington only, and therefore the Old Growth Definition Committee's report does not indicate an acreage estimate of eastside old growth.

The committee defined old growth as an ecological condition, not the specific age of a stand. For Western Washington, the committee's index resulted in an inventory of about 52,666 acres that have a high probability of being old growth. There are an additional 35,769 acres that are identified as potential old growth, but need a secondary screening process for accurate identification. Nearly two thirds of the acreage is on the Olympic Peninsula within the Olympic Experimental State Forest. The total, or roughly 88,000 acres, represents about six percent of the forestland covered by DNR's trust land Habitat Conservation Plan in Western Washington.

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Included in this acreage is old growth within the Natural Area Preserves and Natural Resources Conservation Areas, which contribute to the conservation objectives of the Habitat Conservation Plan.

The committee recommended that DNR complete on-the-ground field verification of these old growth and potential old growth stands that have been identified using the Weighted Old Growth Habitat Index. In some cases, this may change the initial identification of these stands.

At the next meeting of the Board of Natural Resources, DNR intends to brief the Board on this report — Definition and Inventory of Old Growth Forests on DNR-managed State Lands. The meeting is scheduled for July 29, 2005. Additionally, the report will be available on DNR's website.

DNR staff will be available to brief members of the Legislature or their staff when requested.

The index and the information derived from the associated inventory and mapping provides information that DNR will use to address the conservation of old growth. This will be accomplished in part through guidance directed by DNR's Policy for Sustainable Forests, currently being developed.

I greatly appreciate the time and work Dr. Franklin, Dr. Spies, and Dr. Van Pelt, and other team members devoted to this effort. They have given us a valuable product that will be useful not only in the identification and conservation of these important ecological conditions, but also will guide prudent stewardship for the sustainability of other DNR-managed forests as well.

Sincerely,

Doug Sutherland
Commissioner of Public Lands

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June 2005

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By Dr. Jerry F. Franklin
Dr. Thomas Spies
Dr. Robert Van Pelt

SECTION 2

By Tami Riepe
Sabra Hull
Walt Obermeyer

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Acknowledgements

Old Growth Definition Panel of Experts
Dr. Jerry F. Franklin - University of Washington
Dr. Thomas Spies - USDA Forest Service
Dr. Robert Van Pelt - University of Washington

Old Growth Definition Committee
The Experts, and
Dr. Paula Swedeen - Washington State Department of Wildlife
Sabra Hull - DNR
Steve Curry - DNR
Walt Obermeyer - DNR

Initial Analysis for Index
Rob Pabst - Oregon State University

Ecological Consultation and Analysis
Dr. Richard Bigley - DNR
Dr. Rex Crawford - DNR

Field Consultation
Angus Brodie - DNR
Florian Deisenhofer - DNR
Allen Estep - DNR

Reviewers
Dr. Richard Bigley - DNR
Angus Brodie - DNR
Bruce Mackey - DNR
Gretchen Nicholas - DNR
Tami Riepe - DNR

Minutes/Recorder
Angela Cahill - DNR

Copy-editor/Report Production
Jane Chavey - DNR
Nancy Charbonneau - DNR

SECTION 1
Report by the Old Growth Definition Committee

June 2005

Executive Summary

The Old-Growth Definition Committee was chartered by the 2004 Legislature to work with the Washington State Department of Natural Resources (DNR) (Department) to develop a "definition" of old-growth forest that could be used with forest inventory data to provide a map and inventory of old-growth forests on state lands managed by the Department. The three panel of experts (Dr. Jerry Franklin, Dr. Thomas Spies and Dr. Robert Van Pelt) in collaboration with other committee members from Washington State Department of Fish and Wildlife (WDFW) and DNR, are collectively the 'definition committee.'

The committee's approach to the task was to use structural features of the forest — such as the occurrence of large, old trees, large snags, and large logs — as the basis for identifying old-growth forests. The structural features that were used had to be limited to those that were part of the regular DNR inventory process. Although stand age is often used to identify old-growth forest it is actually the level of structural development that is critical to ecological function; also, it is easier to objectively characterize stand structure than stand age.

The Committee developed, tested and refined a structural index based on multiple forest stand features to successfully identify old-growth stands on DNR-managed lands on the Westside (west of the crest of the Cascade Range). In using the index to identify old growth stands in a mapping exercise it must be remembered that this is a first approximation. Secondary screening and field review are essential to confirm any stand as old growth. Decreasing index values indicate a decreasing likelihood that a stand is ecologically old growth.

Break points (thresholds) in the indices to define old growth were subjectively selected based on the experience of the ecologists who were familiar with the variation in stand structure and composition in natural Westside forests with various overstory tree ages and disturbance histories. The break point selected (an index score of 60) for defining old growth generally corresponded to stands whose dominant overstory Douglas-firs were >200 years old. Some younger stands had indices that were higher than this threshold and some older stands had indices that were lower. This variation results from differences in site productivity and disturbance history, that is, it is expected that there may be stands that score under 60 on the index that are, in fact, old growth, while others on especially high productivity sites may score over 60 on the index, and not be old growth. One such stand has been identified thus far.

Westside stands that scored >60 on the index were consistently found to be old growth during two field visits. To date, only a single "false" identification (an incorrect characterization of a stand as being old growth) has been identified. Stands that scored between 38 and 59 in the Olympics and 50 and 59 in the Cascades require additional screening to determine their true status. This secondary screening consists of additional analysis of aerial photo and inventory data and, if still unresolved, a field check of the stand. Factors that caused low scores for old-growth stands included their inclusion within map units that were dominantly of another age class, and low densities of structural elements (e.g., large trees) as a result of site conditions.

Use of the structural index to characterize and identify Westside "mature" forests was also explored; the index does appear to have value for identifying mature stands. Most of the existing mature stands are forests of large but not old trees that are of natural origin and that have not been significantly influenced by human activities. These mature forests regenerated naturally following wildfires (e.g., 1902 Yacolt Burn) or windstorms (e.g. 21 Blow) during the 19th and 20th centuries. The significant structural complexity of the mature stands provides significant wildlife and other ecological values, and represents the next generation of old-growth forest. There are some mature stands on DNR-managed lands that originated from regeneration following harvest, and not from natural causes; they are not considered here.

The Committee originally intended to calibrate the structural index for different plant association groups (PAGs), which might have improved the definition. However, sufficient data were not available to develop this refinement and the same structural index was used as a basis for initial screening of all Westside forest types on DNR-managed forest lands. The structural index will be calibrated for secondary screening of PAGs, which have low productivity and smaller tree diameters.

A map of the index classes, based on DNR's forest inventory units, was developed for Westside DNR-managed lands. Additional field work is expected to determine the status of some stands. The map provides DNR a good first approximation for screening old growth on forested state trust lands. Managers still need to field map and define old growth types through field verification. The current map should provide a first step in the implementation of the Department's final policy regarding old growth.

The Committee's efforts to characterize and map old-growth forests east of the Cascade Crest (Eastside) were not successful. Many factors were responsible, including the significant modification of virtually all forests on the ponderosa pine and dry mixed conifer forest sites as a result of past human activity, including fire suppression, logging, and grazing. Historically, Eastside forests were relatively open, low density stands dominated by large old trees; they were maintained in that condition by frequent low intensity fire. Logging over the previous century has removed most of the large old trees and fire suppression and planting have resulted in dense stands dominated by young to mature trees. Such stands are susceptible to stand-replacement fire and do not resemble the historic old-growth forests in either structure or function.

If the legislature wishes DNR to address the old-growth issue on the Eastside, the committee feels that the priority would be to determine sites where the potential exists to restore historic old-growth conditions. These would be sites where populations of large, old trees still exist that could become key structural elements of a restored ponderosa pine forest. Given current conditions on most DNR-managed Eastside forest lands, restoring stands to historic old-growth conditions and subsequently maintaining them would require significant management effort and expense, only some of which is likely to be recovered from sale of wood products. Large, old ponderosa pines are a scarce resource that may merit conservation. Funds are not currently available to pursue assessments of Eastside old-growth forests.

In any case, substantial study is needed of old-growth issues on DNR-managed Eastside forests. Adequate old-growth definitions do not exist for Eastside forest types. Additional field investigations are needed to provide this information as well as to identify sites where the potential may exist for restoring old-growth forest conditions on ponderosa pine and dry mixed conifer sites.

Section 1

Introduction

The Old Growth Definition Committee (OGDC) (Committee) was formed by the Department of Natural Resources (DNR) in response to a legislative charge, per ESHB 2573, section 905, as follows:

> *(1) The Department of Natural Resources shall conduct an inventory on state lands of old growth forest stands as defined by a panel of scientists. The panel of scientists shall include three scientific scholars with well documented expertise in Pacific Northwest forest ecology, one of whom will serve as the chair by consensus of the panel, one representative from the department of natural resources, and one representative from the Washington department of fish and wildlife. The panel shall review the best available scientific information and develop a definition for old growth stands in Washington state. The inventory shall include maps illustrating the distribution of old growth forest stands on state lands, and tables describing the number of acres of stands in each county, the department's administrative unit, and forest type. The maps and tables shall identify both structurally uniform and structurally complex stands. The department of natural resources shall make a report of the inventory to the appropriate committees of the legislature.*
>
> *(2) For the duration of the study, cutting or removing trees and stands 160 years or older is subject to the department publishing notification of proposed cutting or removal of old growth timber.*
>
> *(3) This section expires June 30, 2005.*

The three scientific scholars are academic scientists with extensive experience in the characterization of old-growth forests in the Pacific Northwest (see appendix for short biographies):

> Dr. Jerry F. Franklin, Professor, College of Forest Resources, University of Washington, Seattle, Washington;
>
> Dr. Thomas Spies, Project Leader, USDA Forest Service Pacific Northwest Research Station, Corvallis, Oregon; and
>
> Dr. Robert Van Pelt, Research Associate, College of Forest Resources, University of Washington, Seattle, Washington.

Also participating were Department of Fish and Wildlife representative Dr. Paula Swedeen, and DNR Representative Sabra Hull. Walt Obermeyer and Steve Curry of DNR provided analysis of DNR's Forest Resources Inventory System (FRIS) data. Dr. Rex Crawford and Dr. Richard Bigley of DNR provided additional valuable ecological consultation and analysis. Rob Pabst of Oregon State University conducted the initial analyses leading to development of the old-growth structural index.

The development of the definitions was a collaborative exercise between the Committee and DNR staff. The definitions were developed and refined in an iterative process that involved three day-long meetings between February and April 2005.

An approach to definition of Westside mature and old-growth forests based on structural complexity was adopted at the initial meeting. This involved the creation of a "structural index" to provide a quantitative comparison of forest stand conditions compared with reference conditions in old forests of Western Washington. This index provides a score for each stand, based on sample statistics from DNR inventory data. This approach underwent testing and development by DNR staff and the Committee during the interim between meetings during which refinements were discussed and adopted. Matching the elements of the structural index to the data available from DNR inventory plots was a critical part of this task; i.e., the definition had to be based upon data that were available from the inventory plots. The resulting index provided a screening tool to use in identifying probable locations of old growth—i.e., stands pre-existing Euro-American settlement in the region and with appropriate levels of structural development.

Two field trips were used to further evaluate the emerging definitions and issues associated with mapping. They proved to be of extraordinary value. The first of these trips was to the Olympic Peninsula and involved Dr. Van Pelt and DNR personnel. The second field trip was to the southern and southeastern Cascade Range and included Drs. Van Pelt, Franklin and Swedeen, and DNR personnel. Key issues in this field trip were structural ratings for mature stands in the Siouxon block and evaluation of stands on the drier eastern slopes of the Cascades.

The definition of old-growth forest conditions for DNR-managed lands and an explanation of how this definition was derived is the subject of this report. This definition was subsequently combined with data from the inventory plots to determine the probable location and acreage of old-growth forests on DNR-managed lands. The purpose of this report is to fulfill the legislative requirement for such an assessment. It is important to note that the task was not simply to define old-growth forest, but to define old-growth forest using attributes that were measured in the DNR inventory plots. This was a challenging task and the reason that the index was used as a screening tool rather than to provide a definitive identification of old-growth forest.

Characteristics of Old-Growth Forests

Forest ecosystems can be characterized by a variety of attributes including composition, function, and structure as well as the age of the dominant trees. **Composition** refers to the diversity of species that are present, such as the number and relative dominance of different tree species. **Function** refers to the "work" or important processes carried out by ecosystems. **Production** — the capture of the sun's energy through the process of photosynthesis and its conversion into energy-rich carbon compounds, including wood — is an important example of such a process or function. **Structure** refers to the diversity of physical features of an ecosystem — such as trees, snags, and logs — and their spatial arrangement.

Most ecological definitions of various stages in forest development, including old growth, focus on the structural attributes of forest. In part, this is because of the difficulty of easily and accurately measuring many of the other attributes. On the other hand, many structural elements are relatively easy to measure and provide surrogates for other ecosystem attributes, such as animal diversity. Structural information is what is collected on forest inventory plots. Finally, structure is what we manipulate during management.

Figure 1. Old-growth forests in the Douglas-fir region are characterized by high levels of structural complexity including a diversity of sizes and conditions of live trees, snags, and logs; this stand is 500 years old, having originated following a major regional fire event around the end of the 15th century (Thornton T. Munger Research Natural Area, Wind River Experimental Forest, southern Washington Cascade Range).

Temperate old-growth forests are characterized by a high diversity of structures, and a high level of heterogeneity in the spatial arrangement of the individual structures (Figure 1). For example, old-growth forests typically incorporate a variety of sizes and conditions of live trees, snags, and logs on the forest floor, including some specimens that are old and/or large for the forest type and site under consideration. Spatial heterogeneity is present vertically — in the form of a vertically continuous but variably dense canopy, and horizontally — apparent in patchiness (including gaps) in stand density.

In contrast with old stands, young even-aged managed forests have very simple structures, with

Figure 2. Young, managed forests have low levels of structural diversity and tend to have high densities of uniformly spaced trees.

low diversity of sizes and conditions of trees, snags, and down logs and a relatively uniform or homogeneous spatial distribution of these features (Figure 2).

Mature forests represent a transitional condition between the young and old forest in which stand dynamics are producing a shift from simple to complex structures (Figure 3). An important part of this process is a shift in causes and patterns of mortality. Tree mortality in young stands results primarily from competition and is density dependent — i.e., mortality varies directly with stand density. As stands mature and become old, mortality shifts increasingly toward mortality caused by such agents as bark beetles, root and butt rots, and wind. This mortality is contagious (spatially aggregated), independent of stand density, unpredictable in time and space, and kills large, dominant or co-dominant trees, thereby creating holes or gaps in stands. While such mortality is viewed as undesirable in stands managed for wood production it is essential to the development of functional old-growth stands.

Figure 3. Mature forests, which are generally between 80 and 200 years old, represent transitional conditions between young and old forests; mature stands typically have a significant population of medium- to large-sized dominant trees but typically lack other structural features of old-growth forests, such as a canopy layer that is continuous from ground to top of dominant tree crowns (Douglas-fir dominated mature stand that originated following the Siouxon Burn, southwestern Washington DNR district.

Details of old-growth forest conditions — such as the tree and snag sizes and the speed with which such stands develop — vary dramatically among forest types and with site productivity within a forest type. In general, old-growth conditions develop faster on more productive sites than on less productive sites. For example, structurally complex conditions develop more rapidly in the coastal Sitka spruce–western hemlock forests than in the Cascadian Douglas-fir–western hemlock forests.

Old-growth conditions vary in detail among essentially all forest types in terms of their exact attributes, which is why type-specific definitions are necessary. However, ***old-growth conditions differ profoundly between moist westside forests***, which are characterized by highly infrequent, stand-replacement events, ***and dry eastside forests***, which were characterized by frequent low-severity fire events. Sites that have extreme environmental conditions — i.e., are very wet, very cold, or very infertile — also tend to display distinctive old-growth structures. Examples would be the coastal western redcedar sites (very wet), subalpine mountain hemlock forests (very cold) and some interior lodgepole pine sites (cold, low fertility, and droughty).

Old-growth conditions may develop at very different rates even on sites that are comparable in productivity or environment, depending on the nature of the most recent disturbance and chance. For example, different intensities of wildfire may leave behind very different levels of live trees, snags, and logs (often called “biological legacies”) to be incorporated into the regenerating forest. Similarly, re-establishment of the new forest may have occurred either rapidly or slowly, depending upon the availability of tree seed sources.

As noted earlier, patterns of old-growth forest structure differ dramatically between West- and Eastside forests, reflecting the differing disturbance regimes. ***Westside forests are characterized by stand-replacement disturbance or tree reproduction regimes*** that occur at very long intervals; for example, return intervals of wildfire and severe windstorms in western Washington were typically 250 to more than 400 years. ***Dry Eastside forests*** — specifically the ponderosa pine and dry mixed conifer plant associations — ***were subject to frequent, low to moderate severity wildfires that created small openings in the stand where tree reproduction could develop***.

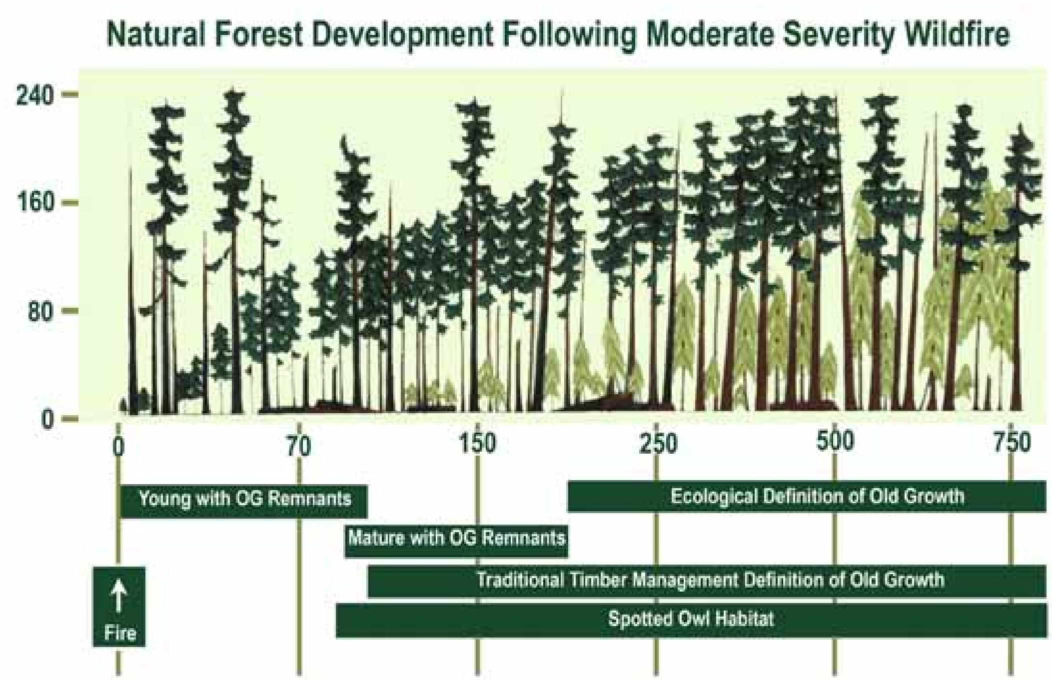

Figure 4. Even-aged stands developed following a major disturbance undergo very long periods of development; on a typical Douglas-fir--western hemlock site the forest typically matures at about 80 to 100 years and begins to strongly exhibit old-growth characteristics (e.g., vertically continuous canopy and gappiness) at around 200 years.

The Westside forests, which originate following stand-replacement fire or windthrow events, undergo several centuries of development before achieving an old-growth state (Franklin et al. 2002) (Figure 4; Figure 5b). Once trees regain dominance on the site following the disturbance, the dense young stands undergo an extensive period (60 to 80 years) of rapid growth and competitive thinning — known variously as the competitive exclusion, stem exclusion, or biomass accumulation stage of stand development. In its second century the young forest matures (Figure 5a). The mature stand gradually takes on more and more of the attributes of old growth, which generally begins to emerge at 175 to 250 years. As noted earlier, mortality shifts from density dependent competitive processes in the young stands to insect, disease, and wind induced mortality in larger trees in the old stands.

Eastside old-growth forests (Ponderosa Pine and Dry Mixed Conifer plant associations) were characterized by chronic disturbances — frequent light to moderate severity wildfire — which maintained them at relatively low density. Structural complexity was present but occurred as a fine-scale, low contrast mosaic of structurally diverse patches (Figure 5c). Logging, fire suppression, grazing, tree planting and other human activities have altered the structure of almost all of these forests. Most commonly they have developed into dense stands capable of supporting stand-replacement fires, which occurred rarely, if at all, under natural conditions.

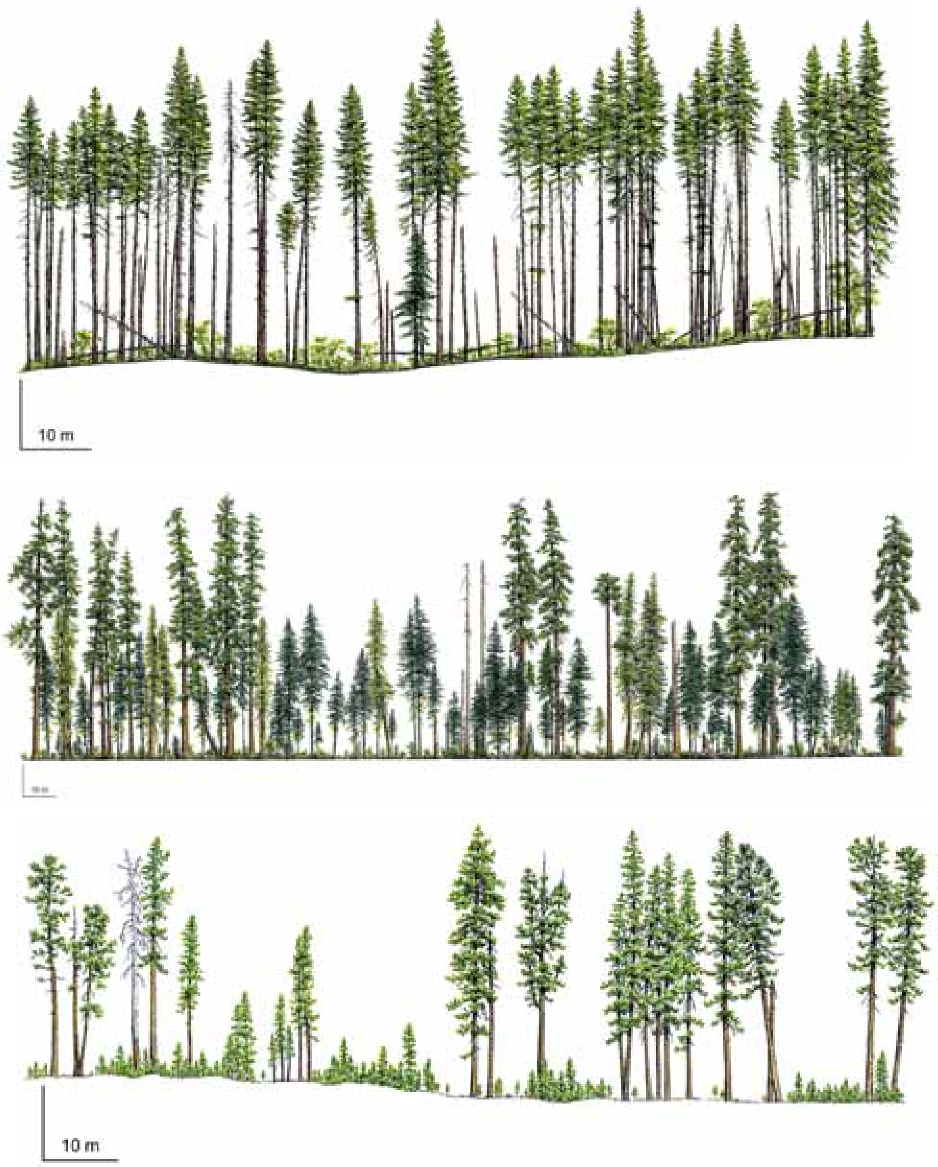

Figure 5. Structural cross sections illustrate the structural heterogeneity of different forests:

(a) maturing even-aged Douglas-fir stand development following a 1902 wildfire in the southern Washington Cascade Range (Martha Creek drainage, Wind River Experimental Forest);

(b) old growth, 650-year-old stand of Douglas-fir, Western redcedar, and western hemlock in the southern Washington Cascade Range (Cedar Flats Research Natural Area, Gifford Pinchot National Forest);

(c) old-growth ponderosa pine stand in southeastern Oregon (Blue Jay Springs Research Natural Area, Winema National Forest).

Premises Underlying Development of DNR Old Growth Definitions

The approach to identifying old-growth stands on DNR-managed land was based on a series of premises. These were that the Committee would:

(1) Attempt to use plant association groups (PAGs) as a basic stratification for the analysis;

(2) Create and utilize structural indices based on multiple stand attributes;

(3) Find that all old growth would have originated prior to European settlement; and

(4) Characterize “mature” as well as old-growth forest many of these are also stands of natural origin (naturally regenerated following wildfire or windstorm), with significant structural complexity, and are generally free of significant human modification.

Use of Plant Association Groups

Since old growth conditions vary with forest types or plant associations, it seemed appropriate to stratify the definitions by plant association or groups of plant associations that have similar old-growth attributes. Had sufficient data existed, we might have opted for definitions for each plant association. However, given the numbers of plots available in the DNR inventory the Committee decided to group the plant associations into larger groupings (PAGs) in developing old-growth definitions. Ultimately a single index was used for all Westside PAGs due to limitations in available data.

The old- growth index is being calibrated for use in secondary screening of old-growth forests belonging to low-productivity PAGs, which will tend to have trees of smaller average diameter.

Use of Structural Indices

Development of old growth involves gradual changes in a variety of structures and functions. Since this evolution generally does not involve abrupt changes the decision as to when the “old-growth stage” begins is rather arbitrary (Hunter and White 1997). The process of defining old growth is further complicated by the fact that not all of the structural and ecological elements change at the same rate and they may not all be present in the same place at the same time. Classifying this continuous and variable process into two classes, old growth and other forests does not do justice to the complexity of forest ecosystems and results in inappropriate classification of stands. A continuous measure of old growth structure, such as an index, offers advantages in assessing the pattern of old growth structure across landscapes. Structure is preferred over age because a single age is difficult to assign to many older forests with trees of many ages. Structure is also more suitable because many ecological processes are related to forest structure and the rate (age) of structural development varies widely with climate and site productivity.

Old-growth indices are metrics constructed by combining structural features of old forests such as large live and dead trees and size diversity. The values of indices range from low to high levels of old-growth structure. While indices rely on several characteristics some, such as large, relatively old trees, are more fundamental to the development of old growth than others. Without large trees in a stand, large dead trees and vertical heterogeneity (e.g., multiple canopy layers) will not readily develop. Consequently, indices based on multiple structural features can be weighted toward large, old trees, which are the source of much, but not all of the structural complexity of old forests.

The value of indices for management lies in the ability to characterize the structural complexity of all stands in a landscape. Managers still need to map and define old growth types through field verification. Index values can be selected to define one or more classes of older forest. The index approach also gives management the flexibility to identify particular structural conditions for specific objectives, such as locating habitat for particular species.

The Committee decided to use the index approach for Westside old growth types because we had relatively well-developed reference data and the forests of these wetter types have undergone little alteration as a result of fire exclusion. Consequently, data from research and inventory plots could be used to develop reference conditions based on a number of important structural attributes including large trees, large snags and logs and variation in tree sizes.

Indices were less suitable for other east side types because less information is available about the structure and dynamics of old growth in these dry fire-prone landscapes. Information is lacking for two reasons. First, fire exclusion and selective logging of large pines has changed the structure of many old-growth stands such that few places exist where fire-dependent old-growth types exist and can be studied. Second, relatively little research has gone into characterizing old growth in these forests so that relevant information is limited. The committee reviewed and field tested the Interim Old Growth Definitions from Region 6 (USFS 1993), and found that they did not accurately reflect old growth conditions on state lands in the areas visited. We currently lack accurate information and time to develop an index for the east side.

In Klickitat County, field-testing of the Westside index resulted in a decision that the index can be successfully used to identify old-growth stands in this Westside-Eastside transitional area.

Development of "old-growthedness" is a gradual process. Experience with earlier efforts to define old growth using an arbitrary set of criteria (e.g. Old Growth Definition Task Group 1986) to categorize a stand as "old growth" or "not old growth" did not work well. Many plots in old-growth stands do not display all of the features that might be used in such a definition, such as densities of large decadent trees, large snags, and large logs. Further — and perhaps most important--such a black-and-white approach does not recognize the continuum of structural or stand development (See, e.g., Franklin and Spies 1991 and Spies and Franklin 1991).

Approach to Eastside Forests

While structural attributes are important in historically fire-frequent forests, such as the ponderosa pine and dry mixed conifer plant associations, a different approach is needed than on Westside and high-elevation Eastside forests. Here the goal is to recognize sites that have the potential for restoration of old-growth conditions based on structure — particularly the presence of large old trees. Once identified such sites would need active management to restore structural conditions to those closer to historic conditions and which would be sustainable under the fire regimes characteristic of these forests.

Identification of Mature Forests of Natural Origin

Characterizations have been provided for mature as well as old-growth forests. Mature stands are not old growth but most do have important attributes from ecological and policy perspectives. Westside forests really have three major developmental stages — Young, Mature, and Old or early, mid, and late successional. Mature forests typically begin to develop around 80 years of age on the Westside and transition to old-growth condition at around 175 to 225 years. The concept or category of "late-successional" was created as part of the Gang of Four process to incorporate all forests over 80 years of age (Scientific Panel for Late Successional Forests 1991). This was done because mature forests are also important in providing habitat for wildlife that specialize in structurally complex forests and their role needed to be reflected in the analysis developed for the United States Congress by the Gang of Four. Of course, mature forests are also the next generation of old-growth forests. DNR has policy both in place and under development to address the conservation of mature forest (HCP IV-180, Draft Policies for Sustainable Forests under development).

The 80-year age parameter selected by the Gang of Four reflected both ecological and historical circumstances. Many of today's mature stands were created by wildfires in the last half of the19th century and by the wildfires of 1902, including the Yacolt and Siouxon Burns. These stands regenerated themselves naturally. Most have significant biological legacies of residual old trees, large snags, and large down logs, since most were not salvaged (Figure 6a). Hence, they have had little or no human activity.

These mature stands typically have a significant population of moderate- to large-size trees (Figure 6b). There is significant structural complexity in these stands and they are, therefore, important wildlife habitat, such as for nesting, roosting and foraging habitat for northern spotted owls. They are developing into old-growth forest, where replacement old growth is a concern.

Figure 6. Mature stands typically have populations of large-diameter trees and moderate levels of structural complexity due to biological legacies from the preceding stand.

6a. Portion of stand with large-diameter western redcedar snags which remain intact and upright over 100 years following their death (DNR stand that originated following the 1902 Siouxon Burn, southwestern Washington).

6b. Typical stand cross section with some woody debris on the forest floor and a short, soft Douglas-fir snags.

Methodology: An Old Growth Structural Definition for Westside Forest

Development of Indices

The details of index development and its application are provided in Appendix I. Briefly, the Weighted Old Growth Habitat Index (WOGHI), is based on previous published and unpublished work (Spies and Franklin 1988, Franklin and Spies 1991). The WOGHI integrates four key elements of old forests:

1. Large trees (number of trees per hectare > 100 cm dbh)
2. Large snags (number of standing dead trees per hectare > 50 cm dbh and > 15 m tall)
3. Volume of down woody debris (cubic meters per hectare)
4. Tree size diversity

The four elements used in the WOGHI are typically available in forest inventory data. They are also generally correlated with other attributes of complex forest structure such as spatial heterogeneity, broken-topped crowns, and the presence of shade-tolerant tree species. The index can be modified by including age or by weighting the scores toward more distinctive structural elements. For the DNR effort, we did not include age and used a weighting scheme based on the strength of the correlation of the structural feature with time since last disturbance. This gave greater weight to large live trees and tree size diversity in the index. The index values range from 0 to 100 (high levels of old-growth structure).

Break points (thresholds) in the indices to define old growth were subjectively selected based on the experience of the ecologists who were familiar with the variation in stand structure and composition in natural west-side forests of various overstory tree ages and disturbance histories. The break point selected (60) for defining old growth generally corresponded to stands whose dominant overstory Douglas-firs were >200 years old. Some younger stands had indices that were higher than this threshold and some older stands had indices that were lower. This variation results from differences in site productivity and disturbance history, that is, it is expected that there may be stands that score under 60 on the index that are, in fact old growth, while others on especially high productivity sites may score over 60 on the index, and not be old growth; one such stand has been identified thus far.

All of the Westside plant association groups were ultimately screened using the same index. The following descriptions of old growth and mature forests for major PAGs are to provide the legislature with additional general information about these stand conditions.

Old Growth Characterization: Western Hemlock–Douglas-Fir SuperPAG

These forests occur in climatic zones and sites that will succeed to western hemlock dominance over time. Well-developed old growth stands are characterized by the presence of many trees with diameters larger than 100 cm dbh; occurrence of shade tolerant trees in seedling, sapling, mid and upper story canopy layers; occurrence of canopy emergent Douglas-fir trees and large (>50 cm dbh) snags; accumulation of large dead tree boles in various stages of decay; and patchy distribution of canopy gaps and understory vegetation. Shade tolerant associates of Douglas-fir in these stands include western hemlock and western redcedar (See appendix I for more details). Stands with western redcedar are typically found on moist valley bottoms.

Many of the characteristics of old-growth structure begin to emerge between 150 and 250 years. Variation in the rate of development is controlled by site productivity and disturbance history. Many stands experienced fire or large wind disturbances during their development; in some cases these disturbances increase the structural complexity of the stand, while in other cases, they may reduce complexity if they result in the establishment of relatively uniform cohorts of younger trees among the surviving canopy trees. All stands experience small canopy gap disturbances that increase the structural complexity, diversity and productivity of the stands. Stands with extremely old Douglas-firs (>800 years) are often found on colder, lower productivity sites, such as in some of the higher elevations of this zone in Mt. Rainer National Park.

Prior to the old-growth stages, many stands go through a mature phase in which structure and composition becomes much more similar to old growth. Trees become larger (>50 cm), canopies increase in height, gaps form and do not readily close, understories develop and overall animal and plant community composition approaches that of old growth stands. For example, the compositional similarity of plant and animal communities to those in old-growth forests reaches 80 percent or more (Hansen et al. 1991). Mature stages may lack the high accumulations of large standing and fallen trees and the high levels of vertical and horizontal spatial patchiness of old growth. For this reason, the WOGHI values for mature forests typically are lower than for old-growth forests; for example, in the Siouxon block the mature stands developed following the 1902 Yacolt Burn typically had stand values that averaged around 40.

Old Growth Characterization: Sitka Spruce–Western Hemlock PAG

Old-growth Sitka spruce–western hemlock forests can be very similar to old-growth Douglas-fir–western hemlock forests in many structural attributes. Sitka spruce replaces Douglas-fir as the dominant tree in coastal areas of the Pacific Northwest. There are a number of reasons for this change, some of which are related to fire and some to climate. Douglas-fir has thick bark which provides considerable fire tolerance while the thin bark of Sitka spruce provides no protection. The moisture regime of the near-coastal areas also favors the drought-intolerant Sitka spruce.

Sitka spruce is theoretically successional to the very shade tolerant western hemlock in forests where they co-occur. However, Sitka spruce has several strategies for maintaining itself. Sitka spruce is intermediate in shade tolerance and is therefore able to effectively reproduce itself on sites with low- density forest canopies or large canopy gaps — as is often the case in windy coastal areas. The abundant logs created by windthrow are the ideal substrate for spruce seed germination and seedling establishment.

Sitka spruce lives about half as long as Douglas-fir, in part because the tree lacks significant decay-resistant chemicals in the heartwood. After 300 to 400 years, dominant spruces are often highly decayed and collapse as a result. There is no record of a Sitka spruce living to 500 years under the good growing conditions in the Pacific Northwest. However, given the extremely rapid growth rates in coastal areas, stands can achieve the stature of old-growth Douglas-fir-western hemlock forests in about half of the time.

Figure 7. Old-growth stands growing on river floodplains in the Sitka Spruce Zone are the "rainforest" old-growth known for several unique attributes, including immense Sitka spruce dominants, open understories, and large accumulations of mosses and other epiphytes (Queets River drainage, Olympic Peninsula).

The riparian forests growing along large rivers within the range of Sitka spruce are a special case (Figure 7.). These are the world famous ‘rainforests’ of the Olympic Peninsula and Vancouver Island. Trees here reach phenomenal sizes and accumulate incredible masses of epiphytes within their crowns. These riparian forests tend to have very open canopies and park-like understories, the latter conditions largely maintained by large populations of native elk. Several hardwood species, which are absent from most upland forests, are present. Black cottonwood and bigleaf maple attract huge accumulations of epiphytes due to both basic bark chemistry, and their more horizontal canopy structure.

Old Growth Characterization: Pacific Silver Fir–Mountain Hemlock SuperPAG

These forests occur at higher elevations than the western hemlock–Douglas-fir forests. In addition to Pacific silver fir and mountain hemlock, these forests may contain other major conifers including noble fir, western white pine, Douglas-fir, western hemlock, Alaska yellow cedar, western redcedar, and subalpine fir. Old growth conditions generally appear at around 180 to 260 or more years (Fierst et al. 1992). The general characteristics of old growth in these forests are the same as in the western hemlock zone, but the sizes of live and dead trees are typically smaller. Shrub and herb layers may remain sparse in younger forest until they reach 200 or more years when canopy break-up allows more light into the understory.

Old Growth Characterization: Western Redcedar Coastal Plain PAG

Old-growth forests dominated by western redcedar are common on the coastal plain on the west side of the Olympic Peninsula (Figure 8.). Many of these forests are on poorly drained soils with low nutrient levels and often have a stunted swampy physiognomy. Associated tree species include western hemlock, western white pine, lodgepole pine, and red alder. While often exhibiting a short stature, these cedar-dominated forests have complex structures and well-developed understories characterized by such plants as salal, evergreen huckleberry, salmonberry, and deerfern. These sites seldom experienced fire under natural conditions and some areas on the coastal plain on the western Olympic Peninsula probably have not burned for several thousand years.

Figure 8. Old-growth western redcedar-western hemlock stands growing on poorly drained soils on coastal plains are a distinctive and uncommon old-growth forest type. Although tree growth is typically very slow on these swampy, nutrient poor sites, the western redcedar live for many centuries and achieve large dimensions.

Western redcedar and western hemlock have an interesting successional relationship in these stands. For a variety of reasons, including its decay resistant wood and conical stem form, western redcedar has a lifespan that is many times longer than its decay- and windthrow-prone hemlock associate. Over time the proportion of western redcedar in the stand increases, resulting in the physical dominance of these sites by the large old redcedars. The shorter-lived hemlock often remains the most numerous but only in the form of relatively small trees. Wood volumes in these forests can be heavily dominated (up to 80 percent) by the cedar.

Even though most of these sites are low in productivity, the longevity of the cedar often allows them to reach phenomenal sizes. Individual trees in excess of 20 feet in diameter and 15,000 cubic feet of wood are known from these coastal forests. It is difficult to manage these sites for sustained timber production as a result of very slow recovery following logging. Problems include elevated water tables following harvest, excessive slash, poor regeneration and slow growth.

Methodology: Eastside Forest Types

Two approaches were considered regarding ways to characterize or define old-growth conditions on the eastside of the Cascade Range. One of these was to attempt to develop a structural index as was done for the Westside forest types. This was quickly rejected due to lack of data, particularly the availability of reference data from known old-growth forest stands.

The second approach, which was adopted and tested, was to utilize the old growth definitions developed for Eastside forest types by the USDA Forest Service. While the Committee had considerable doubt about their applicability, the definitions were tested during the field trip to the Eastside in May. This made clear that the Forest Service definitions had almost no value in recognizing old-growth conditions on the ground.

Consequently, the Committee was unable to make significant progress on characterizing or defining old-growth forest conditions or on identification of Eastside old-growth stands on DNR-managed lands. Substantial effort will be required to develop the necessary data bases for such definition and identification, including development of reference sites. There are possibilities of collaborations between DNR and federal agencies or academic institutions or both in analysis of old-growth conditions on Eastside DNR-managed lands.

It is probable that there are significant old-growth forest stands on the eastside. Certainly this would include old-growth forest stands at higher elevations, such as in the Engelmann spruce-subalpine fir and lodgepole pine types.

Old-growth forest conditions in the ponderosa pine, pine-oak, and dry mixed conifer types are more problematic. There are some small areas of forest with old-growth-like conditions within these forest types; the Committee noted several of these during the Eastside field trip. However, activities—such as logging (especially of large trees), reforestation, fire suppression and grazing—have grossly modified most of these forests.

The primary goal in old-growth assessment on these PAGs would be to identify sites, which have the potential for restoration to an old-growth condition. These are sites where there is at least a small population of remnant old-growth trees that can provide the structural backbone for a restoration effort (Figure 9.). Necessary restoration activities would be reductions in stand densities and basal areas with special attention to levels of ground and ladder fuels. Prescribed burning may also be needed following initial mechanical treatments of sites selected for restoration.

Restoring old-growth conditions on the ponderosa pine and dry mixed-conifer PAGs would require careful analysis by DNR. Not only would there be substantial investments in identification and treatment of candidate sites but continuing management would be necessary — such as in the form of regular prescribed burns — to maintain the restored forest in a sustainable state.

Figure 9. Eastside forests growing on ponderosa pine and dry mixed-conifer habitat types have been greatly modified by human activities, including fire suppression. Douglas-fir and grand fir have developed high densities in many areas creating the potential for uncharacteristic stand replacement fire. Restoring and maintaining old-growth pine forests on most of these sites would require significant investments. Inventories can identify where the best potential exists for such restoration, which are typically sites where remnant old-growth pines remain, as in the stand illustrated.

Other Important Considerations in Analysis of Old Growth

Individual and Small Patches of Old-Growth Trees

Old-growth elements of large, old live and dead trees can occur as individuals or in small patches. While these elements may not support the same communities and ecological functions as larger stands of old growth, they can provide ecological diversity in younger, less diverse forests and act as refugia for species that typically occur in old-growth stands (Sillett and Goslin 1999). These elements are typically difficult to detect in standard inventories or in aerial photography because they are rare or occur beneath the canopy. Consequently, they cannot be inventoried with standard approaches. Any management practices that address these elements will have to be based on field assessments of individual management units.

Stand size

Spatial scale is important to the definition of old growth. Old growth is a spatial mosaic that emerges at areas that range from 1 to 10 or more acres. The grain of this mosaic varies by the processes that form old growth. For example, the grain is relatively small (<1 acre) where canopy gap dynamics are a major process in the development of old growth. The grain may be larger (1 to 10+ acres) where patchy fires formed old growth. Most research efforts have defined old growth at the scale of about 2 to 20 acres.

Forest inventory data may not match the scale of scientific research on old-growth forests. Forest inventory design — including minimum mapping unit size — varies between forest inventories depending on management objectives and budget availability. For example, inventories often adopt 20 acres as a minimum size of polygon or stand. DNR's Forest Resource Inventory System (FRIS) mapping unit size ranges from 5 to 300 acres. Where inventory units exceed 20 acres they many contain a mixture of different forest age classes. Consequently, inventories may underestimate the presence of old-growth stands because plots from polygons representing a mixture of stand ages are averaged together and, as an average, may not meet the index threshold for an old-growth stand. Consequently, where large inventory polygons occur, it is advisable to check for inclusions of old-growth forest using the procedures outlined in the following section — first by review of aerial photography and plot data and, in some cases, by actual ground surveys.

Recommendation for Further Work by DNR

Several additional tasks remain with regards to resolution of old-growth forest status on DNR-managed lands.

Westside Forests

The main task on the Westside forests is to complete the secondary screening process for DNR-managed lands. This can probably most readily be accomplished by contracting with a knowledgeable forest scientist to collaborate with DNR staff in office and field checking of remaining unchecked but problematic polygons.

It would also be appropriate for DNR to consider training a set of its resource professionals in characterizing old-growth forest structure and function, to provide staff expertise associated with questions that might arise in implementing an old growth forest policy. In some circumstances field verification or interpretation of the WOGHI may be needed, since it is intended to be a screening tool. Field verification also might be required to address questions related to individual and small patches of forest trees that are not captured by the stand-level inventory that has been conducted as a part of this process.

Eastside Forests

The status of Eastside old-growth forests remains unresolved due to lack of sufficient knowledge regarding existing old-growth forest conditions, including both:

a) the nature of old-growth forests on higher-elevation forest types, such as Engelmann spruce-subalpine fir and lodgepole pine and

b) a policy with regards to old growth on the ponderosa pine and dry mixed-conifer PAGs.

Development of a set of old growth definitions, including collection of data from reference old-growth forest stands, is a relatively straightforward process for the mid- and high-elevation cooler and moister forest types. However, it will involve substantial field and office work. Funds are not currently available to conduct the necessary studies and to create the set of old growth definitions (probably indices), which then could be used to screen DNR-managed lands using FRIS.

Issues related to the ponderosa pine and dry mixed-conifer PAGs are more complex and require some policy decisions and additional field work. First, there are few small fragments of such forest that approximate historical conditions, and these should be identified and conserved.

Most of the ponderosa pine and dry mixed-conifer forests have been highly modified. A management program would be needed to restore stands to a characteristic and sustainable condition and, ultimately, to maintain such forests. This is a policy decision, not a scientific or technical issue.

If a program for restoration of some old-growth forest on ponderosa pine and dry mixed-conifer PAGs were adopted, the most appropriate next step would be an inventory to identify the sites with the greatest potential for restoration. These would be sites where there are residual old-growth ponderosa pine trees still present. Developing an inventory process involving initial screening using FRIS and aerial photography, and a secondary screening based on field – work, would be relatively straightforward.

Currently DNR lacks the financial resources to deal with either development of old growth definitions for moister, cooler Eastside forest types or development of a restoration program for Eastside ponderosa pine forests. Such work might be conducted in collaboration with other agencies, such as the USDA Forest Service, and with state universities. Several agencies, including the Forest Service and several tribes, are heavily engaged in development of restoration and long-term management programs for ponderosa pine and dry mixed-conifer types; some of these efforts could certainly be utilized to jumpstart a program for Eastside forest lands managed by DNR.

Application of the Old Growth Habitat Index in a policy setting

In cases where inventory data seems to contradict conditions on the ground, and following field assessments questions remain as to whether or not the stand qualifies as old growth, the stand could be re-measured as per DNR Forest Resource Inventory methods and the data applied to the index to determine stand classification. It is anticipated that as the index is used and understanding evolves as to how it applies in various stand types, its use may also evolve.

In using the index to identify old-growth stands in a mapping exercise, it must be remembered that this is a first approximation. Secondary screening and field review are essential to confirm any stand as old growth. Decreasing index values indicate a decreasing likelihood that a stand is ecologically old growth or mature forest.

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Appendices

Appendix 1.

Methodology for developing the old growth index — Rob Pabst

Establishing a Reference Condition for Old Growth in Western Washington

A Report to the Washington Department of Natural Resources
Prepared by Rob Pabst, Forest Ecologist

March 18, 2005

Introduction

Characterizing old growth is essential for conservation planning and to help establish goals in forest management. Definitions that simply label forests as old growth or not old growth do not do justice to the diversity of conditions found across the landscape. For example, research on forest structure and dynamics indicates that some elements of old-growth structure can be found in much younger forests (Spies and Franklin 1988), whereas some old-growth forests have been subject to frequent natural disturbances such as partial fires that remove old-growth structures and move stands toward earlier developmental conditions (Goslin 1997).

This report describes a quantitative method for assessing how forest stands compare with reference conditions in old forests of western Washington. The method is called the Old-Growth Habitat Index (OGHI), originally developed by Tom Spies for forests of western Oregon. The OGHI integrates five key elements of old forests:

1. Large trees (number of trees per hectare > 100 cm dbh)
2. Large snags (number of standing dead trees per hectare > 50 cm dbh and > 15 m tall)
3. Volume of down woody debris (cubic meters per hectare)
4. Tree size diversity
5. Stand age (years)

The five elements used in OGHI are typically available in forest inventory data. They are also generally correlated with other attributes of complex forest structure such as spatial heterogeneity, broken-topped crowns, and the presence of shade-tolerant tree species.

Methods

The OGHI for western Washington is based on data (Spies and Franklin, 1991) from 40 unmanaged forest stands in which the canopy-dominant trees ranged in age from 210 to 900 years. Stands were located in the Cascade Range from just north of the Columbia River through Mount Rainier National Park. Specific methods of data collection are reported in Spies and Franklin (1991).

Each of the five elements making up the OGHI is scored on a scale of 0 to 100. Scoring for each element is determined from regression equations (Tables 1 and 2) that describe single- or multi-segmented lines connecting thresholds in the data (Figure 1). The thresholds for each line segment are linked to the statistical distribution of data for that element from the old stands (Figure 2). For comparison, Figure 2 includes data from the unmanaged young (20-79 years) and mature (80-199 years) stands that were sampled as part of the Franklin and Spies (1991) study. The youngest stand in the study was 42 years. There is substantial variability for each element within and between age classes, although it appears that large trees, tree size diversity, and stand age are the elements that most strongly distinguish old stands from unmanaged young and mature stands. These unmanaged stands may or may not be representative of the current population of stands in these age classes on Washington DNR lands.

Trees, snags and logs

For large trees and large snags, an element score of 50 corresponds to the lower-quartile (25th percentile) value from the old stands (Figures 1a and 1b). A score of 75 corresponds to the median value from the old stands, and a score of 100 corresponds to the maximum value. For log volume, a score of 50 corresponds to the minimum value from the old stands, a score of 75 corresponds to the median, and a score of 100 corresponds to the maximum (Figure 1c). Values for tree and snag densities and log volumes were corrected for slope prior to determining the thresholds.

Tree size diversity

Size diversity of trees in a stand is expressed as the Diameter Diversity Index (DDI), a surrogate for tree height diversity. DDI is based on the slope-corrected number of trees per hectare in each of four dbh classes: 5.0-24.9 cm, 25.0-49.9 cm, 50.0-99.9 cm, and > 100.0 cm. Three steps are involved in determining DDI, as shown in the example in Appendix 1. First, a score for each dbh class is determined from a regression equation that describes a straight line running from the origin (0,0) to a maximum score of 1.0 which corresponds to the median density of trees in that dbh class in the old stands (Table 2, Figure 1d). Second, the scores for each class are multiplied by a weighting factor that reflects the relative height of trees in each class. The weights are 1, 2, 3 and 4 for the smallest to largest dbh classes, respectively. In the third step, DDI is calculated as the sum of the weighted scores multiplied by 10. Maximum DDI is 100 [((1.0 x 1) + (1.0 x 2) (1.0 x 3) + (1.0 x 4)) x 10 = 100].

Age of Canopy Dominants

Stand age is defined as the age of the oldest canopy-dominant trees in the stand. In the Spies and Franklin (1991) study, stand ages were determined from counting rings on cut stumps located near the sampled stand or by extracting increment cores at breast height and then adding 5 to 7 years to the ring count to get total age. Age is not a structural feature but is included in the OGHI because some aspects of old-growth biodiversity, such as low-mobility species, require a long time to colonize and accumulate after stand-replacement disturbance. The score for stand age equals 80 at 200 years and 100 at 450 years (Table 1, Figure 1e). This relationship is based on the finding that community similarity between old-growth stands and mature stands was at least 80% for plant species, amphibians and small mammals (Hansen et al. 1991).

OGHI

There are three forms of the Old Growth Habitat Index for western Washington. The standard OGHI is simply the average of the five element scores. A modified OGHI excludes stand age, making the index purely structural. A weighted OGHI is also based on the scores of the four structural elements, with the element scores weighted by a relativized Spearman rank correlation coefficient between each element and stand age (Table 3). Data from stands in all age classes (young, mature, old) were used to calculate the correlations. Associations with age were strongest for large trees and DDI (of which large trees is one component), thus the weighted OGHI emphasizes the density of large trees in a stand. Log volume was moderately correlated with age, taking on a “U-shaped” pattern over time with stands 80 to 320 years of age having relatively low log volumes (Figure 3). The density of large snags was highly variable and of the four structural elements was least correlated with stand age. Snag densities trended toward an inverted U-shaped pattern over time, peaking in stands at about 400 years.

All three forms of the OGHI are scaled from 0 to 100, allowing direct comparisons among them. A sample calculation of each form of OGHI is provided in Appendix 1.

Results

Standard, modified and weighted OGHI’s were calculated for all of the stands sampled in the western Washington Cascades (n=69) (Table 4). For 10 of the 13 young stands, OGHI was highest using the modified formulation (without stand age and unweighted). In comparison, the standard OGHI (with stand age) was highest for the majority of mature (11 of 16) and old (32 of 40) stands.

The standard OGHI for old stands ranged from 49 to 90, with all but two of these stands scoring greater than 60 (Table 4, Figure 4a). None of the mature or young stands exceeded a standard index value of 60, and there was a fair degree of overlap between stands in those age classes. Standard OGHI values for mature stands ranged from about 27 to 59, whereas the scores for young stands ranged from about 25 to 48.

Taking stand age out of the equation with the modified OGHI (Figure 4b) resulted in lower values for all of the old stands (range 41-88), mostly lower values for mature stands (range 21-61), and extended the range of values on the high end for young stands (range 25-54) compared to the standard OGHI (Table 4). When the four structural elements were weighted by their correlation with stand age, OGHI (weighted) was lower still for about half of the old stands (range 37-89) (Table 4, Figure 4c).

The distribution of weighted OGHI scores among young, mature and old stands is shown in Table 5 and Figure 5a. For old stands these scores are separated further into site moisture classes (Figure 5b). The median value for weighted OGHI increased from dry to wet sites, and there was more variability in weighted OGHI on dry sites than on either mesic or wet sites.

Summary

The Old-Growth Habitat Index integrates five elements of stand structure and successional status into a single measure that recognizes the complexity and diversity of forest habitats across a range of ages. Values for OGHI are on a continuum, allowing an evaluation of the degree to which any forest stand compares to old growth. It should be noted that two stands with similar values for OGHI do not necessarily share similar stand structure. For instance, a young stand with a legacy of large snags and high volume of down wood from the previous stand may have a score similar to that from a mature stand with large trees. Conversely, some old stands, particularly those on dry sites, may have an OGHI value similar to a younger stand. The elements comprising OGHI can be examined individually or in different combinations suited to management needs. For example, a modified OGHI excludes age of canopy dominants to emphasize structural attributes only, while the weighted OGHI emphasizes the presence of large trees. The OGHI can also be extended to landscape-level analyses to project forest structure and the extent of old growth across DNR lands in western Washington.

References

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Table 1 Regression coefficients used to calculate scores for four elements in the Old-Growth Habitat Index for western Washington. Regression equations are of the form y = *m*x + *b* where *y* = score (dependent variable), *x* = element value (independent variable), *m* = slope and *b* = intercept.

Element	Range in element values	Range in scores	Regression coefficients for calculating score	
			Slope	Intercept
Big trees	0 – 16 tph	0 – 50	3.125	0.0
	16 – 28 tph	50 – 75	2.08333	16.66667
	28 – 57 tph	75 – 100	0.86207	50.86207
	≥ 57 tph	100	---	---
Big snags	0 – 5 sph	0 – 50	10.0	0.0
	5 – 9 sph	50 – 75	6.25	18.75
	9 – 20 sph	75 – 100	2.27273	54.54545
	≥ 20 sph	100	---	---
Log volume	0 – 114 m^3/ha	0 – 50	0.4386	0.0
	114 – 383 m^3/ha	50 – 75	0.09294	39.4052
	383 – 1069 m^3/ha	75 – 100	0.03644	61.04227
	≥ 1069 m^3/ha	100	---	---
Stand age	0 – 200 years	0 – 80	0.4	0.0
	200 – 450 years	80 – 100	0.08	64.0
	≥ 450 years	100	---	---

Table 2 Regression coefficients used to calculate scores* for each dbh class in the Diameter Diversity Index (DDI). Regression equations are of the form $y = mx + b$ where y = score, x = trees per hectare in dbh class of interest, m = slope and b = intercept.

Dbh class	Asymptote (median tph in old stands)	Regression coefficients for calculating score		
		Slope	Intercept	Weight
5 – 24.9 cm	295	0.00339	0.0	1
25.0 – 49.9 cm	87	0.01149	0.0	2
50.0 – 99.9 cm	70	0.01429	0.0	3
≥ 100.0 cm	28	0.03571	0.0	4

* For tree densities greater than the median value in each class, the score for that class = 1.0

Table 3. Spearman rank correlation coefficients among the five elements in the OGHI from 69 unmanaged forest stands in the Cascade Range of Western Washington.

Element	Stand age	Big trees	Big snags	Log volume	DDI
Stand age	1.000				
Big trees	0.787	1.000			
Big snags	0.361	0.263	1.000		
Log volume	0.567	0.516	0.358	1.000	
DDI	0.842	0.861	0.315	0.476	1.000

Weighted OGHI based on relativized correlations of the four structural elements with stand age:

Sum of correlations with stand age = 2.557

Weights for OGHI elements:

- Big trees: 0.787/2.557 = 0.31
- Big snags: 0.361/2.557 = 0.14
- Log volume: 0.567/2.557 = 0.22
- DDI: 0.842/2.557 = 0.33

Weighted OGHI =
(Big tree score x 0.31) + (Big snag score x 0.14) + (Log volume score x 0.22) + (DDI score x 0.33)

Table 4 Element scores and three forms of OGHI for 69 unmanaged forest stands in the Cascade Range of western Washington. Moisture class codes: D = dry, M = mesic, W = wet.

Locations of a subset of stands (area, stand, age, location):
2-61 (65 yrs): Martha Creek, Wind River Experimental Forest
4-68 (65 yrs): Silver Creek, Mt. Rainier National Park (young)
2-42 (140 yrs): Panther Creek, Wind River Experimental Forest (mature)
2-20 (375 yrs): T.T. Munger Research Natural Area (old)
4-2 (400 yrs): Carbon River, Mt. Rainier National Park (old)
3-2 (500 yrs): Cedar Flats Research Natural Area (old)
4-21 (900 yrs): Chinook Creek, Mt. Rainier National Park (old)

Area	Stand	Age	Age class	Moist class	Elev (m)	Lat	Long	Element Scores				Standard OGHI	Modified OGHI	Weighted OGHI
								Large trees/ha	Large snags/ha	Log volume	DDI			
2	62	42	Y	M	621	45.80	121.97	0.00	62.94	64.50	32.90	35.43	40.09	33.86
3	67	55	Y	M	763	46.43	121.94	0.00	80.55	59.36	35.40	39.46	43.83	36.02
3	68	60	Y	M	655	46.42	121.83	0.00	75.09	66.08	32.10	39.45	43.32	35.64
2	60	65	Y	M	476	45.85	122.98	6.53	0.00	57.43	34.70	24.93	24.67	26.11
2	61	65	Y	M	541	45.78	121.94	0.00	23.40	63.98	49.00	32.48	34.10	33.52
2	64	65	Y	M	472	45.80	121.97	12.97	70.50	83.23	39.50	46.44	51.55	45.24
3	75	65	Y	M	764	46.50	121.69	0.00	34.50	54.15	31.00	29.13	29.91	26.97
4	68	65	Y	M	1168	46.98	121.52	0.00	0.00	72.17	30.00	25.63	25.54	25.78
3	64	70	Y	M	700	46.12	121.99	13.06	51.13	60.01	46.40	39.72	42.65	39.72
3	69	70	Y	M	841	46.43	121.79	0.00	21.80	73.47	47.80	34.21	35.77	34.99
4	60	70	Y	M	850	46.81	121.55	0.00	68.94	85.31	60.00	48.45	53.56	48.22
3	52	75	Y	M	664	46.68	121.61	0.00	31.90	56.49	53.80	34.44	35.55	34.65
3	65	75	Y	M	704	46.64	121.59	0.00	10.70	68.85	32.70	28.45	28.06	27.44

Table 4. (continued) Element scores and three forms of OGHI for 69 unmanaged forest stands in the Cascade Range of western Washington. Moisture class codes: D = dry, M = mesic, W = wet.

Area	Stand	Age	Age class	Moist class	Elev (m)	Lat	Long	Element Scores				Standard OGHI	Modified OGHI	Weighted OGHI
								Large trees/ha	Large snags/ha	Log volume	DDI			
2	65	80	M	M	769	45.93	121.99	13.50	0.00	56.11	48.70	30.06	29.58	32.60
3	42	95	M	M	890	46.69	121.71	7.22	64.75	62.20	55.00	45.43	47.29	43.14
2	41	105	M	M	483	45.88	121.99	21.19	0.00	59.93	63.20	37.26	36.08	40.61
3	48	105	M	M	792	46.67	121.76	0.00	43.40	60.27	60.00	41.13	40.92	39.14
2	54	115	M	D	623	45.87	121.85	0.00	0.00	36.75	52.80	27.11	22.39	25.51
2	50	130	M	M	598	45.87	121.85	8.59	0.00	19.81	56.20	27.32	21.15	25.57
2	51	130	M	D	516	45.85	121.86	15.13	23.90	37.04	58.90	37.39	33.74	35.62
2	53	130	M	D	904	45.83	121.85	0.00	78.57	40.07	50.50	44.23	42.28	36.48
3	40	130	M	M	586	46.07	121.98	0.00	51.00	56.09	60.00	43.82	41.77	39.28
4	41	130	M	M	869	46.75	121.90	13.81	0.00	65.43	62.20	38.69	35.36	39.20
2	40	135	M	M	672	45.85	121.89	32.66	21.10	44.92	57.40	42.01	39.02	41.90
4	10	135	M	W	651	46.73	121.90	54.27	40.10	64.56	83.30	59.25	60.56	64.13
2	42	140	M	M	503	45.09	121.94	12.91	42.60	31.97	49.70	38.63	34.29	33.40
4	40	165	M	M	958	46.75	121.81	0.00	45.40	56.75	60.00	45.63	40.54	38.64
2	99	180	M	M	492	45.88	121.94	0.00	60.31	65.48	60.00	51.56	46.45	42.65
3	46	190	M	M	1124	46.40	121.97	0.00	91.30	56.68	60.00	56.79	51.99	45.05

Table 4. (continued) Element scores and three forms of OGHI for 69 unmanaged forest stands in the Cascade Range of western Washington. Moisture class codes: D = dry, M = mesic, W = wet.

Area	Stand	Age	Age class	Moist class	Elev (m)	Lat	Long	Element Scores				Standard OGHI	Modified OGHI	Weighted OGHI
								Large trees/ha	Large snags/ha	Log volume	DDI			
3	36	210	O	D	1025	46.53	121.95	16.91	36.80	50.22	59.50	48.85	40.86	41.08
4	20	250	O	M	670	46.74	121.55	78.86	77.52	57.72	87.70	77.16	75.45	76.94
4	23	250	O	M	644	46.72	121.56	31.56	82.07	66.08	64.50	65.64	61.05	57.10
4	30	250	O	D	728	46.75	121.55	0.00	59.44	50.01	56.20	49.93	41.41	37.87
3	34	300	O	D	950	46.59	121.56	22.59	75.36	53.09	70.30	61.87	55.34	52.43
4	32	300	O	D	1218	46.94	121.91	75.65	73.75	68.84	89.90	79.23	77.03	78.59
4	19	320	O	M	1072	46.93	121.91	75.28	42.30	61.16	97.80	73.23	69.13	74.99
4	31	350	O	D	987	46.74	121.80	19.09	76.16	79.01	65.90	66.43	60.04	55.71
2	10	375	O	W	295	45.81	121.95	96.14	50.06	76.77	80.30	79.45	75.82	80.20
2	11	375	O	M	378	45.80	121.98	31.63	77.50	76.22	62.10	68.29	61.86	57.92
2	14	375	O	W	517	45.88	122.01	99.75	77.75	88.36	85.20	89.01	87.76	89.36
2	19	375	O	M	549	45.81	121.95	58.10	63.69	80.05	71.20	73.41	68.26	68.04
2	20	375	O	M	420	45.81	121.97	72.48	100.00	63.22	96.70	85.28	83.10	82.29
2	21	375	O	M	452	45.88	121.99	75.34	86.95	78.67	82.60	83.51	80.89	80.10
2	23	375	O	M	630	45.85	121.99	53.40	66.19	67.18	74.60	71.07	65.34	65.22
2	26	375	O	M	511	45.82	122.00	50.44	77.57	71.93	78.90	74.57	69.71	68.36
2	29	375	O	M	540	45.77	121.94	87.25	56.38	70.00	81.60	77.85	73.81	77.27
2	31	375	O	D	710	45.88	122.01	87.19	75.80	68.21	76.40	80.32	76.90	77.86
2	33	375	O	D	915	45.87	122.11	0.00	92.32	76.11	52.60	63.01	55.26	47.03
2	35	375	O	D	689	45.85	121.99	6.31	79.82	70.95	62.90	62.80	54.99	49.50

Table 4. (continued) Element scores and three forms of OGHI for 69 unmanaged forest stands in the Cascade Range of western Washington. Moisture class codes: D = dry, M = mesic, W = wet.

Area	Stand	Age	Age class	Moist class	Elev (m)	Lat	Long	Element Scores				Standard OGHI	Modified OGHI	Weighted OGHI
								Large trees/ha	Large snags/ha	Log volume	DDI			
3	19	400	O	M	875	46.63	121.85	50.75	77.86	79.24	78.80	76.53	71.66	70.07
4	2	400	O	W	622	46.99	122.90	85.34	40.00	78.95	95.80	79.22	75.02	81.04
3	31	440	O	D	891	46.63	121.85	36.91	78.25	62.96	62.30	67.92	60.10	56.81
2	25	450	O	M	975	45.95	121.95	79.59	92.64	77.92	100.00	90.03	87.53	87.78
2	27	450	O	M	626	45.92	121.99	82.09	97.82	66.03	85.00	86.19	82.73	81.72
2	30	450	O	D	706	45.92	121.95	61.33	31.10	65.69	74.90	66.61	58.26	62.54
2	98	450	O	M	776	45.93	121.99	56.75	43.90	82.77	74.70	71.62	64.53	66.60
3	2	500	O	W	404	46.10	122.01	97.42	88.66	88.96	67.90	88.59	85.73	84.59
3	16	500	O	M	506	46.09	121.89	75.20	79.73	87.08	81.60	84.72	80.90	80.56
3	17	500	O	M	529	46.10	122.01	76.86	77.75	72.18	85.30	82.42	78.02	78.74
4	1	500	O	W	617	46.99	122.91	54.21	81.84	100.00	79.20	83.05	78.81	76.40
4	3	500	O	W	658	46.98	122.86	78.49	84.14	92.52	85.50	88.13	85.16	84.68
4	18	550	O	M	1037	46.91	121.53	79.10	50.63	78.72	98.80	81.45	76.81	81.53
3	3	600	O	W	1168	46.69	121.46	78.60	53.19	67.70	90.60	78.02	72.52	76.61
3	32	600	O	D	1049	46.67	121.46	81.22	51.38	68.70	100.00	80.26	75.32	80.49
3	20	650	O	M	797	46.42	121.95	86.18	42.20	79.79	97.50	81.13	76.42	82.35
4	16	700	O	M	988	46.80	121.90	83.94	89.50	77.07	92.10	88.52	85.65	85.90
4	11	730	O	W	727	46.72	121.84	82.03	69.00	96.90	95.50	88.69	85.86	87.92
4	12	730	O	W	680	46.72	121.84	46.91	0.00	87.27	75.60	61.95	52.44	58.69
4	21	900	O	M	820	46.81	121.55	79.66	0.00	68.57	100.00	69.65	62.06	72.78

Table 5. Distribution of the *weighted* OGHI in unmanaged forest stands in the Cascade Range of western Washington. Comparisons are between (a) age classes, and (b) site moisture classes for old stands only.

Age class	Moist. class	N	Quantile value for Weighted OGHI						
			Min	0.10	0.25	0.50	0.75	0.90	Max
Y	All	13	25.78	26.11	27.44	34.65	36.02	45.24	48.22
M	All	16	25.51	25.57	34.51	39.17	42.27	45.05	64.13
O	All	40	37.87	50.97	61.61	76.77	81.29	85.29	89.36
O	Dry	11	37.87	41.08	47.03	55.71	77.86	78.59	80.49
O	Mesic	20	57.10	61.57	68.20	77.10	81.63	84.13	87.78
O	Wet	9	58.69	58.69	76.61	81.04	84.68	89.36	89.39

Figure 1. Line segments used to determine scores for each element in the OGHI for western Washington: a) trees/ha ≥ 100 cm dbh; b) snags/ha ≥ 50 cm dbh and ≥ 15 m tall; c) log volume (m3/ha); d) Diameter Diversity Index (DDI); and e) stand age (years). Thresholds for each segment are based on distribution of data from old stands and/or ecological criteria. Regression coefficients for each segment are shown in Tables 1 and 2. Lines for DDI are for each dbh class:
1: 5.0 – 24.9 cm; 2: 25.0 – 49.9 cm; 3: 50.0 – 99.9 cm; 4 ≥ 100 cm.

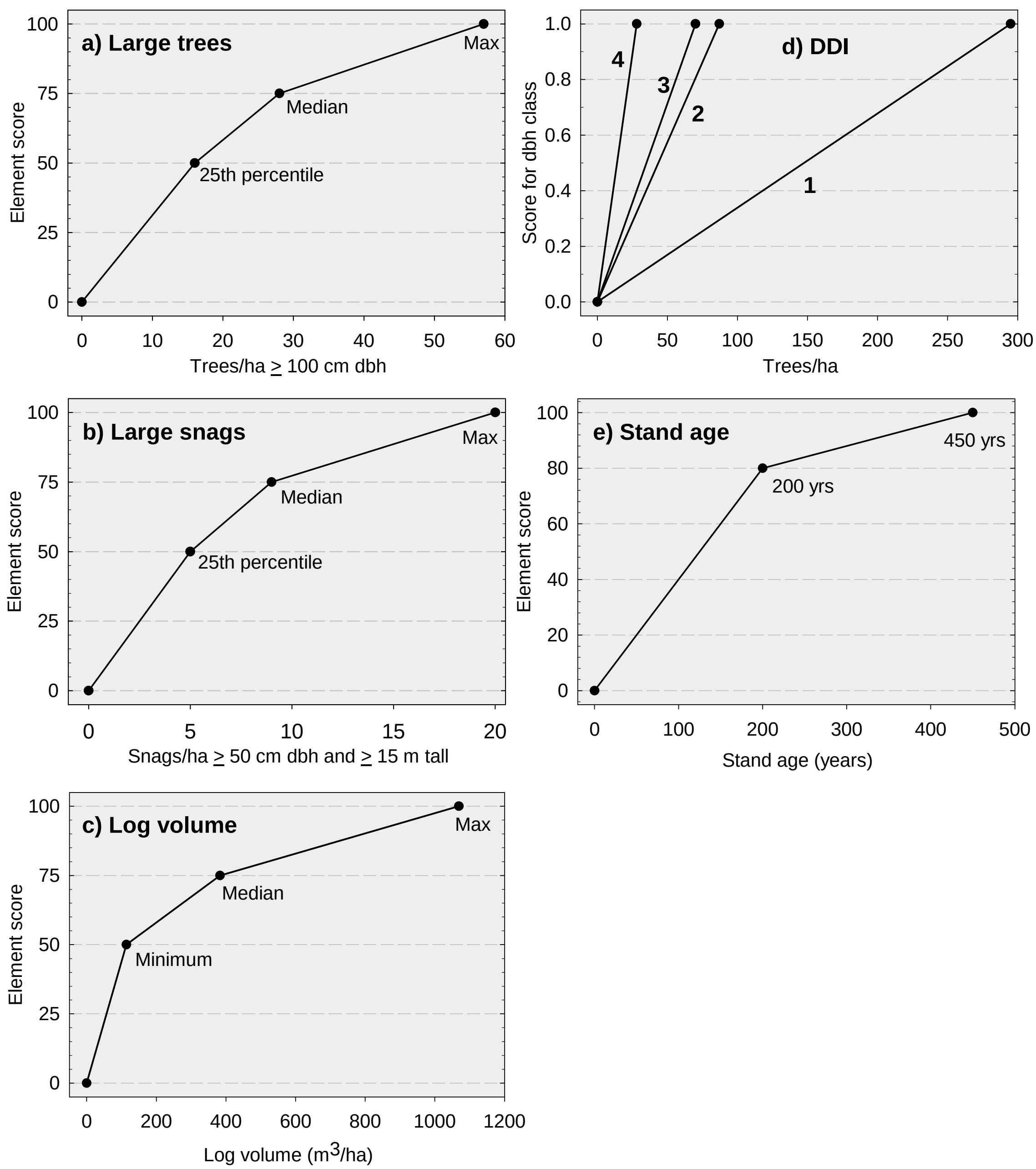


Figure 2. Distribution of data by stand age class from study of unmanaged forest stands in the Cascade Range of western Washington (Spies and Franklin 1991). Each of the five elements in the OGHI is shown: a) trees/ha ≥ 100 cm dbh; b) snags/ha ≥ 50 cm dbh and ≥ 15 m tall; c) log volume (m3/ha); d) Diameter Diversity Index (DDI); and e) stand age (years). In the box-and-whisker plots, boundary of the box closest to zero is the 25th percentile, the line within the box is the median, and the boundary of the box farthest from zero is the 75th percentile. Whiskers (error bars) above and below the box are the 90th and 10th percentiles, with circles representing data points outside those bounds.

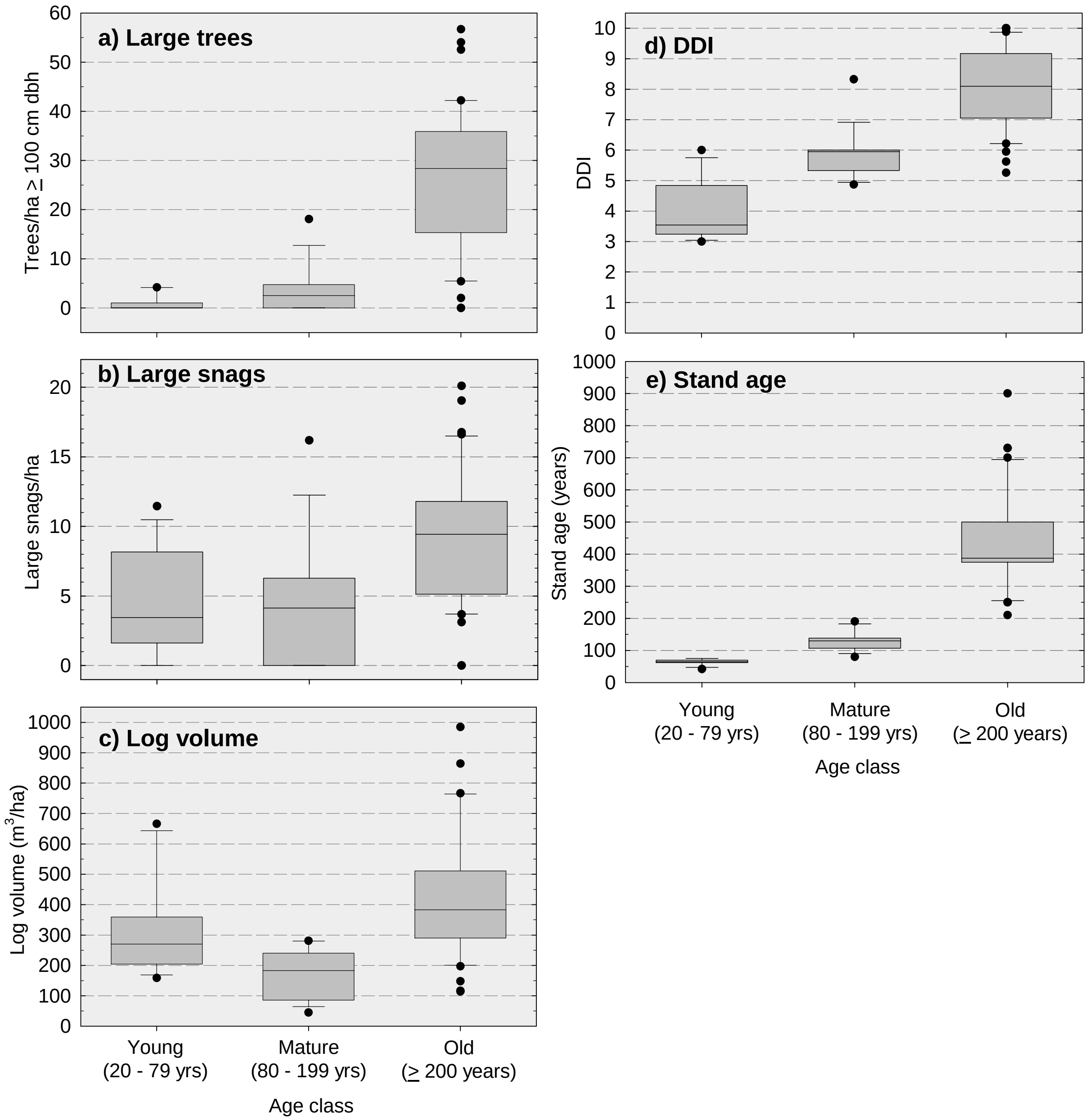


Figure 3. Scatterplots between the four structural elements in the OGHI and stand age for 69 unmanaged stands in forests of the Cascade Range of western Washington.

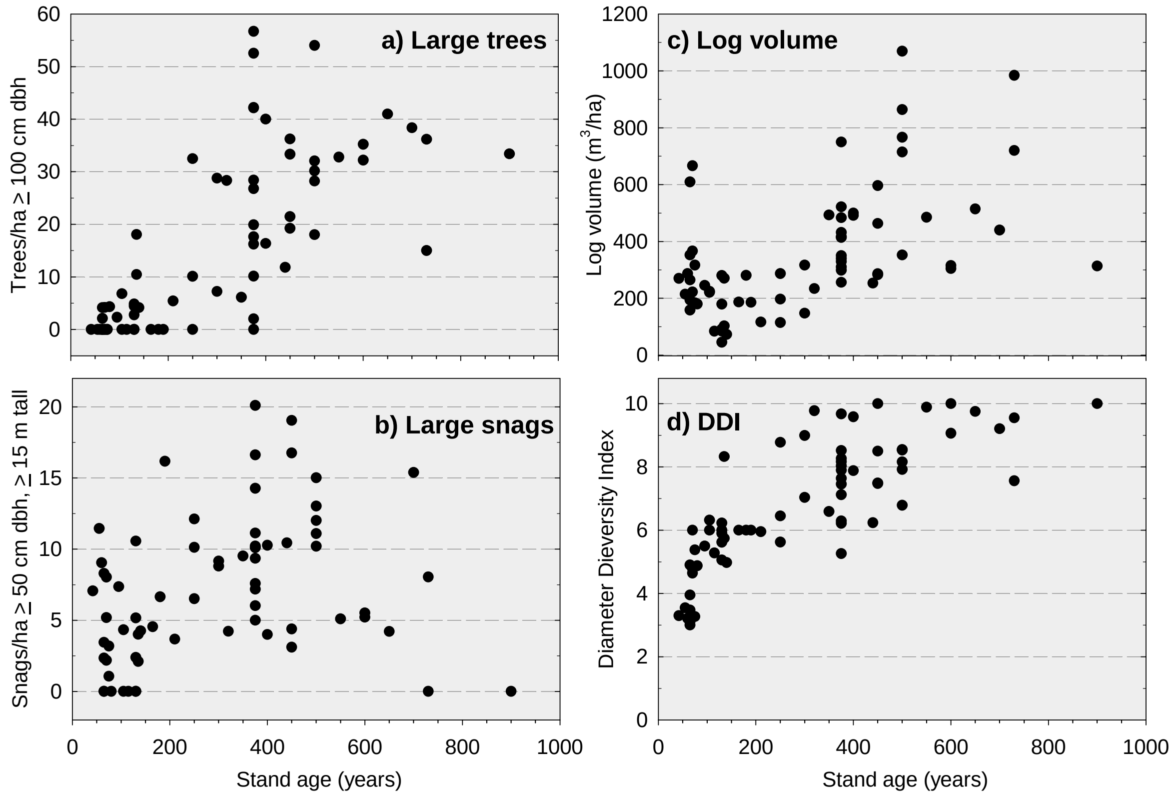


Figure 4. Three versions of the Old-Growth Habitat Index (OGHI) for unmanaged stands in the Cascade Range of western Washington: a) standard, b) modified, and c) weighted.

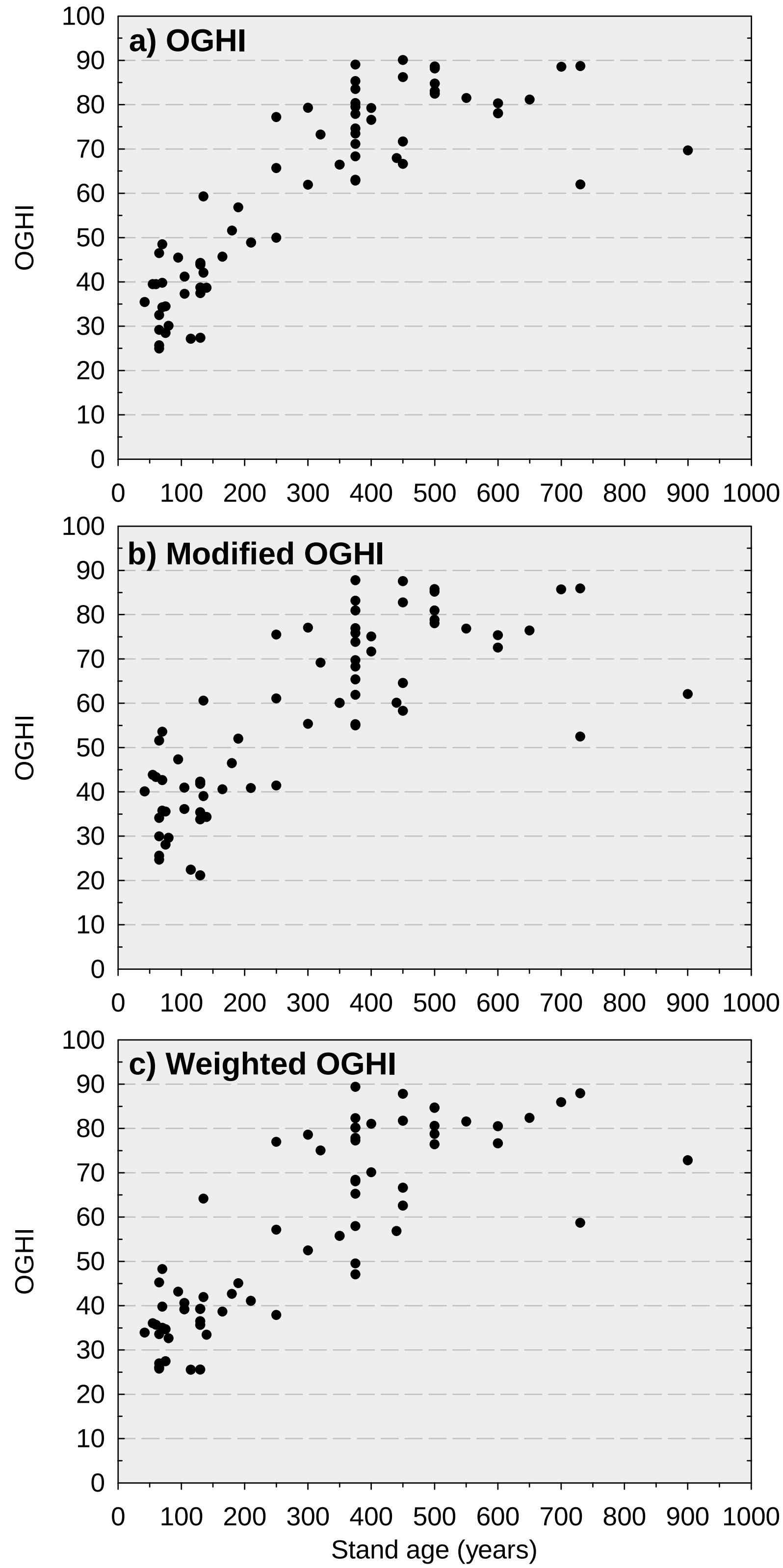
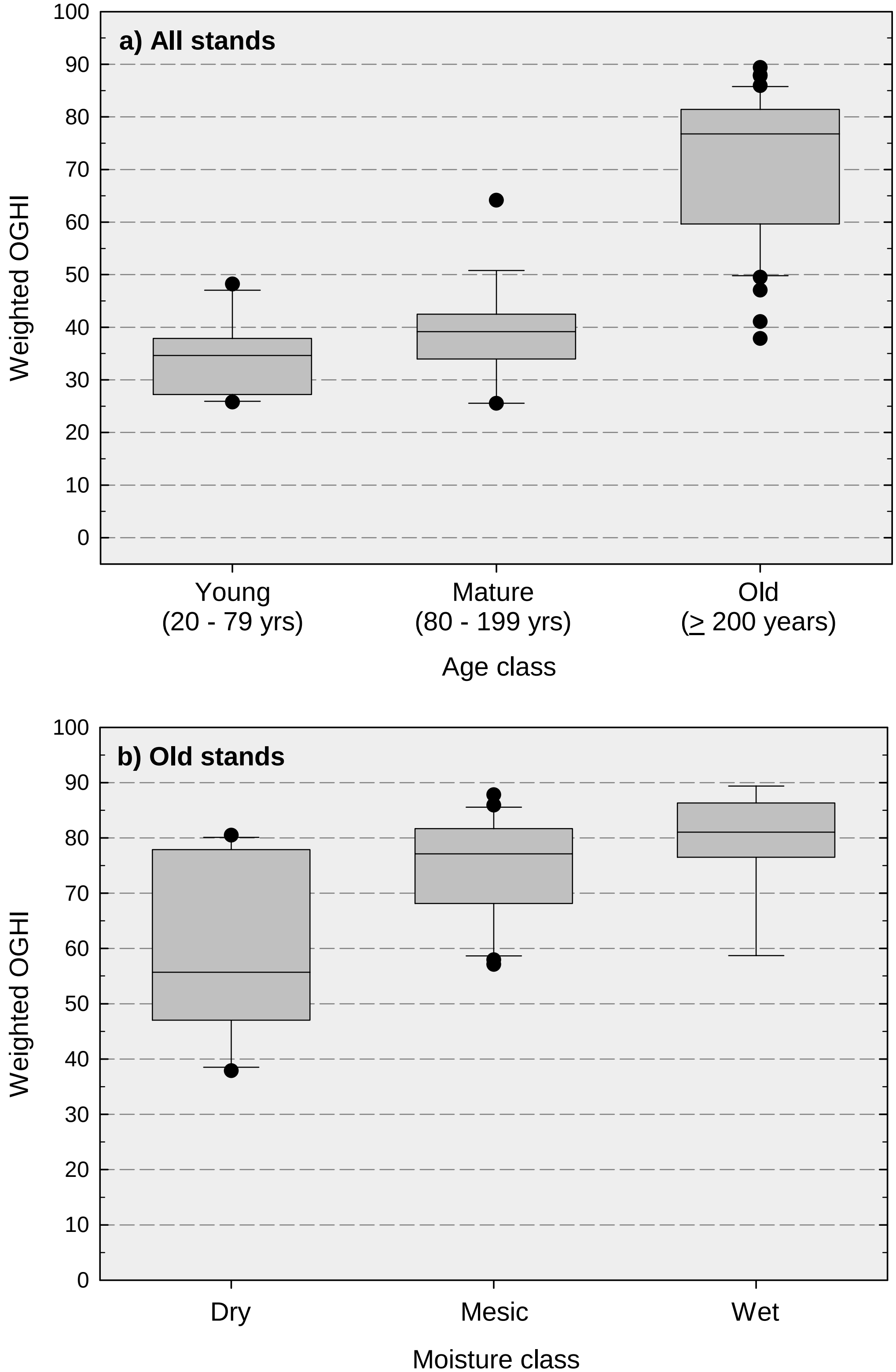


Figure 5. Box-and-whisker plots of weighted OGHI for a) all stands by age class, and b) old stands by moisture class.



Appendix 1. Example of calculating the Old-Growth Habitat Index for western Washington

Stand data

Element 1: slope-corrected number of trees $\geq$ 100 cm dbh = 2.3 trees/hectare
(Note: fraction a result of averaging data from subplots and applying a slope-correction factor.)
Element 2: slope-corrected number of snags $\geq$ 50 cm dbh and $\geq$ 15 m tall = 7.4 snags/hectare
Element 3: slope-corrected log volume = 245.2 m^3/hectare
Element 4: Diameter Diversity Index = 55.0 (derivation shown below)
Element 5: total stand age = 95 years

Calculation of Diameter Diversity Index (DDI) (use coefficients from Table 2)

Slope-corrected tree densities by dbh class (Note that trees < 5.0 cm dbh are not included):

Class 1 (5.0 – 24.9 cm):	725.4 trees/hectare
Class 2 (25.0 – 49.9 cm):	292.1 trees/hectare
Class 3 (50.0 – 99.9 cm):	50.5 trees/hectare
Class 4 ($\geq$ 100 cm):	2.3 trees/hectare

Score for Class 1 = 1.0 (density exceeds median from old stands) x weighting factor of 1 = 1.0
Score for Class 2 = 1.0 (density exceeds median from old stands) x weighting factor of 2 = 2.0
Score for Class 3 = 0.01429 x 50.5 = 0.72 x weighting factor of 3 = 2.16
Score for Class 4 = 0.03571 x 2.3 = 0.08 x weighting factor of 4 = 0.33

DDI = (1.0 + 2.0 + 2.16 + 0.33) x 10 = 54.9

Calculation of other element scores (use coefficients from Table 1)

Score for big trees: 3.125 x 2.3 = 7.2
Score for big snags: (6.25 x 7.4) + 18.75 = 65.0
Score for log volume: (0.09294 x 245.2) + 39.4052 = 62.2
Score for stand age: 0.4 x 95 = 38.0

Calculation of OGHI (average of element scores)

Standard OGHI = (7.2 + 65.0 + 62.2 + 54.9 + 38.0)/5 = 227.3/5 = 45.5

Modified OGHI (without stand age) = (7.2 + 65.0 + 62.2 + 54.9)/4 = 189.3/4 = 47.3

Weighted OGHI* = (7.2 x 0.31) + (65.0 x 0.14) + (62.2 x 0.22) + (54.9 x 0.33) = 189.3/4 = 43.

Appendix 2.

Biographical briefs on panel members

Jerry F. Franklin is Professor of Ecosystem Analysis in the College of Forest Resources, University of Washington, in Seattle. Previously, he has been Chief Plant Ecologist, USDA Forest Service, Corvallis, Oregon, and Professor of Forest Science and Botany at Oregon State University. He also served as Director of the Ecosystem Studies Program of the National Science Foundation in Washington, D.C. He holds B.S. and M.S. degrees in Forest Management from Oregon State University, and a Ph.D. in Botany and Soils from Washington State University, Pullman. He is one of the pioneers of forest ecosystem research, with specializations in structure and function of natural forest ecosystems; successional processes following catastrophic disturbances; effects of changing environmental conditions on forest processes; application of ecological principles to the management of natural resources; and theory and practical applications of landscape ecology. He is a past president of the Ecological Society of America, was a panelist on the White House Forest Conference in 1993, and has served on the Board of Governors of the Nature Conservancy. He has worked on scientific policy analyses for Congress, the federal government, state governments, and for British Columbia. He holds the Barrington Moore Award for outstanding achievement in forest research from the Society of American Foresters, as well as numerous other awards. His research is documented in nearly 300 publications. He is currently extensively involved as a consultant and land steward for sustainable forestry projects in southern Chile and Argentina.

Thomas Spies is a Research Ecologist at the USDA Forest Service, Pacific Northwest Research Station, in Corvallis, Oregon, where he is Committee leader of the Landscapes and Ecosystems Team. He is also a courtesy professor in the Department of Forest Science in the College of Forestry at Oregon State University. He received his Ph.D. in from the School of Natural Resources at the University of Michigan in 1983. He has been a research fellow at Forestry Research Station in Baden-Wurttemberg, Germany and at Harvard Forest in Massachusetts. He was a member of the Forest Ecosystem Management Team that developed the Northwest Forest Plan. His research interests are broad and include stand dynamics, old-growth forest ecology and conservation, wildlife habitat relationships, remote sensing applications, and landscape ecology. He is currently co-leader of the Coastal Landscape Analysis and Modeling Study (CLAMS), an interdisciplinary project to evaluate ecological and socio-economic consequences of forest policies.

Robert Van Pelt is currently on the research faculty at the University of Washington in Seattle where he is engaged in canopy research in *Pseudotsuga*, *Sequoia*, and *Picea* forests. He gives occasional lectures and leads field trips for the University, and teaches several field classes on Pacific Northwest old-growth forests and Northwest canopy ecology.

Bob received his MS in 1991 and PhD in 1995 from the University of Washington. His main research interests are old-growth ecology, canopy structure and its control of the understory environment, spatial patterns in old-growth forests, and tree plant geography.

SECTION 2
Old Growth Inventory

Updated December 2005

Section 2

Introduction

The Old Growth Definition Committee was convened by the Washington State Department of Natural Resources in response to 2004 legislative direction ESHB 2573, section 905[1]. Section 905 directed DNR to conduct an inventory of old growth on state lands as defined by a panel of scientists. As discussed in Section 1 of this document, the Old Growth Definition Committee established an old growth indexing method to use with data from DNR's Forest Resource Inventory System (FRIS). The Committee field-tested the Index by assessing a sample of stands in the Olympic Peninsula, Southwest Washington, and Klickitat County. A Weighted Old Growth Habitat Index of greater than 60 was found to be reliable for identifying potential old growth on the west side. The Committee also established a secondary screening process for stands with somewhat lower Index values that might contain old growth after a secondary screening is conducted.

Old growth stands identified using the Weighted Old Growth Habitat Index

In Western Washington, the FRIS-based Weighted Old Growth Habitat Index identified 52,666 acres that are likely to be old growth. This acreage includes areas where FRIS inventory is not complete, and where old-growth acres have been identified through other processes (such as habitat screening and origin year assessment) as old growth. The 52,666 acres represents approximately 4 percent of the forestland covered by the Habitat Conservation Plan (HCP) for state trust lands in Western Washington. A large majority of this acreage is located on the Olympic Peninsula, located within the Olympic Experimental State Forest (OESF).

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1. [1] ESHB 2573, section 905: "The Department of Natural Resources shall conduct an inventory on state lands of old growth forest stands as defined by a panel of scientists. The panel of scientists shall include three scientific scholars with well documented expertise in Pacific Northwest forest ecology, one of whom will serve as the chair by consensus of the panel, one representative from the department of natural resources, and one representative from the Washington department of fish and wildlife. The panel shall review the best available scientific information and develop a definition for old growth stands in Washington state. The inventory shall include maps illustrating the distribution of old growth forest stands on state lands, and tables describing the number of acres of stands in each county, the department's administrative unit, and forest type. The maps and tables shall identify both structurally uniform and structurally complex stands. The department of natural resources shall make a report of the inventory to the appropriate committees of the legislature.

2. For the duration of the study, cutting or removing trees and stands 160 years or older is subject to the department publishing notification of proposed cutting or removal of old growth timber.

3. This section expires Jun 30, 2005."

Stands needing a secondary screening for potential old growth

On the west side of the Olympic Peninsula, field-testing of the Weighted Old Growth Habitat Index (Index) revealed that it was scoring some known old growth stands below the threshold of 60. This was due to issues in spatial interpretation of FRIS data, and also due to stand characteristics unique to that physiographic region. Consequently, on the Olympic Peninsula, a secondary screening process was recommended for stands that score between 38 and 59 on the Index, to assess whether they include an old growth component. Elsewhere in Western Washington, different climactic and site conditions resulted in a recommendation that a secondary screening be conducted on stands that score between 50 and 59 on the Index. In total, the FRIS-based index has identified approximately 35,769 acres where a secondary screening process is necessary to determine if these stands contain old growth. This acreage also includes areas where FRIS inventory is not complete, and has been identified as potential old growth through habitat screening and stand age assessment.

The first step for this secondary screening process is to visually screen these FRIS mapping units using aerial photography to assess if they contain old growth. The second step is to verify the plant association group (or PAG) to determine if there is a low site potential (slow growth conditions) on the site that would result in old trees with small diameters. The third step, where needed, is to calculate the Weighted Old Growth Habitat Index value for each individual sample plot within the FRIS mapping unit, and perform adjacency analysis on plots in bordering FRIS mapping units to determine the areas meeting the Weighted Old Growth Habitat Index threshold. This process will identify areas of potential old growth within and between the FRIS mapping units. Most of this secondary screening for the western Olympics has been completed. Based on this secondary screening process, there likely will be some adjustments to the acreage identified as old growth.

Old growth on DNR-managed lands in Eastern Washington

The Old Growth Definition Committee researched and field-tested the U.S. Forest Service Region 6 Interim Old Growth Definitions, and determined that they were inadequate for use on DNR-managed forests in Eastern Washington. DNR currently does not have sufficient data to develop a reference condition for old growth forests on the Eastside, nor does the agency currently have a methodology for defining or mapping these stands.

The issues surrounding old growth in Eastern Washington differ from those of Western Washington in many ways:

- Harvest and fire history on the east side of the Cascades has left a very different legacy than on the west side of the Cascades. Where Westside forest development historically proceeded as a result of natural disturbance (such as fire and wind events) that replaced entire stands, Eastside forest development was historically “gap-based”—that is, patches of trees die off as a result of root rot disease, insect infestation, and/or small scale low intensity fires, and are replaced, patch by patch, with younger cohorts of trees.

- Forest structure on the Eastside is affected by a more continental climate than the Westside. On the Eastside, dead, down woody debris does not persist for long periods of time on the forest floor; the trees are widely spaced, giving the stands a more open appearance; and large, legacy trees are scattered throughout stands of younger trees.
- Extensive field assessments will be required to establish an old growth reference condition to enable the development and application of a structural index such as the Weighted Old Growth Habitat Index for the Eastside. DNR plans to conduct the needed research and develop an old growth definition for Eastern Washington as a part of the sustainable harvest calculation for the Eastside.
- Eastside forests evolved with fire, and in the absence of fire, active management will be required to mimic fire-associated processes in order to develop and sustain old growth characteristics over time. In their current fire-suppressed state the stands are vulnerable to stand replacement fires—high intensity fires that kill nearly all the trees in the stand.

Interpretation of the Forest Resource Inventory System data

The sampling methodology used in the DNR Forest Resource Inventory System (FRIS) was not designed to locate stands of old growth on DNR-managed lands. It is important to recognize that errors may occur in applying FRIS within this context. Those forest stands identified by the Old Growth Definition Committee as potential old growth will require field verification.

The Old Growth Definition Committee identified issues connected with interpretation of the Forest Resource Inventory System data:

- **Stand Age –** The original Old Growth Habitat Index, developed by Dr. Tom Spies for western Oregon, used stand age as one of the stand components of the Index. The Old Growth Definition Committee chose not to use stand age for the Western Washington Index in part because FRIS estimates of stand age are not based on the actual age of the oldest trees. Given the nature of available data, the Weighted Old Growth Habitat Index provides a more reliable approach.
- **FRIS Mapping Unit Polygons –** In some cases, a FRIS mapping unit polygon (or forest stand) may include two or more stand age classes. When this occurs, the Weighted Old Growth Habitat Index component values from sample plots in the younger portion of the FRIS mapping unit may dilute the values contributed by plots in the older portion of the mapping unit. The resulting Index value may be lower than the threshold value of 60. To rectify this, a subset of stands with an Index lower than 60 has been identified for which secondary screening is necessary.

In some cases, the boundary of the FRIS mapping unit polygon may be placed along a stream, a road, or a ridge top and may divide an old growth stand into two separate polygons. In cases like these, the Index component values from sample plots in the old-growth portion of the FRIS mapping unit are diluted by the plots value in the younger portion of the mapping unit. The resulting mapping unit Weighted Old Growth Habitat Index value may be too low, giving no indication that there may be areas of old growth embedded within the two FRIS mapping unit polygons. Further analysis of the mapping unit using aerial photo review, site potential assessments or field verification will be necessary to identify these smaller areas of potential old growth.

- **Plant Association Groups** Most FRIS mapping unit polygons include information on plant association. This data has been grouped into Plant Association Groups (PAGs) to reflect ecological conditions, which define growing conditions. Some of these PAGs have abnormally wet, dry, or cold conditions that may result in old trees of smaller diameters. Because large diameter trees are a major component in the Index, the resulting score for these units may be below the threshold value, yet they might have the required structure to be considered old growth. Again, further analysis of the stand such as aerial photo review, site potential assessments, and field verification will be used to identify these units.

Potential errors using the Weighted Old Growth Habitat Index

The Weighted Old Growth Habitat Index evaluation is subject to at least two sources of error.

- First, there is variation in the characteristics sampled; therefore, the Index also is subject to variability. Sampling variation occurs in the characteristics comprising the Index; hence, the Index also is subject to these statistical variations.
- Second, FRIS was designed to sample site-specific data within designated mapping units. A mapping unit is described as a contiguous forest community that is sufficiently uniform in topography and vegetative characteristics to be distinguishable from adjacent communities. These mapping units are used to measure general site potential and vegetative characteristics. FRIS was not designed specifically to identify stands of old growth. Consequently, the stand population will have inclusions of tree groups not required in the committee’s definitions of old growth condition. Conversely, there may be inclusions of old growth tree groups within a stand where the vast majority of the trees are of a younger age and a less diverse condition.

Summary of potential old growth acreage on DNR-managed lands

Using the Old Growth Definition Committee's Weighted Old Growth Habitat Index, DNR FRIS inventory analysis estimates as much as 88,435 acres of potential old growth on DNR-managed forestlands in Western Washington. As previously stated, it was recommended by the Old Growth Definition Committee that these areas receive additional screening and field verification. Included in this acreage is old growth within Natural Area Preserves and Natural Resource Conservation Areas, which contribute to the objectives of DNR's Habitat Conservation Plan for state trust lands.

The legislative mandate ESHB 2573, section 905 required DNR to create tables describing "the number of acres of stands in each county, the department's administrative unit, and forest type."

Potential old growth acres within each Westside county

As previously stated, the 2004 legislative direction ESHB 2573, section 905 directed DNR to conduct an inventory of old growth on state lands as defined by a panel of scientists. This directive also required the inventory to include maps illustrating the distribution of old growth forest stands on state lands, and tables describing the number of acres of stands in each county.

As seen in Table 2.1, the majority of potential old growth is located within the Olympic Peninsula in the Olympic Experimental State Forest (OESF). This majority of the OESF is located in Clallam and Jefferson counties with 16,548 acres and 39,546 acres of high likelihood potential old growth and lower likelihood potential old growth, respectively. The third county containing the majority of the potential old growth is Snohomish County with 16,210 acres.

Table 2.1 Potential Old Growth (Acres) by Western Washington County
(All figures are estimates, subject to field verification)

County	High Likelihood Potential Old Growth (WOGHI = 60+)[1]	Lower Likelihood Potential Old Growth (WOGHI < 60)[2]	Total[3]
Clallam	1,414	15,134	16,548
Clark	26	0	26
Cowlitz	1,607	731	2,338
Grays Harbor	78	146	224
Jefferson	25,363	14,183	39,546
King	2,442	522	2,964
Lewis	53	546	599
Mason	0	12	12
Pacific	290	553	843
Pierce	0	38	38
San Juan	224	0	224
Skagit	3,358	510	3,868
Skamania	1,060	737	1,797
Snohomish	15,834	376	16,210
Thurston	265	33	298
Wahkiakum	0	263	263
Whatcom	653	1,984	2,637
Grand Total	52,666	35,769	88,435

1 Weighted Old Growth Habitat Index (WOGHI) score of 60 or more out of 100 has a high probability of being old growth. This includes stands aged 160 years or more, where the Index is not available.
2 Some stands with a WOGHI score less than 60 that may be old growth but need secondary screening.
3 Acres values are from Sustainable Harvest Implementation data set 2.

Potential old growth acres within each Westside forest type

The 2004 legislative direction ESHB 2573, section 905 also directed DNR to conduct an inventory of old growth on state lands and provide tables describing the number of acres of stands in each forest type. The Old Growth Definition Committee categorized these forest types into plant association groups (PAGs). However, the FRIS inventory does not include plant association data for all stands.

As seen in Table 2.2, the majority of potential old growth is located within the Western Hemlock/Douglas fir moist forest type that is predominantly located within the OESF. Total acreage of potential old growth in this forest type is 16,366 acres. The second largest forest type containing potential old growth is the Douglas fir/Western Hemlock drier Westside forest type located in the western Cascades and contains 13,112 acres. The third forest type containing the majority of the potential old growth is the Silver fir mesic forest, containing 9,836 acres.

Table 2.2 Old growth (acres) by Western Washington forest types
(All figures are estimates, subject to field verification)

Forest Type	High Likelihood Potential Old Growth (WOGHI = 60+)[1]	Lower likelihood Potential Old Growth (WOGHI < 60)[2]	Total[3]
Douglas-fir Western hemlock drier Westside forest	6,057	7,065	13,122
Grand fir moist east Cascades forest	0	21	21
Silver fir mesic forest	6,217	3,619	9,836
Sitka spruce Western hemlock coastal forest	748	7,642	8,390
Western hemlock/Douglas-fir moist forest	4,817	11,549	16,366
Western hemlock/Silver fir high elevation forest	536	613	1,149
Unknown – information not available [4]	34,291	5,260	39,512
Total	52,666	35,769	88,435

1 Washington Old Growth Habitat Index (WOGHI) score of 60 or more out of 100 has a high probability of being old growth. This includes stands aged 160 years or more, where the Index is not available.
2 Some stands with a WOGHI score less than 60 that may be old growth but need secondary screening.
3 Acres values are from Sustainable Harvest Implementation data set 2.
4 Forest Type is unknown where earlier inventory did not observe Plant Associations.

Potential old growth acres within each Westside Administrative Unit

The 2004 legislative direction ESHB 2573, section 905 also directed DNR to conduct an inventory of old growth on state lands and provide tables describing the number of acres of stands in each administrative unit. DNR has specified an “administrative unit” as an HCP Planning Unit.

As seen in Table 2.3 the majority of potential old growth is located within the OESF HCP Planning Unit with 55,705 acres of potential old growth. The HCP Planning Unit containing the second largest acreage of potential old growth is the North Puget HCP Planning Unit, which contains 25,309 acres of potential old growth. The remaining Westside HCP Planning Units contain a much smaller portion of the total potential old growth as identified using the Weighted Old Growth Habitat Index.

Table 2.3 Old growth (acres) by Western Washington Habitat Conservation Plan (HCP) Planning Unit (Administrative Unit)
(All figures are estimates, subject to field verification)

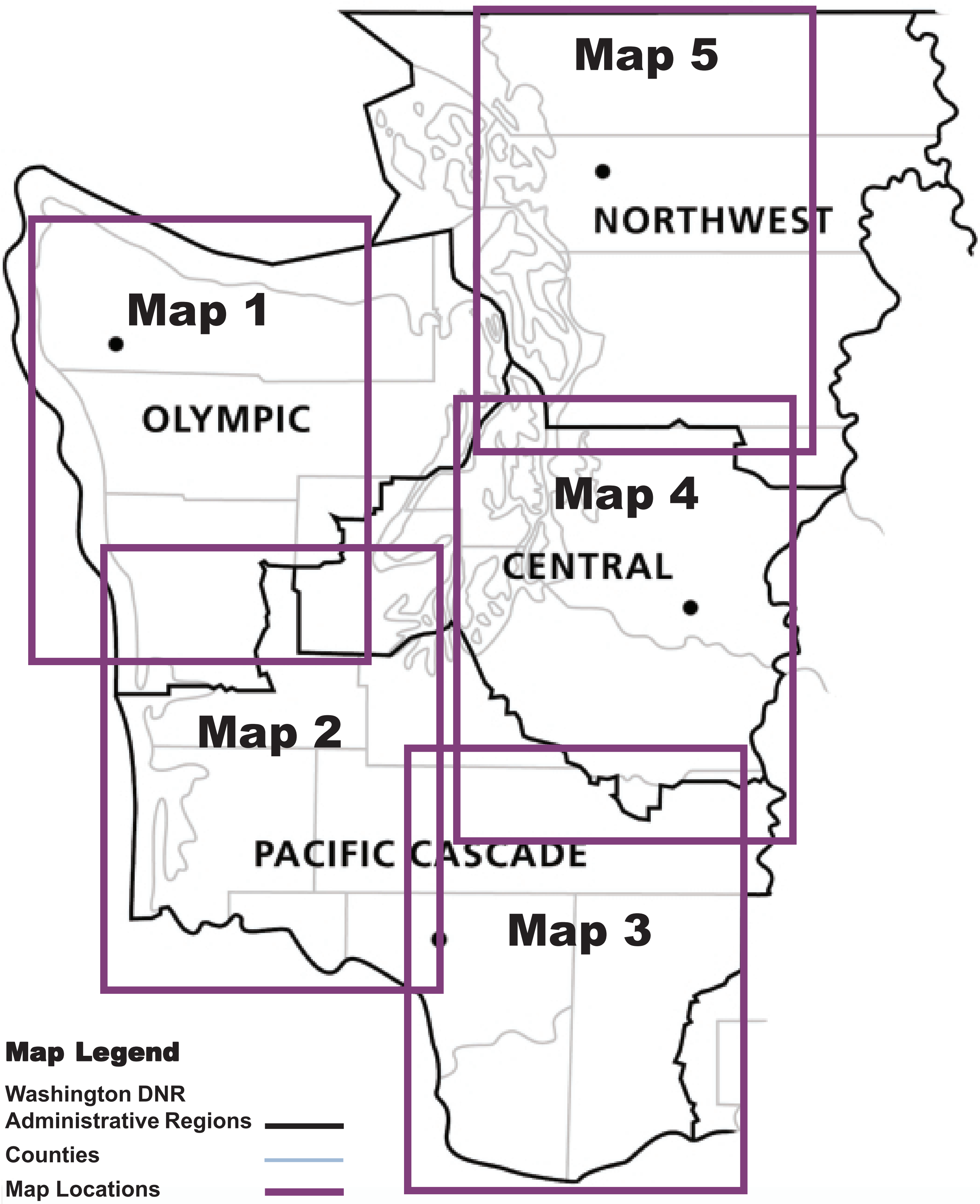
HCP Planning Unit	High Likelihood Potential Old Growth (WOGHI = 60+)[1]	Lower Likelihood Potential Old Growth (WOGHI < 60)[2]	Total[3]
Columbia	2,871	1,845	4,717
North Puget	21,977	3,332	25,309
OESF	26,695	29,011	55,705
South Coast	221	650	871
South Puget	820	613	1,433
Straits	82	318	400
Total	52,666	35,769	88,435

1 Washington Old Growth Habitat Index (WOGHI) score of 60 or more out of 100 has a high probability of being an old growth stand. This includes stands aged 160 years or more, where the Index is not available.
2 Some stands with a WOGHI score less than 60 that may be old growth but need secondary screening.
3 Acres values are from Sustainable Harvest Implementation data set 2.

Maps of old growth on Westside DNR-managed lands

The maps on the following pages show potential old growth, using the Index developed by the Old Growth Definition Committee.

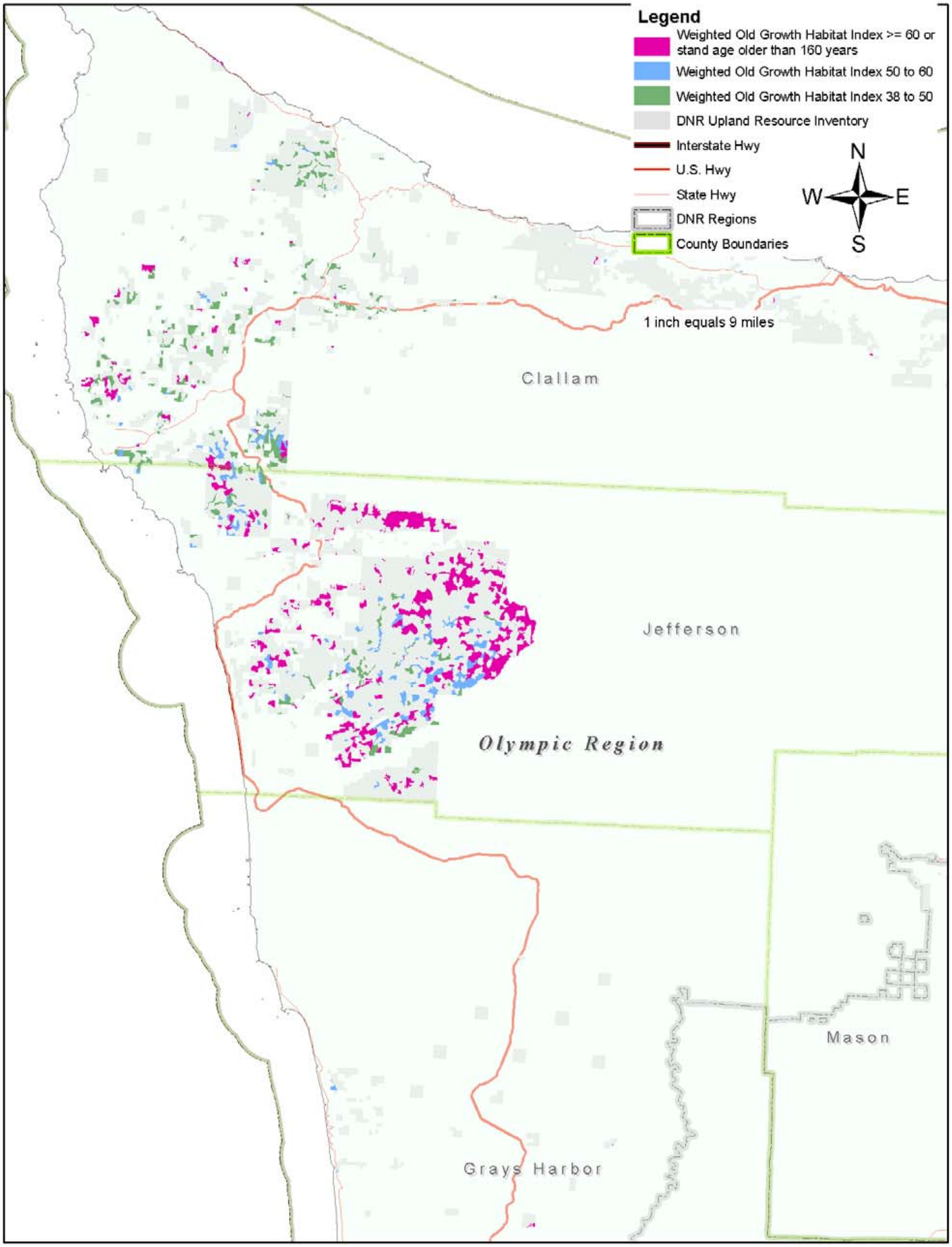
Old Growth Inventory on DNR-managed State Lands
Index Map for Maps Series



Old Growth Potential on DNR-managed Lands

Map 1

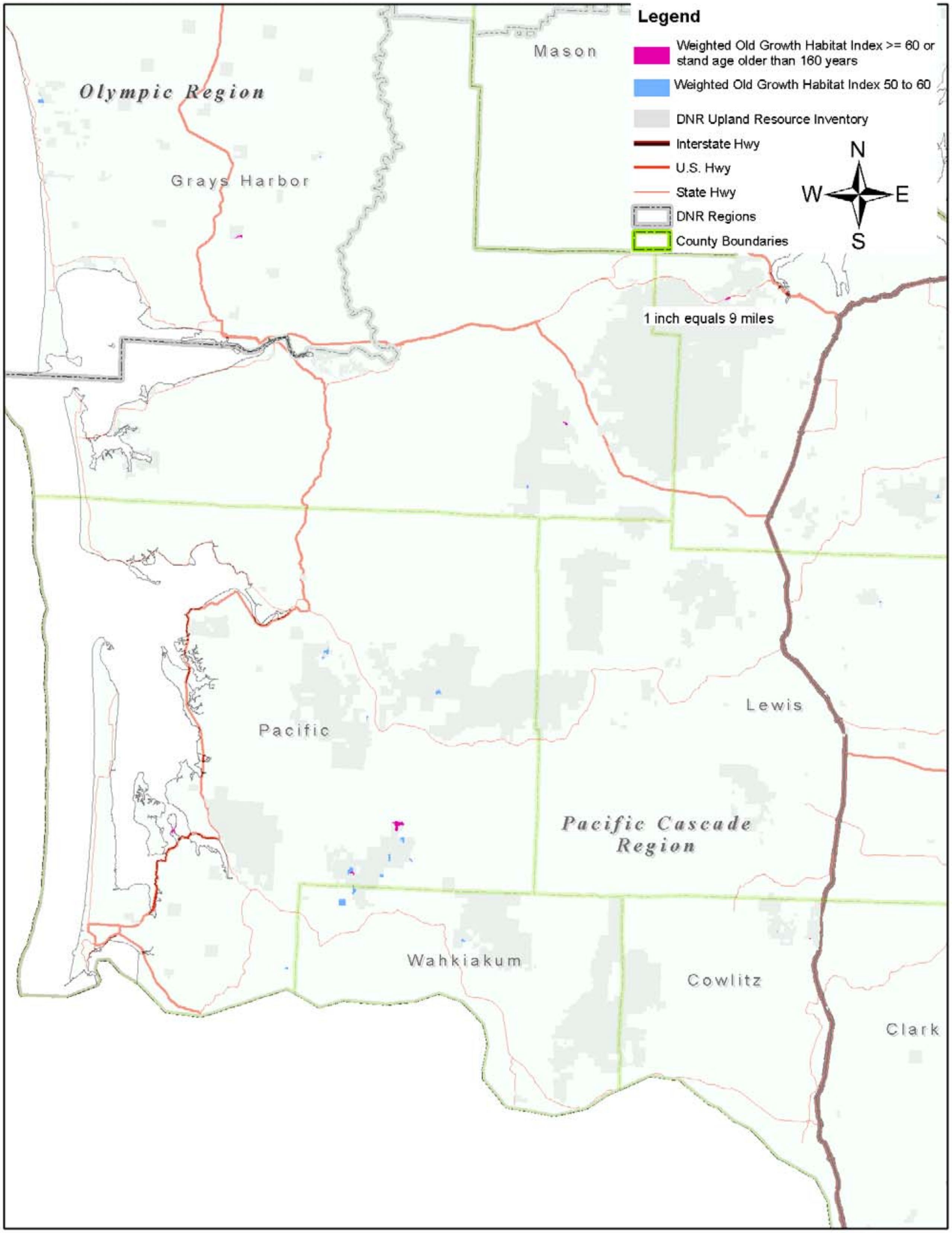
Using Weighted Old Growth Habitat Index, or stand age older than 160 years where the index value is not availiable



Map 2

Old Growth Potential on DNR-managed Lands

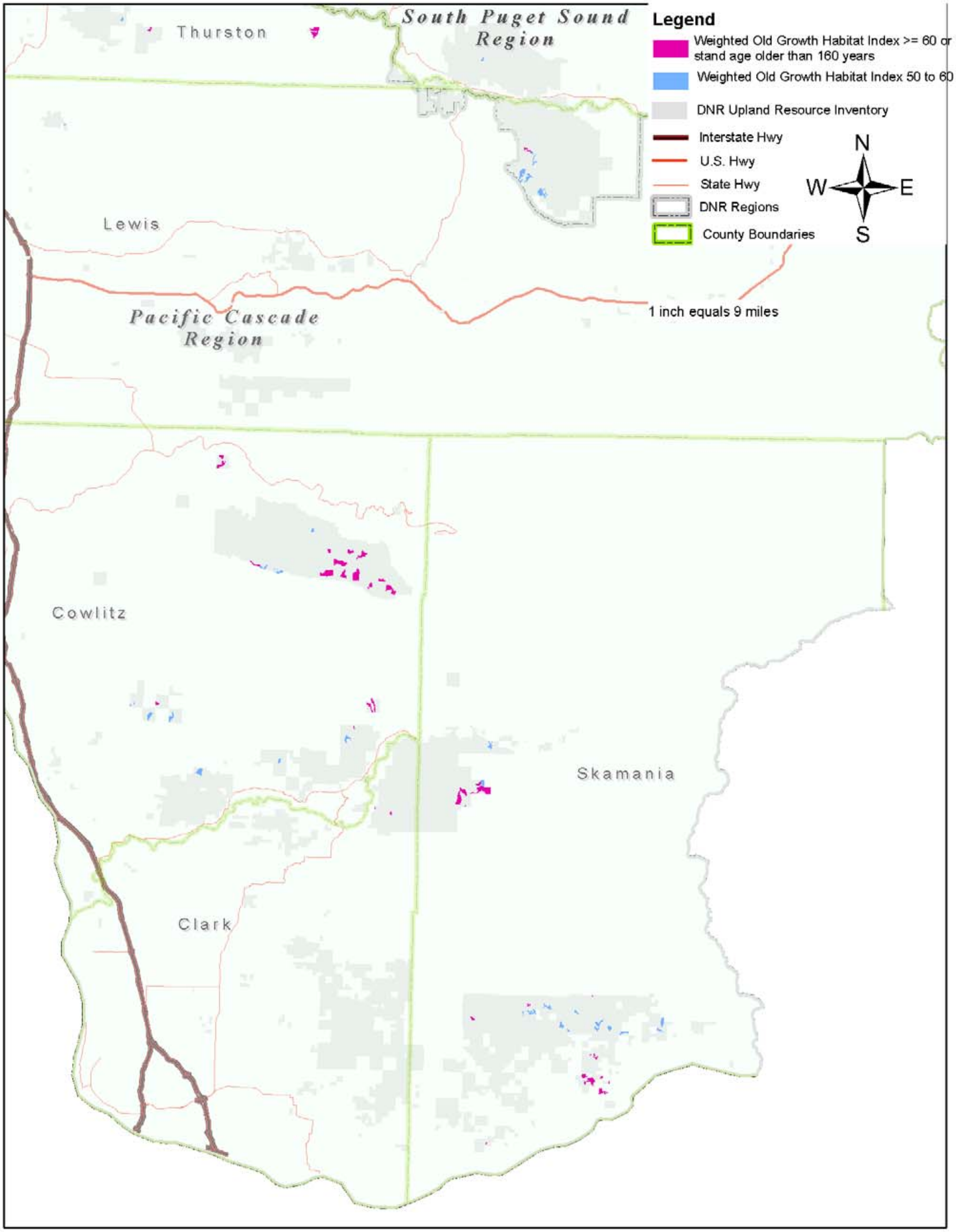
Using Weighted Old Growth Habitat Index, or stand age older than 160 years where the index value is not availiable



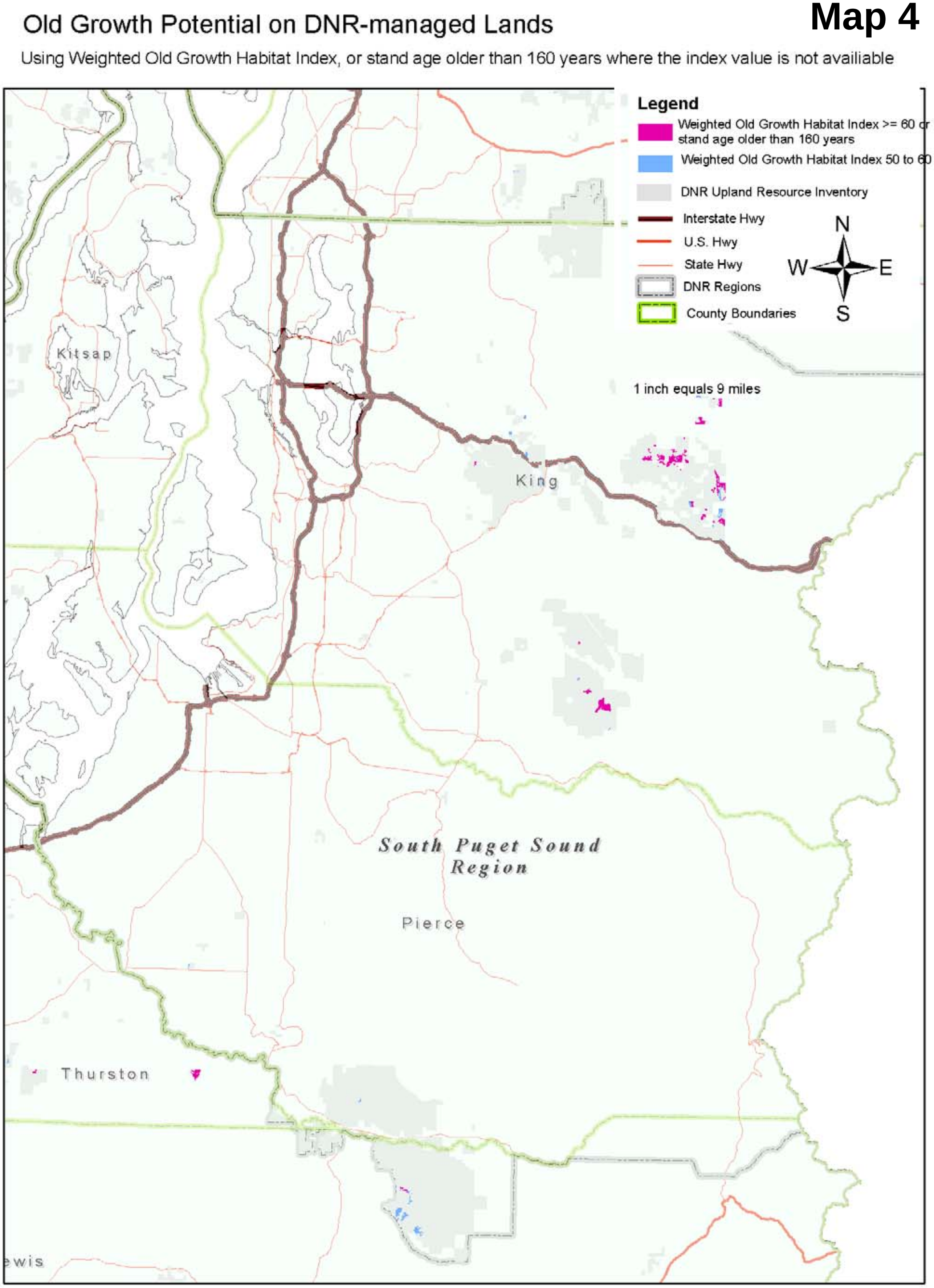
Map 3

Old Growth Potential on DNR-managed Lands

Using Weighted Old Growth Habitat Index, or stand age older than 160 years where the index value is not availiable



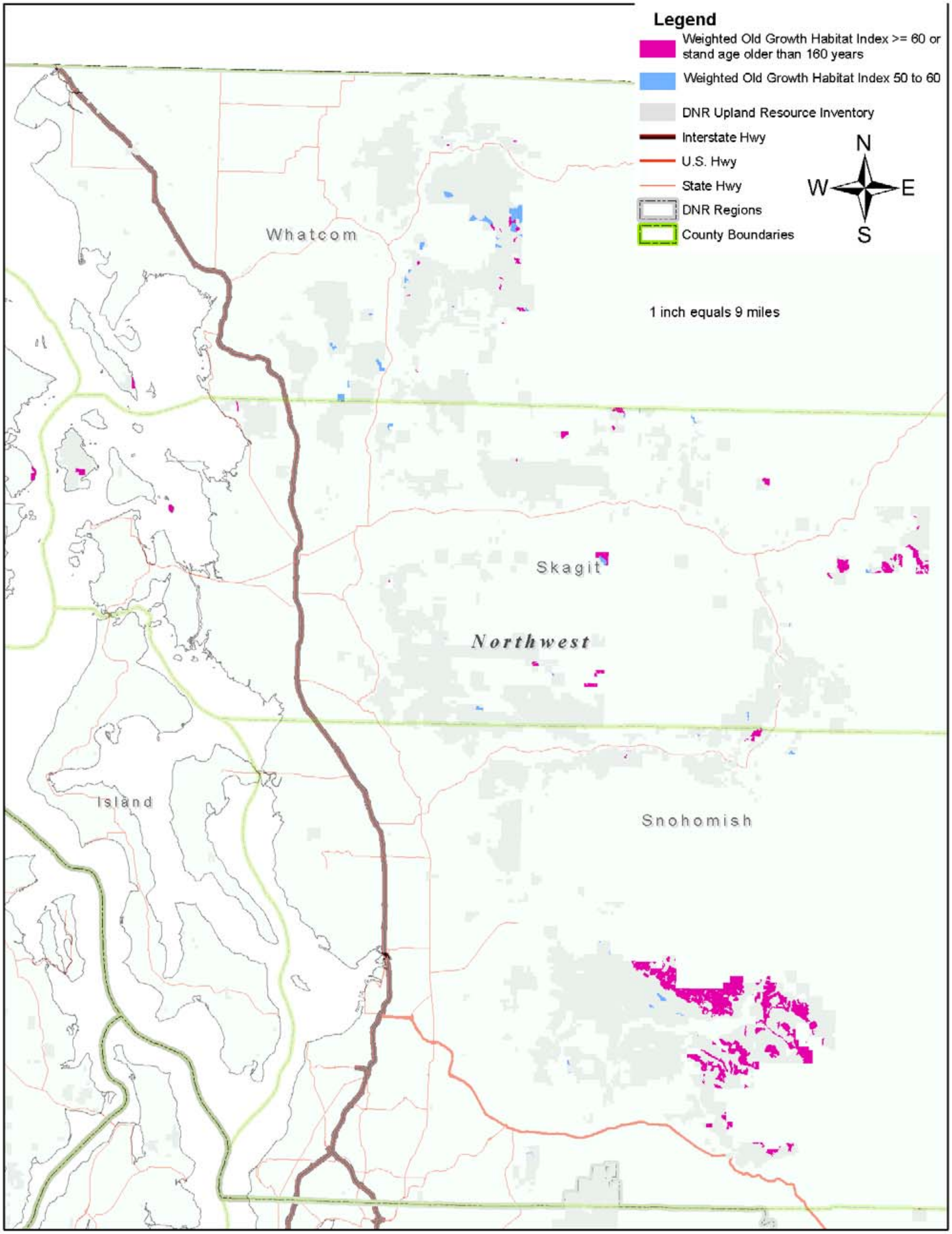
Map 4


Old Growth Potential on DNR-managed Lands
Using Weighted Old Growth Habitat Index, or stand age older than 160 years where the index value is not availiable
Legend
Weighted Old Growth Habitat Index >= 60 or stand age older than 160 years
Weighted Old Growth Habitat Index 50 to 60
DNR Upland Resource Inventory
Interstate Hwy
U.S. Hwy
State Hwy
DNR Regions
County Boundaries
N
W
E
S
1 inch equals 9 miles
Kitsap
King
South Puget Sound Region
Pierce
Thurston
ewis

Old Growth Potential on DNR-managed Lands

Map 5

Using Weighted Old Growth Habitat Index, or stand age older than 160 years where the index value is not availiable



Identifying Mature and Old Forests

IN WESTERN WASHINGTON

by Robert Van Pelt

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Acknowledgements

The need for this guide became apparent after the 2004 Legislature directed DNR to conduct an inventory of old-growth forest stands on state lands as defined by a panel of scientists. The product of that effort, *Definition and Inventory of Old Growth Forests on DNR-Managed State Lands* (2005), made it clear that it was important for field personnel to be able to identify with confidence mature and old-growth forests throughout western Washington.

It is essential to acknowledge the people I worked with on the Old Growth Definition Committee: Dr. Jerry F. Franklin, Dr. Thomas Spies, Dr. Paula Swedeen, Dr. Rex Crawford, Sabra Hull, Steve Curry, and Walt Obermeyer, all of whom contributed to the concepts which form the basis of this guide.

Many people reviewed the text during its various iterations, which greatly contributed to improvements in both readability and scientific content:

Richard Bigley
Angus Brodie
Chris Earle
Jerry Franklin
Keala Hagman
Sabra Hull
Arthur Jacobson
Andrew Larson
Corina Logan
Tami Miketa
Kyra Nourse
Walt Obermeyer
Jeff Ricklefs

Many thanks to the University of Washington College of Forest Resources for their contribution to the printing effort.

The layout and design of this guide was ably and beautifully conducted by Nancy Charbonneau and Jane Chavey of the DNR Communications Group.

Photos, maps, and drawings by author except where indicated otherwise.

Washington State Department of Natural Resources

This guide was produced under contract as part of the ongoing research and application of new information to inform both land management and resource protection goals of the department. The Washington State Department of Natural Resources manages 5 million acres of land - forests, farms, commercial properties and aquatic lands to provide perpetually for both revenue and conservation objectives for the people of Washington State.

Identifiying Mature and Old Forests in Western Washington will be a valuable tool for agency forestland managers and others interested in the complexities and ecological relationships that give rise to older forests. This guide will be used by the department to aid in the identification and protection of these unique forest structures.

Suggested Citation

Van Pelt, R. 2007. Identifying Mature and Old Forests in Western Washington. Washington State Department of Natural Resources, Olympia, WA. 104 p.

This guide was developed
to support management of
forested state trust lands.

Washington State
Department of Natural Resources
Land Management Divison
Ecosystem Services Section

June 2007

Identifying Mature and Old Forests

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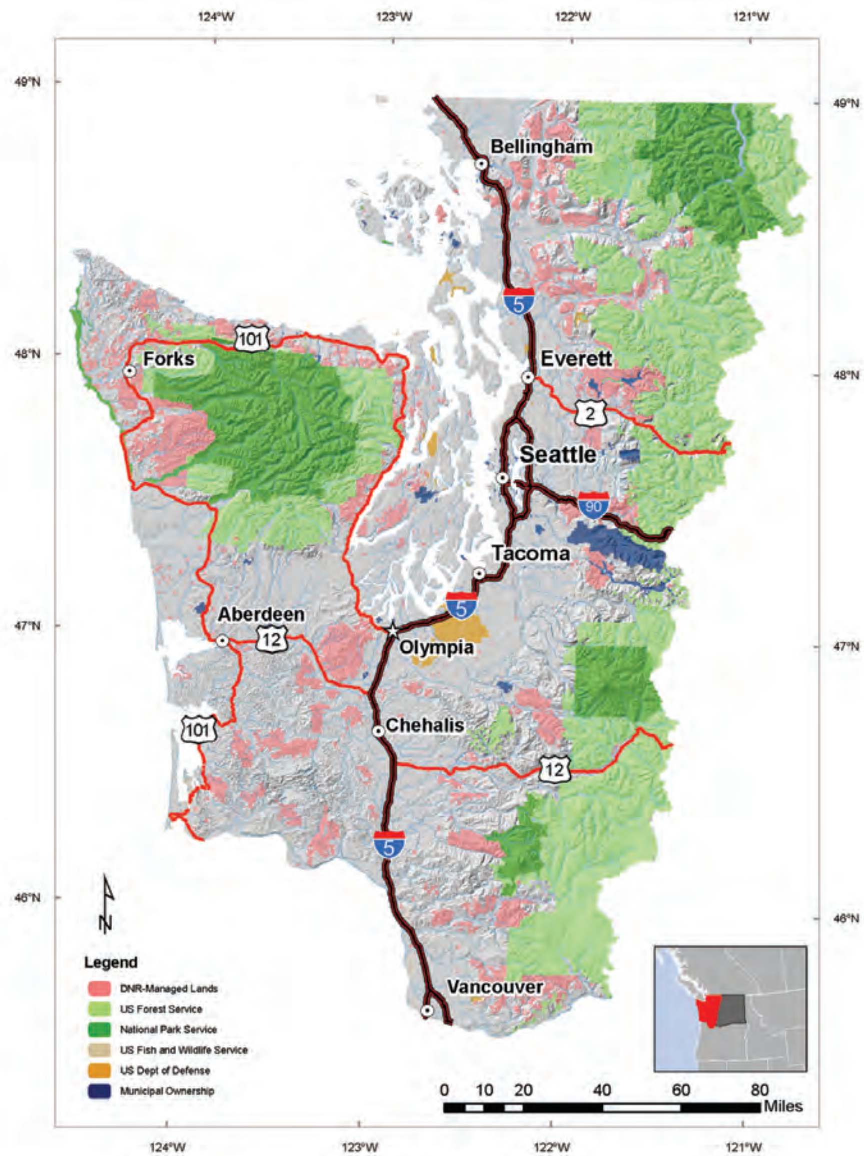
WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Table of Contents

Locator map of Western Washington with major public ownerships



Map developed by Jeff Rickleffs and Ned Wright, DNR

Introduction

Western Washington is part of the most heavily forested portion of the United States. Within this small region, a great diversity of environments can be found, ranging from the coastal rain forests of the Olympic Peninsula to the gravelly plains of the Puget lowlands and the glacier-clad peaks of the Cascade Mountains. Across this landscape, complex patterns of precipitation have resulted in a diversity of fire regimes. Despite this diversity, relatively few species of trees, primarily represented by long-lived conifers, are found within these forests.

Such varied environmental conditions can affect the physiology and appearance of the trees that occupy the region. The purpose of this guide is to help the reader interpret the ecology, disturbance history, and age of a given stand using features of the environment, including the physical characteristics of the trees themselves.

This guide is intended to provide much of the necessary information needed to reconstruct stand history and discern stand development stages for the major forest types found in western Washington. The great size achieved by many trees coupled with the heart rots common in western Washington makes the use of increment borers impractical in many forests. Assessing the age of a forest without specific knowledge of the ages of the trees contained within is an exercise in gathering and deciphering the relevant pieces of data. A working ecological understanding of the major tree species, the environments where they grow, and the dominant disturbance regimes at play in a given stand is required when making determinations of stand age.

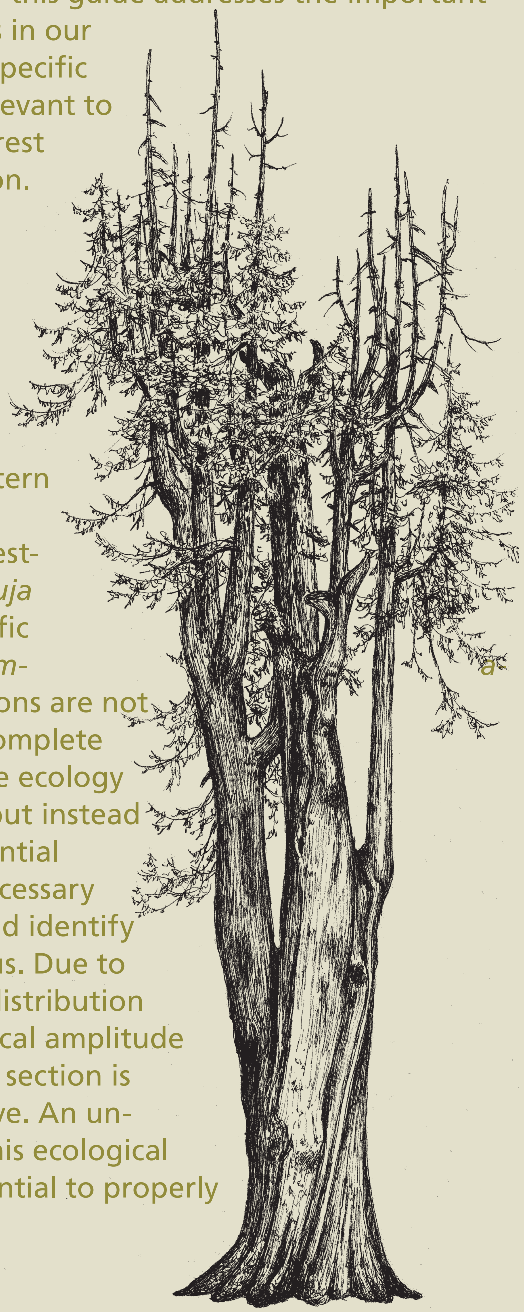
The scope of this guide will be limited to western Washington; a separate guide will cover eastern Washington.

Guide Organization

In order to identify mature and old forests, the great diversity of environments present in western Washington must be acknowledged. In addition, to discern age patterns in forests, one must understand a number of ecological concepts. Finally, the characteristics of the dominant species, important in the identification of mature and old forests, must be clearly understood.

This guide presents the general forces that drive the composition, structure, and the nature of western Washington forests. Physiographic and environmental gradients, fire and wind disturbance patterns, and the ecological characteristics of shade tolerance are discussed. An idealized model of forest stand development is presented in detail, applicable to most forests in western Washington. Variations of the model are also examined.

The latter part of this guide addresses the important individual species in our forests, and the specific characteristics relevant to discussions on forest age and succession. This includes sections on Douglas fir (*Pseudotsuga menziesii*), Sitka spruce (*Picea sitchensis)*, noble fir (*Abies procera*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), and Pacific silver fir (*Abies ambilis*). These sections are not intended to be complete discussions on the ecology of each species, but instead focus on the essential characteristics necessary to understand and identify successional status. Due to the widespread distribution and wide ecological amplitude of Douglas fir, its section is the most extensive. An understanding of this ecological amplitude is essential to properly



understand and discern stand development where Douglas fir occurs.

Several tree species are not specifically treated in this guide, including red alder (*Alnus rubra*), grand fir (*Abies grandis*), bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), mountain hemlock (*Tsuga mertensiana*), yellow cedar (*Cupressus nootkatensis),* and subalpine fir (*Abies lasiocarpa*). These species are mentioned in the text when appropriate, but a specific section on each was deemed unnecessary. While red alder is abundant at lower elevations in western Washington, and pure stands are not uncommon, it is rare to find specimens older than 100 years of age. Its usefulness in a guide on identifying mature and old forests is therefore limited.

Environmental Setting of Western Washington

Although it is the smallest of the western states (184,824 km^2), Washington is arguably the most diverse, encompassing nearly all of the major biological habitats found in the west. Annual precipitation ranges from 20 cm in the deserts of the Columbia Basin to 600 cm along the western flanks of Mount Olympus on the Olympic Peninsula. The Cascade Mountains divide the state into two regions: western Washington, with a strong maritime climatic influence; and eastern Washington, with a more continental climate. Near the Columbia Gorge, the boundary between eastern and western Washington is defined by the ridge between the Wind and Little White Salmon rivers. The total area is 66,824 km^2.

Western Washington lies on the edge of a large Mediterranean climate zone, centered on California. Mediterranean climates are characterized by warm, mild winters and hot, dry summers. While Washington is neither as hot nor as dry as California, the seasonal patterns are very similar. Throughout the entire region, including the coastal lowland rainforests, the summer months of July-September receive less than 5 percent of

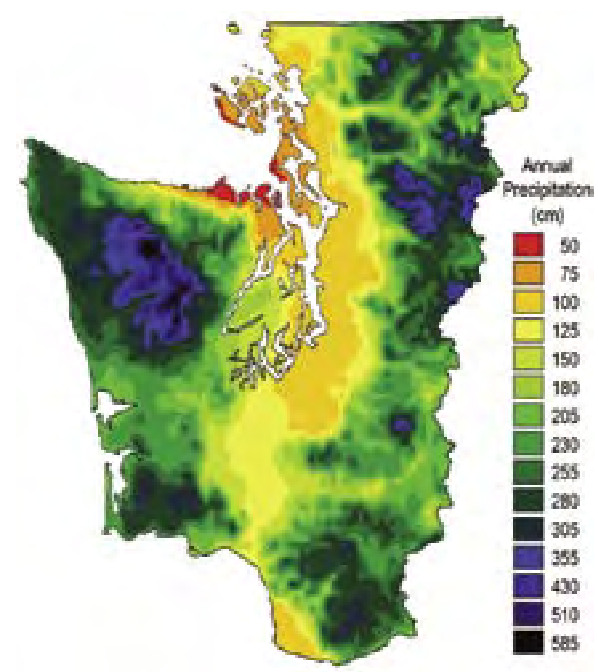


Figure 1. Annual Precipitation for Western Washington.

the total annual precipitation. Southwesterly oceanic storms are the primary source of precipitation for the region.

Western Washington contains a great diversity of habitats, from rain forests to alpine meadows and dry prairies. Along the northeastern, leeward side of the Olympic Mountains for example, a rain shadow is formed, parts of which receive only 43 cm of annual precipitation (Figure 1). Prior to the arrival of Euro-American settlers in the nineteenth century, all of western Washington was forested with the exception of 8.9 percent of the landscape above the alpine timberline and another 1.4 percent of non-forested prairies or wetlands

The dominance of evergreen conifers in the Pacific Northwest makes it unique among the temperate regions of the world. In all other temperate regions, including eastern North America, Europe, Asia, Australia, Chile, and New Zealand, conifers are relegated to early successional roles, limited to extreme habitats, or at best share dominance with flowering plants. Here, the opposite is true: flowering plants are relegated to early successional roles, as in the case of alders and cottonwoods, or limited to stressful habitats, as in the case of oaks and madronas. Prior to Euro-American settlement, more than 96 percent of the forests of western Washington were coniferous.

Physiographic regions are often used to divide areas by interrelated geology, physiography, soils, climate, and vegetation. Western Washington is usually

Figure 2. Physiographic Regions in Western Washington.
Background image courtesy of NASA

divided into six physiographic regions, each with distinct, definable characteristics (Figure 2). The **Olympic Peninsula** is surrounded on three sides by salt water, and contains the massive Olympic Mountains with extensive areas above 1700 meters. The **Willapa Hills** are the Washington extension of the Coast Ranges, which continue southward into Oregon. Both the Olympic Peninsula and Willapa Hills are exposed to oceanic storms, and as such, are the Northwest's wettest regions. In the lee of these two regions are the **Puget Trough** and **Cowlitz/Chehalis Valleys.** These two regions are characterized by low elevations and much drier conditions. The Puget Trough occupies the region once covered by several hundred meters of ice from the Cordilleran glaciers of the Pleistocene. To the east of these valleys lie the Cascade Mountains. Within Washington, the Cascade Mountains are broken into two very different sections. The **North Cascades** are steep, dramatic

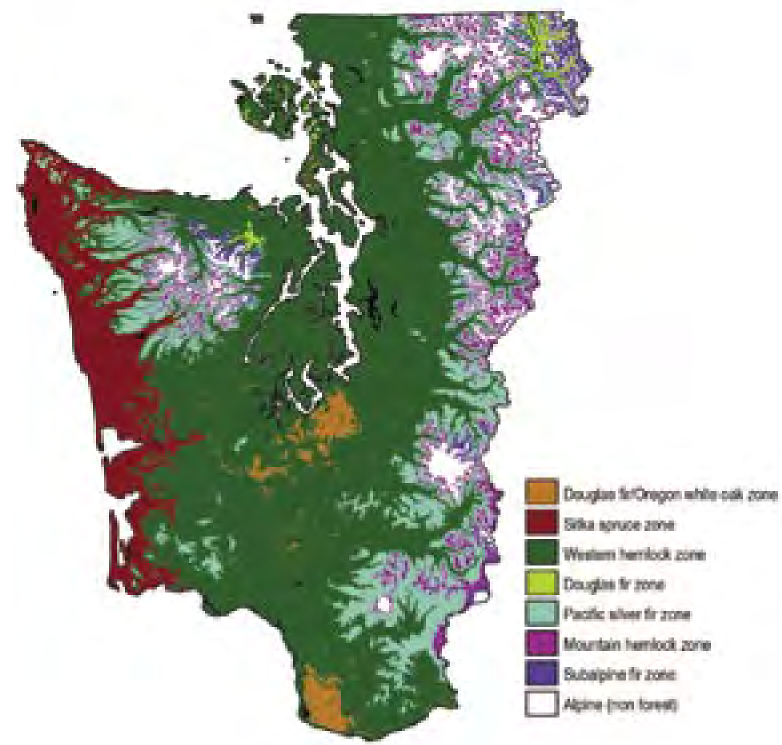


Figure 3. Vegetation Zones in Western Washington

mountains with complex geology. More than fifty glaciers coat the spires, peaks, and ridgelines of this mountainous landscape. In contrast, the **South Cascades** are characterized by low, forested ridges covering much older geologic features. Punctuating this ancient geologic landscape are three huge Quaternary volcanoes — Mount Rainier, Mount Adams, and Mount Saint Helens.

The steep, mountainous topography of western Washington has dramatic effects on precipitation and temperature. Accordingly, tree species have become stratified by their tolerance and competitive abilities. In **The Natural Vegetation of Oregon and Washington**, Franklin and Dyrness (1973) separate the region into vegetation zones based on the dominant tree species. Subsequent efforts by the USDA Forest Service and other agencies have further expanded and subdivided the vegetation zones into plant associations. Plant associations are groupings of plant species that recur on the landscape with particular environmental tolerances. They can be useful tools for predicting environmental conditions, site productivity, and response to forest management. In the simplest terms, western Washington can be divided into seven vegetation zones (Figure 3).

Key[1] to Vegetation Zones in Western Washington.

1.	Subalpine fir ≥ 10% cover	Subalpine fir zone
	Subalpine fir < 10% cover	2
2.	Mountain hemlock ≥ 10% cover	Mountain hemlock zone
	Mountain hemlock < 10% cover	3
3.	Pacific silver fir ≥ 10% cover	Pacific silver fir zone
	Pacific silver fir < 10% cover	4
4.	Sitka spruce ≥ 10% cover	Sitka spruce zone
	Sitka spruce < 10% cover	5
5.	Western hemlock present	Western hemlock zone
	Western hemlock absent	6
6.	Douglas fir and/or Oregon white oak present and below 200 m elevation	7
	Douglas fir present and above 200 m	Douglas fir zone
7.	Oregon ash present	Western hemlock zone
	Oregon ash absent	Douglas fir/Oregon white oak zone

[1]Each dichotomous key used in this guide consists of a series of paired descriptions, or couplets, describing a given forest stand. Beginning with the first couplet, read each description to determine which most appropriately describes the stand in question. At the end of each description you will find either a number, indicating the next couplet to examine, or a name, indicating the conclusion.

Figure 4. Mountain hemlock zone. Many picturesque timberline views in western Washington are framed by mountain hemlock — our high-elevation conifer found in the wettest and snowiest locations.

The **subalpine fir** and **mountain hemlock** zones include all of the upper treeline forests in our region. Most of the high-elevation forests in western Washington are very wet and snowy, and fall within the mountain hemlock zone (Figure 4). Only a small section of subalpine fir zone occurs in western Washington, most notably in the northeastern section of the Olympic Mountains where a significant rain shadow exists (Figure 5). The great width of the north Cascades also produces a large rain shadow near the Cascade crest where subalpine zone forests also occur.

Together, the **Pacific silver fir**, **Sitka spruce**, and **western hemlock zones** account for the majority of forested land in western Washington. These three zones are the primary focus of this guide. The Pacific silver fir zone occupies the mid- and upper montane zones of the Olympic and Cascade Mountains and the highest elevations of the Willapa Hills; the Sitka spruce zone occupies the outer coastal areas; the western hemlock zone occupies the remainder of the region.

A few exceptions are notable. Western hemlock, Pacific silver fir, and western redcedar are lacking in parts of the Puget Trough and the driest montane areas

Figure 5. Subalpine fir zone. Abundant as the dominant timberline tree in eastern Washington, in western Washington subalpine fir is mostly found where a significant rain shadow exists at high elevations, such as this scene in the northeastern Olympic Mountains.

of the rain shadows (Figure 6). Here, Douglas fir is the primary tree species and is also found uncharacteristically in the understory. These forests are included in the **Douglas fir zone** and are similar to many mid-montane forests in eastern Washington.

A seventh vegetation zone, the **Douglas fir/Oregon white oak zone**, is found in the excessively drained sands and gravels of southern Puget Sound and the Willamette Valley of Oregon. This zone is characterized by the presence of Oregon white oak (*Quercus garryana*), western Washington's most drought-tolerant tree (Figure 7). Douglas fir and Oregon white oak are found along the perimeter and scattered throughout the native prairies of the Puget lowlands, Chehalis, Cowlitz, and Willamette valleys.

Oregon white oak, with its bimodal ecological distribution, may also be found in wetlands. This key includes the Oregon ash/Oregon white oak wetland forests common in wetlands south of the Puget Sound. As an edaphic type within the larger western hemlock zone, they do not warrant their own zone.

Figure 6. Douglas fir zone. At low and mid-elevations in the rain shadow of the Olympic Mountains (see Figure 1), the Douglas fir zone occurs in the absence of western hemlock.

Figure 7. Douglas fir/Oregon white oak zone. Some of western Washington's only native prairies and oak savannas occur in the excessively drained soils of the south Puget Sound region. Limited occurrences of the Douglas fir/Oregon white oak zone are found within and around these prairies.

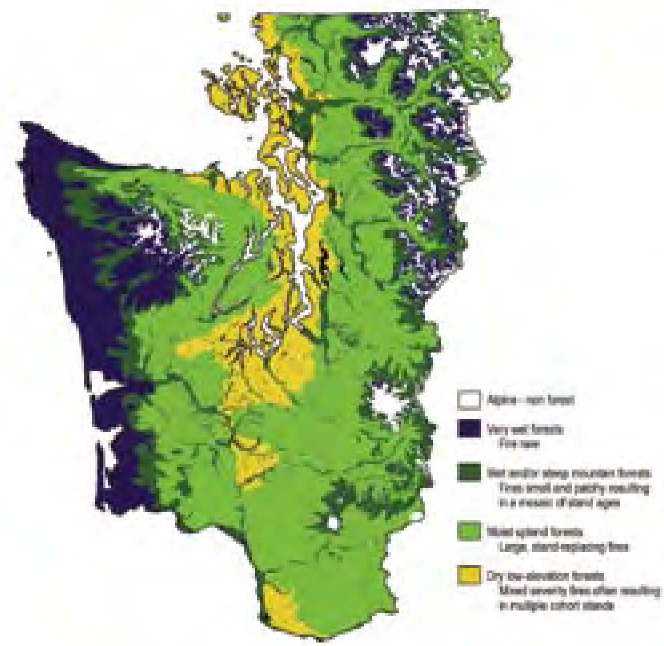


Figure 8. Pre-Euro-American settlement fire regimes in western Washington.

Fire in Western Washington Prior to Euro-American Settlement

Given the wide range in precipitation for western Washington, there is naturally a wide range in how fire has modified the environment over the centuries. Some areas near the coast or in the wettest spots in the mountains have had no fire for several thousands years. In other areas fire is common, serving to continually reset the successional clock. While the arrival of Euro-Americans in the region during the nineteenth century has had a tremendous impact on the forests of western Washington, Native Americans also modified the landscape with fire to a lesser degree. Because their occupation of the region goes back for thousands of years, however, it is difficult to distinguish between anthropogenic influences on vegetation patterns and the natural background patterns.

Figure 9. Ancient forest on the coastal plain in Olympic National Park near Lake Ozette. Western redcedar dominates the entire region with the exception of the dark-colored hills, which are populated by western hemlock.

For the period before Euro-American settlement, fire regimes in western Washington can be divided into four broad categories, based on fire frequency and severity (Figure 8). Ancient fire events may be dated by examining radioisotopes of carbon in the decay-resistant charcoal layers found in the soil. Fire is rare along the coast, as many areas show no evidence of fire for the past several thousand years. The stands located on the broad coastal plains of the Olympic Peninsula and Willapa Hills are composed primarily of western redcedar and western hemlock (Figure 9). Sitka spruce, red alder, and cascara are also common in places. While western hemlock is typically the most abundant tree species in these stands, it is short-lived in such warm, moist environments. Western hemlocks over 200 years old can be found, but invariably they have rotten centers and will not live to 300 years. In contrast, western redcedars over 1000 years old are not rare in these coastal plain forests. Some of these ancient trees are not very large, because, unlike the rich and productive soils of the nearby uplands, many areas of the coastal plain have heavily organic soils and productivity may be low (Figure 10).

Figure 10. Interior of an ancient cedar-hemlock stand near Forks. Even though the stand is ancient, the largest trees are less than 200 cm diameter. Photo: DNR/Steve Curry.

A lack of fire has also been detected in some areas of the Pacific silver fir and mountain hemlock zones. These cool, wet forests are composed of shade-tolerant species: mountain hemlock, western hemlock, Pacific silver fir, western redcedar, and yellow cedar. In the most closed sections of the forests, Pacific silver fir is usually the most abundant tree. Mountain hemlock and yellow cedar also become numerous at higher elevations near the upper tree line. The size and age records for western hemlock (290 cm diameter, > 1,238 years), mountain hemlock (189 cm diameter, > 924 years), Pacific silver fir (233 cm diameter, > 900 years), and yellow cedar (416 cm diameter, > 1,693 years) all come from these locations (Figure 11).

Although rare, fires do occur in these areas from time to time. A fire could easily start from a lightning strike along the coast during the drier summer months. Similarly, a fire burning in a river valley could travel upslope into the mountain hemlock zone during a dry year. Such fires tend to go out quickly or not burn very extensively.

Environmental Setting of Western Washington

Figure 11. The largest known western hemlocks grow in the cool, moist environments at high elevations with mountain hemlock and Pacific silver fir (pictured in the background). Here, the decay fungi, so aggressive at low elevations, are at a disadvantage.

Surrounding these areas are regions that are slightly less wet, including wetlands and floodplains nested within areas of more frequent fire (Figure 8). While these regions do have fire histories, fires are infrequent: fire return intervals are usually > 500 years. Fires in these regions are commonly small and patchy, typically spreading into this zone from adjacent, more fire-prone areas. The fires are commonly not self-sustaining and soon go out. Even so, they occur within the lifespan of Douglas fir. Most of these forests contain either a component of live Douglas fir established after a fire, or snags or logs that indicate a former presence of Douglas fir.

The bulk of western Washington is moist uplands, where large-scale, stand-replacing fires are the dominant force shaping the landscape (Figure 8). The forests created by stand-replacing fire events are the most widespread and most relevant to forestry in western Washington. This is detailed in a following section entitled *Stand development in natural Douglas fir forests.*

Since forests in the driest portions of the Puget Trough and Cowlitz and Chehalis valleys have largely been replaced or extensively modified by human developments of one sort or another, they are of limited interest in a guide to older forests. Nevertheless, fine examples of old forests still exist in these regions, such as at Point Defiance Park in Tacoma (Figure 12), Seward, Schmitz, and O.O. Denny parks in Seattle; Deception Pass State Park on Whidbey Island; and Moran State Park on Orcas Island. In these areas, charcoal is common on the bark of older Douglas fir trees, an indication they survived a previous fire event. Indeed, older stands throughout this zone consistently contain multiple age classes of Douglas fir.

Sections of this zone are much drier, located within the rain shadow of the coastal mountain ranges. As a result, stand densities, and the proportion of western hemlock and western redcedar is lower. Other sections of this zone have very dry forests resulting from the excessively-drained, gravely and sandy soils left behind by glaciers. Douglas fir is one of the most fire-tolerant trees in western Washington; with its thick bark it can often survive fires of low or moderate intensity.

Figure 12. Multiple age classes of Douglas fir trees within the same stand are common in the old forests within the Puget Trough. Point Definance Park in Tacoma has trees up to 240 cm in diameter with charcoal on the bark, yet also has large and old trees with none.

Figure 13. A section of the *21 blow* with no residual canopy trees. However, the dense hemlock understory quickly responded to the removal of the canopy to form a nearly pure hemlock stand 80 years later.

Wind Disturbances

Wind is the most prevalent disturbance type in forests close to the ocean. European explorers first reported stand-destroying windstorms along the Washington coast in 1788. Since then, a dozen other hurricane-force storms have hit the coast. The two strongest of these storms were the ***21 Blow*** of 1921 and the ***Columbus Day Storm*** of 1962, each with winds recorded in excess of 240 kilometers per hour. Both of these began as tropical typhoons that strayed into our region assisted by the jet stream.

Violent winds and fires disturb forests in very different ways. Trees that survive a fire are likely to be among the largest trees in the stand — those with high crowns or thick bark. In contrast, smaller trees have a greater chance of surviving a severe windstorm: understory trees are more prone to be crushed by falling trees than blown over.

On the other hand, taller trees usually remain standing in the more common windstorms that coastal forests experience approximately once a year. Because these trees are constantly buffeted by wind, they become wind firm. Thus in common storms, it is often the intermediate canopy trees that blow over. These trees tend to grow in sheltered conditions, and the wind protection they receive from their larger neighbors is usually sufficient for them to remain standing. They are therefore less wind firm than their taller neighbors.

Each tree species responds differently to wind. Forest surveys conducted after historic storms have shown that western hemlock and Pacific silver fir are much more likely to blow over than their larger associates. Both western hemlock and Pacific silver fir carry heavy amounts of foliage, making them more susceptible to wind. Ancient western redcedars are the least likely to blow over; their wide bases and often short stature serve to increase their stability.

Even though western Washington receives major storms at approximately 20 year intervals, 100 percent canopy removal within a wind-disturbed area is uncommon. Succession after a canopy-removing windstorm proceeds differently than after fire. In most cases, many of the trees that will form the new canopy are already in place in the understory (Figure 13).

Figure 14. A generalized view of leaf photosynthesis with increasing light levels. Peak photosynthetic efficiency occurs at the saturation point.

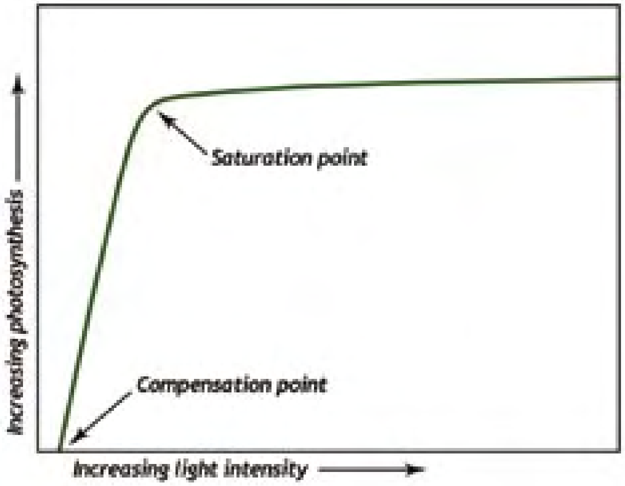


Figure 15. Leaf arrangement in response to light. The left photo is of a fully illuminated shoot from the top of a noble fir tree showing aggregated leaves and self-shading. The photo on the opposite page is a shaded shoot from the same stand with little self-shading and a very high SAR value (see page 26).

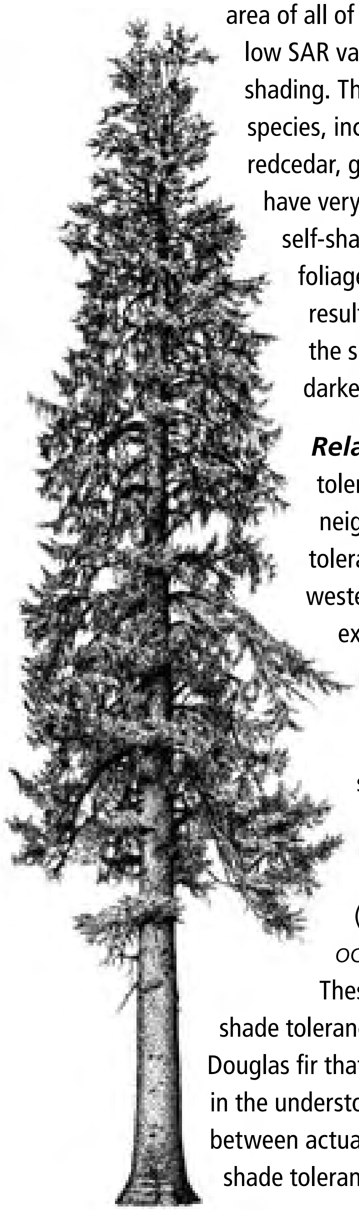
Important Information on Shade Tolerance

Shade tolerance can be thought of in two ways — actual and relative. ***Actual shade tolerance*** refers to the light level at which a tree can photosynthesize. At low light levels, photosynthesis may be insufficient to balance leaf respiration. With many trees, this balance, known as the ***compensation point*** (Figure 14), occurs at light levels of 2–3 percent of full sunlight. With light levels above this, photosynthesis increases nearly linearly up to a threshold, called the ***saturation point,*** at which peak photosynthetic efficiency occurs. Leaves cannot use all of the light from a fully illuminated position, so once the photosynthetic apparatus of the leaf is saturated, additional photons are converted to heat. Too much heat can be lethal to the leaf. Although the details will differ, the shape of this curve is common to all leaves.

Most trees, including our coniferous tree species, arrange their leaves differently around the stem under differing light conditions. For example, noble fir, a shade-intolerant species from subalpine forests of the south Cascades, displays dramatic differences in shoot morphology between those growing under fully sunlit

conditions and those found in the shade (Figure 15). Leaves at the top of the tree receive much more light than they can possibly use and aggregate their leaves to provide self-shading. The leaves are oriented in such a way that no individual leaf is fully illuminated. In contrast, leaves in the deep shade exist in lighting conditions well below their saturation point, so aggregation and self-shading would not be beneficial. Instead, heavily shaded leaves are often oriented so that there is maximum exposure to the few photons that do reach them — they minimize self-shading and orient themselves perpendicularly to the sun's rays to maximize light interception. In most of our old-growth forests, only 1–5 percent of light reaches the ground, and most of this arrives in the form of diffuse light. Many of our understory species, such as wood sorrel (*Oxalis oregana*) or vine maple (*Acer circinatum*), orient their leaves parallel to the ground to maximize exposure to the small amount of diffuse light.

Each species varies with respect to its ability to aggregate and disperse its leaf orientation. Pines, in general, lack the ability to orient their leaves perpendicularly to the sun's rays or to minimize self shading. As a result, leaves from pines cannot exist in low-light levels. Firs, in contrast, are quite adept in this regard. A common measure of the ability of a shoot to maximize exposure is known as the Silhouette Area Ratio (SAR). SAR is the ratio of the projected area of a shoot to the projected area of all of the leaves individually. Pines typically have low SAR values of 0.3–0.5, indicating a high level of self-shading. The shade shoots of our most shade-tolerant tree species, including western hemlock, Pacific silver fir, western redcedar, grand fir, and Pacific yew (*Taxus brevifolia*), can have very high SAR values (0.95–0.99), indicating almost no self-shading. Shade-tolerant species are thus able to hold foliage deeper into their crowns than other trees, often resulting in deeper, denser crowns. As a consequence, the shade cast by shade-tolerant trees is often much darker than that of their shade-intolerant associates.



Relative shade tolerance refers to the shade tolerance of one tree species when compared to its neighbors. Douglas fir, for example, is not shade tolerant at all when growing with western hemlock and western redcedar. In such cases, its foliage will only exist in areas with high light levels, which in an older forest will be the upper canopy. All of the lower canopy levels, including regenerating trees in the understory, will be occupied by the leaves of shade-tolerant tree species.

In eastern Washington, however, where Douglas fir commonly grows with ponderosa pine (*Pinus ponderosa*) and western larch (*Larix occidentalis*), it behaves as a shade tolerant species. These species of pine and larch have an even lower shade tolerance than Douglas fir. Thus, in these forests, it is the Douglas fir that occupies the lower canopy levels and regenerates in the understory. For these reasons, it is important to distinguish between actual and relative shade-tolerance when discussing the shade tolerance of tree species.

Stand Development in Natural Douglas Fir Forests

The stand developmental sequence as presented in Franklin et al. (2002) provides an introduction to the concept of forest disturbance and succession. This developmental sequence, while simplistic, was the most common in the forests of western Washington prior to Euro-American settlement and provides a useful framework when considering the many divergent scenarios.

Disturbance and legacy creation

The first stage in a developmental sequence is the disturbance itself. For the purposes of this simplified discussion, disturbances are limited to stand-replacing events that allow a new cohort of trees to establish. In our region, the three primary stand-replacing disturbance events are crown fire, catastrophic blowdown, and timber harvest. While the canopy of the previous stand is removed under each of these scenarios, in most respects these disturbances are very different from each other.

Figure 16. Aftermath of a catastrophic wildfire. Note that besides killing the trees, the fire did not consume much wood. The trees were alive and thus full of water. Subsequent fires, if they occur, will burn up much of this wood.

Figure 17. Living legacies. Survivors after a catastrophic wildfire are often found in drainages or other moist areas. These surviving trees are the primary seed sources for the next stand.

Figure 18. Blow-down. All of the organic matter from the killed trees — leaves, branches, stems, and roots — remain on the site. Some of the under-story trees will survive to make up part of the next stand.
Photo: Jerry Franklin

Crown fires will kill the previous stand of trees, but will often only consume a small proportion of the total wood from the previous stand. Landscapes destroyed by wildfire are often a sea of snags in a post-fire condition (Figure 16). Individual trees in stream drainages or other wet or protected areas will often survive even

Stand Development in Natural Douglas Fir Forests

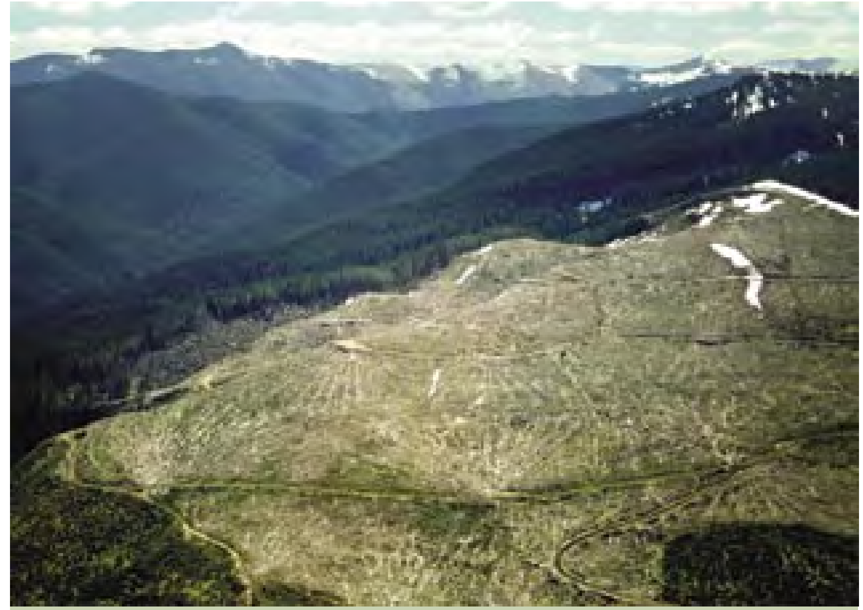


Figure 19. Clearcutting was the dominant silvicultural technique used through most of western Washington's timber harvest history and is the origin of many of today's stands. Apart from the stumps, foliage, and small branches, little organic matter remains in this large industrial clearcut. Modern silvicultureal techniques recognize the value of retaining live trees, snags and logs (biological legacies).

severe fire events (Figure 17). The individuals that manage to survive are typically the larger trees, as the smaller individuals are more susceptible. Individual large trees that have survived the fire, as well as snags and logs on the forest floor, are termed ***biological legacies.***

Catastrophic windstorms, in contrast, leave virtually all of the organic matter from the previous forest (Figure 18). This disturbance type tends to work from the top down, blowing over the canopy trees. Survivors from large wind events are often the small understory trees that were not crushed by falling trees. This cohort of surviving understory trees is usually the source of canopy trees for the subsequent stand, which differs from other developmental sequences in that it consists primarily of shade-tolerant species. In western Washington, this disturbance type is most common in coastal areas.

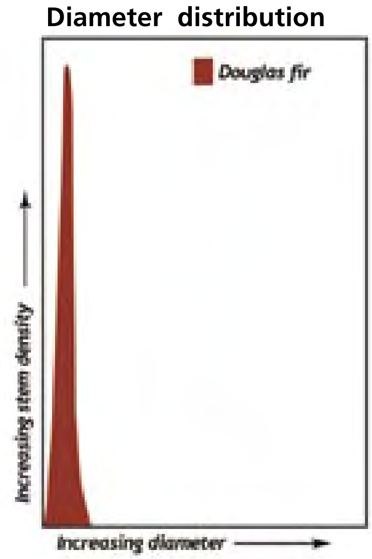
Figure 20

Cohort Establishment

After Wildfire

After Blowdown

After Clearcutting



Although it is only one harvest technique of several employed in modern silvicultural management, clearcutting was the dominant harvesting technique practiced in western Washington for many decades. As such, it constitutes an important part of the disturbance history of many post-Euro-American settlement stands. Traditional clearcutting leaves very little from the previous stand—no live trees and very few, if any, snags. The few logs that remain tend to be heavily decayed or small in diameter (Figure 19). During the late nineteenth and early twentieth centuries, these areas were allowed to reseed themselves naturally from surrounding forested areas. Since the 1960s,

Figure 21. The Yacolt Burn. The view from Lookout Mountain into the headwaters of the East Fork Lewis River shows areas that have burned as many as four times since 1902. Some areas still do not support trees.

clearcut harvest units have generally been replanted within a year or two after harvest. Stands resulting from natural reseeding are patchier and may take longer (in places) to reach canopy closure.

Cohort establishment

Cohort establishment is the initiation of a new set of trees that forms the basis of a future forest (Figure 20). Conditions for cohort establishment following a fire vary tremendously between sites, depending on the extent and severity of the fire. Very large fires may leave limited seed sources with which to repopulate the area. Smaller fires will not usually create this problem. Even stands subject to very large fires can regenerate quickly if there is a small but diffuse population of surviving

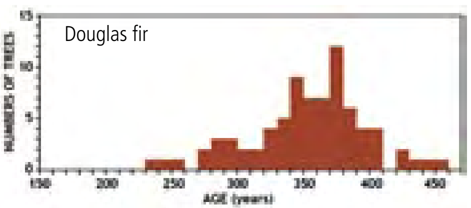
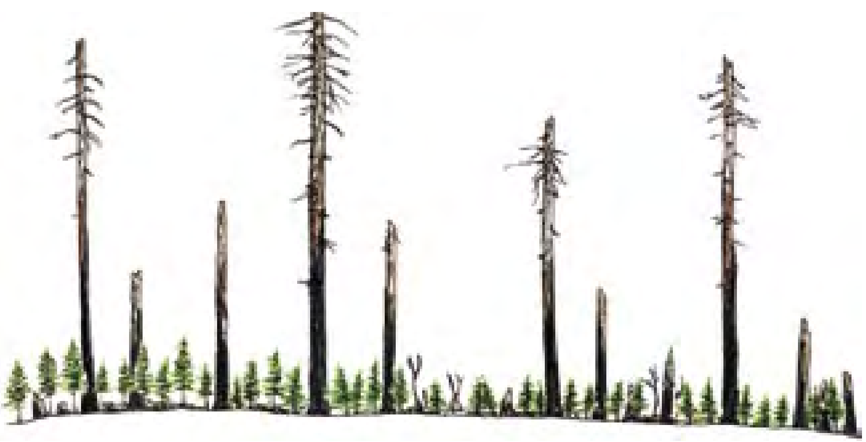
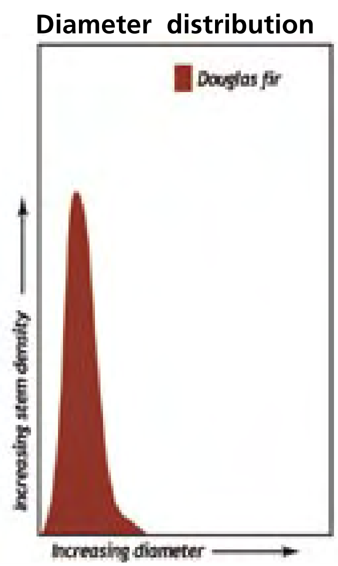


Figure 22. Diameter distribution of trees in the old-growth forest at the Wind River Experimental Forest in the south Cascades. Note the wide age range of the canopy dominants. Modified from Franklin and Waring 1980.

Figure 23
Canopy Closure





trees. The 1902 Yacolt Burn, one of the largest recorded fires in western Washington, regenerated very quickly.

Repeat disturbances, such as subsequent fires, confound regeneration on several levels:

1. The few surviving trees that were seed sources may be killed.
2. The dense crop of newly regenerating trees will most likely be killed.
3. More of the biological legacies and residual organic matter will be consumed.

Indeed, all of these processes will commonly take place in areas that burn repeatedly. For the sake of simplicity, and to develop the concept of stand development, this section will only examine in detail the scenario in which the initiating disturbance is wildfire, as depicted in the upper panel of figure 20.

Large sections of the Yacolt Burn did re-burn. Indeed, some areas experienced as many as four fires during the first half of the twentieth century. 100 years later, some of these areas still have not fully regenerated (Figure 21). This scenario was probably not unusual in western Washington prior to Euro-American settlement, particularly in the south Cascades. With witness records of this burn and all of the subsequent fires, we are able to discern the different age classes and their boundaries. As time passes, however, the slight differences in ages between neighboring cohorts become increasingly difficult to distinguish. In addition, as the stand ages, fewer individuals from the original cohort remain. After several centuries, only a small selection of trees remains from the various disturbance and succession events. In the distant future, an examination of trees in stands that originated from multiple fires might only indicate that the dominant canopy trees have a wide age range.

This may have been the case in the old-growth forest that was consumed by the Yacolt Burn. An examination of the old forests adjacent to the Yacolt Burn at the Wind River Experimental

Figure 24
Biomass Accumulation/Competitive Exclusion

Forest shows this pattern of a wide variety of age classes in the dominant canopy trees (Figure 22). After several centuries it is difficult to tell whether this pattern was created by multiple fires or by a single, vast fire followed by slow colonization. The nearby situation of the Yacolt Burn may provide important clues.

Canopy closure

Canopy closure between two trees occurs when the two crowns begin to touch. While this can take place within a single growing season, at the stand level it may take decades, as determined by the initial spacing of the young trees (Figure 23). Modern planting methods attempt to minimize the time for this process to occur, but natural processes are much more irregular. Natural colonization is random, and at times aggregated. In these situations, canopy closure may occur in one spot decades before it does only a short distance away. Large piles of woody debris, competition from dense shrub layers, or exposed soils can all create situations that delay tree seedling establishment.

More dramatic environmental changes occur during this stage than in any other. During this relatively brief period, the area goes from open to closed canopy

Stand Development in Natural Douglas Fir Forests

— from full sun to deep shade. Near the ground surface, temperature becomes highly moderated, and relative humidity increases. Many plant species, adapted to growing in the high-light environment of the early-colonizing stand, may perish in the deep shade imposed by the overlapping tree-crowns.

Biomass accumulation/ Competitive exclusion

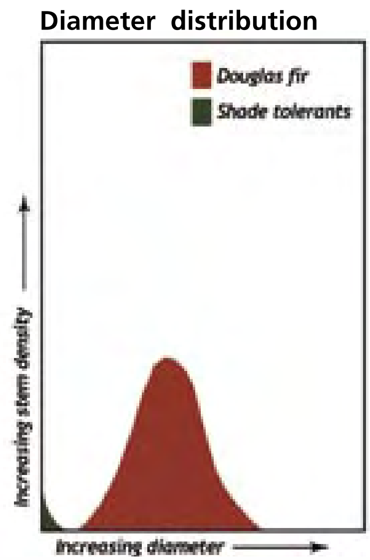
For several decades following canopy closure, until the stand reaches maturity, it will be in the biomass accumulation/competitive exclusion stage (Figure 24). In western Washington, this may take 30-40 years on highly productive sites such as in the Willapa Hills, or nearly 100 years on poorer sites in the Cascades.

At this stage, it is characteristic for a site to be completely dominated by trees. The trees can grow rapidly, converting a shrub field of tiny trees into a tall forest. Standing biomass increases by many orders of magnitude, yet recruitment of new individuals is limited due to the deep shade at the forest floor. Depending on initial stem densities, density-dependant mortality will also be prevalent during this stage. If the initial stocking of trees was high, many of the thinner/shorter stems will be overtopped and perish. If, however, the initial stocking was low, this type of mortality may be limited. These dead, small-diameter trees can often be quite abundant, depending on initial stocking levels, and appear to be strewn about like jackstraws. Small-diameter logs and snags decay very rapidly and contribute little habitat value to species that require coarse woody debris.

As the trees grow taller, many shade-intolerant tree species (such as Douglas fir) will shed their lower branches as they die in the deep shade cast by branches above them. Crown depths may not change appreciably during these several decades. Crown bases will rise at the same rate as height increases, leaving bare trunks below the living crown.

Figure 25

Maturation I: Pre-Euro-American settlement



The forest understory is at its most depauperate level during this stage. Deep shade is ubiquitous due to a dense, upper canopy layer. It is common for such stands to have only a thin layer of mosses with widely scattered shade-tolerant understory plants.

Maturation I: Forests originating after Euro-American settlement

At maturity, trees have reached 60-70 percent of their ultimate height. Further height growth proceeds more slowly than it did in the earlier stages of development. Mortality of the slower-growing, overtopped trees continues, as does the height differentiation of the remaining dominant trees (Figure 25). Since taller trees move more in the wind, the crowns of adjacent trees occasionally bump into each other, causing twig breakage at the branch tips. Tree crowns become more individualized to their own space, rather than intermingling with neighboring trees as they did when younger.

All of these factors combine to make the canopy less dense and to allow more light to reach the ground surface. While still very dark, the increased light levels

Figure 26. The Bole Zone. Below the main canopy and above the understory vegetation is a section with no leaves — just the trunks of canopy trees.

in the understory soon reach the point at which shade-tolerant plants can begin to grow, including tree species such as western hemlock. The rates at which new plants colonize the understory will naturally depend on many factors, including the proximity of seed sources. If the initial disturbance was very extensive, hemlock seedlings may not colonize for many decades, even if conditions are favorable.

The middle canopy will be completely free of foliage, and will consist only of the trunks of canopy trees (Figure 26). This area, known as the ***bole zone,*** is most dramatic at this stage.

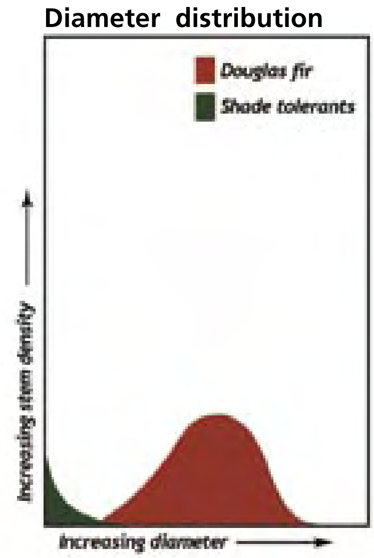
Maturation II: Forests originating before Euro-American settlement

Approximately 80-90 percent of the height growth of the stand is completed by this stage. This is the last stage at which trees exhibit the pointed tops characteristic of juvenile stands (Figure 27, Figure 28). The spatial, competition-based mortality process that was dominant up to this point now shifts to a mortality process driven by fungi, wind, and insects. Of these agents, fungi are the more important in western Washington. Decay from root and stem rots becomes

Figure 27

Maturation II: Pre-Euro-American settlement

Figure 28. View of the top of the canopy of a 160 year-old stand in the south Cascades. Note the model-conforming tops of a stand still growing in height.



the dominant mortality agent from this stage forward. While wind is an important component of mortality near the coast, many mortality events that may at first appear to be uprooting or stem-snap caused by wind are instead the result of trees already significantly weakened by decay fungi.

At this stage, the understory is often fully recovered and remains so for all subsequent stages. Hemlock and other shade-tolerant tree regeneration, depending on seed source availability, is often quite abundant. The amount of woody debris in the stand is at a minimum during this stage: most of the wood left over after the initial disturbance has decayed, and the current stand has yet to produce woody debris of a significant diameter.

The bole zone begins to be repopulated with foliage from a new source, epicormic branches (Figure 29). Epicormic branches start from dormant buds on the cambium, not from terminal buds. These often occur at old branch wounds or other places where the bark is very thin. Whereas the original branch died due to low light levels, the surrounding stand continues to grow and change, allowing more light into lower levels of the canopy. An epicormic branch may form and expand into this new light environment. A more detailed discussion of this phenomenon is found in the section on Douglas fir (Page 45).

Vertical diversification

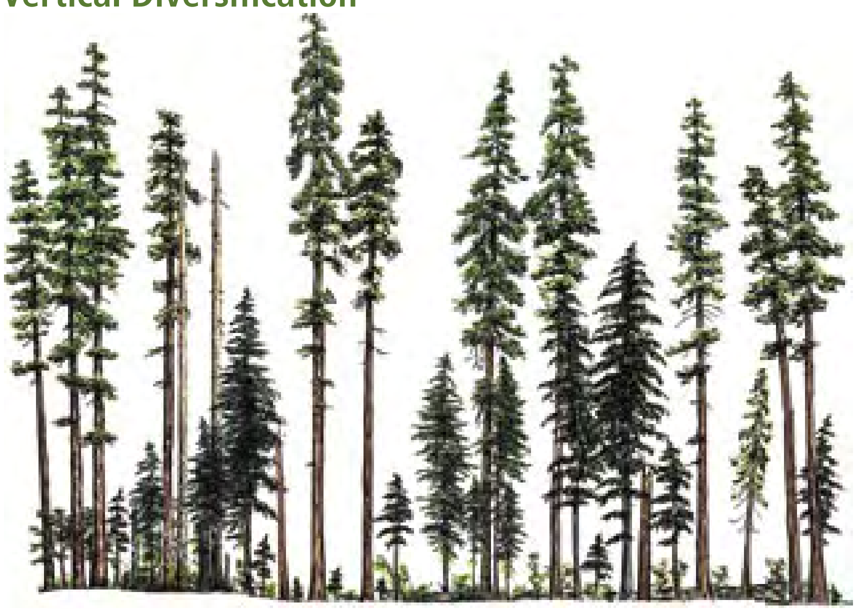
Vertical diversification is the first stage of old-growth. The shade-tolerant trees are now continuously establishing in the understory and have expanded to occupy the areas below the crowns of the main Douglas fir canopy (Figure 30).

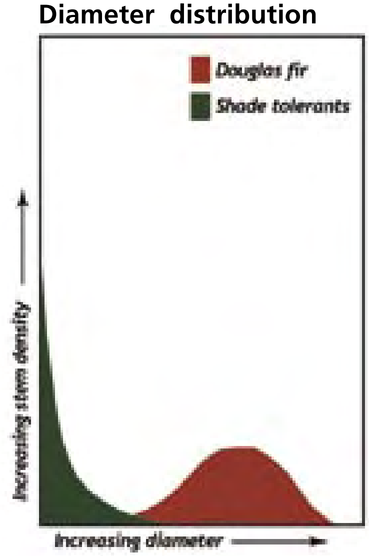
Epicormic branching is found on many of the canopy trees, effectively lowering their crown bases (Figure 31). This crown deepening permits trees of the main canopy to greatly increase the amount of foliage they carry, thus allowing for

Figure 29. Epicormic branching. Branches can form below the main crown at old branch wounds when light levels increase in that section of the stem.

Figure 30

Vertical Diversification





Stand Development in Natural Douglas Fir Forests

Figure 31. Crown deepening through epicormic branching.

increased growth. Height growth, however, proceeds very slowly; most of this new growth goes into wood production and below-ground processes. Many of the Douglas firs in the main canopy become very large during this stage.

Mortality will continue as decay and other agents kill occasional trees. The snags and logs produced during this stage, however, are now large enough to have a significant lifespan and begin to accumulate.

Horizontal diversification

Decadence of the Douglas fir canopy continues, with significant mortality events centered on large individual trees. Many of these large trees will die standing; others will fall, often taking one or several smaller neighboring trees down with them. The gaps created by the dead trees open up the understory to higher light levels and increased nutrient availability. This pattern of gap formation, followed by infilling from trees in the understory, creates the horizontal diversification of this stage in stand development (Figure 32). In addition, mortality is higher near pre-existing gaps; gap expansion accentuates this horizontal variability. Sections of the stand are still dominated by large Douglas firs, and older gaps may now contain dense regions of hemlock regeneration.

In western Washington, this stage often begins when the stand is between about

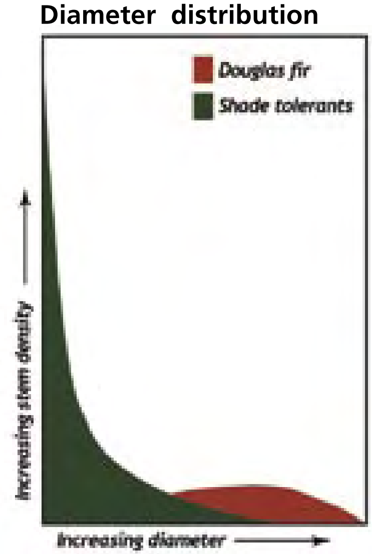
Figure 32
Horizontal Diversification

300 and 400 years old, depending on site location and productivity. This is the classic stage of old-growth forest that comes to mind for many people: towering Douglas firs with hemlocks present in all size classes, from juveniles to large canopy trees (Figure 33). Since Douglas fir can easily live for 600-800 years, and occasionally 1,000-1,300 years, this stage may last for many centuries.

Pioneer cohort loss

The final stage of stand development begins when the last of the Douglas firs dies. At this point, none of the trees in any of the canopy levels originated immediately after the initial disturbance (Figure 34). The structural presence of the giant Douglas firs extends for several centuries after the last tree dies: snags can last for a century or more, and logs are often still recognizable for several centuries.

The word climax is often used to describe forests dominated by western hemlock and western redcedar and falsely implies an endpoint to forest succession. The phrase is discouraged by many ecologists, as it represents an idea, not reality. Succession does not stop when it reaches this point. The term steady-state more aptly describes this condition and implies variation within a final equilibrium. Even

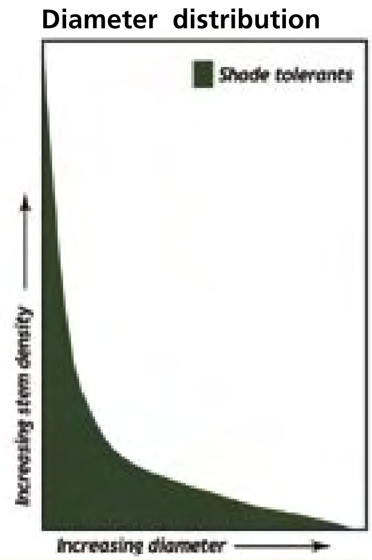


this term, however, has short-comings given the long lifespan of some trees (> 1000 years). At this time scale, the climate itself is continually changing. A stable condition in one millennium will be different during the next—even if the same species are present.

This final stage of the stand developmental sequence is rarely ever reached. It is likely that some event will occur to divert a forest from this developmental trajectory. The most common is another catastrophic wildfire, which serves to reset the developmental sequence to the beginning.

Figure 34

Pioneer Cohort Loss



Other scenarios

The idealized situation presented above, while not uncommon, has countless variations. For example, the catastrophic wildfire scenario assumes that all of the biological legacies are dead. Even in the Yacolt Burn, trees survived in ravines and around the edges of the burn. In wetter environments, such as the Willapa Hills, western Olympics, or North Cascades, the likelihood increases that a stand-replacing fire will not kill every tree. Even though current belief suggests that wetter forests exist in a stand-replacing fire regime, the chances are high that *some* trees will survive as living biological legacies.

At the drier end of the spectrum, such as sections of the Puget Trough located within a rain shadow, the chances that individual trees will survive a fire are also high. Low stand densities combined with the presence of thin and dry soils allows some trees to survive with only minimal charring. A newly developing stand containing a few surviving trees from the previous stand would be described as an even-aged stand with surviving biological legacies. If enough trees survive, the subsequent stand would be termed a two-cohort stand. Fire boundaries are sometimes fairly abrupt, the result of a landscape feature capable of stopping a

fire, such as a ridgetop or a stream crossing. In most situations, however, the boundaries will be a gradual change from a burned to an unburned area. The edge environment in these situations is termed a ***feathered edge.*** As a new cohort of trees develops following this type of disturbance, several different stand structures will be present over a relatively short distance (Figure 35). At one end of a feathered edge will be an even-aged stand, followed by an even-aged stand with biological legacies. In the central portion of the feathered edge will be a two-cohort stand, then an old forest with a minor underburn, and finally an unburned forest.

Figure 35. A feathered edge. On the right side is an unburned old-growth forest, and on the left is an 80 year-old stand. The boundary between the two stand types is very irregular.

Key to Stand Development Stages in Western Washington for Western hemlock, Sitka spruce, and Pacific silver fir zones.

While this key has been tested in a wide variety of stands in western Washington, there may exist stands that do not key out properly. In these situations, relax the percentage values slightly and retry.

1. Cut stumps present throughout stand 2
   No cut stumps. . . . . Natural forest*. 3

2. Stumps cut by chain saw (short stumps – planted seedlings) 3
   Stumps cut by hand saw (tall stumps, springboard notches – naturally reseeded) 3

3. Legacy trees – trees considerably older/larger than the others, or a subset of trees with charcoal on bark present. 4
   No legacy trees 6

4. Legacy trees < than 20 % canopy cover. . . . . . . Stand with legacies 6**
   Legacy trees ≥ 20 % canopy cover . . . . Two cohort stand 5

5. Each cohort must be keyed out separately
   Older cohort 10
   Younger cohort 6

6. Douglas fir (live or dead) ≥ 25 % of main canopy stems 7
   Douglas fir < 25 % of main canopy stems 15

7. Young, planted Douglas fir trees < 10 years old. **Cohort establishment phase**
   Not as above 8

8. Young, planted Douglas fir trees 5-20 years old, abundant shrub cover . . . . **Canopy closure**
   Not as above 9

9. Douglas fir trees, not yet overhead, overlapping crowns, shrubs present ≥ 15 % . . . . **Canopy closure**
   Not as above 10

10. Douglas fir canopy overhead, self pruning, scant understory . . . . **Biomass accumulation/stem exclusion**
    Not as above 11

11. Douglas fir overhead, self pruning; western hemlock, western redcedar, or Pacific silver fir present only in understory . . . . **Maturation I—Forests originating after Euro-American settlement*****
    Not as above 12

12. Douglas fir overhead, epicormic branches present, western hemlock, western redcedar, or Pacific silver fir seedlings, saplings, or small poles present, yet no main canopy trees . . . .
    Maturation II — Forests originating before Euro-American settlement***
    Not as above 13

13. Douglas fir upper canopy, western hemlock, western redcedar, or Pacific silver fir abundant and in many height classes, including main canopy . . . . **Vertical diversification**
    Not as above 14

14. Douglas fir canopy patchy, large canopy gaps present, western hemlock, western redcedar, or Pacific silver fir abundant in all canopy levels . . . . **Horizontal diversification**
    All Douglas fir trees dead (snags or logs), western hemlock, western redcedar, or Pacific silver fir abundant in all canopy levels . . . . . **Pioneer cohort loss**

15. Sitka spruce, noble fir, or red alder ≥ 25 % of main canopy stems . . . . **use steps 7-14, replacing Douglas fir with Sitka spruce, noble fir, or red alder**
    Sitka spruce, noble fir, or red alder < 25 % of main canopy stems . . . . **use steps 7-14, replacing Douglas fir for western hemlock, western redcedar, and Pacific silver fir collectively******

* Certain areas in the Puget Basin were cleared of stumps during the early days of Euro–American settlement. While very few of these cleared areas have been reconverted to forests, the occasional stand may be encountered.

** For Douglas fir legacies, see the Rating System for Aging Legacy Trees on page 64. For Sitka spruce, western hemlock, or western redcedar legacies, use visual indicators under their individual sections.

*** Key was written in 2007. While stands keying out to Maturation I and II will be valid in any year, their relation to Euro-American settlement will not.

**** The horizontal diversification stage in this sequence is equivalent to the pioneer cohort loss stage of both the Douglas fir and Sitka spruce sequences.

Figure 33. Classic old-growth. Interior of a 600+ year old stand near Mount Saint Helens showing a diversity of tree sizes and spatial heterogeneity.

Douglas fir (*Pseudotsuga menziesii*)

Douglas fir is the largest and tallest member of the pine family. Living trees have been documented up to 485 cm in diameter, up to 99.4 m tall, and with volumes up to 349 m^3. Even larger and taller trees once existed in western Washington. It is also the most widespread of all western trees. It can be found growing from southern Mexico to central British Columbia (a distance of 5,000 km) and from Colorado to the coast (another 1,600 km). Even in western Washington, it grows in all but the wettest locations – anywhere with a fire history (Figure 36). Throughout much of its native range in the Rocky Mountains, it has high relative shade-tolerance, capable

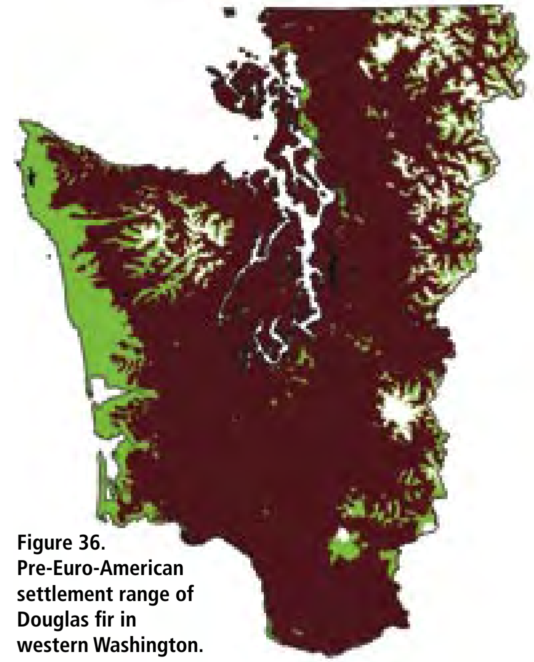


Figure 36. Pre-Euro-American settlement range of Douglas fir in western Washington.

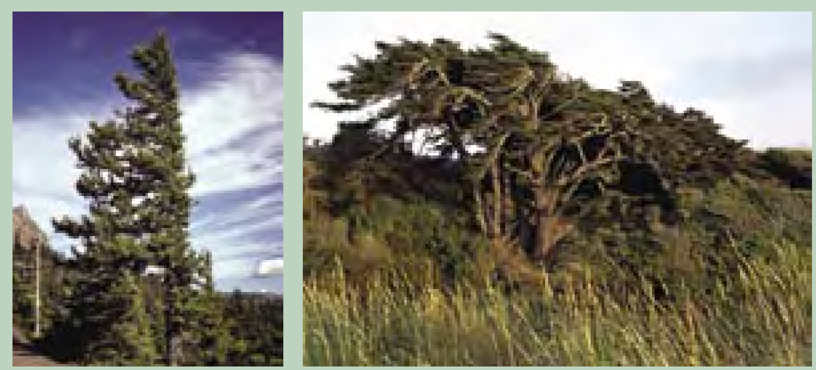


Figure 37. Left: Windswept Douglas fir at 1500 m near timberline on Hurricane Ridge in Olympic National Park. **Right: Windswept Douglas fir at sea level** at Point Wilson near Port Townsend

of regenerating in the understory of other tree species (primarily pines). This subspecies is called *Pseudotsuga menziesii glauca*. The coast form, which grows from Vancouver Island south into the Sierra Nevada of California, is subspecies *menziesii*. This subspecies behaves largely as a long-lived pioneer tree, due in part to the tree species with which it is found growing, and the higher productivity and denser forests found along the coast,.

This great adaptability is well displayed in the forests of western Washington. It can be found windswept, growing at 1,500 m elevation along the eastern ridges in Olympic National Park, and just a few kilometers away, windswept again, along the shores of the Straits of Juan de Fuca (Figure 37).

A generalist species, Douglas fir grows in a wide range of habitats and assumes a wide range of identities. Like many tree species, size and age are poorly correlated in Douglas fir. It can become a large tree in just a few decades, or grow for centuries and still remain small (Figure 38).

The wood of Douglas fir is considered intermediate in terms of decay resistance. Species such as western redcedar or coast redwood (*Sequoia sempervirens*)

Figure 38. Poor correlation between size and age in Douglas fir. Left: 80 year-old tree growing on a productive site in the Willapa Hills is already 130 cm in diameter. Right: 400 year-old trees on a poor site in the south Cascades. Center tree is only 61 cm in diameter.

are far more decay resistant, while Sitka spruce or western hemlock are far less resistant. Decay resistance helps this species live to great age; trees 600-800 years old are not uncommon in certain parts of its range with long fire return intervals. Trees 1,000 years or older have been recorded from several parts of its range, including several individuals between 1,300 and 1,400 years old.

Certain characteristics of Douglas fir change predictably during its lifespan, including bark characteristics, epicormic branching in the lower crown, and tree shape and crown form. The next sections will examine these in detail.

Bark characteristics

Douglas fir is probably the most fire-resistant of all the trees native to western Washington, due largely to the protective bark that it develops as it ages. Old trees have very coarse and rugged bark, which occasionally can reach a thickness of 35 cm. The thin bark of young trees begins to thicken and develop vertical fissures as trees mature. For the first 100-200 years, the bark is hard and boney, and usually brown to gray (Figure 39). At some locations within western Washington, crustose lichens or mosses may adorn the bark at this stage. This is the most common

Figure 39. Bark of two trees from the south Cascades. Left: 100 years. Right: 150 Years

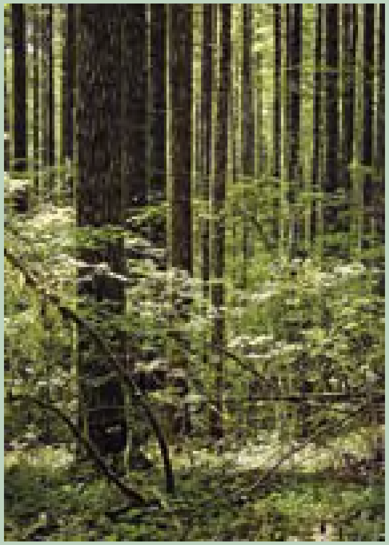


Figure 40. The 1902 Yacolt Burn stand. The hard, boney bark of the densely-stocked stand is evident. Crustose and fruticose lichens adorn the bark.

Figure 41. A 170 year-old stand in the Hoh Rain Forest. Trees are very large for their age, but still have the hard bark of a mature stand. Mosses, rather than lichens, grow on the bark.

condition of many of our second-growth forests, whether they developed naturally or following harvest (Figure 40). Even on productive sites, where Douglas fir trees can become very large at maturity, the characteristic younger bark appearance remains (Figure 41).

It is often difficult to assess the ages of trees in late maturity and in the vertical diversification phase. At the stand level, all of the characteristics of an old-growth forest may be present, including large trees, logs, snags, and a diversity of canopy heights within the western hemlock community (Figures 42 and 43). With the exception of the forest floor bryophytes, all of the green in Figure 42 is hemlock foliage, even though the view of trunks is completely dominated by Douglas fir. These trees are 55-70 m tall, and they have very little foliage below 30 m. Even these large Douglas firs share many characteristics with younger trees, including crown characteristics and youthful bark. The colorful, flakey bark of older trees begins to appear near the tree base, which is what people quickly see when walk-

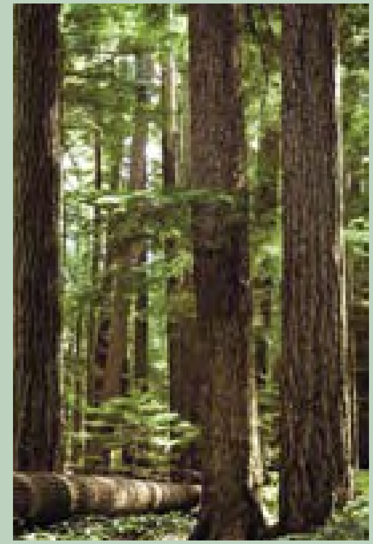


Figure 42. A 280 year-old stand at Mount Rainier National Park. The bark is becoming more colorful and flaky near the base of the tree, but branch wounds are still evident.

Figure 43. A 330 year-old stand in the south Cascades. Colorful, flaky bark extends up the stem; branch wounds no longer evident. Tree in front center is a western hemlock.

ing around in such a forest. An inspection of the tree bole, however, reveals that the harder bark of a younger tree is still present for most of the height of the tree.

Bark grows outward from the cambium; wood is formed on the inside of the cambium. As the tree grows, new bark forms underneath older bark, forcing it outward. The bark develops fissures in some trees as it expands, since the outer layers of bark were formed when the tree diameter was smaller. On trees with thick bark, the outermost bark is the oldest (Figure 44). Thin barked trees either do not make very much bark each year (alders) or have bark that exfoliates regularly (spruces). Douglas fir produces large amounts of bark which it retains it for a long time. This is characteristic of many fire-resistant tree species. Many older Douglas firs in the Puget Trough have charcoal on their outer bark, an indication that they survived a previous bout with fire (Figure 45).

The final stage of bark development in Douglas fir is characterized by the development of the colorful papery bark of an ancient tree (Figure 38 – right). At this stage

Figure 44. Close up of a 250+ year-old tree in the Puget Trough. Note thick bark but the color is still the brownish-gray of youth. On a few of the outermost bark flakes, the smooth, juvenile bark has yet to be shed.

Figure 45. A 300+ year-old tree in the Puget Trough. The hard, boney bark of youth is now completely vanished and colorful flakey bark is beginning to appear. Also note the charcoal — which usually indicates the presence of more than one age class of Douglas fir.

the bark can take on many different appearances, depending on exposure, lean, and neighboring trees. Since it is soft and papery, it can easily come off in sheets, as illustrated by the bark on a leaning tree. Over the centuries, small branches, leaves and other small bits of debris are continually shed from the canopy during storms or other events. On a leaning tree, the upper surface of the bark is exposed to this constant rain of debris, gradually sloughing off the outermost ridges of bark and creating a smooth surface (Figure 46). The bark is not damaged by this process; only the outermost ridges of bark, produced centuries earlier, are removed. The hard bark of youth is not always shed when the softer, papery bark is produced. On protected locations, such as on the underside of a leaning tree, the bark can remain very thick (Figures 46 and 47).

Lower crown characteristics

The growth of Douglas fir is whorl-based, like that of many conifers. Whorl-based growth occurs at the end of the growing season when the terminal leader pro-

Figure 46. Leaning 600+ year-old tree displays the two major bark types on old Douglas firs. The protected side has very thick bark from centuries of accumulation. The exposed side is smooth. It still has plenty of thickness to protect the tree, it has just lost the outermost ridges.

Figure 47. The protected side of a very large tree showing the 30+ cm bark thickness that they can occasionally obtain.

duces several buds at the tip. One of these buds will be the new terminal leader for the next growing season; the remainder will be branches. Pines, firs, spruces, and Douglas firs all share this pattern (Figure 48). Since the original branches are formed at the terminal leader, their pith is directly connected to the pith of the trunk. The trunk has virtually no diameter when this occurs; hence original branches remain perpendicular to the trunk, even as the trunk gets larger. Since this pattern repeats every year, the distance between whorls corresponds to one year of tree growth. Trees that maintain this morphology are termed ***model conforming***, since they are following their architectural model of growth.

In Douglas fir, the lower crown begins to recede once a stand has achieved canopy closure. The lower branches die when they become too heavily shaded. Once dead, they often rot at their base and drop off the tree, leaving just a small scar in the otherwise typical bark (Figure 49, Figure 38 left). If shading occurs rapidly and many branches die at once, these stubs may be visible in groups for

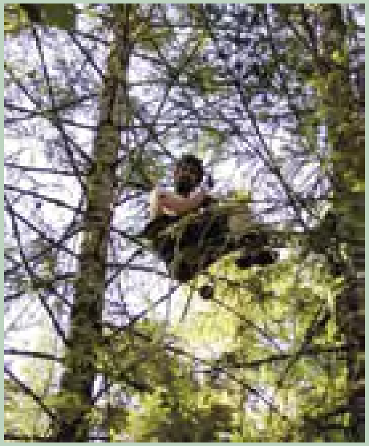


Figure 48. Whorl-based growth. Easily visible behind Karl are whorls of 4-6 branches coming out of the tree at the same height. This pattern is repeated every 80 cm or so in this tree, which was the annual height growth of the tree when these were formed.

many years, radiating around the stem (Figure 50). Ultimately, these will also drop off and their presence will be masked years later by the continually expanding bark. The complete masking of these patterns, however, may take anywhere from several decades to more than a century. During that interval, the bark will be thinner at these spots than in the surrounding areas. If changes occur, such as the opening up of the canopy during maturation, epicormic branches may begin to form at some of these old wounds.

Since epicormic branches start from dormant buds located on the cam-

Figure 49. Whorls of branch wounds still visible below the main crown in this 150+ year-old tree.

Figure 50. Stubs from dead branches being retained below the main crown in this 200+ year-old tree.

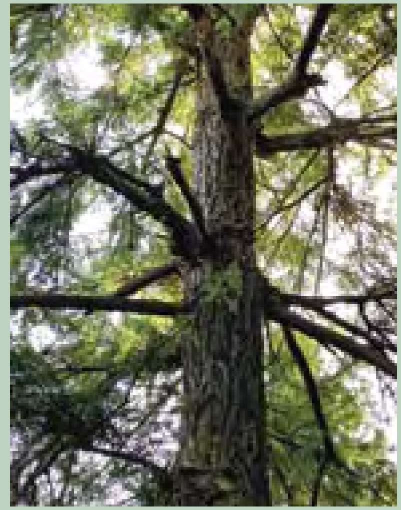


Figure 51. Epicormic branches in the lower crown of a 250+ year old tree showing the haphazard and often tangential direction they take upon leaving the trunk.

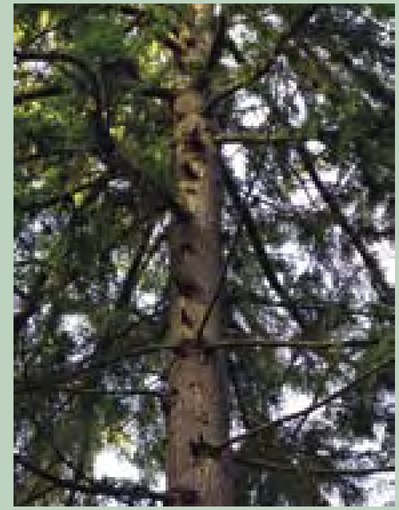


Figure 52. Lower crown of a 200+ year-old tree showing large original branches at the top of the picture and epicormic branches at the crown base.

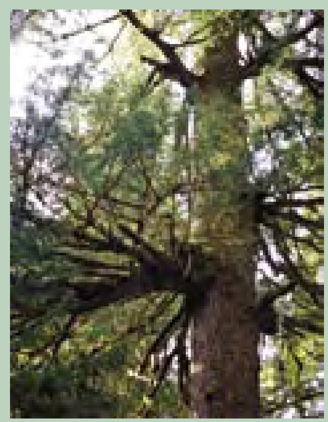


Figure 53. A massive, radiating epicormic branch system on a giant tree.

Figure 54. A small secondary trunk emerging from a large epicormic branch system.

bium on the outside of the trunk, their growth is not restricted to be perpendicular to the bole. Indeed, since these new branches are responding to increased light levels, they will often grow every which way, and may be completely tangential to the trunk (Figure 51). As light conditions in the lower crown improve due to further canopy openings, more and more epicormic branches may be produced. Trees at late maturity or in the vertical diversification phase are often composed of an upper crown of original branches and a lower crown composed of the stubs of dead original branches surrounded by many younger epicormic branches (Figure 52).

Since it is uncommon for very old trees to grow appreciably in height, they do not produce any more original branches. Instead, existing branches, either original or epicormic, are maintained through the process of within-branch epicormic shoot production. This process occurs at the branch level, not the tree level. The individual branches can reach massive proportions in these old trees (Figure 53), often producing secondary trunks of their own (Figure 54).

Crown form and tree vigor

As a Douglas fir tree ages, it transforms itself from a simple, whorl-based growth form, to a highly individualistic shape. The individuality is due in part to the long lifespan of the species. As time proceeds, shading from neighbors, damage from storms or falling trees, the effects of decay, and differences in their specific growth environments all combine to make each tree unique.

In homage to the ponderosa pine crown classes developed by Keen (1943), crown profiles of Douglas fir at four ages (1–4) and four vigor classes (A–D) for western Washington forests are presented in Figure 55. Trees depicted at the left of the drawings (A classes) are the most vigorous, with decreasing vigor proceeding to the right. These are presented to a unified scale in Figure 55, and on the following pages are at different scales with approximate heights and ages for the four series. Not all of the trees in one series will make it to the next series. For example, competition-based mortality will ensure that most of trees in classes 1C and 1D do not make it to the next stage.

Vigor can be thought of as how much leaf mass there is compared to how much respiring tissue the tree has. Class A trees all have large amounts of leaf mass and represent rapidly growing trees. In contrast, class D trees have low amounts of

Figure 55. Crown form and tree vigor.

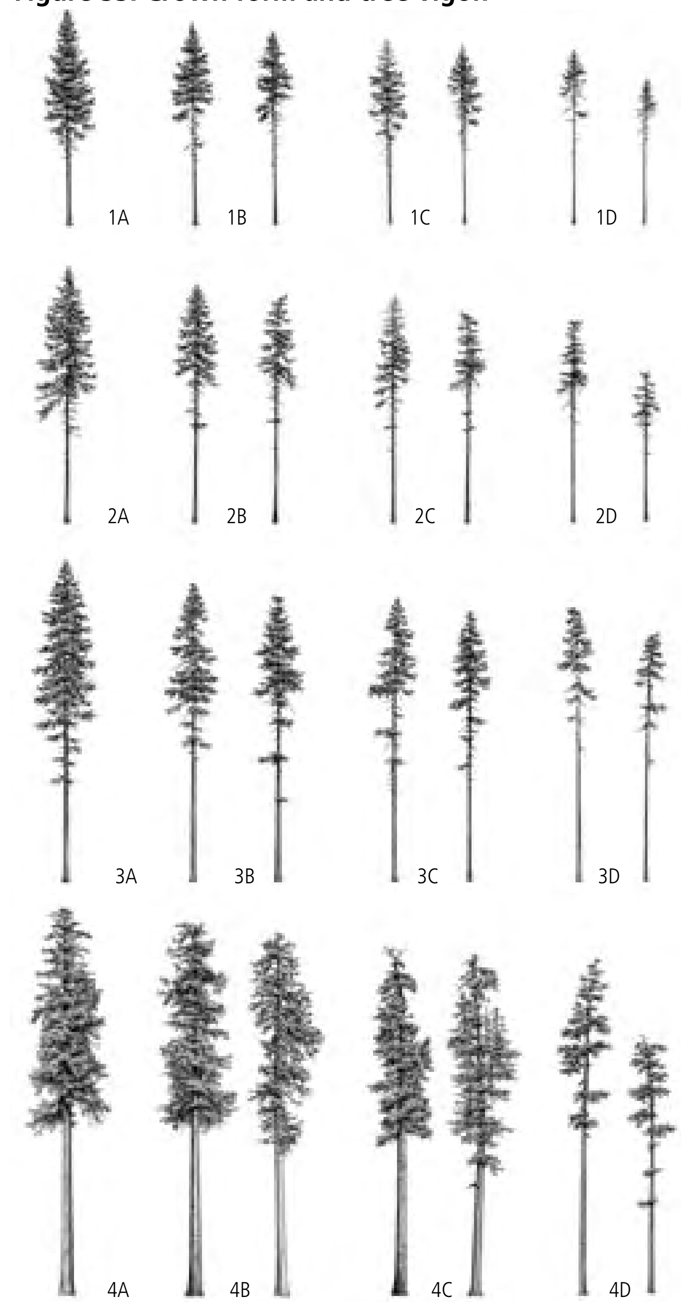
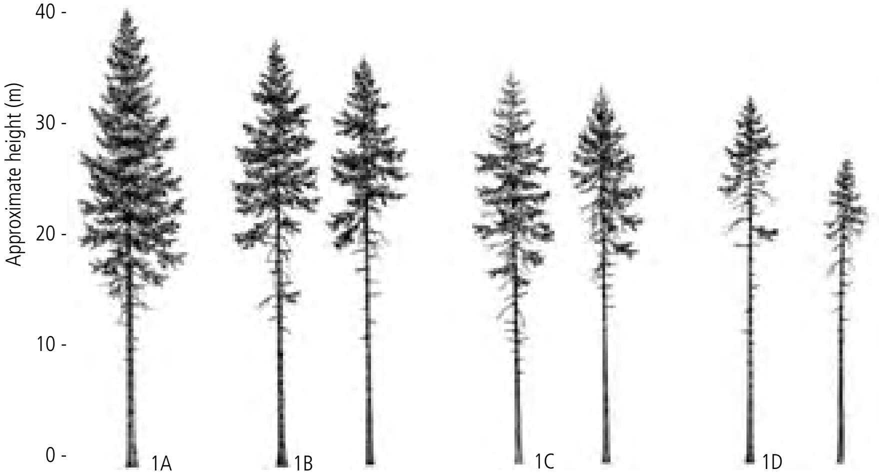


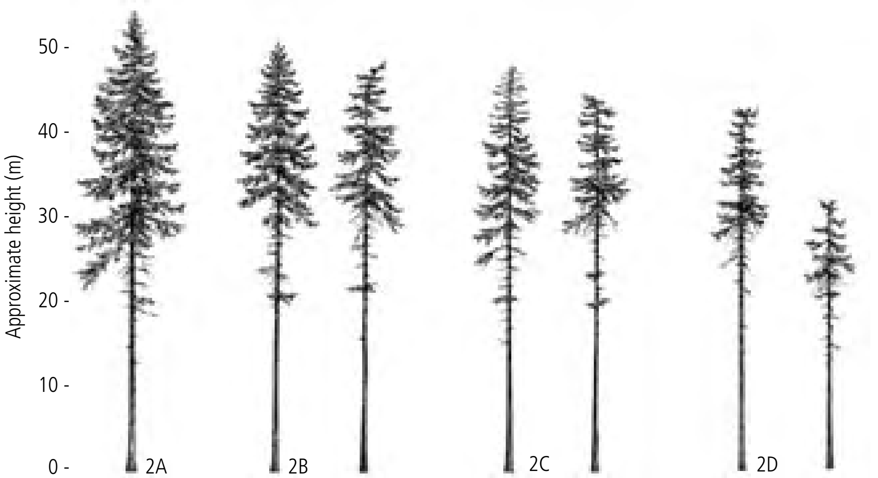
Figure 55. Crown form and tree vigor. The Douglas firs depicted are idealized forms representing four age classes (1-4) and four vigor classes (A-D) in western Washington. The 28 trees are all at the same scale. On the following pages the four age classes are presented individually, with scales added.

Figure 55. Continued

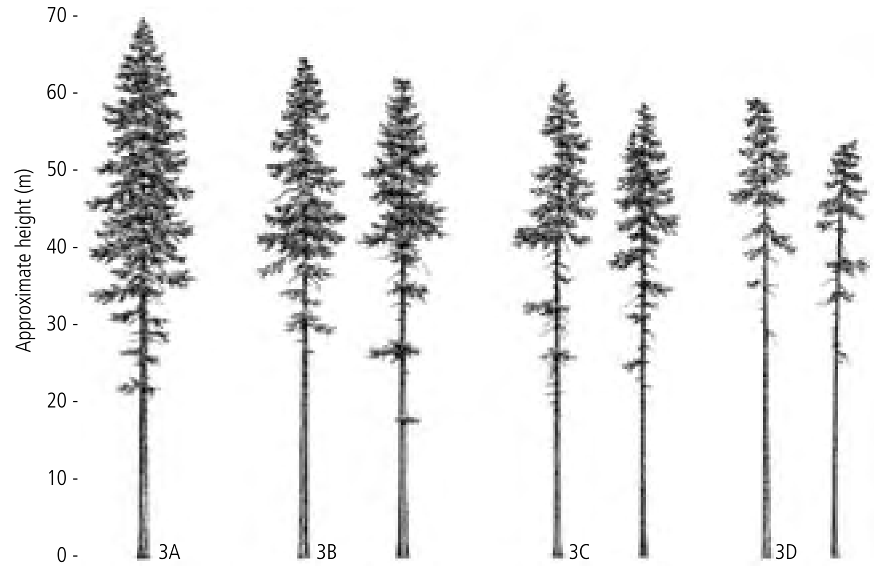
Age class 1 60-100 years



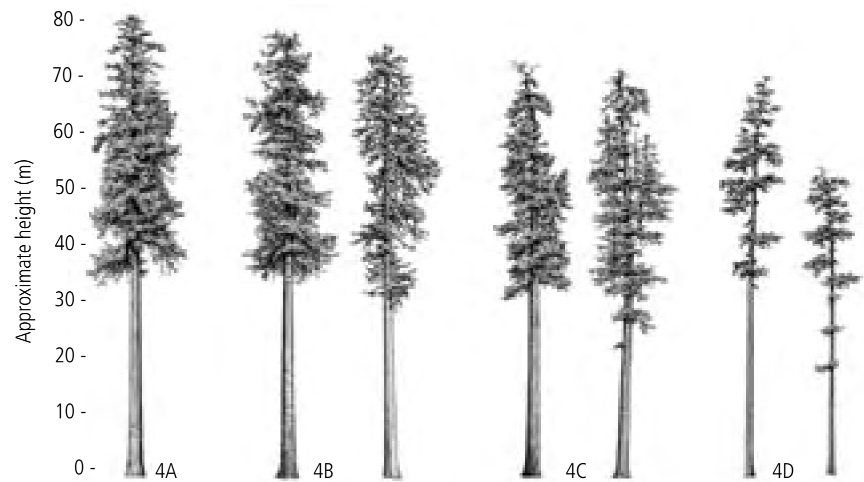
Age class 2 140-180 years



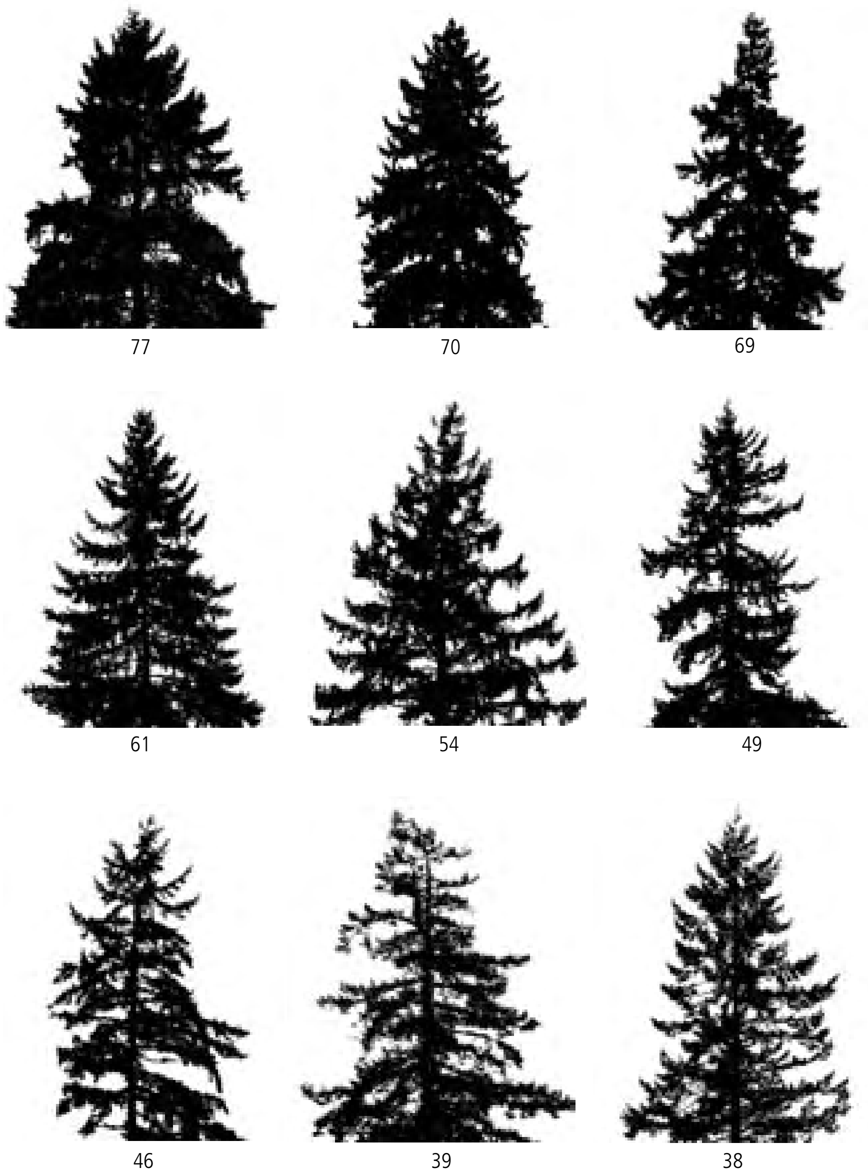
Age class 3 260 - 340 years



Age class 4 400 - 600 years



Douglas fir



Douglas fir

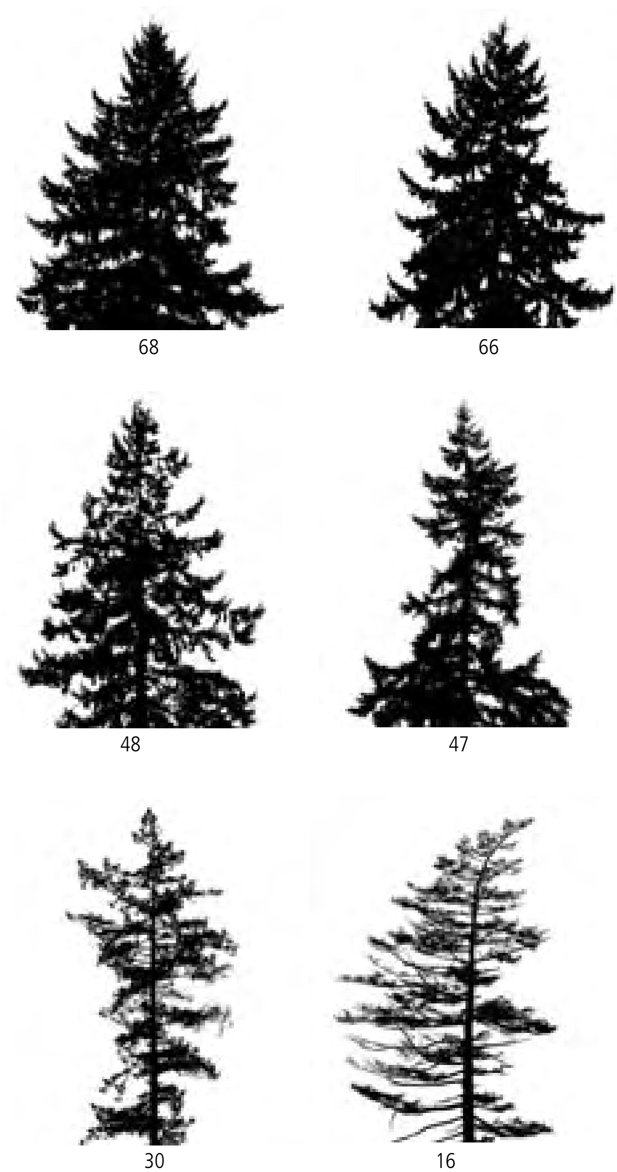


Figure 56. Crown opacity. An indirect measure of tree vigor. Numbers represent the percentage of sky that is blocked by the crown silhouette. Low numbers represent trees in decline that will probably not last long.

foliage and thus will probably not be able to sustain the amount of respiring tissue of all of their leaves, roots, and cambium.

Leaf mass is difficult to quantify, but it is related to the amount of sapwood area in the trunk, since this is the main transport of water and nutrients up from the soil. The density of the crown is also correlated with the amount of foliage. Crown opacity is a measure of the amount of sky that is blocked by the silhouette of a crown, and is another measure of tree vigor (Figure 56).

Rating system for determining general age of Douglas fir legacy trees

Choose one score from each category and sum scores to determine developmental stage

Bark condition, lower one-third of tree	Score
Hard, boney bark with small fissures	0
Hard bark with deep fissures	1
Hard bark with charcoal present	2
Soft, flaky bark with deep fissures	2
Flaky bark with charcoal present	3
Knot indicators, lower one-third of tree	
Branch stubs present	0
Old knot/whorl indicators visible	1
No knot/whorl indicators visible	2
Lower crown indicators	
No epicormic branches	0
Small epicormic branches present	1
Large and/or gnarly epicormic branches present	2

Scoring Key

< 2	Biomass accumulation/stem exclusion (35–80 years)
2–3	Maturation I – Forests originating after Euro-American settlement (70–160 years)
4–5	Maturation II – Forests originating before Euro-American settlement (140–240 years)
> 5	Old-growth (210+ years)

Longevity and death

A Douglas fir tree that has survived the myriad agents of mortality (root disease, stem rot, bark beetles, etc.) to become a canopy tree in an old-growth forest must still contend with the velvet top fungus (*Phaeolus schweinitzii*). This slow-growing fungus is often overlooked by many foresters, because it can often take 250-300 years before it makes its presence known (Figure 57). For stands of this age or older, it is the primary cause of Douglas fir mortality. This fungus causes decay in the upper roots and lower stem of old trees, weakening them. The sapwood of the tree is unaffected; many infected trees appear healthy and vigorous. Structurally, however, they have been compromised and a minor windstorm is often the final blow. Tip-ups with small root plates or snapped boles near the base indicate death caused by velvet top fungus (Figure 58).

Figure 57. Conks of the velvet top fungus. Photo: Jerry Franklin

Figure 58. Death by velvet top fungus. Top: The tip-up of a 361 cm diameter Douglas fir with a very small root wad — a sign of root rot. Lower images are of trees shattering near the base due to heart rot. The lower left is of a 323 cm diameter tree, near Lake Crescent and to the right is a 408 cm diameter tree at Quinault Lake — both on the Olympic Peninsula. Both show the classic ***barber chair*** stump — healthy sapwood splintering around the decayed heartwood.

Sitka spruce (*Picea sitchensis*)

Sitka spruce is a maritime species, growing along the outer coast from Cape Mendocino in northern California to the Aleutian Island chain of Alaska. Within this range it seldom strays very far from salt water. A tolerance for salt spray combined with a wood that has among the highest known strength/weight ratios allows it to thrive in the outer coastal environment (Figure 59). The species achieves its best growth in western Washington, where it is found further from the sea than anywhere else in its range (Figure 60).

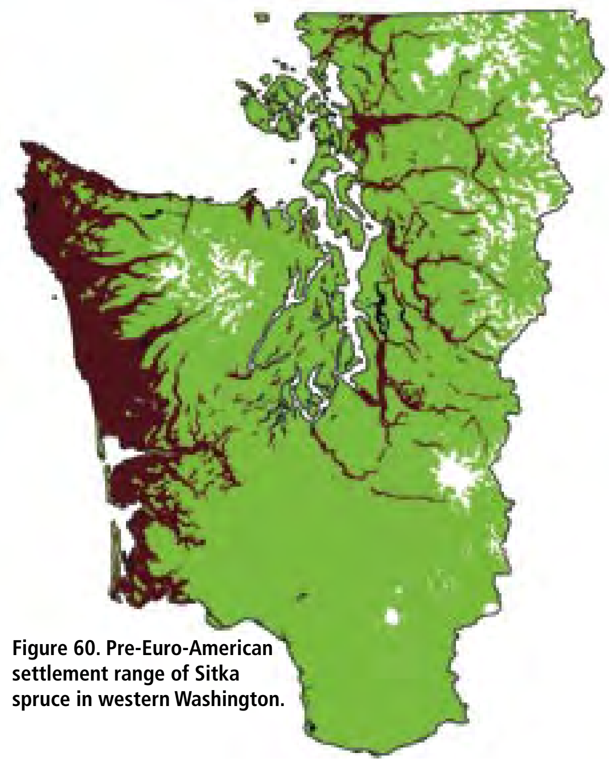


Figure 60. Pre-Euro-American settlement range of Sitka spruce in western Washington.

Of the major tree species found in western Washington, Sitka spruce is the most restricted tree to low elevations. It can be found away from the coastal environment only along the floodplains of large, ocean-flowing rivers (Figure 61). The combination of medium shade tolerance and its preference for well watered, productive soils allows it to grow as far as 80 km from saltwater. It is so restricted to these productive, coastal sites that its presence is the basis for identifying one of our major forest zones (Figure 3). Forests within the Sitka spruce zone have some of the highest forest productivities reported for the planet (Figure 62). As a site-sensitive species, Sitka spruce is unable to establish in poor or dry environments — as illustrated by its absence from the slope forests adjacent to the river floodplains of the Cascade and Olympic Mountains.

Along with Douglas fir, Sitka spruce is the other giant member of the pine family. The tallest and largest known trees are nearly the same size for both species (Douglas fir: 99.4 m, 349 m^3; Sitka spruce: 96.6 m, 337 m^3) The largest known diameter Sitka spruce (539 cm) is the largest recorded for any member of the pine family. It is odd that Sitka spruce and Douglas fir can be so similar in so many ways, yet could not be more different in others.

Early growth patterns

Perhaps the greatest difference between these two species is their seeding characteristics. While of similar size, the seed requirements of each species are completely different. The mineral soil of sand or ash preferred by Douglas fir is a poor seed bed for spruce. It instead prefers elevated organic substrates such as logs or stumps. In the moist, coastal environments where it grows, the forest floor is often a dense carpet of bryophytes and other plants. The thickness and competition these provide presents a difficult obstacle for the tiny seed to overcome. A log, however, especially one freshly fallen, provides a wonderful organic substrate that is (at least temporarily) free from this competition (Figure 63). Lines of trees are often visible in some of these coastal forests where competition on the forest floor is high (Figure 64). As the trees mature they form what is known as a ***forest colonnade*** (Figure 65).

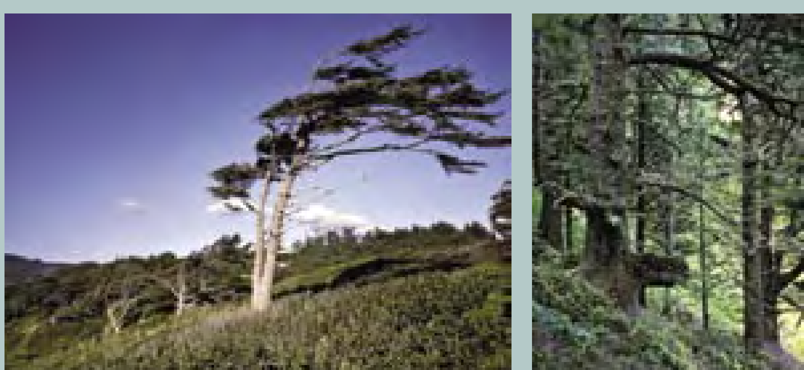


Figure 59. Left: Windswept Sitka spruce trees adorn the outer coast from northern California to the Aleutian Islands of Alaska. **Right: Trees along the ocean front often develop strange forms** as a result of nearly constant exposure to high winds, even inside the protection of a forest.

Figure 61. Large floodplains in western Washington provide ideal conditions for Sitka spruce to dominate, such as on the South Fork Hoh River on the Olympic Peninsula.

Figure 62. Rainforests dominated by Sitka spruce and western hemlock have some of the highest growth rates known — often producing record-sized trees in just two or three centuries.

Figure 63. Several groups of spruce seedlings can be seen colonizing wood in this grassy glade in the rain forest.

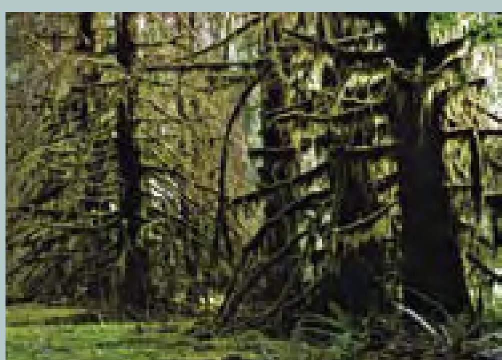


Figure 64. Young Sitka spruce trees growing in lines reveal that they started their lives on a log.

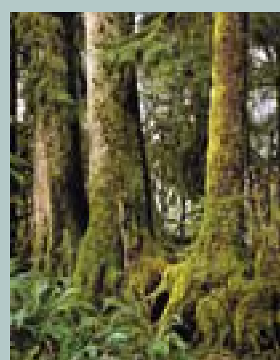


Figure 65. A forest colonnade. Mature trees in a row with interwoven roots is sometimes the only evidence of the former location of a nurse-log.

Life is precarious for a seedling that starts on an elevated substrate. The bark of a decaying log may slough off, taking the young plants with it. If the log decays quickly, the young seedling might not be able to get roots into the ground in time to support its own weight. To survive, the tree must ultimately be able to support its own weight and the roots that were in the log will become stems when the log disappears (Figure 66). If the log or stump on which the young spruce started its life was very large, huge buttresses may be the only evidence centuries later of the tree's origin (Figure 67).

Since Sitka spruce is a site sensitive species, variation in growth rates between trees is far less pronounced than for Douglas fir. Consequently, size and age are more closely correlated for Sitka spruce. This relationship holds true only for height and total volume, however, not for the diameter at breast height (DBH). Buttresses are highly variable and exhibit a considerable influence on DBH, depending on the size of the stump or log on which the spruce germinated. In older stands, measuring the DBH of a Sitka spruce amounts to nothing more than measuring buttress

Figure 66. If a spruce started on a very large log, the resulting tree can often have a bizarrely shaped root system.

Figure 67. The Quinault Lake Spruce. The huge buttresses found on trees such as this indicate that they started life on a very large stump or log.

roots, a measurement with limited usefulness. As an extreme example, how do you measure the DBH on the Quinault Lake Spruce (Figure 68)?

Patterns in mature trees

Many of the clues used to determine the age or successional stage of a Douglas fir do not apply to Sitka spruce. The textural patterns of the bark, for example, do not change much over time. The bark flakes that develop on trees during their first century of life continue, relatively unchanged, throughout the remainder of their life (Figure 69).

The pattern of epicormic branching in mature trees is also not as consistent as for Douglas fir. While Sitka spruce is every bit as capable as Douglas fir in producing epicormic branches, it often does not need to. Two primary reasons account for this: Sitka spruce is slightly more shade-tolerant than Douglas fir; and often grows in less dense stands. The loss of original branches and the lifting of the crown during the biomass accumulation/competitive exclusion phase is a major pattern in

densely-stocked Douglas fir stands; such a patten is often less of a factor in many Sitka spruce stands. This is particularly true in the floodplain forests where spruce is often growing up through an alder canopy, rather than a dense stand of other spruces. Since alders are leafless for half of the year, some of the spruces will keep many of their original branches and thus maintain deeper crowns (Figure 70).

Even in the older Sitka spruce/western hemlock stands growing on floodplains, stand densities are much lower than their Douglas fir/western hemlock counterparts. This may be due in part to a shared dominance with bigleaf maple, and to a lesser degree, alder and cottonwood. Moreover, heavy grazing by deer and elk is common in many spruce floodplain forests and influences understory vegetation and seedling recruitment. Chronic, small-scale disturbances created by wind and/or flooding are common, as are the shorter life-spans of most of the tree species.

The strength of Sitka spruce wood makes it common for trees to live well into their third century with the simple architecture of their youth (Figure 71). By then, most of their height growth has been completed. Wind, decay, and the exposure to the elements begin to take their toll, creating the individuality seen in old spruce crowns (Figure 72).

Longevity and death

The pattern of slowed height growth in older stands is common to both Sitka spruce and Douglas fir. While the ultimate height and size of Sitka spruce and Douglas fir are similar, Sitka spruce achieves these dimensions in about half the time. This is advantageous for

Figure 68. The Quinault Lake Spruce. The red line indicates where DBH would be measured. How useful is such a measurement?

Figure 69. Bark characteristics do not change much with Sitka spruce. The left photo shows small trees near the coast that have similar bark flakes to the 450 cm tree in the right photo.

the spruce, since its lifespan is about half that of Douglas fir. On productive sites, a Sitka spruce has never been successfully aged to over 400 years, making it one of the shortest-lived of all western conifers. This may seem strange considering it is one of the largest trees in North America. Individual trees, such as the Quinault Lake Spruce, certainly live slightly beyond this but they cannot be aged by non-destructive methods. Even if cut, their centers would likely be rotten and hollow. Sitka spruce, like Douglas fir, is susceptible to velvet top fungus. Giant spruces are frequently killed by this disease after only 250-350 years (Figure 73). Trees that have their tops broken during storm events will also begin to decay from the top down, often breaking off in sections (Figure 74).

Figure 70. Changes in crown form in Sitka spruce over time. Note that despite a few epicormic branches in the lower crown, trees retain a simple architecture for the first two centuries. Decay puts an upper limit on longevity.

Figure 71. Upper canopy of a 250+ year-old spruce stand in Olympic National Park. Many of the trees still retain the branch structures of young trees.

Figure 72. Upper crown profiles of several 300+ year-old spruces. The simple growth pattern of youth is still detectable in a few trees, but their individuality and idiosyncrasies become apparent.

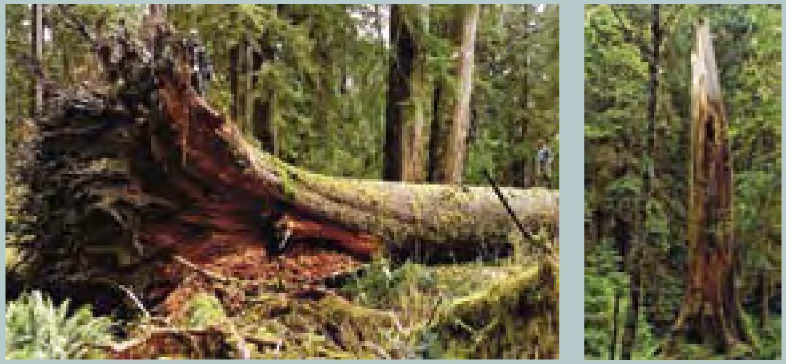


Figure 73. Death by velvet top fungus. The two classic cases are the fallen trunk, full of rot, with a small root wad (left), or the splintered stump, with sapwood still intact (right).

Figure 74. The rotten top of a 400+ year-old spruce snapped off in a violent winter storm, only to impale itself in the ground a full 20 m away from its base.

Noble Fir (*Abies procera*)

Within western Washington, noble fir is a subalpine species largely restricted to the south Cascades (Figure 75). A disjunct population also occurs at the higher elevations of the Willapa Hills. Noble fir is a very popular ornamental tree throughout the Pacific Northwest and is considered a premiere Christmas tree. Some of its beauty is attributed to the color of the foliage (Figure 15, left), which is derived from stomatal bands on both the upper and lower surfaces of the needles. Noble fir is the tallest (89.9 m tall) and largest (290 cm diameter, 161 m^3 volume) recorded member if the true firs (genus *Abies*). It also can form pure, incredibly dense stands that can rival Douglas fir stands in total volume (Figure 76).

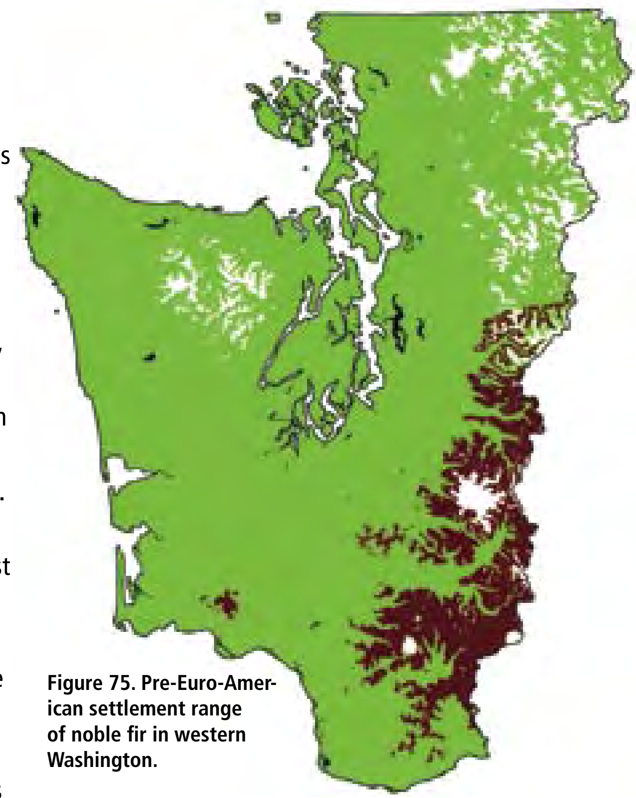


Figure 75. Pre-Euro-American settlement range of noble fir in western Washington.

In many ecological aspects, noble fir shares more in common with Douglas fir than other members of its own genus. Unlike most western true firs, noble fir is a shade-intolerant, pioneer tree that can regenerate abundantly after a severe disturbance. An important physical adaptation is its large cones, which are sparsely produced at the top of trees at maturity (Figure 77, Figure 15, left). These cones contain very large seeds, which can provide a young sprout with nutrients for up to a year while its roots are trying to find a favorable spot to grow. Like many other

Figure 76. One of the densest forests in the Pacific Northwest is surprisingly, *not* a Douglas fir forest, but this noble fir forest at the Mount Saint Helens National Volcanic Monument. This forest contains 3120 m^3/ha, 64 percent of which is noble fir.

Figure 77. Noble fir cones, while not prolific, are produced near the top of the tree, providing the best opportunity for seed dispersal. Each large seed stands a better chance of survival than the multitude of tiny seed produced by a tree such as western hemlock.

Figure 78. A stunted old noble fir growing at 1500 m timberline in the south Cascades. Mount Saint Helens is visible in the distance.

true firs, the young seedlings can be very stiff and sturdy, not needing an elevated surface on which to grow. This characteristic allows noble firs to be very successful in areas with deep winter snowpacks (Figure 78). Four to five months of debris can accumulate atop the snowpack found in high elevation forests, smothering or crushing the small seedlings of species such as Douglas fir during spring snowmelt. Noble fir seedlings, even young ones, will often survive such abuse. While large seeds commonly limit seed dispersal distances, the snowy and icy environment of high-elevations can allow seeds to blow around to sometimes great distances (Figure 79).

Like Douglas fir, noble fir can regenerate quite abundantly after a severe fire (Figure 80). This quality, combined with the ability to withstand a deep snowpack, makes noble fir ideal for high-elevation forestry applications. Noble fir is the tree of choice wherever the replanting of Douglas fir is limited by snowpack. The wood of true firs is generally considered soft and weak, lacking the strength and decay resistance of Douglas fir or western larch. As such, the wood is often used for low-grade lumber products or pulp. Noble fir, however, produces a stronger and more durable wood, with a very high strength-to-weight ratio.

Figure 79. A small noble fir seedling in the middle of the pumice plain on the northeast section of Mount Saint Helens. The nearest mature noble fir to this tree is more than 5 km distant.

For this reason, noble fir along with Sitka spruce was used for airplane and ladder construction. When our ancestors discovered that noble fir did not have the poor quality wood associated with true firs, they called it larch, so that people would buy the wood. Both Oregon and Washington have a Larch Mountain, which was named for the noble fir growing atop them.

Like many other true firs, noble fir maintains a very symmetrical shape to its crown well into its second century. It also rigidly adheres to a whorl-based architecture. Young trees often appear perfectly symmetrical. Over time, exposure to wind and elements transforms the symmetrical crowns into the more individualistic crowns typical of older forests (Figure 81). Many members of the pine family, most notably Douglas fir, continually replace their foliage through epicormic branching. Minor crown damage, from a windstorm for example, is quickly replaced by new foliage. The ability of noble fir to produce epicormic shoots or branches appears to be extremely limited; wind-damaged trees rarely recover. This, combined with susceptibility to root rots, ultimately limits the longevity of noble fir. Noble fir is abundant in old growth forests with ages up to 300, after which there is a rapid decline. A 400 year-old forest will have very few noble firs remaining, most of which will be declining.

Figure 80. Two views of pure noble fir stands. The upper photo shows a pure stand of noble fir (bluish crowns in upper left of photo), that came in very densely after the 1902 Yacolt Burn. Note the scattered noble fir trees in the bottom right of the photo, which is an unburned section of older forrest. The bottom photo is the interior of a stand during the height of the biomass accumulation/stem exclusion phase of stand development — note the lack of vegetation in the understory. Also note the white, lichen-covered trunks are just beginning to develop the cracks that lead to bark appearance of mature trees. Photo below: Jerry Franklin.

Figure 81. Mature crowns of Noble fir begin to loose their symmetrical, model-conforming crowns of youth.

Western hemlock (*Tsuga heterophylla*)

As one of our most shade-tolerant tree species, western hemlock is abundant in nearly all old forests in western Washington (Figure 82). Although it is often overlooked when growing with its much larger associates – Douglas fir, Sitka spruce, or western redcedar – western hemlock can occasionally reach impressive dimensions. It has been recorded to 78.0 m tall, 290 cm in diameter, and with a volume of 121 m^3 (Figure 11). Even though it only represents a fraction of the wood volume in old-growth forests, it nearly always represents more than half of the foliage (Figure 83). Accordingly, western hemlock controls the understory light environment in these old stands. A mature hemlock tree casts a very dense shade, only allowing shade-tolerant plants to persist.

Figure 82. Pre-Euro-American settlement range of western hemlock in western Washington.

Like Sitka spruce, western hemlock seedlings are mostly limited to elevated woody substrates (Figure 84). Large logs can present the same problems for a young hemlock seedling as for spruce, and successful seedlings can form similar rows of trees as they grow along the length of a log (Figure 85).

Besides stumps and logs, a third woody substrate exists that Sitka spruce does not typically exploit. Large Douglas fir trees often have a wide skirt of bark that forms at their base (Figure 86). Douglas firs produce large amounts of bark during their lifetime, which accumulates at the base of the tree as it sloughs off. Because it is elevated and continually accumulating, it has reduced competition from other plants and roots. Bark decays very slowly, so this skirt of organic substrate makes the perfect growing medium for a young hemlock seedling. In old-growth Douglas fir forests it is common to see a big old tree with its ***minion*** – groups of small hemlocks clustered around the tree base (Figure 87).

Even though western hemlock is one of our most shade-tolerant tree species, it still needs a gap or other opening to ascend into the canopy. Like most shade-tolerant tree species, western hemlocks can persist in dark forest understories for decades, even centuries, without growing much (Figure 88). These small, ***suppressed*** trees often develop an umbrella shape, in an attempt to capture as much light as possible. In many cases, these suppressed trees are often nearly the same age as large hemlocks growing nearby that had better opportunities when younger. If an opening in the canopy occurs, such as when a large tree falls over, the small tree may be able to ***release***, responding by increasing its growth in the new light environment. Usually, however, the light gap will be closed by neighboring trees or other trees present in the understory. In most old-growth forests, upper canopy western hemlocks have experienced repeated periods of suppression and release.

Figure 83. An old-growth Douglas fir/western hemlock stand at Mount Rainier National Park. Apart from some moss on the branches and a few ferns on the forest floor, all of the green in the photo is western hemlock foliage.

Figure 84. A Douglas fir log covered with moss and abundant western hemlock seedlings.

Figure 85. Western hemlock seedlings colonizing an open area with the help of a nurse log.

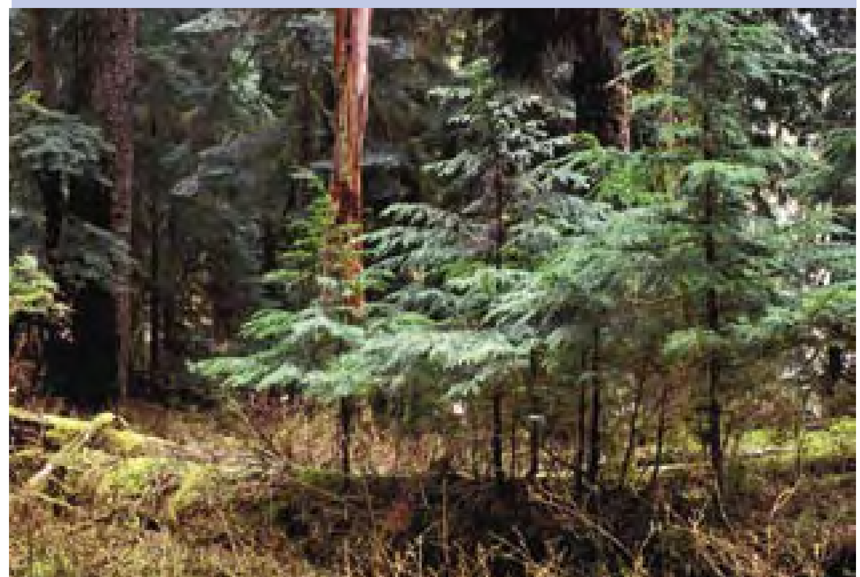


Figure 86. The common sight of a large skirt of bark at the base of an old Douglas fir tree. Note hemlock seedlings using bark as a growing substrate.

Many of the clues that reveal the age of Douglas fir trees, such as bark characteristics or epicormic branches, are often absent in western hemlock. Since old western hemlock trees often have bark similar to much younger trees, the bark appearance gives few clues to tree age. Due to western hemlock's high shade tolerance, the branch-pruning seen in Douglas fir may not occur. Epicormic branches are often not present, even in trees several centuries old (Figure 89). Branch size, however, does change predictably through time. Hemlock trees less than 150 years old typically have very small, but numerous, branches (Figure 90). The presence of large (> 10 cm) branches on a western hemlock is usually an indication of an older tree (Figures 89 and 91).

Hemlocks often do not appear in a stand until the second century, as outlined in the ideal stand development scenario presented earlier. Even at 200 years in many stands, depending on disturbance intensity and proximity to seed sources, hemlocks have yet to grow into the upper canopy. The presence of hemlocks of different sizes in a Douglas fir forest, including canopy trees, is therefore an excellent indication of an old-growth forest.

Even in coastal forests, where western hemlocks can sometimes be the oldest trees, a mixed structure stand will still take considerable time to develop. For example, a coastal stand that is blown over, burned, or clearcut, can come back to a pure hemlock canopy (Figure 13). The same patterns of development will occur under the idealized scenario presented earlier, substituting western hemlock for Douglas fir. Vertical diversification will still take time to develop.

Figure 87. Douglas fir *minion*. Western hemlock seedlings growing on shed bark accumulated at the base of the tree.

Hemlock dwarf mistletoe

A distinctive characteristic – mostly unique to western hemlock in western Washington – are mistletoe infections. Mistletoes are parasitic plants that grow in the canopy of many tree species. The leafy mistletoe popular at Christmastime is a member of the genus *Viscum* found on hardwood trees in Europe. Crowns of our native oak, (*Quercus garryana*), become infected with another leafy mistletoe of the genus *Phoradendron*. In contrast, dwarf mistletoes are small, leafless mistletoes that often infect the twigs in the outer crowns of trees (Figure 92). Many members of the *Pinaceae*, including Douglas fir, western larch, and several of our pine and fir species become infected with dwarf mistletoes of the genus *Arceuthobium*. In western Washington only one species is common: *Arceuthobium tsugense*, which is mostly limited to western hemlock crowns.

These parasitic plants possess a unique seed dispersal mechanism: the seeds are explosively discharged when ripe and coated with a sticky covering that can adhere to the leaves or stems on which they land. Depending on wind conditions and the location of the plant within the tree crown, the seeds can sometimes travel 10-12 m away from the parent plant. While impressive, this is a limited distance when compared to other mechanisms of seed dispersal. Occasionally the sticky seeds will adhere to a bird and be transported to another tree.

Figure 88. A 210 year-old hemlock that is scarcely 2 m tall in the south Cascades. Such suppressed trees form an umbrella shape — producing only a few leaves each year.

As a parasite, the mistletoe makes use of sugars produced by the host tree, reducing their availability for tree growth. Hormones produced by the mistletoe cause excessive, but deformed growth of the tree in the vicinity of the infection. This often results in broom formation – dense areas of foliage and branches which appear as star-shaped formations on branches (Figure 93).

Because of the relatively slow manner in which this species propagates itself, hemlock dwarf mistletoe is, with some exceptions, generally only found in older forests. The most common exception to this general rule is when infected hemlocks are the residual trees in a developing stand. The mistletoe is in a perfect position to rain down seeds onto the new cohort of trees. This scenario is most common along the coast, in areas where wind was the disturbance agent. After a catastrophic wildfire, the few surviving hemlock trees will not usually persist long enough to infect the next generation of hemlocks, which may not establish for a century or more under the new Douglas fir canopy.

Figure 89. A 300 year-old hemlock in a 400+ year-old Douglas fir/western hemlock forest in the south Cascades. The extreme shade-tolerance of this species allows it to maintain its original branches close to the ground

Longevity and death

Throughout much of its range in western Washington, western hemlock will be susceptible to decay

Figure 90. Post-Euro-American settlement hemlocks rarely have branches > 10 cm, regardless of trunk size. Wood production is devoted to height growth and trunk enlargement, well into the second century.

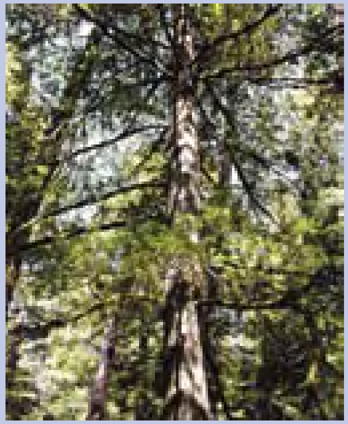


Figure 91. Branches > 10 cm in diameter usually indicate an older hemlock, regardless of the trunk size.

Figure 92. A male hemlock dwarf mistletoe plant infecting a branch at 50 m above the ground. Female plants explosively discharge seeds which can occasionally fly 10 m or more away from the parent tree.

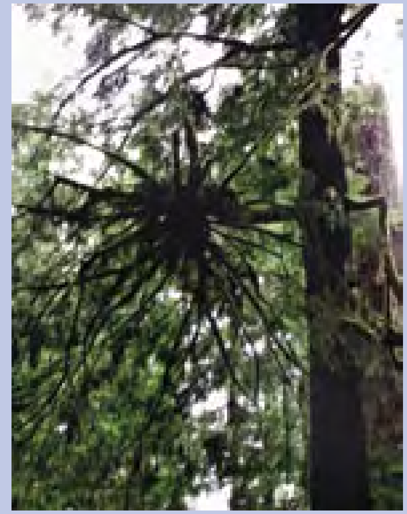


Figure 93. A mistletoe broom. Hormones within the mistletoe cause excessive growth in the hemlock in the vicinity of the infection. Such dramatic infections are usually only found in old forests.

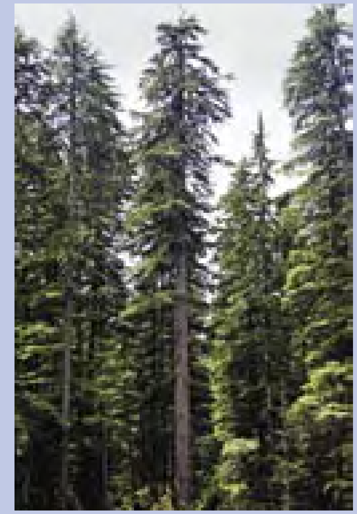


Figure 94. A section of pure western hemlock within a 400+ year-old Douglas fir/western hemlock forest. Such sights are usually the result of the Douglas fir being killed off by disease.

fungi and will likely die before reaching 300 years of age. This is true in nearly all forests below 1,000 m in elevation. The tree does not produce decay-resistance extractives in its heartwood, and the warmth and moisture of these low elevation sites is ideal for fungal growth.

Both Douglas fir and western hemlock are subject to a wide array of different decay fungi, several of which will attack one species and not the other. Particularly on poor sites, one will occasionally encounter sections of an old-growth Douglas fir/western hemlock forest in which all of the Douglas firs have died. In these situations, a limited area of pure hemlock forest might be found (Figure 94).

Because fungi are limited in their effectiveness at high elevations, such as the upper Pacific silver fir or mountain hemlock zones, western hemlock in these locations routinely reaches ages of 800+ years, even up to 1,200 years (Figure 95, Figure 11).

Figure 95. A section of forest that is several thousand years-old near Glacier Peak in the north Cascades. If the frequent avalanches do not kill the trees, many can survive for more than 1000 years.

Extremely old western hemlock forests, such as those on the coast or in the North Cascades, are also susceptible to one of our only outbreak insects – the hemlock looper (*Lambdina fiscellaria*). This moth has been known to defoliate small sections of pure hemlock stands from time to time. Given that most old hemlock stands are already infected with hemlock dwarf mistletoe, the results of a looper infestation can be particularly unsightly (Figure 96).

Figure 96. A pure hemlock stand in the north Cascades killed by the hemlock looper. The added stress of these dramatic mistletoe infections probably made the trees more susceptible to the defoliation.

Western redcedar (*Thuja plicata*)

Western redcedar might be considered the long distance runner of our native trees. It persists in small numbers for the first several hundred years and only shows its stamina with great age.

Like western hemlock, redcedar is very shade tolerant and often does not appear in Douglas fir forests until maturity. Western redcedar is the largest tree in the Pacific Northwest, with living individuals recorded up to 599 cm in diameter and 500 m^3 of volume. With the exception of yellow cedar, western redcedar is the longest lived tree species in western Washington. Many specimens over 1,500 years of age have been recorded. Older trees probably exist, but are impossible to date due to their large sizes and often hollow centers. Western redcedar has a very wide ecological amplitude, tolerating of a wide range of soil conditions, from sea-level to near timberline (Figure 97).

Figure 97. Pre-Euro-American settlement range of western redcedar in western Washington.

Most coniferous trees found in western Washington are members of the pine family. Western redcedar, in contrast, is a member of the cypress family, (*Cupressaceae*). Studies have shown the soils underneath an ancient redcedar are different than those under members of the pine family and influence seedling regeneration though a higher pH. In forests where western hemlock and western redcedar co-occur, seedlings of each species are more abundant under trees of their own

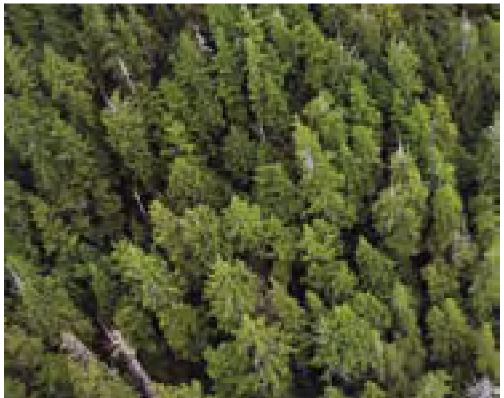


Figure 99. Extensive stands of nearly pure western redcedar are only found along the coasts of Washington and British Columbia. Photo: Bruce Van Pelt.

Figure 98. Away from the coast, pure groves of redcedar are limited to forested wetlands or sections of alluvial forest in the north Cascades, such as this stand from a swamp in the south Cascades.

species, than under trees of the other. Since western redcedar is such a long-lived species, one would expect its numbers to gradually increase over time. This is indeed what happens. Throughout most of western Washington, however, and particularly in the Puget Sound or Cascade provinces, forests over 500 years-old are uncommon. With the exception of some swampy areas, western redcedar is a minor component throughout this entire region (Figure 98).

Extensive forests dominated by western redcedar are found only along the coast (Figure 99, Figure 9). The dominance of redcedar in many coastal forests is only partly due to the moisture; it is also due to the great ages of the forests there. There are (or were) extensive forested areas along the coast where 1,000 years or more has passed since the last major fire event (Figure 100). In some of these coastal forests, several thousand years has passed without fire. No individual trees are that old, but some of these sites have been fire-free for 3-

4000 years or more. Had all of western Washington been kept free of fire for the last 1,500 years, western redcedar would be the dominant tree throughout the region.

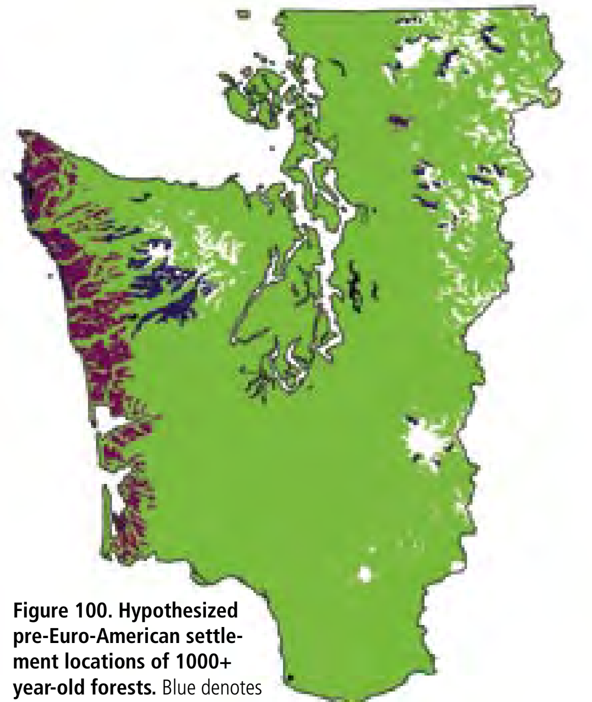


Figure 100. Hypothesized pre-Euro-American settlement locations of 1000+ year-old forests. Blue denotes areas where such forests remain intact.

Young redcedars preference for soils already occupied by redcedar is evident in some second-growth forests. Redcedar-dominated second-growth stands are only found on coastal sites that were previously ancient redcedar forests (Figure 101).

Redcedar is also different from members of the pine family in the decay-resistance of its wood. As with other cypress family trees such as coast redwood and yellow cedar, western redcedar has highly decay-resistant wood. It is thus unlike its common associates Sitka spruce or western hemlock, in that it can survive major crown damage. When the top of a spruce or hemlock is blown out, the tree will often be unable to outgrow the incipient decay. A redcedar, in contrast, will resprout new leaders and continue on.

Top die-back is common on redcedar in particularly hot, dry summers. After the die-back, a new leader (or leaders) will develop from an existing branch (or branches) below the dead top. The dead leader often will remain on the tree after this recovery, so that after many centuries of this process, many of these dead tops will be present – giving rise to the term ***candelabra top*** (Figure 102). In many other trees, top dieback followed by reiteration from a side branch also occurs, but with different results. In a hemlock or a spruce, for example, the dead top will rot and fall away, so that after several decades the only evidence of the disturbance will be a slight kink in the trunk at the location of the resprout. The redcedar preserves its history of die-back and resprouting, so an ancient tree is a living record of its past.

Figure 101. Above a young, pure stand of western redcedar that regenerated after a cedar stand was logged.

Figure 102. Changes in crown form of western redcedar over time. Note that trees remain relatively simple for the first several centuries — it is only in great age that the individual character and ***candelabra*** tops often seen in ancient stands emerge.

Pacific silver fir (*Abies amabilis*)

Like western hemlock, Pacific silver fir is extremely shade-tolerant and is often represented in a variety of size classes in old-growth forests. However, it is less tolerant of warm temperatures and drought, and is more typically restricted to the cooler environments found at higher elevations than western hemlock. An exception is near the coast, where it is commonly found at low elevations (Figure 103). The largest recorded Pacific silver fir grew at only 283 m elevation on the coastal plain of the Olympic Peninsula (237 cm diameter, 63.4 m tall, and 74 m^3 volume).

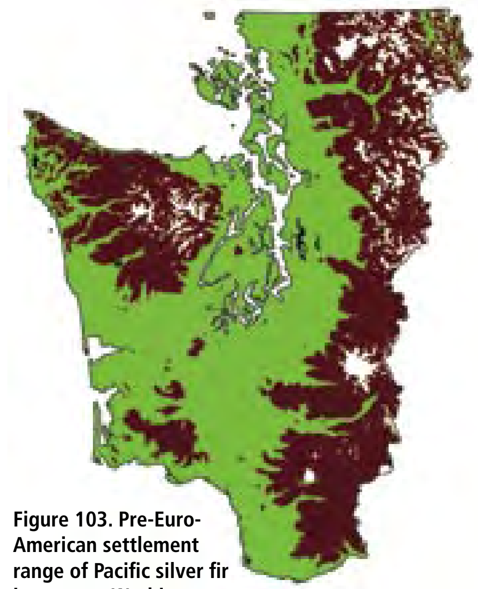


Figure 103. Pre-Euro-American settlement range of Pacific silver fir in western Washington.

The microclimate in the understory of an old-growth forest is heavily moderated by the canopy, being much cooler and moister in the summer and warmer in the winter. Because of this, it is not uncommon to see understory silver firs in portions of the western hemlock zone – places where it is absent or cannot survive in the upper canopy (Figure 104). Many of these understory trees, like their western hemlock associates, can exist for decades or even centuries as small, umbrella-shaped trees.

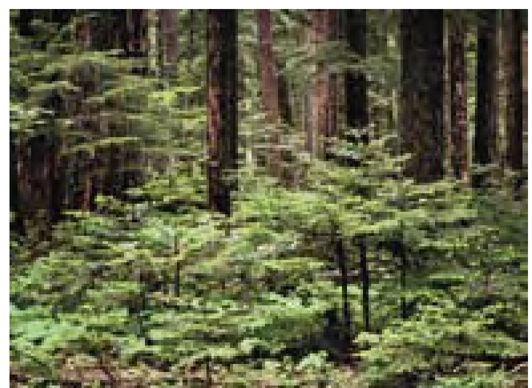


Figure 104. Small patch of understory Pacific silver fir in a Douglas fir/western hemlock forest in the south Cascades. Many of these small trees are up to 170 years old, yet are still less than 2 m tall.

Figure 105. A very old forest of Pacific silver fir and western hemlock in the Olympic Mountains. Old individuals of silver fir can often be 600-800 years old and develop the flakey bark more characteristic of spruce.

Unlike its shade-tolerant associate western hemlock, Pacific silver fir does not prefer logs as a seedbed. The seeds of Pacific silver fir are very large, and can provide sustenance for young seedlings for a year or so while they get their small roots established. In addition, the young sprouts of Pacific silver fir are extremely stiff, and are often able to withstand the debris that small understory plants are subject to – the same debris that often smothers young hemlock seedlings. These factors combine to allow seedlings of Pacific silver fir to do well on many forest floor substrates.

While usually neither the largest or most conspicuous tree in the forests within the Pacific silver fir zone, Pacific silver fir is often the most numerous tree in mature and old forests (Figure 11). Young to mature trees maintain a relatively smooth bark that is often coated with one or several species of white, crustose lichens (Figure 11). Since silver firs are not decay-resistant, and few trees live more than a couple hundred years, these white-barked trees are all that many people ever see. In the cooler and moister parts of its range, however, silver firs can live to great ages. Older trees develop a flakier, sometimes purplish bark reminiscent of Sitka spruce (Figure 105).

In most situations, silver firs will only be a part of the upper canopy in the later stages of succession – just as western hemlock was in the stand development sequence presented earlier. Exceptions to this can occur if the forest blows over, leaving a hemlock and silver fir understory to become the new canopy. A similar situation occurred after the 1980 eruption of Mount Saint Helens. A Pacific silver fir understory was present underneath a dense snowpack in May when the eruption occurred. The overstory was killed by the intense heat, leaving only these small understory trees to start the new forest (Figure 106).

With very shade-tolerant trees such as western hemlock or Pacific silver fir, it is often useful to think of ***functional ages***. In the example cited following the volcanic eruption, or in the example of the 21 Blow windstorm, understory trees grew as unconstrained seedlings as if they had been recently planted. Even though the trees may have been 100-200 years old, their functional age, such as the trees in Figure 13, will date from the time of the canopy removal.

Figure 106. Survivorship at Mount Saint Helens. A deep snowpack allowed a group of Pacific silver fir understory trees to become the new cohort when the remaining canopy was killed by the blast from the 1980 eruption.

Conclusion

The great diversity and ages of forests found in western Washington makes the task of creating a comprehensive guide difficult. There will be occasional forests that do not fit the keys properly, and others where the ages are difficult to discern. Each stand presents its own set of mysteries, and there are sure to be cases when professional judgment will have to substitute for certainty. Ultimately, however, it is to be hoped that the ecological knowledge contained in this guide can be used to narrow the range of possibilities and give the user increased confidence in making age determinations in older forests.

English Equivalents

When you know:	Multiply by	To find
Centimeters (cm)	.39	Inches (in)
Meters (m)	3.28	Feet (ft)
Kilometers (km)	.62	Miles (mi)
Square kilometers (km^2)	.386	Square miles (mi^2)
Square kilometers (km^2)	247.1	Acres (ac)
Hectares (Ha)	2.47	Acres
Cubic meters (m^3)	35.3	Cubic feet (ft^3)
Cubic meters (m^3)	177	Approx*. Board feet (bf)

*Based on ft^3 x 5

Citations

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Appendix

Crosswalk between stand development terms used in this guide and terms used in other DNR publications.

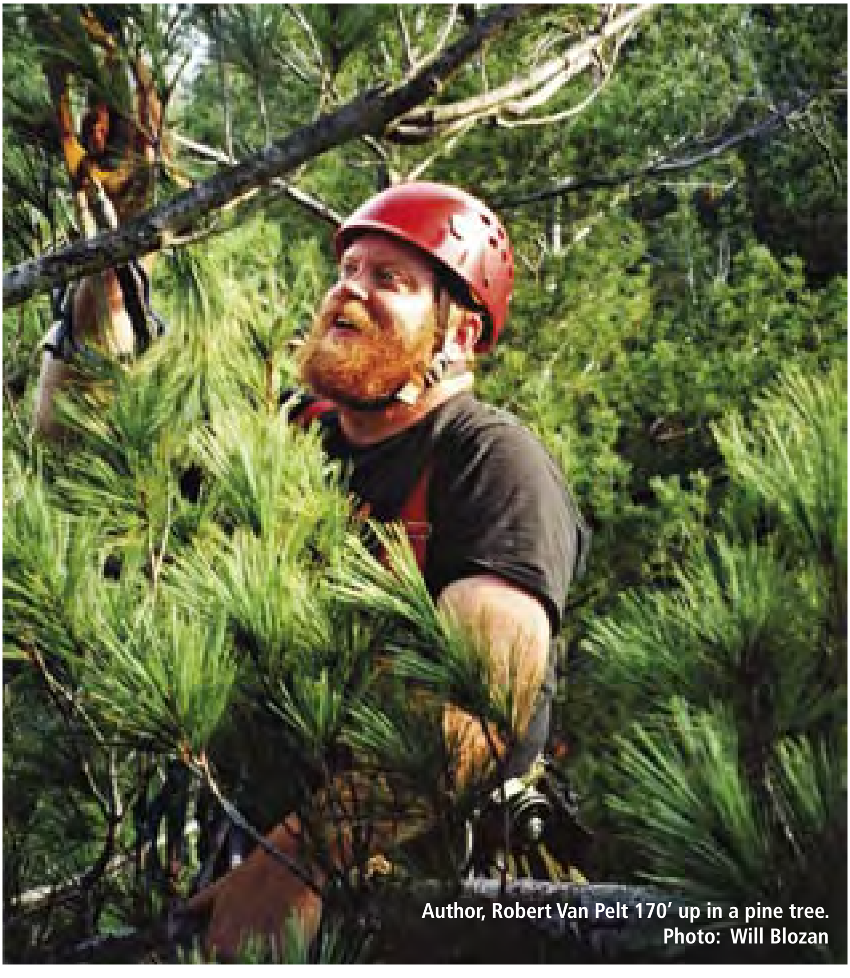
OG Guide	DNR Glossary	Essential Ecological process, elements and other notes
Cohort establishment phase	Ecosystem initiation	Establishment of cohort individuals
Canopy closure	Competitive exclusion: sapling exclusion	Canopy closes
Late canopy closure and early Biomass accumulation/stem exclusion	Competitive exclusion: pole exclusion	Inter-tree competition is the dominant ecological process. Live trees compete with each other for resources (light, water, nutrients). Loss of stems <2" dbh due to shading; Self pruning begins
Biomass accumulation /stem exclusion and early Maturation I	Competitive exclusion: large tree exclusion	Inter-tree competition is the dominate ecological process. Live trees compete with each other for resources (light, water, nutrients). Loss of stems <5" dbh due to shading.
Maturation I	Understory development And Botanically diverse	A shift of the dominate mortality processes occurrs from inter-tree competition to stochastic events (disease, wind, fire, pests) resulting in stem loss of larger trees (dominant and co-dominant) and a loss of shade. Openings in the canopy appear, allowing regeneration of shade tolerant species. High rate of biomass accumulation is maintained. In later stages, rate of live biomass accumulation begins to decrease. Continued understory development and stochastic stem loss. Stages generally lacking large down woody debris and large snags.
Maturation II	Botanically diverse	Development of additional species in lower and mid canopy. Large down woody material and large snags are generally absent or at low levels.
Vertical diversification	Niche diversification	Development of additional species in lower and mid canopy to abundant additional species at all canopy levels and increasing levels of large down woody debris and large snags.
Horizontal diversification	Fully functional	More stochastic stem losses create larger gaps. High accumulation of large woody debris, large snags.

Development stages used in this guide from Franklin et al. 2002. DNR stages adapted from Carey et al 1996 and Franklin et al 2002.

About the author

Robert Van Pelt is a research ecologist at the University of Washington in Seattle, where he received both his Ms and PhD. A native of the Midwest, he has lived in Seattle for more than 20 years. He has studied old-growth forests extensively across North America, particularly in California and the Pacific Northwest.

Currently, he is involved in canopy research on the structure and physiology of the world's tallest trees – coast redwood, Douglas fir, Sitka spruce, giant sequoia, and mountain ash in Australia. Always fascinated with facts and figures, his passion for trees led him to start the Washington Big Tree Program in 1987, which keeps records on the largest of each species of tree in the state. This ultimately led Robert to write *Forest Giants of the Pacific Coast* (2001), which chronicles in detail the largest trees in western North America.



Author, Robert Van Pelt 170' up in a pine tree.
Photo: Will Blozan

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Land Management Division
P.O. Box 47016
Olympia, WA 98504-7016

www.dnr.wa.gov

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N A T U R A L R E S O U R C E S

FINAL
ENVIRONMENTAL IMPACT STATEMENT

on the

POLICY FOR SUSTAINABLE FORESTS

JUNE 2006

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland • Commissioner of Public Lands

exclusively used when making financial decisions. Other tools are also utilized when circumstances call for other approaches. See also Appendix H, Financial Assumptions subsection.

1.8.3 Old-Growth Stands in Western Washington

A suggestion was made that old growth should be protected down to 5 and 10 acre stands. The Board's Preferred Alternative has been amended to defer harvest of old growth for stands 5 acres and larger that originated naturally before the year 1850.

1.8.4 Wildlife Habitat

A comment was made that "if DNR believes that managing for biodiversity is the underpinning for sustainable forestry, what justification does it have for not employing these techniques on some portion of trust lands?" Biodiversity may be applied at both the landscape and stand levels and at various intensities. DNR will deliberately manage for various levels of biodiversity on all of our harvestable lands. To that end, DNR utilizes "cohort management" where multi-rotational, or legacy cohorts co-exist with one or more rotational, commercial cohorts within the same forest management unit. While legacy cohorts are managed to achieve environmental forest management unit (FMU) objectives (such as wildlife and mycorrihizal habitats), one or more commercial cohorts within the same FMU are managed to achieve the economic FMU objective.

DNR's objective of a "biodiversity pathways" approach to silviculture is for simultaneous increases in both habitat and income (Board of Natural Resources Resolution No. 1134) through the creation of more structural diversity across the landscape. The use of biodiversity pathways to accomplish habitat objectives will be done in a manner that fulfills trust objectives, e.g. under HCP obligations that require certain types of habitat, in exchange for benefits to the trusts.

1.8.5 Watershed Systems

Comments were submitted that the HCP planning unit scale is not adequate to address cumulative effects and also that landscape planning should include the watershed scale analysis to address cumulative effects. The Board's Preferred Alternative for Watershed Systems provides for cumulative impacts analyses to be conducted at different scales, including the watershed scale.

1.8.6 Riparian Management Zones

Alternatives Suggested But Not Analyzed are discussed under the Riparian Conservation policy subject area below.

1.8.7 Riparian Conservation

A comment was made that larger stream buffers could benefit stream stability, fish habitat and water quality and that Alternative 3 and the Board's Preferred Alternative provides no additional protection to some Type 4 and 5 streams in Eastern Washington over Alternative 1. In Eastern Washington, DNR recognizes that in some cases, simply

3.2.5 Old-Growth Stands in Western Washington (formerly "Older Forests and Old Growth")

INTRODUCTION

This policy subject area addresses old-growth stands on forested state trust lands in Western Washington. Old Growth in Eastern Washington is discussed in the Affected Environment subsection. The environmental analysis on large, structurally unique trees from the *Draft* and *Final Environmental Impact Statement Habitat Conservation Plan*, page 4-487, and the discussion on large, structurally unique trees from the *Final Habitat Conservation Plan*, pg. IV-156 and IV-157, are incorporated by reference.

The significance of the policy debate on old-growth forests stems from the economic, ecologic and social importance that is associated with old growth forests and DNR's trust management responsibilities (Smith et al., 1995; and Thomas et al., 1993). The significance of old growth forests arises largely from the difference between its historical range of variability and the current range. Prior to the 1850s (referred to as pre-European settlement), the historical range of variability of old growth forests was estimated at between 54 and 70 percent of the entire forested area in Western Washington, while today only about 13 to 18 percent of the forest area is estimated to be in an old growth condition (National Research Council, 2000). Of the current extent, 80 percent is estimated to be on federal forestlands (Bolsinger and Waddell, 1993).

Although the Old-Growth Stands in Western Washington policy subject primarily meets the following Policy Objectives:

- Balance trust income, environmental protection, and other social benefits from four perspectives: the prudent person doctrine; undivided loyalty to and impartiality among the trust beneficiaries; intergenerational equity; and not foreclosing future options (Policy Objective 2); and
- Identify trust lands that provide special ecological, social or cultural benefits that are incompatible with active management, and look for opportunities to protect such areas through creative partnerships and funding mechanisms with appropriate compensation to the trusts (Policy Objective 8);

it works in conjunction with other policy subjects to fulfill the need and purpose of the *Policy for Sustainable Forests* in meeting the 10 policy objectives set out by the Board of Natural Resources.

AFFECTED ENVIRONMENT

Western Washington

Old growth forests demonstrate enormous heterogeneity in terms of their composition, function and structure. The nature of old growth leads to multiple definitions of old growth forests, even when the discussion is restricted to a limited geographic zone (Pacific Northwest Science Update, 2003; Franklin and Spies, 1991; Forest Ecosystem Management Assessment Team, 1993; and Spurr and Barnes, 1973). While the end-state of old growth seen today is significant in terms of conservation, current science is placing as much ecological importance on how old growth forests develop as in the end-state (Spies et al., 2002).

In the Pacific Northwest, old growth forests are commonly defined in structural terms as having very large living trees; large living trees with decadent limbs and crowns; large standing dead trees (snags); large down logs or woody debris; a variety of live tree sizes distributed in two or three tree canopy layers at different heights within the stand; and spatial heterogeneity across a stand in terms of clumps of trees and gaps in the forest canopy. Plant associations provide valuable information on probable historic disturbances that lead to the development of the current conditions (Spies et al., 2002). The extent of the forest stand is recognized as an important component in the definition of old growth. Stand size is an appropriate measure of the functionality of the stand within its landscape context (Old Growth Task Force, 1984).

Having multiple definitions poses a problem not only in terms of estimating the area of old growth within a forest inventory, but also for communicating with the public and decision-makers about what type of forest is actually being discussed. The term “old growth” is well-used, but has different meanings for different groups. A recent United States Department of Agriculture Forest Service publication provided an illustrative summary: “The term ‘old growth’ came from foresters in the early days of logging. In the 1970’s research ecologists began using the term to describe forests at least 150-years old that developed a complex structure characterized by large, live and dead trees; distinctive habitats; and a diverse group of plants, fungi, and animals. Environmental groups use the term ‘old growth’ to describe forests with large, old trees and no clearly visible human influences” (Pacific Northwest Science Update, 2003).

A definition of old growth that relates to forested state trust lands is in the HCP glossary: “A successional stage after maturity that may or may not include climax old-growth species; the final seral stage. Typically contains trees older than 200 years. Stands containing Douglas fir older than 160 years, which are past full maturity and starting to deteriorate, may be classified as old growth. DNR’s GIS forest classification for old growth is a dominant dbh of 30 inches or greater; usually more than eight dominant trees/acre; three or more canopy layers with less than complete canopy closure; several snags/acre with a 20 inch dbh or greater; and several down logs per acre with a 24 inch dbh or greater” (*Final Habitat Conservation Plan* glossary, page 10).

Table 1 displays the current acreages of old growth on Western Washington forested state trust lands, as defined by the HCP, using the criteria included in the HCP definition.

In addition to the HCP definition, DNR has distinguished those old growth forest stands on forested state trust lands that are 80 acres and larger (Old Growth Definition Task Group, 1986). Stands of less than 80 acres are often influenced by edge conditions and are not expected to provide interior fully functioning old growth forest conditions. Still, stands less than 80 acres may provide the forest structures that may still play important ecological roles within a landscape context.

Table 1: Estimated Extent of Old-Growth Stands (as defined by the HCP)

HCP Planning Unit	Old Growth acreage deferred from harvest to meet existing regulatory or HCP Requirements*			Old Growth acreage not deferred from harvest to meet existing regulatory or HCP Requirements			
	Stand size (acres)			Stand size (acres)			
	0-80	>80	Sub-total	0-80	>80	Sub-total	Total
Columbia	1,110	1,180	2,290	510	320	830	3,120
North Puget	12,640	16,850	29,490	2,260	170	2,430	31,920
OESF**	250	39,750	40,000	-	-	-	40,000
South Coast		10	10	-	-	-	10
South Puget	250	330	580	-	-	-	580
Straits	10	-	10	-	-	-	10
Total	**14,260**	**58,120**	**72,380**	**2,770**	**490**	**3,260**	**75,640**

The estimated area of old growth in the Olympic Experimental State Forest comes from a combination of DNR's Forest Resource Inventory System with a field assessment (Horton, S., personal communication). Inventory only estimate is approximately 20,800 acres.
*Deferred from harvest to meet HCP commitments relates to nesting, roosting and foraging and dispersal habitat thresholds, marbled murrelet habitat, riparian habitat and older forest condition landscape targets in the Olympic Experimental State Forest; but does not include deferrals to meet older forest targets outside of the Olympic Experimental State Forest as required by current Board of Natural Resources policy.
**While old growth in the Olympic Experimental State Forest as defined by HCP helps meet contractual commitments, harvest operations that further the HCP and Olympic Experimental State Forest objectives related to research may occur in old-growth stands subject to the March 2006 Settlement Agreement.

Recent legislation in 2004 (Engrossed Substitute House Bill 2573, section 905) directed DNR to convene a scientific committee to both define and inventory old growth forests on forested state trust lands in both Western and Eastern Washington. The Old Growth Definition Committee developed a method to estimate the extent of old growth forests on forested state trust lands in Western Washington. This work was completed by June 30, 2005. This method is based on assessing how forest stands on state trust lands compare with reference conditions in old growth forests of Western Washington. A full description of this method and an inventory of potential old growth using this method is contained in DNR's report, "Definition and Inventory of Old Growth Forests on DNR-Managed State Lands." This method, known as the Weighted Old Growth Habitat Index (WOGHI) (2005), and is based on previously published and unpublished work (Spies and Franklin, 1988; Franklin and Spies, 1991). The WOGHI integrates four key elements of old forests:

- Large trees (number of trees per hectare greater than or equal to 100 centimeters in diameter at breast height);
- Large snags (number of standing dead trees per hectare greater than or equal to 50 centimeters in diameter at breast height and greater than or equal to 15 meters tall);
- Volume of down woody debris (cubic meters per hectare);
- Tree size diversity.

Table 2 shows the acreages of old growth as defined by the Old Growth Definition Committee on forested state trust lands in Western Washington land classes. As discussed in the report, 52,666 acres in Western Washington have a high probability of being old growth, while 35,769 additional acres are potential old growth, but require secondary screening (Table 2). Based on some early field verification efforts, it appears that the actual acres of old growth will be closer to the 52,666 acreage using this method (Land Management Division, summer 2005).

Using either the HCP or the WOGHI method definition, all old growth is currently deferred from harvest to meet existing regulatory and HCP requirements, as well as older forest targets as directed by current Board of Natural Resources policy, with one exception. Old-growth stands in the Olympic Experimental State Forest may be available for harvest operations to meet research objectives of the Olympic Experimental State Forest and the HCP, except stands that are currently identified as occupied marbled murrelet sites. Any harvest of old growth must also be in accordance with DNR's decision to enter into a Settlement Agreement in March 2006. Under the terms of that agreement and for the length of the Agreement, DNR will not authorize or conduct any harvest in old-growth stands in the Olympic Experimental State Forest. Using the HCP definition, there are potentially about 40,000 acres of old growth in the Olympic Experimental State Forest. Using the WOGHI, there are about 27,000 acres having a high probability of old growth in the Olympic Experimental State Forest.

Table 2: Status of Old Growth Definition Committee Defined Old Growth (acres) by Land Class in Western Washington (all figures are estimates, subject to field verification)

Status	Sustainable Harvest Land Classes	Old Growth (WOGHI = 60+)[1]	Potential Old Growth (WOGHI = <60)[2]	Total
Currently contributing to regulatory or HCP conservation strategies	Owl Habitat	4,424	2,057	6,481
	Marbled Murrelet	2,689	1,278	3,967
	Riparian	15,245	14,059	29,304
	OESF[3]	14,101[4]	15,863	29,964
	Other	1,573	507	2,080
Permanently deferred	Natural Areas	14,379	1,266	15,645
Not currently contributing to regulatory or HCP conservation strategies	Stand size ≥ 80 acres	107	536	643
	Stand size < 80 acres	147	204	351
Total		52,666	35,769	88,435

1 – Weighted Old Growth Habitat Index (WOGHI) score of 60 or more out of 100 have a high probability of being old growth.
2 – Stands with a WOGHI score less than 60 may be old growth but need secondary screening.
3 – Harvest operations linked to the research objectives of the Olympic Experimental State Forest and HCP may occur in some old-growth stands and that are also in accordance with the March 2006 Settlement Agreement.
4 – This number does not include approximately 12,900 acres of old growth in riparian areas in the Olympic Experimental State Forest. These acres are part of the 15,245 acres identified in the riparian land class. Using the WOGHI method, there are approximately 27,000 acres in the Olympic Experimental State Forest that have a high probability of old growth.

Eastern Washington

The Scientific Committee on Old Growth could not define nor can DNR inventory old growth forests on forested state trust lands in Eastern Washington at this time (see page 15 of the *Definition and Inventory of Old Growth Forests on DNR-Managed State Lands* (2005) report). For Eastern Washington, insufficient research data exists to define an old-growth reference condition and for this reason, the committee was unable to create an old-growth habitat index for Eastern Washington within the timeframe provided in the legislation. During the 2006 legislative session, ESSB 6384 section 189 was added as a condition to the 2006 supplemental budget to direct DNR to conduct an inventory of old growth forests located on state lands east of the crest of the Cascade mountains. This inventory is to be completed in two phases. The first phase, to be completed by July 1, 2007, will identify reference stands for various plant associations; while the second phase, to be completed by December 15, 2007, will use the definition to produce an inventory of old growth forests. This information will then be used in the Eastern Washington sustainable harvest calculation. At that time, DNR will assess the need for Board of Natural Resources policy to address Eastern Washington old growth forests. The Eastern Washington sustainable harvest calculation is expected to be completed within the next five years. Until that time, DNR, in its land management strategies for Eastern Washington, is retaining forest structures thought to be elements of older forests in Eastern Washington. Along the east slope of the Cascades and within the range of the northern spotted owl, DNR is maintaining and developing sub-mature and mature habitat that is expected to develop into older forest structures. In the Klickitat HCP planning unit, DNR is retaining an average of six to 12 trees per acre of the largest diameter classes as part of its forest health and HCP Northern Spotted Owl Conservation Strategy. In Northeast Washington, DNR is also developing late successional forests as part of its *Loomis State Forest Final Landscape Plan* (June 1996). In addition, DNR retains selected large diameter trees as part of its land management activities across all of Eastern Washington.

The remaining discussion relates to Western Washington only.

Old growth forests have important ecological functions. Old growth forests in general are biotically more complex than forests in most earlier successional stages and, as a consequence, provide important habitat for various species. For example, approximately one-third of the vertebrate species using western forests were identified as likely associated with older forest conditions, including old growth (Thomas et al., 1993).

The wet, temperate, locally variable forest environment and high richness of plant species in the western Pacific Northwest are highly conducive for growth of a wide variety of fungi. Forest fungi are ecologically important to the region, because of their important role in forest food webs (Forest Ecosystem Management Assessment Team, 1993). Recent research has revealed that the diversity and productivity of mycorrhizal fungi are higher in older stands of Douglas-fir than in young or clearcut stands (Amaranthus et al., 1994). Scientists have identified 527 species of fungi that are closely associated with older and old growth forests in the Pacific Northwest (Forest Ecosystem Management Assessment Team, 1993).

Seventeen species of salamanders, including 14 endemic species, and the tailed frog are closely associated with older and old growth forests (Forest Ecosystem Management Assessment Team, 1993).

Forest dwelling mammals that are closely associated with old growth forests in the Pacific Northwest include martens, fishers, red tree voles, and several species of bats (Forest Ecosystem Management Assessment Team, 1993; and Thomas et al., 1993). The geographic distribution of martens and fishers has decreased during this century primarily due to habitat loss (Aubrey and Houston, 1992; Powell and Zielinski, 1994; and Buskirk and Ruggiero, 1994).

Old growth forests with diverse understory vegetation and abundant snags and coarse woody debris typically support one and a half times more biomass and wildlife species than do young forests (Carey, 1995; and Carey and Johnson, 1995).

Nine species of forest-dwelling bats, including Townsend's big-eared bats, are assigned some level of special status in states where they occur. Most of these species also were targeted for special consideration in the *Northwest Forest Plan*. Most common bat species in the Washington Cascades and Oregon Coast Range are up to ten times more abundant in old growth forests than in younger forests (Thomas and West, 1991). Several species are closely associated with old growth forests, because they roost in large trees and snags with deeply furrowed bark and cavities (Perkins and Cross, 1988; Thomas, 1988; Thomas and West, 1991; Cross, 1993; Cross and Waldien, 1994 and 1995; and Perkins, 1994).

Thomas et al., (1993) listed 38 species of birds closely associated with older and old growth westside forests, including Vaux's swift (Bull and Collins, 1993), northern goshawks (Reynolds, 1989) and pileated woodpecker. Suitable cavity-nesting substrates are assumed to occur at highest density in the large trees and snags found in old growth forests (Mannan and Meslow, 1984).

The bird species that are most closely associated with old growth forests are marbled murrelets, northern spotted owls and Vaux's swifts (Ruggiero et al., 1991). Long-term declines in the availability of suitable breeding and nesting habitat prompted the listing of the marbled murrelet and the northern spotted owl as threatened under the Endangered Species Act (ESA). The northern spotted owl, in particular, has been the centerpiece of the debate about forest management practices in the Pacific Northwest for the last several decades because of its preference for large tracts of old-growth forest (Thomas et al., 1990, 1993; Forest Ecosystem Management Assessment Team, 1993). Ongoing northern spotted owl population declines documented on 14 study areas in the Pacific Northwest have been attributed to several factors including declines in prey abundance, changing weather patterns, emerging threats such as competition with barred owls and West Nile virus, and habitat loss from timber harvest and catastrophic wildfire (Anthony et al., 2004; Courtney and Gutierrez, 2004).

Some recent information has been published on the effects of harvest rates over several years on northern spotted owl habitat. In 1997, there were approximately 350,000 acres of suitable spotted owl habitat on westside DNR-managed lands (Biological Opinion –

USDI, 1997). This comprises approximately 12 percent of suitable spotted owl habitat in Washington State (Biological Opinion -USDI 1997). In response to a request by the Forest Practices Board, the WDFW recently completed an analysis of harvest rates between 1996 and 2004 on private, state, and federal lands, as part of a review of the Forest Practices Board's rules regarding northern spotted owl habitat (Pierce et al., 2005). Overall results of the study indicate a decline in habitat in varying degrees depending on location within or outside of owl management circles, spotted owl special emphasis areas, or HCPs.

Land ownerships differ in terms of the role forested lands play in supporting northern spotted owl recovery efforts. For example, USFWS designated spotted owl "critical habitats," which are defined under Section 4 of the ESA as geographic areas "on which are found those physical or biological features essential to the conservation of the species and which may require special management consideration or protection". In Washington State, these critical habitat designations occur solely on federal lands (USDI, 1992). This is due to the greater quantity and continuity of forests constituting habitat on federal lands. Critical habitat areas are thought to be essential to maintaining the life processes and successful reproduction of a species. To this end, federal lands in Washington are vital for spotted owl conservation efforts, supporting source populations where reproductive rates exceed mortality rates (Minkova and Riepe 2004). In contrast, nonfederal lands appear to play a supporting role in spotted owl conservation (see the role of non-Federal lands in Spotted Owl Conservation, *DNR HCP Draft Environmental Impact Statement*, Executive Summary, pg. ix and x). The primary means for protecting spotted owl habitat on state trust lands in Washington is through the DNR's HCP (DNR 1997) which contains provisions for designating northern spotted owl Nesting, Roosting, and Foraging (NRF) and Dispersal Management Areas. These areas are intended to provide some demographic support for northern spotted owls, but are most important for maintaining the overall distribution of the species within its historic range and for facilitating species dispersal (i.e., movement of individuals between subpopulations). Additionally, a percentage (40 percent) of each landscape within the Olympic Experimental State Forest is maintained in a condition that supports spotted owls. Support for northern spotted owls on private forest lands is provided through HCPs and the state forest practices rules.

Old growth stands on forested state trust lands can play varying roles in northern spotted owl support, depending on size of the stand and its location on the landscape with respect to spotted owl habitat on federal lands and within HCP designated nesting, roosting and foraging or dispersal habitat areas.

REGULATORY FRAMEWORK

A number of other DNR policies and management strategies potentially affect the management status of old growth forests on forested state trust lands, including old growth research areas, the Commission on Old Growth Alternatives and the HCP.

In 1984, the Board of Natural Resources approved the *Forest Land Management Program*, a comprehensive plan for managing state lands and the precursor to the *Forest Resource Plan*. A section of the *Forest Land Management Program* directed DNR to establish seral stage deferral sites: "The department will identify and remove certain old-growth stands in Western Washington from the sustainable harvest base during this planning period to retain the option of acquiring information on old growth ecological relationships which may have application to intensive timber management" (*Forest Land Management Program,* page 54).

Based on this direction, DNR identified 12 old growth research areas covering approximately 1,800 acres in Western Washington. All sites are over 80 acres in size. These areas were deferred from harvest with the intent to carry out research to help DNR manage second growth forests for all ecological values. The *Forest Resource Plan* continued the deferral of these sites for much of the same purposes as identified in 1984.

In 1989, an Old Growth Commission was established by Public Lands Commissioner Brian Boyle. This commission recommended formation of the Olympic Experimental State Forest to gain and apply knowledge about old growth forests and modern commercial forest management. The Olympic Experimental State Forest was to be managed for both forest commodities and for ecological values. The commission also recommended 15,000 acres of "mature natural stands" to be deferred from harvest until 2007 (*Forest Resource Plan).*

The HCP conservation strategies and requirements influence the management of all existing old growth forest on forested state trust lands in Western Washington. The specific HCP conservation strategies determine how older forests are managed for riparian areas, the northern spotted owl, the marbled murrelet, multiple unlisted species and conservation research strategies in the Olympic Experimental State Forest. These strategies are designed to develop forests that will have characteristics of function, composition, and structure similar to "old growth" forests. These older forests will be managed over time to develop and maintain the specific forest conditions of structurally complex forests, while providing revenue to the trusts. Silviculture will be used as the principle disturbance regime, in combination with natural processes. In addition, the HCP's multiple unlisted species conservation strategy of retaining large, structurally unique trees should result in old growth components dispersed across the landscape outside of HCP designated Nesting, Roosting and Foraging (NRF) and Dispersal Management Areas for the northern spotted owl.

In addition to the HCP conservation strategies, the Board of Natural Resources approved a policy in the 2004 sustainable harvest calculation process targeting 10 to 15 percent of each Western Washington HCP planning unit for old forests based on structural characteristics (Final HCP, page IV 180 and Board of Natural Resources Resolution No. 1134) and that DNR will focus on existing old-growth, as defined by the HCP, as a priority in achieving these targets. This Board of Natural Resources direction and the HCP management strategy influence the designation of forest stands for conservation and management. Currently, DNR conserves all of the existing old growth forests as a result of HCP conservation strategies. Although, harvest operations in old-growth stands in the Olympic Experimental State Forest may occur in the future to meet research objectives of the Olympic Experimental State Forest, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement.

ALTERNATIVES

■ ALTERNATIVE 1 (NO ACTION)

DISCUSSION

Alternative 1 would continue to defer from harvest for ten years, 12 old growth research areas, representing approximately 1,800 acres in Western Washington. The 1992 deferral of 15,000 acres of structurally complex forests in the Olympic Experimental State Forest would continue until 2007. Alternative 1 also retains existing old growth as defined by the HCP to meet the old forest targets, which are currently expected to take up to 70 years. Once old forest targets are met, old growth in excess of that needed to maintain the target may be available for harvest. Alternative 1 does not appear to meet Policy Objectives 2 and 8 as well as other alternatives.

POLICY STATEMENTS

***Forest Resource Plan* Policy No. 14, Old Growth Research Area Deferrals: "During this planning period, the department will continue to defer from harvest certain old growth research stands in Western Washington to maintain the ability to acquire information on ecological relationships which may affect intensive timber management."**

The department will continue deferral of 15,000 acres of structurally complex forest in the Olympic Experimental State Forest until 2007.

The department will target, over time, 10 to 15 percent of each Western Washington *Habitat Conservation Plan* planning unit for old forests based on structural characteristics. In meeting these targets, old growth research areas will continue to be deferred and existing old growth (as defined by the *Habitat Conservation Plan*) and older stands will be a priority focus in developing the *Habitat Conservation Plan* planning unit targets.

■ ALTERNATIVE 2

DISCUSSION

Alternative 2 would permanently defer from harvest all old-growth stands, as defined by the HCP, outside of the Olympic Experimental State Forest, regardless of stand size. Under Alternative 2, once HCP targets were met, any old growth stand no longer needed to meet HCP or regulatory requirements or targets would likely be transferred out of trust status to permanently protect those stands from harvest activities, with full market value compensation to the trusts.

Old-growth stands within the Olympic Experimental State Forest may be subject to experimental application of silvicultural techniques, if consistent with the HCP and Olympic Experimental State Forest research objectives. However, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement. The purpose of the Olympic Experimental State Forest is to experiment with harvest and regeneration methods to enhance habitat characteristics and commodities production.

Under Alternative 2, all old growth research areas currently meet the HCP's definition of old growth and would be permanently deferred from harvest. However, under Alternative 2, they would no longer be classified as old growth research areas. In addition, Alternative 2 replaces the term "old" forest with "older" forest to ensure consistency in terms.

Under Alternative 2, exceptions to the policy for operational considerations could be made with Board of Natural Resources review. For example, these exceptions could include removal of some individual trees that are part of an old growth stand to allow road construction, where no feasible alternatives for road location were available. Criteria for field operations would be developed to guide these exceptions. In all cases, Board of Natural Resources review would be required for any exceptions.

Small clumps of large diameter old growth trees (greater than or equal to 30 inches in diameter at breast height) and individual old growth trees would be the focus in complying with HCP retention requirements for large, structurally unique trees. Old-growth stands, older forest stands and small clumps of large diameter old growth trees that are socially or culturally-significant would be considered for transfer out of trust status with compensation, when in the best interest of the trusts. Alternative 2 appears to meet Policy Objective 8 better than Alternative 1.

POLICY STATEMENTS

The department will target, over time, 10 to 15 percent of each Western Washington *Habitat Conservation Plan* planning unit for older forest conditions. The department will use retention of existing old-growth stands, as defined by the *Habitat Conservation Plan*, as a priority in achieving these targets. Any exceptions to this policy for operational considerations will be reviewed by the Board of Natural Resources.

Inside the Olympic Experimental State Forest, the department may conduct research in old-growth stands to meet the objectives of the Olympic Experimental State Forest and the *Habitat Conservation Plan*.

The department will retain large diameter (greater than or equal to 30 inches in diameter at breast height), old growth trees to meet *Habitat Conservation Plan* retention requirements for large, structurally unique trees. Department proposals to harvest any large *diameter old growth trees not retained to meet Habitat* Conservation Plan retention requirements, will be reviewed by the Board of Natural Resources, as will any other exceptions to this policy for operational considerations.

When in the best interest of the trusts, the department will transfer old-growth stands and small clumps of large diameter old growth trees having high social or cultural value, out of trust status, when full compensation is secured.

■ ALTERNATIVE 3

DISCUSSION

Alternative 3 differs from Alternative 2 in that all old-growth stands would not automatically be permanently deferred from harvest. Under Alternative 3, all old-growth stands greater than 80 acres in size will be deferred from harvest to achieve HCP targets for older forest structures. Under Alternative 3, once HCP targets were met, any old growth stand no longer needed to meet HCP or regulatory requirements or targets would be evaluated for either transfer out of trust status with full compensation to the affected trusts or considered for harvest activities.

Old-growth stands within the Olympic Experimental State Forest may be subject to experimental application of silvicultural techniques including harvest operations, if consistent with the HCP and Olympic Experimental State Forest research objectives. However, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement. The purpose of the Olympic Experimental State Forest is to experiment with harvest and regeneration methods to enhance habitat characteristics and commodities production.

As with Alternative 2, under Alternative 3 and the Board's Preferred Alternative, exceptions to the policy for operational considerations could be made with Board of Natural Resources review. Old-growth stands less than 80 acres that are not already deferred from harvest would be evaluated for their contribution to HCP older forest targets and management decisions will be made based on that evaluation. Under Alternative 3, some of the old-growth stands smaller than 80 acres, i.e., currently a total of 2,770 acres using the HCP definition or approximately 147 acres using the WOGHI method (Table 3), may be made available for harvest activities at some point in time, when and where they do not contribute to attainment of HCP commitments, and are in excess of acreage needed to meet HCP older forest targets.

Individual and small clumps of large diameter old growth trees would be the focus in complying with DNR's HCP retention requirements for large, structurally unique trees. Old-growth stands, older forest stands and small clumps of large diameter old growth trees that are socially or culturally significant would be considered for transfer out of trust status with full compensation, when in the best interest of the trusts. Alternative 3 meets the applicable policy objectives by providing balance between trust income and environmental protection (Policy Objective 2), including permanent protection of special old-growth stands through full compensation to the affected trust beneficiaries (Policy Objective 8).

The severity of the effects of harvesting old growth under Alternative 3 would vary with the stand size, location and structural characteristics of the stand. Small (less than 80 acres), isolated stands may lack interior forest conditions and connectivity to other old-growth stands (Old Growth Definition Task Group, 1986). As such, habitat in small, isolated stands is less likely to provide all of the ecological functions described in the Affected Environment subsection.

POLICY STATEMENTS

The department will target, over time, 10 to 15 percent of each Western Washington *Habitat Conservation Plan* planning unit for older forest conditions. The department will use retention of existing old-growth stands, as defined by the *Habitat Conservation Plan*, 80 acres and larger as a priority in achieving these targets. Any exceptions to this policy for operational considerations will be reviewed by the Board of Natural Resources.

Old-growth stands smaller than 80 acres not already deferred from harvest by regulatory and *Habitat Conservation Plan* requirements, will be evaluated for contribution to *Habitat Conservation Plan* objectives, for their social and cultural significance and conserved or managed based on that evaluation. Any proposal to harvest any old-growth stands smaller than 80 acres will be reviewed by the Board of Natural Resources.

Inside the Olympic Experimental State Forest, the department may conduct research in old-growth stands to meet the objectives of the Olympic Experimental State Forest and the *Habitat Conservation Plan*.

The department will retain large diameter (greater than or equal to 30 inches in diameter at breast height), old growth trees to meet *Habitat Conservation Plan* retention requirements for large, structurally unique trees. Department proposals to harvest any large diameter old growth trees not retained to meet *Habitat Conservation Plan* retention requirements, will be reviewed by the Board Natural Resources, as will any other exceptions to this policy for operational considerations.

When in the best interest of the trusts, the department will transfer old-growth stands and small clumps of large diameter old growth trees having high social or cultural value, out of trust status, when full compensation is secured.

■ BOARD'S PREFERRED ALTERNATIVE

DISCUSSION

The Board's Preferred Alternative defers harvest of all old-growth stands with the exception of old-growth stands in the Olympic Experimental State Forest, to meet a variety of objectives. This policy defines old-growth stands as stands five acres or larger with a natural origin prior to European settlement (year 1850) and in the most structurally complex stage of stand development, also referred to as the fully functional stage of stand development.

All three criteria must be met for a stand to be identified as old growth for the purposes of this policy.

However, as with all of the alternatives, if an old-growth stand suffers blowdown, fire, etc., such that it no longer retains the structure that makes it old growth, it would no longer be subject to the old growth policy statements. The stand would then be managed according to other Board of Natural Resources' policy, legal and contractual obligations, including the possibility of being protected, salvaged, or retained as a special ecological feature.

Similar to Alternatives 2 and 3, exceptions to this policy for operational considerations can be made with notification to the Board of Natural Resources. This policy also focuses single tree retention on very large, structurally unique trees, rather than trees of a certain diameter (Policy Objective 3). It was determined that specifying a diameter threshold (i.e., 30 or 40 inches) may not be consistent with the HCP requirements for very large, structurally unique trees. There can be trees with very large diameters that are not structurally unique and therefore, do not meet the intent of the HCP's conservation strategy. Trees targeted for retention under this policy, sometimes referred to as *old-growth remnants,* are characterized by very large diameters (may be 60 to 90 inches or more, depending on the species and growth environment) and possess large, strong limbs; open crowns; large, hollow trunks; broken tops and limbs; and deeply furrowed bark and are the focus for retention to meet HCP requirements for very large diameter, structurally unique trees.

As in Alternatives 2 and 3, old growth in the Olympic Experimental State Forest may be subject to experimental application of silvicultural techniques including harvest operations, if consistent with the HCP and the Olympic Experimental State Forest research objectives. However, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement. The purpose of the Olympic Experimental State Forest is to experiment with harvest and regeneration methods to enhance habitat characteristics and commodities production.

When in the best interest of the trust, old-growth stands will be transferred out of trust status if the trust receives full market value for the lands transferred. Such transfers can occur at any time and in such a way that these old-growth stands can continue to contribute to HCP habitat requirements and older-forest targets, even when no longer in trust status.

As in Alternatives 2 and 3, old-growth stands would be subject to transfer out of trust status with full market value compensation to the trust with a priority on those old growth stands not subject to protection under the HCP.

POLICY STATEMENTS

The department will defer from harvest old-growth stands (stands 5 acres and larger that originated naturally, before the year 1850), in order to help meet DNR's *Habitat Conservation Plan* and regulatory requirements, older-forest targets, and social/cultural values. This policy is subject to the following conditions:

- **The Board of Natural Resources will be notified of any exceptions to this policy for operational considerations; and**
- **The department will retain known very large diameter, structurally unique trees to meet DNR's *Habitat Conservation Plan* requirements for large, structurally unique trees. The department will notify the Board of Natural Resources of**

proposed harvests that may involve removals of very large diameter, structurally unique trees.

Inside the Olympic Experimental State Forest, the department may conduct operations in old-growth stands consistent with the requirements of DNR's *Habitat Conservation Plan* to meet the research objectives of the Olympic Experimental State Forest.

When in the best interest of the trust(s), the department will actively seek to transfer old-growth stands and areas containing very large diameter trees of high social or cultural significance out of trust status, when full market value compensation to the trust(s) is secured. In seeking to transfer such stands out of trust status, the department will immediately prioritize old-growth stands that are not subject to protection under DNR's *Habitat Conservation Plan* or other applicable regulations.

■ ALTERNATIVES SUGGESTED BUT NOT ANALYZED

A suggestion was made that old growth should be protected down to 5 and 10-acre stands. The Board's Preferred Alternative has been amended to defer harvest of old growth for stands 5 acres and larger that originated naturally before the year 1850.

SIGNIFICANT IMPACTS AND MITIGATION MEASURES

The comparative impacts of the alternatives using the HCP definition for old growth and the WOGHI method are illustrated in Table 3, by assessing the extent of old growth forests that may be subject to disturbance through silvicultural activities. The distinction between the alternatives is relatively small, due to influence of existing policies and HCP commitments.

Table 3: Summary of Western Washington Old Growth Policy Differences Among the Alternatives using HCP & WOGHI Definitions

Assumption		Alternative 1 (No Action)	Alternative 2 (Permanent Protection)	Alternative 3 (Protection > than 80 Acres)	Board's Preferred Alternative
Acres of Old Growth Deferred for HCP and Board of Natural Resources Policy *	HCP Definition	75,640	75,640	72,380	75,640
	WOGHI	52,666	52,666	52,519	52,666
Acres of Old Growth Not Deferred	HCP Definition	0***	0	2,770 acres < 80 acres	0**
	WOGHI	0***	0	147 acres < than 80 acres	0**

*Harvest operations consistent with the HCP and the Olympic Experimental State Forest research objectives and the March 2006 Settlement Agreement may occur in old-growth stands in Olympic Experimental State Forest.
** Old growth as defined by Board of Natural Resources policy is pre-European prior to 1850, 5 acres and larger and stands in the most structurally complex stage of stand development.
*** Once older forest targets are met, acres of old growth not needed to maintain the targets may be available for harvest.

Under all four alternatives, most existing old growth on forested state trust lands would be conserved as part of the strategies to achieve existing Board of Natural Resources policy and HCP objectives. Under Alternative 1, all 75,640 acres (using the HCP definition) or 52,666 acres (using the WOGHI method), are deferred from harvest until HCP and Board of Natural Resources targets for habitat and older forests are met, in approximately 60-90 years. Under Alternative 2, old-growth stands would continue to be permanently protected (primarily through transfer from trust status with full compensation), even after HCP requirements were met. Under Alternative 3, all but 2,770 acres using the HCP definition for old growth or 147 acres using the WOGHI method are deferred to meet regulatory and HCP requirements and Board of Natural Resources policy. It is likely that some of this 2,770 acres or 147 acres would be protected to help meet older forest targets. Under all the alternatives, harvest operations in old-growth stands in the Olympic Experimental State Forest could occur consistent under the HCP and the research objectives of the Olympic Experimental State Forest. However, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement.

Under Alternative 1, old growth forests may be impacted by harvest activities after HCP requirements and older forest targets are met in approximately 70 years. Alternative 1 would then release approximately 3,260 acres of old growth (using the HCP definition) or 254 acres of old growth (using the WOGHI method), which represents approximately .1 percent and .009 percent of the existing suitable spotted owl habitat in Western Washington respectively (Biological Opinion - USDI, 1997). Because release of these acres could take up to 70 years, as noted above (once HCP requirements are met), Alternative 1 would have no impacts until the targets are met (see discussion of policy adopted under sustainable harvest in the Regulatory Framework section of this policy subject area).

Under Alternative 2, all old growth forests are permanently deferred from harvest both before and after HCP requirements and older forest targets are met with the exception of harvest operations consistent with the HCP in old-growth stands in the Olympic Experimental State Forest directly tied to research objectives. However, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement. As under Alternative 1, Alternative 2 would have no short-term impacts on the availability of northern spotted owl habitat, as all old growth outside the Olympic Experimental State Forest would be deferred during the life of the HCP. Within the Olympic Experimental State Forest, all old growth is deferred from harvest during the term of the March 2006 Settlement Agreement and only experimental harvesting of old growth related to research could occur after the term of the Settlement Agreement. The additional mitigation of impacts provided by the policy adopted under sustainable harvest related to using existing old growth stands to meet older forest targets is previously discussed in the Regulatory Framework section of this policy subject area. However, the permanent deferral of old growth proposed under Alternative 2 and the Board’s Preferred Alternative would provide the greatest long-term protection to northern spotted owls and other old growth associated species, compared to Alternatives 1 and 3. Over time, a greater amount of northern spotted owl habitat would exist collectively between the existing old growth, and the creation of new suitable northern spotted owl habitat through active management on other trust lands.

Under Alternative 3, some old growth forests in stands greater than 80 acres may be impacted by harvest activities after HCP requirements and older forest targets are met (targets are not expected to be met for 70 years or more). Old growth forests in stands smaller than 80 acres (HCP 2,770 acres and WOGHI 147 acres) may be impacted by harvest activities after 2014. The March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement. Using the WOGHI method, 97 acres of old growth in stands smaller than 80 acres exist in the Columbia HCP planning unit, 21 acres in the North Puget planning unit and 28 acres in the South Coast planning unit. All of these stands are located outside of areas designated to provide nesting, roosting and foraging and dispersal habitat in support of owls on federal lands. All of these stands are also found outside of riparian management areas.

As a result, due to the location and site of these stands, they do not provide the necessary habitat requirements or play a role in supporting reproducing northern spotted owls, or other species associated with old growth that require large, contiguous blocks of habitat. However, by making these small stands available for harvest after 2014, Alternative 3 would most likely increase the level of fragmentation of older forest on DNR-managed lands across the landscape which could result in further isolation of sub-populations of spotted owls, reduce territory occupancy and nest success, or prevent the future colonization of suitable northern spotted owl habitat that is not currently occupied (Blakesley, 2004). All of these factors could accelerate the decline of northern spotted owl populations.

In addition, harvest of these smaller old growth stands under Alternative 3 would carry the risk of reducing or effectively eliminating the ecological benefits of the old growth habitat condition in those locations. For example, removal of large trees and snags may eliminate nest sites for cavity-dependent birds, roost sites for bats or den sites for Pacific fishers. Reduction of canopy cover would result in changed microclimatic conditions and reduced interior forest habitat. This “edge effect” may create habitat conditions that favor edge-associated species and species that are habitat generalists.

However, compliance with the HCP conservation strategy for retention of very large structurally unique trees in these stands would mitigate for some of these impacts.

Under the Board’s Preferred Alternative, all existing old growth outside of the Olympic Experimental State Forest is permanently deferred from harvest. Old-growth stands in the Olympic Experimental State Forest may be subject to harvest operations consistent with the HCP to meet the research objectives of the Olympic Experimental State Forest. However, the March 2006 Settlement Agreement does not allow any harvest of old growth during the term of the Agreement. This Agreement provides mitigation for impacts to owls in the short-term by not allowing any harvest in old growth for research purposes until 2014 or until the calculation of a new sustainable harvest level, whichever is later. All impacts as a result of any harvest of old growth in the Olympic Experimental State Forest related to research after 2014 cannot be identified or analyzed at this time.

Any proposal to harvest old growth for research purposes in the Olympic Experimental State Forest would be subject to SEPA analysis at that time. Single very large diameter, structurally unique trees, often referred to as old-growth remnants, are the focus for retention to meet HCP requirements for very large structurally unique trees. Impacts to northern spotted owls, and other old growth associates, under the Board's Preferred Alternative would be similar to those described for Alternative 2, with the exception that stands would be classified as old growth based on stand age, as well as specific structural characteristics. For this reason, this alternative would not protect older stands that originated after 1850, but may still have some structural complexity. These stands could meet habitat requirements for northern spotted owls and other old-growth associates, which include biological legacies such as large diameter snags, multiple canopy layers, and large downed logs. However, these older stands, while not protected under this policy, would be considered for and in many cases retained, to help meet other HCP commitments and the older forest targets discussed under the General Silvicultural Strategy policy.

CUMULATIVE IMPACTS

DNR recognizes that cumulative impacts have the potential to occur with relation to old growth forest habitats. The loss of old growth forests in the Pacific Northwest has resulted in cumulative adverse impacts in the loss and endangerment of wildlife and plant species. The listing of the northern spotted owl, marbled murrelet and various salmonid species are responses to these adverse cumulative impacts.

Old growth forests on forested state trust lands represent a small percentage of the remaining old growth in Western Washington. Timber harvest and development have reduced the amount of old-growth forests in Western Washington and Oregon from a range of approximately 54-70 percent to 13-18 percent of the forests (National Research Council, 2000). Using the WOGHI method for determining forest stands with a high probability of old-growth forests the amount represented on forested state trust lands in Western Washington ranges from 1.8 (52,666 acres) to 2.6 percent (88,435 acres) of the entire old-growth forests in Western Washington. Using the HCP definition for old growth, the amount represented on forested state trust lands in Western Washington (75,640 acres) ranges from 2.7 to 3.7 percent of the entire old-growth forests in Western Washington.

Using the WOGHI method, old growth represented on forested state trust lands represents from 1.8 to 3.0 percent of all suitable spotted owl habitat in Western Washington (2,916,666 acres). Under the HCP definition it is approximately 2.6 percent of the entire suitable spotted owl habitat in Western Washington.

However, the existing old growth forests on forested state trust lands play an important role in DNR's HCP conservation strategies. The potential for harvest of old growth under all of the alternatives on forested state trust lands is 0 under the terms of the March 2006 Settlement Agreement until at least 2014. After 2014, the potential for harvest of old growth on forested state trust lands outside of the Olympic Experimental State Forest, ranges from 0 to 147 acres (contiguous stands of < 80 acres) under the WOGHI method and from 0 to 2,770 acres (contiguous stands of < 80 acres) under the HCP definition.

Thus, the maximum acres available for harvest under the two definitions, after 2014, ranges from less than 1/100 percent to approximately 1/10 percent of the entire suitable spotted owl habitat in Western Washington under Alternative 3. Although significant impacts to the natural environment after 2014, such as to populations of old-growth dependent species are unlikely under this alternative due to the size of the stands that may become available for harvest (under 80 acres) and the low percentage of existing old growth in Western Washington they represent, some of these stands may act as corridors or islands for dispersal between habitat patches and their removal could result in increasing the level of habitat fragmentation and impacts to old-growth dependent species populations, e.g., northern spotted owls. However, the potential for significant impacts from the harvest of any of these stands under Alternative 3 would be evaluated through a separate SEPA process in the event that these stands were proposed for harvest.

Under the Board's Preferred Alternative, the amount available for harvest is limited to stands under 5 acres that may exhibit some of the other characteristics of old growth, but are not defined as old growth in the Board's Preferred Alternative. It is highly unlikely that stands of this size represent a normally functioning old growth stand (Old Growth Definition Task Group, 1986). In addition, these small patches will be the focus for rotation to meet the HCP Conservation Strategy for very large structurally unique trees. Therefore, there are no significant impacts related to exclusion of these small patches from the definition of old growth.

Under Alternatives 1, 2 and the Board's Preferred Alternative there are no significant adverse cumulative impacts to the natural environment related to the harvest of old growth. It is also unlikely that potential harvest under Alternative 3 would result in significant adverse impacts to the natural environment although there may be greater impacts to old growth dependant species as discussed in the Significant Impacts and Mitigation Measures discussion. Significant impacts are avoided because mitigation currently provided by existing Board of Natural Resources policy already sets aside most of the DNR's old growth. These policies include the non-harvest of old growth stands to help meet a target of 10-15 percent of older forest structure (high quality spotted owl habitat) in each Western Washington HCP planning unit over time; DNR's HCP conservation strategies; the March 2006 Settlement Agreement; state forest practices rules; the *Northwest Forest Plan* and other regional programs, such as the salmon recovery efforts (Salmon Recovery Funding Board); and a number of habitat conservation plans developed by other forest landowners and local government utilities (e.g., Seattle City Light and Tacoma Water). The requirement to conduct SEPA review on state timber sales also provides a safety net for identifying, mitigating, and avoiding any potentially significant impacts of harvest proposals that could occur under Alternative 3. The Board's Preferred Alternative, by prohibiting harvest of any contiguous stands of old growth (greater than 5 acres), further avoids any potentially significant impacts related to the natural function of old growth stands.

3.4.2 General Silvicultural Strategy

INTRODUCTION

DNR defines silviculture as the art and science of cultivating forests to achieve outcomes identified by state and federal law and Board of Natural Resources policy. Silviculture is a tool that consists of a set of methods or techniques used to create a desired outcome (future) for a forest/stand, such as revenue or habitat. The application of silvicultural strategies is one of the primary mechanisms for achieving desired outcomes across landscapes. These strategies may be developed and analyzed through forest land planning. Silvicultural prescriptions incorporate activities, such as site preparation; planting specific tree species at specified densities; fertilization; removal of non-desirable species; and intermediate as well as final harvesting of trees. Stand-specific activities contribute to landscape and statewide outcomes, such as the sustainable harvest calculation and the HCP.

Although the General Silvicultural Strategy policy subject primarily meets the following Policy Objectives:

- Use professional judgment, best available science and sound field forestry to achieve excellence in public stewardship (Policy Objective 5); and
- Promote active, innovative and sustainable stewardship on as much of the forested land base as possible (Policy Objective 7);

it works in conjunction with other policy subjects to fulfill the need and purpose of the *Policy for Sustainable Forests* in meeting the 10 policy objectives set out by the Board of Natural Resources.

AFFECTED ENVIRONMENT

The practice of silviculture on forested state trust lands potentially affects several elements of the environment, including habitat, plants and animals, water, earth and aesthetics. Although these elements may be directly affected by the practice of silviculture, its impact to specific elements are addressed under other specific policy subject areas, e.g., Forest Health; Wildlife Habitat; Watershed Systems; Riparian Conservation; and Visual Impacts. These other policy subject areas cover the range of silvicultural activities used on forested state trust lands and their potential for affecting elements of the environment. Silvicultural prescriptions are designed and implemented to accomplish site-specific stand objectives. Stand objectives are written to help meet landscape or statewide objectives or outcomes, such as revenue generation, restoration of structurally complex forests and creation of habitat. Silvicultural treatments do not always result in removal of material from the stand. These types of treatments, known as pre-commercial thinnings, leave cut material in the stand to provide woody debris or habitat value to the stand.

In contrast, commercial thinning removes a portion of a stand, leaving a substantial number of trees and portions of debris (limbs, roots, nutrients, etc.) after a timber harvest.

Commercial thinnings are typically carried out where there are multiple objectives, such as generating revenue, while accelerating the forest stand’s development towards functional wildlife habitat.

In meeting economic and other landscape and statewide objectives, DNR most often implements commercial thinnings in stands that are in the competitive exclusion stage of stand development, particularly in stands where thinning would accelerate achievement of wildlife habitat objectives or outcomes. For a description of the stand development stages, see the *Final Environmental Impact Statement on Alternatives for Sustainable Forest Management of State Trust Lands in Western Washington*¸ Appendix B. Trees in the competitive exclusion stage compete for direct sunlight, nutrients and water. Where soil moisture is in ample supply, competition is generally between tree-crowns for sunlight. In arid forests, common to the oak, ponderosa pine and Douglas-fir series in Eastern Washington competition for soil moisture is keen, resulting in open-grown stands due to root, instead of crown, competition. At the competitive exclusion stage, stands are nearing, full-site occupancy and have little diversity in tree size, unless legacy trees remain from previous successions or management. Traditional commercial forestry thinning sought to capture natural tree mortality before it occurred, by harvesting the smaller trees that would likely die without harvest. Commercial thinning in these competitive exclusion stands is usually conducted from below the upper canopy, i.e., the thinning treatment removes the smallest trees first. Thinning usually results in about 70 percent of the initial stand remaining after harvest. Traditional thinning treatment typically does not affect the stand’s most dominant trees. The diversity of tree sizes of the dominant trees remains much the same as prior to the thinning treatment, but the stand’s optimal growth rate is sustained.

A structurally complex forest stage must have vertical and horizontal diversity in terms of tree heights, diameters, tree spacing, large standing dead trees (snags) and large woody debris. To obtain those structural characteristics, a stand needs to develop along somewhat specific developmental “pathways” through time. The earlier a stand’s intended pathway is initiated, the better control the forest manager has over mixtures of shade tolerant and intolerant species, which influence vertical development and diversity, as well as stocking levels, which influence horizontal development and diversity. Stands that have progressed to a competitive exclusion stage present a decision as to whether or not to accelerate the stand’s transition into an understory development stage. Establishing shade tolerant tree species under the main tree canopy provides smaller trees that can grow and develop into a mid-story. This development will, in time, accelerate the vertical and horizontal diversity of tree sizes. The remaining overstory trees will continue to develop and grow larger until they can be recruited either naturally or artificially through management intervention to provide large standing dead trees or large woody debris.

Managing stands along developmental pathways require forest managers to have a comprehensive understanding of the structures and processes in forest stands (Franklin, 2002; and Carey, 2003). Carey et al., (1996) used the phrase “biodiversity pathways” for the management of forest stands and forested landscapes to achieve objectives of conserving biodiversity and generating revenue through the application of innovative silviculture that accelerates the development of structurally complex stands. This is particularly important on those lands targeted to provide the most benefit to wildlife species, i.e. spotted owl conservation areas, the Olympic Experimental State Forest, and owl areas as described in the March 2006 Settlement Agreement (approximately 74 percent of forested state trust lands in Western Washington).

Although the developmental pathways approach has focused on forests west of the Cascade crest, the ecological principles apply to Eastern as well as to Western Washington. Silvicultural treatments, if grounded in biological capabilities of each site and constraints of surrounding landscapes, will accelerate and guide stand development along pathways that may be designed to optimize achievement of landscape and statewide objectives.

DNR uses chemicals and other biologic pathogens or predators in three primary silvicultural applications: site preparation, reducing competition from species in areas to be reforested; vegetation management, reducing competition from species after reforestation has been initiated; and to temporarily reduce impacts from insect epidemics. The first two involve herbicides and the last involves insecticides, other biologic pathogens or predators.

Site preparation and vegetation management are performed on more than one-half of all forest management units on forested state trust lands managed by DNR and often more than one treatment is required. Some competing vegetation or weed species may be reduced to acceptable levels by leaving an overstory of trees when harvesting timber. However, this approach is often counterproductive in that it precludes successful reforestation and vigor of planted seedlings and is, therefore, generally not considered. Other weed species may be treated by manual slashing during a period each year when growth hormones are entirely in the crowns of the target species and thus, re-sprouting is precluded. Other weed species, however, do not have such a period and respond to manual slashing by accelerating growth. The latter can be controlled by herbicides.

Insect epidemics occur sporadically, but often with serious consequences. As discussed in the Forest Health policy subject area, forest insects occupy natural niches in the forest ecosystem when present endemically. However, when forest insect populations reach epidemic proportions, the subsequent fire danger from dead and dry trees can pose an unacceptable hazard to human life, resources and property. In order to stave off outbreaks in high risk forests for a year or two before converting them to a more healthy condition, insecticide or other biologic pathogen applications or introducing predators are sometimes the best short-term approach.

Between fiscal years 1999 and 2003, DNR annually treated an average of 4,194 acres with aerial-applied herbicides and 3,891 acres with ground-applied herbicide. DNR last applied aerial pesticides in fiscal year 2000 to 3,618 acres.

Chemical and processed natural fertilizers have been applied to forested state trust lands. In recent years, severe budget restrictions have precluded application of chemical fertilizer. Fertilization is an investment that, if applied to sites with high potential for favorable response, are highly likely to generate positive returns both in terms of trust revenue and accelerated stand development for non-fiduciary objectives, such as wildlife habitat and visual quality. DNR's application of chemical fertilizer has averaged 2,647 acres between fiscal years 1999 and 2003.

DNR has also applied bio-solids (a processed natural fertilizer) to forested state trust lands, primarily in King County, with a general objective to dispose of processed urban sewage effluent where it could be done with mechanical scattering techniques. A measurable favorable growth response has been recorded through sampling.

REGULATORY FRAMEWORK

The regulatory framework consists of the State Environmental Policy Act (RCW 43.21C), the Forest Practices Act (RCW 76.09), the federal Endangered Species Act (16. U.S.C. 1531 et seq.), implemented primarily through DNR's HCP and the modified *Lynx Habitat Management Plan*. In addition, at the federal level, silvicultural application of chemicals is governed by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA—7 U.S.C. s/s 136 et seq. 1996). This act provides federal control of chemical distribution, sale and use. Under the Federal Insecticide, Fungicide and Rodenticide Act, only chemicals certified and labeled for safe use by the United States Environmental Protection Agency may be used and only for the particular applications the agency has approved, and then only with conformance of the requirements specified on the chemical label. Furthermore, the act requires users to register chemical purchases and applicators to possess a current certification for the class of application they practice. Certification is delegated to the states under federal standards.

At the state level, the Washington State Department of Agriculture is responsible for ensuring that chemicals are used safely and legally. To this end, the Department of Agriculture performs a number of activities, including registering the pesticidal products in the state, investigating complaints of possible misuse, maintaining a registry of pesticide-sensitive individuals and administering a waste pesticide collection program. These duties are performed under the authority of the Washington Pesticide Control Act (15.58 RCW), the Washington Pesticide Application Act (17.21 RCW), the General Pesticide Rules (WAC 16-228), the Worker Protection Standard (WAC 16-233) and a number of pesticide and/or county-specific regulations. In addition, forest practices rules (WAC 222-38-020) translate these various legal requirements into rules that govern details of pesticide handling, storage and applications on forested state trust lands, particularly in regard to aerial application and protection of wetlands and riparian areas.

The primary regulatory framework that pertains to application of chemical fertilizer on forested state trust lands is found in the forest practices rules, which govern handling, storage and application of chemical fertilizers, with particular emphasis on aerial application in the vicinity of bodies of water. State Forest Practices Rules and DNR procedures require buffering of water bodies from application. Notification of the public of proposed aerial application is also required. Other requirements involve analysis of potential environmental impacts due to application of chemicals through SEPA.

The Federal Insecticide, Fungicide and Rodenticide Act encourages and DNR practices Integrated pest management. Integrated pest management is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks. In addition, SEPA requires site-specific analysis of the adverse environmental impacts of proposed actions.

ALTERNATIVES

■ ALTERNATIVE 1 (NO ACTION)

WESTERN WASHINGTON

Policy No. PO14-C was adopted for Western Washington by the Board of Natural Resources on September 8, 2004, as part of the sustainable harvest calculation decision. It canceled *Forest Resource Plan* Policy Nos. 11 and 30 for Western Washington only.

PO14-C GENERAL SILVICULTURAL STRATEGY APPLIED TO THE TIMBER RESOURCE BASE AVAILABLE FOR SUSTAINABLE HARVEST IN WESTERN WASHINGTON

POLICY STATEMENTS IN PO14-C

The department will follow legal requirements in maintaining the greatest possible portion of the trust forestlands as on-base.

The department will provide professional management of forestlands through active stewardship of on-base lands. Active management of the land base will be carried out as an integral part of the department's fiduciary responsibilities to achieve, on a landscape basis, a combination of forest structures that over time provide for broad and balanced economic, ecological and social benefits. The department will use intensive and innovative silviculture to guide the desired progression of stand development to simultaneously produce trust revenue and create structural diversity across the landscape.

The department will target over time 10 to 15 percent of each Western Washington *Habitat Conservation Plan* planning unit for old forests based on structural characteristics. In meeting these targets, Old Growth Research Areas will continue to be deferred and existing old growth (as defined by the *Habitat Conservation Plan*) and older stands will be a priority focus in developing the *Habitat Conservation Plan* planning unit targets.

EASTERN WASHINGTON

Under Alternative 1 for Eastern Washington, *Forest Resource Plan* Policy Nos. 11 and 30 still apply.

***Forest Resource Plan* Policy No. 11, Managing On-Base Lands: "The department will manage on-base forestlands at different levels of intensity depending on biological productivity and economic potential. Investment decisions will be made according to expected returns."**

***Forest Resource Plan* Policy No. 30, Silviculture Activities: "The department will plan and implement silvicultural activities to meet trust responsibilities. In cases warranting special attention, the department will accept a reduction in current income or return on investment when the department determines it is necessary to provide extra protection for soil, water, wildlife, fish habitat and other public resources."**

STATEWIDE

Under Alternative 1, the following policies from the *Forest Resource Plan* apply in both Western and Eastern Washington and were not directly addressed as part of the Board of Natural Resources decisions on September 8, 2004.

***Forest Resource Plan* Policy No. 31, Harvest and Reforestation Methods: "The department will select the harvest method which produces the best mix of current and long-term income, achieves reforestation objectives and integrates non-timber resource objectives identified in the *Forest Resource Plan*. Reforestation objectives must ensure adequate restocking, produce acceptable benefits to the trusts and protect public resources."**

***Forest Resource Plan* Policy No. 33, Control of Competing Vegetation: "To prevent domination of crop trees by other vegetation, the department will select from these methods for controlling competing vegetation:**

- **No treatment.**
- **Non-herbicide.**
- **Ground-applied herbicide.**
- **Aerial-applied herbicide.**

The department will consider the no treatment method first and then move sequentially down the list. The department will select the first method on the list which is both effective and produces an acceptable return on investment. A method lower on the list may be used only if it substantially outperforms other methods."

***Forest Resource Plan* Policy No. 34, Fertilizing, Thinning and Pruning: "The department will use fertilization, thinning and pruning on stands which will respond and produce an acceptable rate of return on investment."**

■ ALTERNATIVE 2

Under Alternative 2, the following policy statements apply statewide. Alternative 2 modifies Policy No. PO14-C that was adopted by the Board of Natural Resources on September 8, 2004, by moving the policy statement related to older forests and old growth research areas to the Old-Growth Stands in Western Washington policy subject area in this Final EIS for the *Policy for Sustainable Forests* and extending policies adopted by the Board of Natural Resources for Western Washington to Eastern Washington as well. Alternative 2 recognizes that the subjects addressed in *Forest Resource Plan* Policy Nos. 31, 33 and 34 are silvicultural “methods” or “techniques,” rather than policy statements. They specify harvest and reforestation methods; control of competing vegetation; and fertilizing, thinning and pruning as necessary to achieve a combination of forest structures over time, as well as to provide for balanced economic, ecological and social benefits.

Under Alternative 2 and the Board’s Preferred Alternative, *Forest Resource Plan* Policy Nos. 11, 30, 31, 33 and 34 would be discontinued. Alternative 2 and the Board’s Preferred Alternative direct DNR to use intensive and innovative silviculture to achieve desired stand and landscape objectives in both Western and Eastern Washington. Alternative 2 and the Board’s Preferred Alternative best meet the applicable policy objectives by promoting use of professional judgment, best available science and sound field forestry to achieve excellence in public stewardship (Policy Objective 5) through active, innovative and sustainable management of all forested state trust lands (Policy Objective 7).

Management of a stand does not always imply that activities will occur on the ground. Active management means also reviewing the progress of a stand to meet its objective, and evaluating that progress on a regular basis. Field staff will evaluate if an activity would speed the progress of the stand to meet its stand level objective and if the investment in the stand would be warranted. DNR’s field staff reviews the progress of many stands on a regular basis and only proposes activities when stand level objectives will be delayed or will not be met without intervention. By management of “the greatest possible portion of forested state trust lands” more of the stand will meet its objectives sooner.

POLICY STATEMENTS

The department will follow legal requirements in actively managing the greatest possible portion of forested state trust lands.

The department will provide professional management of forestlands through active stewardship of forested state trust lands. Active management of the forestland base will be carried out as an integral part of the department’s fiduciary responsibilities to achieve, on a landscape basis, a combination of forest structures that over time provide for broad and balanced economic, ecological and social benefits. The department will use intensive and innovative silviculture to guide the desired progression of stand development to simultaneously produce trust revenue and create structural diversity across the landscape.

■ BOARD'S PREFERRED ALTERNATIVE

DISCUSSION

The Board's Preferred Alternative builds on Alternative 2 by including the following: the discussion for old growth has been moved to the Old-Growth Stands in Western Washington policy subject area; specifies how suitable older stands will be identified to help meet older-forest targets; emphasizes that the 10-15 percent older-forest targets will be accomplished over time; and specifies that once older-forest targets are met (expected to take 70 years or more), structurally complex forest stands that are not needed to meet the targets may be considered for harvest activities.

DNR intends to actively manage structurally complex forests, especially those suitable stands in the botanically diverse stage of stand development, to achieve older-forest structures across 10-15 percent of each Western Washington HCP planning unit in 70-100 years. Older-forest structures that contribute to this target are represented by stands in the niche diversification or fully functional stage of stand development.

The landscape context of a structurally complex stand greatly influences its suitability to be managed to meet older-forest targets. The size of the stand, its proximity to old-growth or other structurally complex forest stands, or the scarcity of old-growth and other structurally complex stands are all factors in determining if a stand is suitable for contributing to older-forest targets. Assessment of the landscape conditions can identify the relative contribution that a structurally complex forest stand can make toward achieving those targets. Decisions regarding old growth are guided by the Old-Growth Stands in Western Washington policy.

POLICY STATEMENTS

The department will provide professional management of forested state trust lands through active management and stewardship of the greatest possible portion of these lands.

The department will carry out active management as an integral part of the department's fiduciary responsibilities to achieve, on a landscape basis, a combination of forest structures that, over time, provide for broad and balanced economic, ecological and social benefits.

The department will use intensive and innovative silviculture to guide the desired progression of stand development to simultaneously produce trust revenue and create structural diversity across the landscape.

The department will target 10-15 percent of each Western Washington *Habitat Conservation Plan* planning unit for "older" forests-based on structural characteristics-over time.

Through landscape assessments, the department will identify suitable structurally complex forest stands to be managed to help meet older-forest targets. Once older-

forest targets are met, structurally complex forest stands that are not needed to meet the targets may be considered for harvest activities. However, old growth is addressed in the Old-Growth Stands in Western Washington policy.

■ ALTERNATIVES SUGGESTED BUT NOT ANALYZED

A suggestion was made that language from *Forest Resource Plan* Policy 30 that granted discretion to reduce trust income to provide extra protection for certain resources should be included in the updated policy. Since the protection of resources is covered in the individual policy subjects, and coupled with the fact that the General Silvicultural Strategy is simply the means of integrating and implementing the policies on the ground, it is unnecessary to include this language in the updated policy.

SIGNIFICANT IMPACTS AND MITIGATION MEASURES

For impacts associated with the first two policy statements under Alternative 1 for Western Washington, see the *Final Environmental Impact Statement on Alternatives for Sustainable Forest Management of State Trust Lands in Western Washington*.

The risk of adverse impacts to the environment, particularly wildlife habitat, plants and animals, water, earth and aesthetics, is increased under Alternative 1. Alternative 1, in retaining *Forest Resource Plan* Policy Nos. 31 and 34, attempts to provide a site-specific and outcome-oriented approach to managing DNR's forested state trust lands. In doing so, Alternative 1 mandates techniques and field craft that are something less than a landscape scale approach to silviculture. This approach will most likely focus on stand-level technical proficiency at the expense of achieving desired landscape conditions for wildlife, forest health, water and soil. Alternative 1 emphasizes activity or unit objectives over strategic landscape objectives. Activity objectives are construed without comparison to strategic landscape objectives. Examples include: planting a standard number of trees per acre regardless of objective-based rotational outcomes and biological productivity of the specific site; thinning at a prescribed age to a routine stand density without regard to rotational site objectives; and foregoing control of invasive vegetation, because techniques rather than outcomes are dictated. Impacts from *Forest Resource Plan* Policy No. 33 would continue to be minimized and mitigated through the integrated pest management approach.

The risks of adverse impacts to the environment are expected to be less under Alternative 2 and the Board's Preferred Alternative, because statewide and landscape scale strategic objectives are considered and integrated into site and stand-level silviculture treatments. In any one landscape, landscape-level ecological services, such as wildlife diversity, habitat complexity and hydrologic processes, are more likely to occur under Alternatives 2 and the Board's Preferred Alternative than under Alternative 1. By including landscape and broader scale concerns and needs in silvicultural planning, Alternative 2 and the Board's Preferred Alternative will more likely avoid or reduce effects of large stand-replacing fires, insect outbreaks or other extreme natural events than Alternative 1. Although complete avoidance of the effects of broad-scale extreme events is not possible, Alternative 2 and the Board's Preferred Alternative will provide increased protection of potential adverse impacts to plants, wildlife species and habitats, water quantity and quality, and soils than Alternative 1, by integrating stand-level activities into the realities of naturally-occurring landscape-level processes. For example, silviculturally treating stands most likely to initiate insect outbreaks or treating stands to reduce fuel ladders can reduce fire spread and severity. The moderation of the extremes under Alternative 2 and the Board's Preferred Alternative mitigate probable significant adverse impacts to well-functioning ecosystems.

CUMULATIVE IMPACTS

In managing for multiple objectives, DNR seeks to manage landscapes in forest management units (stands) or smaller. Nature operates at all scales, without artificial boundaries from cataclysmic scale at a multi-century to multi-millennium interval, to smaller scales at more frequent intervals. The resulting ecosystem function and balance, including that related to species populations, often fluctuate beyond an acceptable range of variation to avoid the risk of cumulative impacts from forest management activities. By managing landscapes, Alternative 2 and the Board's Preferred Alternative seeks to moderate extreme events, thereby reducing the risk of cumulative impacts, especially fire and pathogen epidemics, by managing forests to meet multiple objectives and values at a constant rate, by manipulating the forest at the stand level. Alternative 2 and the Board's Preferred Alternative seeks to perpetuate relatively stable and viable ecosystems within their natural range of variability. To accomplish this, it is necessary to define statewide landscape and stand outcomes (e.g., specific wildlife habitats, revenue for the trusts, visual management, etc.) and to implement forest management unit silvicultural prescriptions that achieve the outcomes. These outcomes must be synchronized at all levels so that any and all activities support rotational forest management unit (stand) objectives, which in turn support desired balances and spatial arrangements over landscapes.

Alternative 1 mitigates probable significant adverse impacts caused by isolated activities by limiting or promoting certain techniques. However, none of the policy statements have direct linkage to landscape management. In fact, Alternative 1 fails to provide a viable mechanism for linking individual projects to management of cumulative impacts over landscapes e.g., Policy No. 11 links management intensity to return on investment, but not to ecosystem maintenance over landscapes. The landscape concepts therefore, did not translate into practical silvicultural means.

Alternative 1 addresses cumulative impacts by mitigating the likelihood of significant adverse impacts at the activity level. Alternative 1, however, likely constrains individual activities in such a way that broader landscape objectives become unattainable or may even be adversely affected. For example, financial inability to control undesirable vegetation likely delays attainment of desired wildlife habitat structure at the stand level, thereby affecting habitat needs at the landscape level. Thus, Alternative 1 increases the risk of adverse impacts to wildlife habitat, plants and animals, water, earth and aesthetics, due to lack of landscape objectives.

Alternative 2 and the Board's Preferred Alternative benefit from being fully integrated into a landscape-level sustained harvest implementation process. Integrating unit-by-unit objectives with landscape-level processes over space and time reduces probable significant adverse cumulative impacts from individual projects.

Alternative 2 and the Board's Preferred Alternative emphasize an overall vision of long-term, viable landscape-level ecosystems for native species and other ecosystem values by dovetailing silvicultural policies into a landscape-level system of planning and implementation. This integrated approach addresses and mitigates the potential for cumulative significant adverse environmental impacts from activities not only during the operation, but over landscapes and through time and provides a foundation for beneficial effects on the environment. Habitats for threatened and endangered species are restored and social concerns are addressed in consideration of ecological and economic scientific knowledge. For example, frequency and timing of creating openings in the forest canopy or use of forest chemicals, primarily herbicides and fertilizer, will be implemented, postponed or avoided based on their likelihood of achieving desired outcomes over time and space. Alternative 2 and the Board's Preferred Alternative provide linkages between silvicultural practices and landscape scale strategies that can reduce risks of significant adverse cumulative impacts over both the short- and long-term and increase both short- and long-term benefits to water, wildlife and other elements of the environment.

Policies

The *Policy for Sustainable Forests* is composed of multiple policies, which together provide broad direction to the Washington State Department of Natural Resources (DNR) to effectively and sustainably manage the forested state trust lands in its care.

On the pages that follow, individual policies are grouped into four major policy categories. Each category addresses a key aspect of sustainable forest management:

- Economic Performance
- Forest Ecosystem Health and Productivity
- Social and Cultural Benefits
- Implementation

Within each category, individual policy subject areas are introduced with a discussion, followed by the policy statements. The policy on any given subject may have multiple parts.

Although the individual policies are separated into categories and subject areas, taken collectively they create DNR's overarching policy to support healthy forest ecosystems to provide a perpetual flow of economic, ecological and social benefits from forested state trust lands.

- **The department will coordinate with local, state and federal fire prevention programs; the scientific community; other agencies; and other landowners to reduce the risk of forest resource loss from catastrophic events.**

The department will defer from harvest old-growth stands…to help meet DNR's Habitat Conservation Plan and regulatory requirements, older-forest targets, and social/cultural values.

Old-Growth Stands in Western Washington

DISCUSSION

From a historic perspective, old-growth forests are a result of a natural pre-European settlement origin (prior to year 1850) and of having been left unmanaged and relatively undisturbed by humans for hundreds of years. Consequently, unlike other structurally complex stands, old-growth stands in Western Washington are not a result of, nor will they result from, active management. From a scientific perspective, old-growth stands in Western Washington are characterized by the highest levels of structural complexity including a diversity of sizes and conditions of live trees, snags and logs. Therefore, for the purposes of this policy, old-growth stands on forested state trust lands are defined as follows:

- Stands in the most structurally complex stage of stand development, sometimes referred to as the fully functional stage of stand development; and
- A stand with a natural origin date prior to 1850, generally considered the start of European settlement in the Pacific Northwest.

Both criteria must be met for a stand to be identified as old growth for the purposes of this policy.

The 2004 Washington State Legislature directed DNR to inventory old-growth forest stands on state lands as defined by a panel of scientists. By applying an old-growth habitat indexing method to DNR's Forest Resource Inventory System, potential old-growth stands were identified (*Definition and Inventory of Old Growth Forests on DNR-Managed State Lands,* July 2005). The minimum mapping unit size of the Forest Resource Inventory System is five acres. Consequently, for the purposes of this inventory effort and this policy, five acres is the minimum stand size for old growth.

Because old-growth stands are the most structurally complex, they can help DNR meet regulatory requirements and can make important ecological contributions to meeting key elements of DNR's *Habitat Conservation Plan* (HCP), particularly older-forest targets and requirements related to wildlife and riparian habitats (see discussion of HCP older-forest targets in the General Silvicultural Strategy policy subject area). The majority of potential old-growth stands recently identified on DNR-managed lands are deferred from harvest to meet HCP and regulatory requirements related to northern spotted owl, marbled murrelet, and riparian habitat.

Socially and culturally, old-growth stands are often valued and revered as representatives of what used to exist. When in the best interest of the trust involved, old-growth stands will be transferred out of trust status if the trust receives full market value for the lands transferred. Such transfers can occur at any time and in such a way that these old-growth stands can continue to contribute to HCP habitat requirements and older-forest targets, even when no longer in trust status.

The conservation strategies for the Olympic Experimental State Forest HCP planning unit are somewhat different from the strategies for the other five Western Washington HCP planning units. The goal in the Olympic Experimental State Forest is to use management, research and monitoring to build new knowledge about integrating commodity production and conservation. Consequently, operations, including harvest, in some old-growth stands will occur in the Olympic Experimental State Forest to meet this goal.

In conifer forests of Western Washington, single, very large diameter, structurally unique trees are important habitat elements. These trees, sometimes referred to as old-growth remnants, are characterized by very large diameters (60 to 90 inches or more, depending on the species) and possess large, strong limbs; open crowns; large, hollow trunks; broken tops and limbs; and deeply furrowed bark. They are the focus for retention to meet HCP requirements for very large diameter, structurally unique trees.

POLICY ON OLD-GROWTH STANDS IN WESTERN WASHINGTON

- **The department will defer from harvest old-growth stands (stands 5 acres and larger that originated naturally, before the year 1850), in order to help meet DNR's *Habitat Conservation Plan* and regulatory requirements, older-forest targets, and social/cultural values. This policy is subject to the following conditions:**
    - **The Board of Natural Resources will be notified of any exceptions to this policy for operational considerations; and**
    - **The department will retain known very large diameter, structurally unique trees to meet DNR's *Habitat Conservation Plan* requirements for large, structurally unique trees. The department will notify the Board of Natural Resources of proposed harvests that may involve removals of very large diameter, structurally unique trees.**
- **Inside the Olympic Experimental State Forest, the department may conduct operations in old-growth stands consistent with the requirements of DNR's *Habitat Conservation Plan* to meet the research objectives of the Olympic Experimental State Forest.**

- **When in the best interest of the trust(s), the department will actively seek to transfer old-growth stands and areas containing very large diameter trees of high social or cultural significance out of trust status, when full market value compensation to the trust(s) is secured. In seeking to transfer such stands out of trust status, the department will immediately prioritize old-growth stands that are not subject to protection under DNR's *Habitat Conservation Plan* or other applicable regulations.**

DEFINITION AND IDENTIFICATION OF OLD-GROWTH STANDS IN EASTERN WASHINGTON

In Eastern Washington, definition and identification of old-growth stands is difficult due to several reasons. Fire exclusion and selective logging of large pines have changed the structure of many old-growth stands, therefore, there are few places where fire-dependent old-growth types exist and can be studied. In addition, relatively little research has gone into characterizing old growth in these forests, so relevant information is limited. Finally, DNR's forest inventory information for Eastern Washington needs to be improved to help identify potential old-growth stands.

As a result of legislation in 2006, DNR is conducting an inventory of old-growth forest located on state lands east of the crest of the Cascade Mountains. This two-phased project is to be completed by December 15, 2007. This information will be used in the Eastern Washington sustainable harvest calculation. Until that time, DNR is retaining forest structures that may be important elements of historic old-growth forests. Along the east slope of the Cascade Range, in the range of the northern spotted owl, DNR is maintaining and developing submature and mature owl habitat that is expected to develop into older-forest stands. In the Klickitat HCP planning unit, DNR is retaining an average of 6 to 12 trees per acre of the largest diameter classes as part of its forest health and HCP strategies. DNR is also developing late successional forest as part of its *Loomis State Forest Final Landscape Plan* (June 1996). In addition, DNR retains large diameter trees as part of its land management activities across all of Eastern Washington.

Policy may be developed for Eastern Washington older forests and old-growth stands as part of an Eastern Washington sustainable harvest calculation.

Wildlife Habitat

DISCUSSION

An important trust objective is the conservation of upland, riparian, and aquatic wildlife species, including fish and their habitats, species listed as threatened and endangered, and non-listed species.

DNR's *Habitat Conservation Plan* (HCP) enables DNR to meet the requirements of the federal Endangered Species Act by setting wildlife habitat objectives for 1.6 million of the 2.1 million acres of forested state trust lands. The HCP is a long-term management plan to conserve not only currently threatened and endangered species, but also to help avoid the future listing of additional species. In addition to

- **The department may use different geographic scales to address special circumstances.**
- **The department will utilize the requirements of the State Environmental Policy Act to communicate department objectives and outcomes; to consider local, regional and statewide interests and concerns; and to develop and analyze forest management strategies.**
- **The department will prioritize and develop new forest land plans over time. The development of plans will depend on available resources and budget.**
- **As plans are developed, the department will integrate previous planning work within new forest land plans as appropriate.**

The department will provide professional management of forested state trust lands through active management and stewardship…

General Silvicultural Strategy

DISCUSSION

DNR defines silviculture as the art and science of cultivating forests to achieve objectives. Innovative silvicultural treatments may be used to create, develop, enhance, or maintain forest biodiversity, health and revenue potential. All silvicultural strategies are applied within a context of specific objectives (stand-level or larger-area) to achieve ecological outcomes, long-term sustainable flow of forest products, services, and other values. DNR generally intervenes with the management of stands whose progress toward objectives is below potential. Site-specific silvicultural prescriptions include intensive activities, such as improved planting stock, site preparation, fertilization and thinning. Stands selected for regeneration harvests include, but are not limited to, those that are not likely to positively respond to partial harvest regimes.

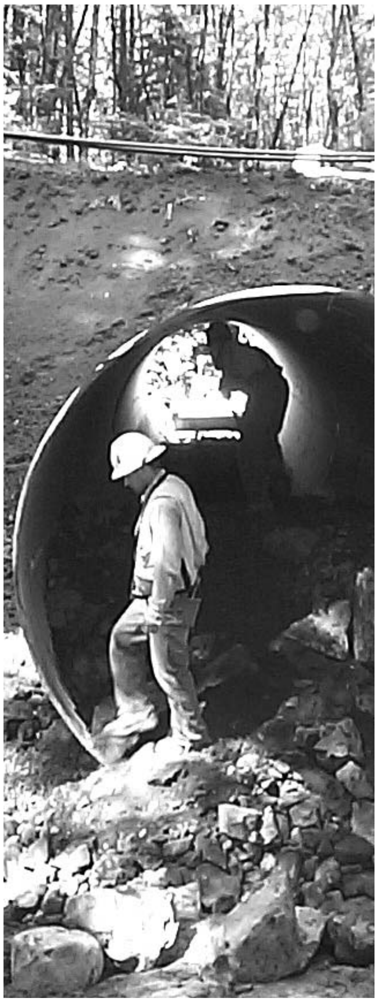
Treatments such as biodiversity pathways can be used to create complex, multi-aged forest stand structures that sustain key forest stand elements, replicating vital ecological functions at the stand and landscape levels. By developing the stand structures that are typical of older forests, this approach can be used to meet the older-forest targets of DNR's *Habitat Conservation Plan* (HCP).

DNR intends to actively manage suitable structurally complex forests to achieve older-forest structures across 10-15 percent of each Western Washington HCP planning unit in 70-100 years. Older-forest structures that contribute to this target are represented by stands in the fully functional or niche diversification stage of stand development.

The landscape context of a structurally complex stand greatly influences its suitability to be managed to meet older-forest targets. The size of the stand, its proximity to old-growth or other structurally complex forest stands, or the scarcity of old-growth and other structurally complex stands are all factors in determining if a stand is suitable for contributing to older-forest targets. Assessment of the landscape conditions can identify the relative contribution that a structurally complex forest stand can make toward achieving those targets.

POLICY ON GENERAL SILVICULTURAL STRATEGY

- **The department will provide professional management of forested state trust lands through active management and stewardship of the greatest possible portion of these lands.**
- **The department will carry out active management as an integral part of the department's fiduciary responsibilities to achieve, on a landscape basis, a combination of forest structures that, over time, provide for broad and balanced economic, ecological and social benefits.**
- **The department will use intensive and innovative silviculture to guide the desired progression of stand development to simultaneously produce trust revenue and create structural diversity across the landscape.**
- **The department will target 10-15 percent of each Western Washington *Habitat Conservation Plan* planning unit for "older" forests—based on structural characteristics—over time.**
- **Through landscape assessments, the department will identify suitable structurally complex forest stands to be managed to help meet older-forest targets. Once older-forest targets are met, structurally complex forest stands that are not needed to meet the targets may be considered for harvest activities. However, old growth is addressed in the Old-Growth Stands in Western Washington policy.**



Forest Roads

DISCUSSION

DNR repairs and maintains about 14,000 miles of forest roads statewide (12,000 on forested state trust lands and 2,000 on other non-DNR lands). The road system is a trust asset that facilitates cost-effective management of other trust assets and increases their value.

DNR's road system also provides a variety of social benefits, including recreational access and access to private forestlands and residences. However, if not properly managed, roads have the potential to cause increased costs and risks by damaging the environment or providing opportunities for illegal activities on forested state trust lands. Design, location and abandonment of forest roads are carefully considered in regard to the impacts to the environment and forestland management needs. Public access and recreation can also be a consideration.

POLICY ON FOREST ROADS

- **The department will develop and maintain forest roads to meet trust objectives and Board of Natural Resources policy, including protecting and enhancing the asset value.**
- **To minimize adverse environmental impacts, the department will rely on the requirements of DNR's *Habitat Conservation Plan*, state forest practices rules and the State Environmental Policy Act, and will minimize the extent of the road network, consistent with other Board of Natural Resources policy.**

Murrelet-specific conservation acres	Alternative							
	A	B	C	D	E	F	G	H
High-quality P-stage (0.47 to 0.89) habitat patches	n/a	n/a	5,000	n/a	5,000	n/a	10,000	n/a
Existing northern spotted owl habitat—low-quality[b]	n/a	n/a	n/a	n/a	n/a	73,000	n/a	n/a
Total	33,000	9,000	49,000	51,000	54,000	176,000	75,000	37,000

[a]For alternative F only, this category includes old forest habitat, old forest buffers, and high quality adjusted habitat in the OESF.

[b]For the purpose of this FEIS, northern spotted owl low quality habitat refers to the following DNR mapped habitat classes as of 2018: dispersal habitat, movement plus habitat, structural habitat, sub-mature habitat, and next best stands.

■ Putting It All Together: Long-term Forest Cover

The combination of lands that provide marbled murrelet conservation through existing DNR policies (for example, riparian zones), plus marbled murrelet-specific conservation areas, provides a network of long-term forest cover for the murrelet on DNR-managed lands. Long-term forest cover means lands on which DNR maintains and grows forest cover for conservation purposes, including habitat conservation for the marbled murrelet, through the life of the 1997 HCP. (Refer to Figure 2.2.2 and Appendix G for a more detailed description of long-term forest cover.) Table 2.2.4 shows the total acres of conservation by alternative.

Table 2.2.4. Total Acres of Conservation by Alternative (Rounded to Nearest 1,000)

	Alt. A (no action)	Alt. B	Alt. C	Alt. D	Alt. E	Alt. F	Alt G	Alt H
Acres of existing conservation under the 1997 HCP, *Policy for Sustainable Forests*, and Washington State Law	567,000	567,000	567,000	567,000	567,000	567,000	567,000	567,000
Acres of additional, marbled murrelet-specific conservation[16]	33,000	9,000	49,000	51,000	54,000	176,000	75,000	37,000
Total approximate acres of conservation	600,000	576,000	617,000	618,000	621,000	743,000	642,000	604,000
Acres of DNR-managed lands within analysis area	1,380,000	1,380,000	1,380,000	1,380,000	1,380,000	1,380,000	1,380,000	1,380,000
Total approximate percentage of acres in conservation	43%	42%	45%	45%	45%	54%	46%	44%

[16] Acres reported here are those which do not overlap other existing conservation lands.

Table 4.6.2. Estimated Acres of Habitat Released for Harvest in the Analysis Area by the End of the Planning Period (Raw Acres)

		Alt. A (no action)	Alt. B	Alt. C	Alt. D	Alt. E	Alt. F	Alt. G	Alt. H
Low-quality habitat loss to harvest (P-stage value 0.25–0.36)	Southwest Washington strategic location	4,002	7,620	4,342	4,341	4,341	1,683	2,352	5,264
	OESF and Straits (West of the Elwha River) strategic location	6,670	8,648	6,876	7,400	6,197	3,535	1,008	6,419
	North Puget strategic location	11,946	12,234	10,929	10,976	10,595	6,969	9,822	10,869
	Other high-value landscape	7,184	9,261	8,930	8,931	8,938	5,594	8,907	8,948
	Marginal landscape	932	1,530	1,530	1,530	1,530	1,525	1,530	1,530
Subtotal		30,734	39,293	32,608	33,178	31,600	19,307	23,619	33,030
High-quality habitat loss to harvest (P-stage value 0.47–0.89)	Southwest Washington strategic location	7	259	0	174	0	76	0	174
	OESF and Straits (West of the Elwha River) strategic location	727	1,495	0	1,230	0	459	0	1,241
	North Puget strategic location	2,509	2,556	0	2,340	0	1,396	0	2,194
	Other high value landscape	900	1,348	0	1,249	0	673	0	1,312
	Marginal landscape	97	97	0	97	0	92	0	97
Subtotal		4,240	5,754	0	5,090	0	2,697	0	5,017
Total acres		34,974	45,047	32,608	38,268	31,600	22,004	23,619	38,047

Most harvest of inland habitat outside of long-term forest cover in the first decade is expected to be in low-quality habitat. Of the total habitat released for harvest under each alternative, 87 to 100 percent is low quality. The most habitat released for harvest overall is under Alternative B, followed by Alternatives