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

PARt 1 of 3

FINAL HABITAT CONSERVATION PLAN

September 1997

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Jennifer M. Belcher - Commissioner of Public Lands

Authority

This Plan was approved and adopted by the Board of Natural Resources (Resolution 96-911, November 5, 1996).

Board of Natural Resources

The following individuals were seated on the Board at the time of adoption.

Jennifer Belcher, *Chair, Commissioner of Public Lands*
Judith Billings, *Superintendent of Public Instruction*
David Thorud, *Dean, College of Forest Resources, University of Washington*
Dorothy Duncan, *County Commissioner representing the Forest Board counties*
Bob Nichols, *Executive Policy Division, OFM -- designee for Governor Mike Lowry*
James Zuiches, *Dean, College of Agriculture and Home Economics, Washington State University*

Jennifer M. Belcher
Commissioner of Public Lands

September 1997

Dear Reader:

The Washington Department of Natural Resources manages 3 million acres of state lands in trust for common schools, state universities, other public institutions, and county services. About 2.1 million acres are forestlands.

As a prudent trust manager, the department follows all applicable laws, including the Endangered Species Act. Since 1990, when the northern spotted owl was listed as a threatened species, the department has been subject to continually changing requirements for the management of state forest lands, resulting in uncertainty and instability that is expected to increase due to the prospect of additional species being listed as threatened or endangered in the future. At the same time, current regulations don't necessarily provide certainty or stability for the future of the protected species.

The department is charged with preserving the productivity of the trusts in perpetuity, which we believe requires protecting the long-term health of forests and the ecosystem. We therefore began to look for a better way to manage the state's forested trust lands and protect threatened and endangered species. The Endangered Species Act offers such an option through the creation of a habitat conservation plan (HCP), which allows more flexibility in land management activities and innovation in protection of threatened wildlife.

With assistance from wildlife experts, our own silvicultural experts, trust beneficiaries, and the public, I believe the Washington State Department of Natural Resources has developed an HCP that will keep state trust lands at the forefront of excellence in forest land management. At the same time, our HCP will provide certainty, stability, and flexibility to both the trusts and wildlife.

Sincerely,

Jennifer M Belcher

JENNIFER M. BELCHER
Commissioner of Public Lands

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NATURAL RESOURCES

FINAL HABITAT CONSERVATION PLAN

September 1997

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Jennifer M. Belcher - Commissioner of Public Lands

Acronyms

ACRONYMS USED IN THE TEXT OF THE HCP

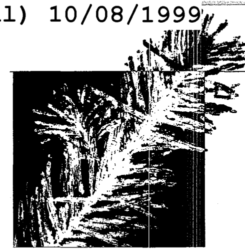
dbh	Diameter at breast height
DNR	Washington Department of Natural Resources
EIS	Environmental Impact Statement
FEMAT	Forest Ecosystem Management Assessment Team
GIS	Geographic Information System
HCP	Habitat Conservation Plan
NRF	Nesting, roosting, and foraging habitat
OESF	Olympic Experimental State Forest
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
WAC	Washington Administrative Code
WAU	Watershed Administrative Unit

ACRONYMS USED IN CITATIONS

C.F.R.	Code of Federal Regulations
LULC	Land Use/Land Cover (GIS data layer)
MPL	Major Public Lands (GIS data layer)
NMFS	National Marine Fisheries Service
ODFW	Oregon Department of Fish and Wildlife
PFRT	Peregrine Falcon Recovery Team
PHS	Priority Habitat and Species
U.S.C.	U.S. Code
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
WDF	Washington Department of Fisheries (merged into WDFW in 1994)
WDFW	Washington Department of Fish and Wildlife
WDW	Washington Department of Wildlife (merged into WDFW in 1994)
WFPB	Washington Forest Practices Board
USEPA	U.S. Environmental Protection Agency

ACRONYMS WITH LIMITED USE IN THE TEXT (I.E., ONE TO TWO PAGES)

ESU	Evolutionarily Significant Unit (Chapter III - salmonids and riparian areas)
HAU	Hydrologic Analysis Unit (Chapter IV - riparian conservation strategy)
NAP	Natural Area Preserve (Chapter I - land covered)
NRCA	Natural Resource Conservation Area (Chapter I - land covered)
PFA	Post-fledgling family area (Chapter IV - multispecies conservation strategy)
TFW	Timber/Fish/Wildlife Agreement
WRIA	Water Resource Inventory Area (Chapter I - planning area organization)



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I. Introduction

DNR's Habitat Conservation Plan

The Washington Department of Natural Resources (DNR) has prepared a multi-species Habitat Conservation Plan (HCP) to address state trust land management issues relating to compliance with the federal Endangered Species Act (16 U.S.C. 1531 et seq.). The plan will cover approximately 1.6 million acres of state trust lands managed by DNR within the range of the northern spotted owl.

A habitat conservation plan is a long-term land management plan authorized under the Endangered Species Act to conserve threatened and endangered species. For DNR, it means a plan for state trust lands that allows timber harvesting and other management activities to continue while providing for species conservation as described in the Endangered Species Act. Section 10 of the Endangered Species Act (16 U.S.C. 1539) authorizes a landowner to negotiate a conservation plan with the Secretary of the Interior to minimize and mitigate any impact to threatened and endangered species while conducting lawful activities such as forest practices. The HCP offsets any harm caused to individual listed animals with a plan that promotes conservation of the species as a whole. Incidental take, including the disturbance of habitat of an endangered or threatened species, is allowed within limits defined by an incidental take permit issued by the federal government.

As a trust manager, DNR has unique obligations. (See Chapter II discussion on trust duties.) Briefly, among these are acting with undivided loyalty to the interests of the trusts, recognizing their perpetual nature, managing in a prudent manner, minimizing the risk of loss, and using sound principles that will preserve the productivity of the trusts in perpetuity while striving to provide the most substantial support to the beneficiaries over the long term. An HCP will help meet these trust obligations by providing greater certainty in management, greater stability in harvest levels, and greater flexibility in operations.

According to the Endangered Species Act, the draft HCP is part of an application for incidental take permits and unlisted species agreements that will be submitted to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service for review. The federal agencies will conduct a biological assessment and jeopardy analysis of DNR's HCP to determine whether the proposal complies with the Endangered Species Act. If the permits are issued, they will allow the incidental take on DNR-managed lands of northern spotted owls, marbled murrelets, and other listed upland species, and, on the west side of the Cascade Range, selected other species if they become listed. To minimize and mitigate the impacts of incidental take to the maximum extent practicable, DNR will implement the HCP.

Based on a careful review of the final HCP, Final Environmental Impact Statement, analysis of benefits and impacts to the trusts, results of the analysis by the federal agencies, other appropriate analyses, and public review, the Board of Natural Resources will determine whether to enter into an agreement with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Species Covered by the HCP

DNR's HCP provides mitigation for incidental take permits for two federally listed species — the northern spotted owl *(Strix occidentalis caurina)* and the marbled murrelet *(Brachyramphus marmoratus)*. The HCP also conserves habitat for unlisted species in western Washington for which DNR is seeking unlisted species agreements. These include western Washington runs of several salmonids, other federal and state candidate species (i.e., species proposed for listing), and other unlsted species west of the Cascade crest. In addition, although DNR does not expect to take any individuals of these species, it is requesting incidental permits for the other upland species listed by the federal government as endangered or threatened within the range of the northern spotted owl. These additional species are the Oregon silverspot butterfly *(Speyeria zerene hippolyta)*, the Aleutian Canada goose *(Branta canadensis leucopareia)*, the peregrine falcon *(Falco peregrinus)*, the bald eagle *(Haliaeetus leucocephalus)*, the gray wolf *(Canis lupus)*, the grizzly bear *(Ursus arctos)*, and the Columbian white-tailed deer *(Odocoileus virginianus leucurus)*. (See Chapter III for a discussion of habitat needs of the species covered by the HCP.)

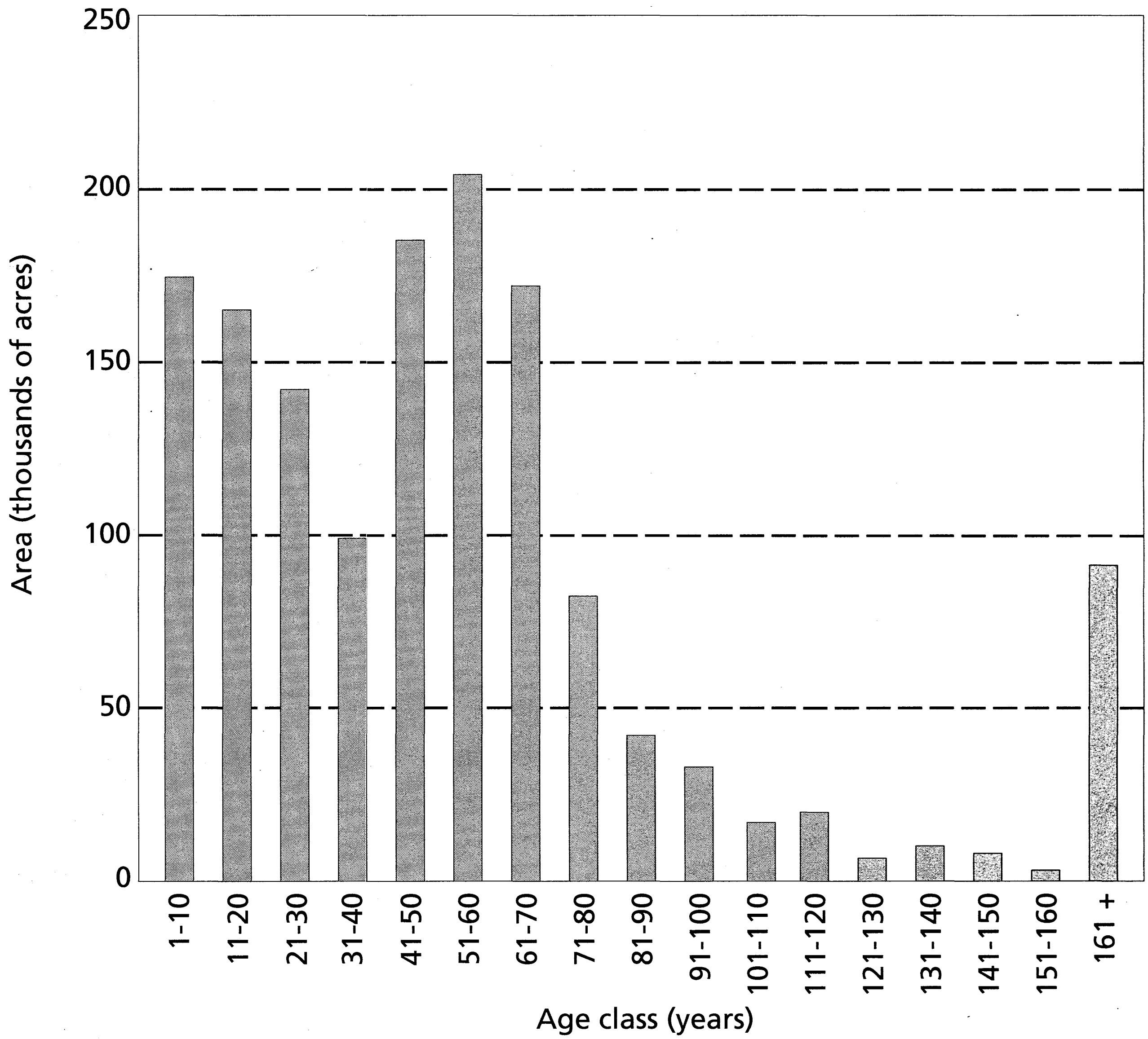
Land Covered by the HCP

In Washington, the range of the northern spotted owl includes all of the western part of the state as well as lands on the east slopes of the Cascade Range. This HCP covers all DNR-managed forest lands within the range of the northern spotted owl, excluding those lands designated as urban or leased for commercial, industrial, or residential purposes and those lands designated as agricultural. All DNR management activities on these lands are covered. The total area of trust lands covered by the HCP is approximately 1,630,000 acres, of which all but about 50,000 acres are forested. These lands range from scattered isolated parcels under 40 acres to large contiguous blocks in excess of 110,000 acres. The conservation strategies apply to lands DNR manages or will manage under the HCP; however, DNR is not precluded from buying, selling, or exchanging such lands as long as the overall integrity of the HCP is maintained. (See the Implementation Agreement for additional information.) Map I.1. shows DNR-managed lands covered by the HCP.

The majority of the forest on DNR-managed lands covered by the HCP is conifer. Less than 10 percent is in hardwood. Most DNR-managed lands have been logged at least once in the last 100 years. For DNR-managed lands covered by the HCP, approximately 1,421,000 acres are in even-aged stands and 155,000 acres are in uneven-aged stands. Map I.2 shows the location of these even-aged and uneven-aged stands. One-fourth of the even-aged stands are 20 years old or less, and more than half are 60 years old or less. Figure I.1. summarizes by age class the acreage of even-aged forests managed by DNR in the HCP area. Currently available information for uneven-aged stands describes the volume or number of trees in each of four size classes. Although most uneven-aged stands have trees in more than one size class, Table I.1 summarizes stands by the dominant size class for each stand.

Figure I.1: DNR-managed HCP lands by age class and area for even-aged stands

(Source: DNR GIS LULC coverage, April 1995)



CURRENT LAND USE

Of the 1,580,000 acres of forested land covered by the HCP, approximately 1,520,000 acres are in timber production. Special uses of forested land on the remaining 60,000 acres include old-growth research areas and gene pool reserves that DNR has deferred from harvest, riparian management zones, and recreation sites.

Table I.1: DNR-managed HCP lands by dominant size class and area for uneven-aged stands

Size class (diameter at breast height in inches)	Acres	Percent of uneven-aged acres
0-6	22,000	14.2
6-9	11,000	7.1
10-18	71,000	45.8
20+	51,000	32.9

ADJACENT OWNERSHIP

Although DNR-managed lands are distributed throughout the plan area, most tend to be adjacent to or near large blocks of federal land along the Cascade and Olympic mountain ranges. The major exception to this pattern is in southwestern Washington, where DNR manages more than 250,000 acres that are not near federal ownership.

DNR-managed lands covered by the HCP are interspersed among a variety of other ownerships as shown in Map I.3. Table I.2 summarizes the approximate acreage held by land owners and managers in the plan area.

Table I.2: Acreage by ownerships in the area covered by the HCP

(Source: DNR GIS MPL coverage, April 1995)

Landowner or manager	Acres	Percent of plan area
Private	9,488,000	44.4
U.S. Forest Service (national forests)	4,463,000	20.9
U.S. Forest Service (wilderness areas)	2,297,000	10.8
National Park Service	1,919,000	9.0
WA Department of Natural Resources	1,777,000[1]	8.3
Tribal lands	1,015,000	4.8
U.S. Department of Defense	123,000	0.6
WA Department of Fish and Wildlife	100,000	0.5
Municipal watersheds	101,000	0.5

Table I.2: Acreage by ownerships in the area covered by the HCP *(continued)*

Landowner or manager	Acres	Percent of plan area
State Parks & Recreation Commission	41,000	0.2
U.S. Fish and Wildlife Service	19,000	0.1
Other state lands	10,000	>0.1
U.S. Bureau of Land Management	5,000	>0.1

[1] Approximately 1,630,000 acres of this total are covered by the HCP.

NATURAL AREA PRESERVES AND NATURAL RESOURCES CONSERVATION AREAS

DNR also manages approximately 66,000 acres of non-trust lands as Natural Area Preserves and Natural Resources Conservation Areas. Natural Area Preserves provide the highest level of protection for excellent examples of unique or typical natural features of Washington. Natural Resources Conservation Areas are established to protect outstanding examples of native ecosystems, habitat for endangered, threatened, and sensitive plants and animals, and scenic landscapes.

Approximately 45,000 acres of these special lands lie within the area covered by the HCP. (See Map I.1.) Some of these lands currently provide habitat in areas identified as important for achieving the conservation objectives of the HCP. It is expected that these lands will continue to provide this habitat into the future because the legislature clearly intended for these special lands to be maintained for future generations. The purpose statement for the legislation that established Natural Area Preserves includes the following: “It is, therefore, the public policy of the state of Washington to secure for the people of present and future generations the benefit of an enduring resource of natural areas by establishing a system of natural area preserves, and to provide for the protection of these natural areas” (RCW 79.70.010). A similar commitment to the future is contained in the findings for the legislation that created Natural Resources Conservation Areas: “There is an increasing and continuing need by the people of Washington for certain areas of the state to be conserved, in rural as well as urban settings, for the benefit of present and future generations” (RCW 79.71.010). Land characteristics identified as worthy of conservation under this legislation include: areas that have high natural system and wildlife values, land or water that has flora or fauna of critical importance, and examples of native ecological communities.

While not subject to the HCP, DNR is given credit for the habitat contributions provided by these lands in terms of meeting the conservation objectives of the HCP. Whether these lands continue to provide such contributions to the conservation objectives, and the remedy if they do not, will be discussed at each of the scheduled comprehensive reviews. (See the Implementation Agreement.) DNR’s management of the Natural Area Preserves and Natural Resources Conservation Areas is not expected to increase the level of take for any species covered by the incidental take permit. DNR’s management of these lands shall maintain the conservation objectives described in Chapter IV of this HCP. Should an unforeseen circumstance arise that increases the level of take, DNR will follow the process for making a major amendment to the HCP and the Incidental Take Permit as outlined in the Implementation Agreement. Management of Natural Area Preserves and Natural Resources Conservation Areas is not intended to alter DNR's obligations for mitigation as set forth in this HCP.

VEGETATIVE ZONES

Vegetative zones are broad areas that have similar types of vegetation. The HCP area includes land in the eight zones described below. These brief descriptions are followed by Table I.3, which lists selected plant species found in each zone.

Sitka Spruce Zone

Along the Pacific coast and extending inland up river valleys is a narrow band of vegetation where Sitka spruce is considered the climax species. This is the Sitka spruce zone. In most places, it is usually only a few miles wide and occurs where summer fog and drip precipitation are common. The climate in this zone is the mildest of any Washington forest zone. Winter rains are heavy, and snow is infrequent. Trees are tall, and stands are dense. Productivity and biomass are high, and there are relatively few hardwoods. Rain forests of the Olympic National Park are a special type of Sitka spruce zone.

Western Hemlock Zone

The western hemlock zone extends from sea level to 2,000 feet throughout most of Washington. The inland boundary of this zone coincides roughly with the western boundary of the national forests in the Cascade Range. The climax trees are western hemlock, with western redcedar in wetter areas and Douglas fir in drier areas. The forest canopy is dense, tall conifers. This forest zone is the largest in the state and contains some of the most productive and intensely managed forest lands. Most state forest land in western Washington is in this zone. However, because of its extent and accessibility, most of the western hemlock zone has been disturbed, logged, or burned at least once in the past 200 years. As a result, large portions are now dominated by Douglas fir in seral stands or contain mixtures of hardwoods. Even before settlement by Europeans, there were extensive Douglas fir stands, probably the result of old fires. Remnants of these original stands are commonly referred to as old growth. Red alder is a common pioneer species throughout the zone.

Climate in the western hemlock zone is mild, wet, and maritime. Snow is common but not persistent. The Puget Sound lowlands are considered a special type; forest composition is modified by the rain shadow of the Olympic Mountains and gravelly glacial soils.

Another type of western hemlock zone occurs east of the Cascade Range. Extensive stands of western hemlock and western redcedar occur in moist localities and along streams and rivers throughout northeastern Washington, as well as farther east. The trees, understory vegetation, and high precipitation give these inland stands their distinct maritime appearance.

Pacific Silver Fir Zone

The Pacific silver fir zone extends from about 2,000 to 4,000 feet in elevation in Washington. On the west side of the Cascades, it abuts the western hemlock zone at lower elevations and extends upward to the subalpine forest in the Olympic Mountains and Cascade Range. Pacific silver fir community types are also found east of the Cascades. Throughout the zone, the climate is cool and wet, but the growing season is short. It is common in this zone for up to half of the annual precipitation to fall as snow and persist as winter snowpacks for three to seven months. Dense forests consist of tall conifers and patches of shrubby undergrowth. Huckleberry species are common. Douglas fir is also a major component of this zone.

Subalpine Fir/Mountain Hemlock Zone

Subalpine fir/mountain hemlock forests make up the highest forest zone in the Olympics and on both sides of the Cascade Range, extending from about 4,000 feet to the timberline. Mountain hemlock predominates at the lower elevations and is replaced by subalpine fir at higher elevations. The zone ends at the high altitudes in a mosaic of tree groups, glades and meadows. East of the Cascades and in the Okanogan highlands, subalpine fir is associated with Engelmann spruce. Scattered pockets of Engelmann spruce are also found on the eastside of the Olympics and west of the Cascades in the Mt. Baker-Ross Lake area. The subalpine zone is Washington's coolest and wettest forest environment. Forests here are dense and contain short to medium-tall conifers, often with an understory mixture of shrub and herbaceous vegetation.

Alpine Zone

Alpine meadows and high-altitude barrens are found in the Olympics and Cascades above timberlines. This zone lacks timber production potential. Vegetation consists of complex mixtures of forbs, grasses, sedges, and low shrubs. The several types of plant communities on Washington alpine lands are linked to local microclimatic variations of moisture, snowpack duration, and substrate. Winters are cold and long, and summers are brief. Growth, except for spectacular floral displays, is slow.

Grand Fir Zone

An extensive grand fir zone occurs below the subalpine forest in eastern Washington. From a management point of view, the grand fir zone and Douglas fir zone, with which it merges, are usually considered together. However, in an ecological sense, they should be considered separately. The grand fir zone is cooler and wetter than the lower Douglas fir zone, but warmer and with less snow accumulation than subalpine forests.

Douglas Fir Zone

The Douglas fir zone in eastern Washington is particularly dominate in the northern portion of the state. Subtle limitations of temperature and moisture are probably important in separating this zone from the moister grand fir zone and the drier ponderosa pine zone. At lower and drier elevations in Washington, Douglas fir is commonly bordered by a band of ponderosa pine that separates it from shrub steppe and grass communities of the Columbia Basin. Forests in both the grand fir and Douglas fir zones consist of dense medium and tall conifers. Where overstory density permits, understory vegetation may be of extensive brush or grass, depending on soil moisture content.

Ponderosa Pine Zone

The ponderosa pine zone, lowest of the forest zones in eastern Washington, occurs between 2,000 and 4,000 feet elevation. It typically borders the shrub-grassland zone, but in south central Washington, an Oregon white oak community is located between the two.

This zone is the driest of the Washington forest zones. Precipitation is low, especially in summer. Winter precipitation commonly falls as snow, which accumulates as a result of low temperatures. Summer days are hot and summer nights cool. The effective growing season is short and probably moisture-limited. Soil moisture regulates the distribution of understory vegetation, which ranges from brush to grass. The forest consists of dense to open stands of tall trees.

Table I.3: Vegetative zones in the area covered by the HCP

(Source: Franklin and Dyrness 1973)

Vegetative zone	Elevation range (feet)	Average precipitation (inches)	Major tree species	Common shrubs	Herbaceous plants
Sitka spruce	0 - 500	80 - 120	Sitka spruce, western hemlock, western redcedar, Douglas fir, grand fir, Pacific silver fir, red alder	red huckleberry, devil's club, salmonberry	sword fern, Oregon oxalis, false lily-of-the-valley, evergreen violet, Smith's fairybells
Western hemlock	0 - 3,000	60 - 120	Douglas fir, western hemlock, western redcedar, red alder, bigleaf maple	vine maple, Pacific rhododendron, creambush ocean-spray, California hazel, western yew, Pacific dogwood, red huckleberry, Oregon grape, salal, trailing blackberry	deerfoot vanillaleaf, evergreen violet, white trillium, sword fern, twinflower, Pacific peavine, common tarweed, white hawkweed, snow-queen, common beargrass, Oregon iris, western fescue, western coolwort, Hooker's fairybells, wild ginger, ladyfern, deerfern, Oregon oxalis
Pacific silver fir	2,000 - 4,500	80 - 120	Pacific silver fir, western hemlock, noble fir, Douglas fir, western redcedar	vine maple, salal, Oregon grape, red huckleberry, Alaska huckleberry, oval-leaf huckleberry, devil's club	beargrass, twin-flower, bunchberry dogwood, deerfoot vanillaleaf, queencup beadlily, dwarf blackberry, western coolwort, white trillium, ladyfern

Table I.3: Vegetative zones in the area covered by the HCP *(continued)*

Vegetative zone	Elevation range (feet)	Average precipitation (inches)	Major tree species	Common shrubs	Herbaceous plants
Mountain hemlock and subalpine fir	4,000 - 6,000	65 - 110	mountain hemlock, subalpine fir, lodgepole pine, Alaska-cedar	big huckleberry, oval-leaf huckleberry, Cascade azalea, blueleaf huckleberry, rustyleaf	beargrass, one-sided wintergreen, dwarf blackberry, Sitka valerian, evergreen violet, avalanche fawnlily
Alpine	4,000+	60-120		western cassiope, blueleaf huckleberry, red mountain-heath, luetkea	Alaskan clubmoss, mountain hairgrass, American bistort, Sitka valerian, showy sedge, feathery mitrewort, American false hellebore, arctic lupine, fireweed, black alpine sedge, alpine willowweed, slender hawkweed, fanleaf cinquefoil, smallflower paint-brush, western pasqueflower
Grand fir	3,500 - 6,500	25 - 50	grand fir, ponderosa pine, lodgepole pine, western larch, Douglas fir	common snowberry, shineleaf spirea, woods rose, Nootka rose, mallow nine-bark, creambrush oceanspray	pinegrass, north-western sedge, elk sedge, broadleaf arnica, kinnikinnick

Table I.3: Vegetative zones in the area covered by the HCP (continued)

Vegetative zone	Elevation range (feet)	Average precipitation (inches)	Major tree species	Common shrubs	Herbaceous plants
Douglas fir	2,000 - 4,500	30-60	Douglas fir, ponderosa pine, lodgepole pine, western larch	baldhip rose, Oregon boxwood, prickly currant, big huckleberry	Columbia brome, sweetscented bedstraw, starry solomonplume, western meadow-rue, heartleaf arnica, sideflower mitrewort, bigleaf sandwort, white hawkweed, twinflower, trail plant, Piper anemone, Lyall anemone, wood violet, white trillium, queencup beadlily, wild ginger, broadleaf lupine, dwarf blackberry
Ponderosa pine	2,000 - 4,000	15 - 30	ponderosa pine, western juniper, quaking aspen, Oregon white oak	Saskatoon serviceberry, chokecherry, blackhawthorn, creambush oceanspray, common snowberry, woods rose, Nootka rose, mallow ninebark, shinyleaf spirea, creeping western barberry, Wyeth buckwheat, snow eriogonum, yellow leafless mistletoe	bluebunch wheatgrass, Idaho fescue, Sandberg's bluegrass, western yarrow, western gromwell, yellow salsify, large-flowered brodiaea, beauty cinquefoil, purple-eyed grass, spreading dogbane, arrowleaf balsamroot, sagebrush, buttercup, low pussytoes, slender fringecup, littleflower collinsia, miner's lettuce, Japanese brome, cheatgrass brome, narrow-leaved montia, smallflower forget-me-not, vernal draba, autumn willowweed, Nuttall's fescue, little tarweed, pink annual phlox, shining chickweed

CLIMATE

Washington's climate is controlled by three factors: (1) location on the windward coast of the Pacific Ocean; (2) the north-south Cascade Range that runs through the center of the state; and (3) the semi-permanent high- and low-pressure regions located over the north Pacific Ocean. These factors combine to produce dramatically different conditions within short distances. The Cascade Range, for instance, blocks the initial thrust of Pacific storms into eastern Washington while protecting western Washington from the polar-continental influence. Thus, western Washington has a marine climate and eastern Washington has a marine-continental climate.

Successive moisture-laden storms move into the Pacific Northwest during late fall, winter, and early spring. They are intercepted first by coastal ranges (the Olympic Mountains and Willapa Hills) and then by the Cascade mountains, leaving most of eastern Washington in a rain shadow with an almost desert-like climate. From late spring to early fall, the Pacific high pressure area moves progressively farther north, weakening storms and limiting rainfall.

Annual precipitation ranges from 75 inches along the coast to 175 inches along the western slopes of the Olympic Mountains and nearly 100 inches in the Willapa Hills. The rain-shadow effect of the Olympic Mountains results in only 16 to 25 inches on the northeast part of the Olympic Peninsula and in parts of the San Juan Islands.

From the Puget Sound lowlands south to the Columbia River, the mean annual precipitation is 40 to 60 inches. Precipitation increases along the west slopes of the Cascades, reaching 120 inches annually in some places. Striking gradations in precipitation totals are also noted on the eastern slopes of the Cascades, decreasing to an annual mean of 12 inches 40 miles from the crest and down to only 8 inches in the southern part of the central basin.

Approximately 80 to 85 percent of the annual precipitation falls between October and April in western Washington. The driest months are typically July and August. Above 2,500 to 3,000 feet, precipitation generally falls as snow from about November through March. Maximum snow accumulations in higher elevations normally occur in the last part of March or early April. Snow above the 5,000-foot level in western Washington may remain into July. Snowfall decreases rapidly on the east slopes of the Cascades as distance east of the crest increases.

The influence of the Pacific Ocean provides generally mild temperatures in western Washington. Winter minimums are 25° to 30° F and maximums are 40° to 45° F. July is the warmest month, with maximum temperatures of 65° to 75° F in the coastal areas and 75° to 80° F inland. Minimum temperatures average near 50° F. Temperatures are more extreme in eastern Washington because of the continental influence. January maximums there average generally between 30° and 40° F and minimums between 15° and 25° F. July maximums average 85° to 90° F and minimums 45° to 55° F.

Prevailing winds are generally southwesterly over the state from late fall to early spring and northwesterly and lighter during the rest of the year.

The most intense storms take place in late fall and early winter. Wind velocities range from 50 to 70 miles per hour or higher along the coast almost every winter. Speeds approaching or exceeding 100 miles per hour have been observed occasionally on coastal ridges. Wind speeds inland are lower during these storms but have been observed at 50 to 60 miles per hour.

Rain usually accompanies lightning storms. Western Washington has 10 to 12 such storms each year, mostly along the western slopes of the Cascades. There are about 25 lightning storms each year in eastern Washington, but they are usually accompanied by less rain. However, an outbreak of "dry lightning" typically occurs two to three times each year in eastern Washington and on rare occasions in western Washington.

In western Washington, the sun shines about 24 percent of the time in December. In July, the figure is typically about 61 percent. In eastern Washington, the sun shines 25 to 30 percent of the time in December and January, but the figure increases to 80 to 85 percent in July and August. Frost-free days in western Washington begin in late April and continue to early November, while in eastern Washington the frost-free period begins in late May and ends in late September.

Organization of the Planning Area

NATURAL SYSTEMS

As discussed earlier in this chapter, DNR-managed lands covered by the HCP include a complex mix of parcel sizes and configurations, vegetation types, and species of concern. To tie the minimization and mitigation more closely to the natural systems and geographic variations in habitat, to gain economies of scale, and to provide greater efficiency in planning, the area covered by the HCP has been divided into nine planning units based on watersheds. (See Map I.4.)

These planning units are delineated by clustering Water Resource Inventory Areas (as defined by the Washington Department of Ecology and commonly referred to as WRIAs) that drain to common water bodies. (See Maps I.5 - I.13.) For example, WRIAs that drain into Grays Harbor and Willapa Bay define the South Coast Planning Unit, WRIAs that drain into the Straits of Juan de Fuca define the Straits Planning Unit. Some planning units are modified to accommodate administrative boundaries; one example is the Olympic Experimental State Forest. Watershed-based boundaries have been recognized in making these adjustments by using Watershed Administrative Unit (as defined by DNR in cooperation with other agencies, tribes, and the public and commonly referred to as WAU) boundaries when possible. There are two exceptions: (1) the boundary separating the Straits and the Olympic Experimental State Forest planning units makes a short deviation due north from near Lake Crescent to the Strait of Juan de Fuca, and (2) the eastern boundary of the three planning units east of the Cascade crest is the eastern boundary of the range of the northern spotted owl. Planning units are named on the basis of where they drain (North Puget Sound) or general location (Klickitat).

The three east-side planning units form the east-side planning area and are included only in the conservation strategies and mitigation for the northern spotted owl and other federally listed species. (The marbled murrelet is not known to cross over the Cascade crest into the east-side planning area, and the unlisted species including salmon are not covered by this HCP in the east-side planning area.) Because of the unique history and role of the Olympic Experimental State Forest Planning Unit, its conservation strategies and mitigation for the spotted owl and riparian areas differ from the other planning units. (See the next subsection for a full explanation.) The remaining planning units west of the Cascade crest are referred to as the west-side planning area. Table I.4 describes major features and acreage of DNR-managed land for each planning unit and planning area.

Table I.4: Major features and acreage of DNR-managed lands by planning unit and planning area

Planning unit name and planning area	Counties and parts of counties containing DNR-managed lands in the area covered by the HCP	Major rivers	Acres of DNR-managed lands covered by the HCP
Chelan (east side)	Chelan and western Okanogan	Wenatchee, Entiat, Stehekin, Twisp, and Methow	15,000
Yakima (east side)	Kittitas and northwestern Yakima	Tieton, Bumping, Naches, Yakima, and Teanaway	81,000
Klickitat (east side)	southwestern Yakima, western Klickitat and southeastern Skamania	White Salmon and Klickitat	132,000
North Puget (west side)	Whatcom, Skagit, Snohomish, northern King, San Juan, and Island	Nooksack, Skagit, Sauk, Stillaguamish, Skykomish, and Snoqualmie	362,000
Straits (west side)	eastern Clallam, eastern Jefferson, and northwestern Mason	Elwha, Dungeness, Dosewallips, Duckabush, Hamma Hamma, and Skokomish	112,000
South Puget (west side)	southern King, Pierce, eastern Thurston, north-central Lewis, Kitsap, and eastern Mason	Cedar, Green, White, Carbon, Puyallup, Nisqually, and Deschutes	144,000
South Coast (west side)	Grays Harbor, western Thurston, Pacific, and western Lewis	Quinault, Humptulips, Chehalis, Hoquiam, Wishkah, Wynoochee, Satsop, Black, Skookumchuck, Newaukum, North, Willapa, and Naselle	234,000
Columbia (west side)	eastern Lewis, southeast Pacific, Wahkiakum, Cowlitz, Clark, and Skamania	Cowlitz, Toutle, Coweeman, Kalama, Lewis, Washougal, Wind, and Grays	286,000
Olympic Experimental State Forest (separate planning area)	western Clallam and western Jefferson	Hoko, Quileute, Soleduck, Calawah, Bogachiel, Hoh, Clearwater, and Queets	264,000

WHY THE OLYMPIC EXPERIMENTAL STATE FOREST PLANNING UNIT IS UNIQUE

The Olympic Experimental State Forest Planning Unit (also referred to as the OESF and the Experimental Forest) is unique among planning units in this HCP because of its experimental nature, integrated approach to management, and planning history. The long-term vision for the Experimental Forest is of a commercial forest in which ecological health is maintained through innovative integration of forest production activities and conservation.

This vision evolved from recommendations of the Commission on Old Growth Alternatives before the listing of the northern spotted owl and marbled murrelet. The Commission's intent was for DNR to avoid management disruptions from future listings and conservation issues by learning to manage for healthy ecosystems that included older forest features. A look back at the Old Growth Commission's original recommendation reveals this visionary nature of the OESF, looking beyond the needs of individual species to the ecological values of old-growth forests as a whole and to the relationships between forest management activities and the complex ecosystem relationships within forests:

> The Commission believes that the ecological values of old-growth forests include but go beyond spotted owl habitat. Scientists are only just beginning to understand the complex ecosystem interrelationships in these forests, and the comparatively lower elevation mature forests remaining on state lands have particularly rich diversity. Forest scientists and managers are increasingly discussing the ability to sustain key elements of ecological diversity within managed commercial forests as an alternative to past approaches. The Commission sees a clear need for further research in this area and a great opportunity to conduct it on state-owned lands. The intent is to experiment with harvest and regeneration methods to enhance habitat characteristics and commodities production. The Commission believes this recommendation may lead to entirely new models of forestry including workable alternatives which balance production with ecology (Commission on Old Growth Alternatives for Washington's Forest Trust Lands 1989 p. 2).

The OESF was included in the 1992 Forest Resource Plan as a "state forest that will be managed separately from other lands in western Washington" (DNR 1992 p. 21). See Chapter II for a discussion of the Forest Resource Plan.

The Experimental Forest's planning history has led to a strategy that differs from the other planning units in both concept and detail by combining conservation, production, research and monitoring, innovative silvicultural techniques, and communication and education in a unified effort. The aim will be to learn how to manage the forest so that habitat conservation and timber production are melded across the landscape, rather than separated into designated areas.

In addition to providing income and other benefits to the trusts, the OESF will help find field-tested solutions to forest management issues related specifically to integrating production and conservation. Through the Experimental Forest, DNR will actively question its knowledge about the relationships between forest ecosystem functions and forest management activities. It will explore these questions through monitoring and research and by sharing knowledge with and seeking insights from other professionals and publics around the world. As the research provides new information, management activities will be adapted accordingly. Ultimately, what is learned in the OESF can be applied where appropriate to other DNR-managed forest lands. (See also Section E of Chapter IV on the OESF Planning Unit.)

The Experimental Forest is included as a planning unit of this HCP in order to fulfill one of the stated purposes of the proposed action:

> To enable DNR to conduct management and research activities within the OESF in areas currently occupied by listed species in order to build new knowledge relevant to trust management obligations and species conservation. (See also the Draft Environmental Impact Statement.)

There are three components of this experiment: (a) habitat conservation strategies based on an experimental concept of an "unzoned" forest, that is, a forest without areas deferred from timber management; (b) a commitment to monitoring, research, and information sharing as the basis for experimental management; and (c) creation of a process for integrating intentional learning with management decision making and course adjustments.

The following points summarize the objectives of the Experimental Forest:

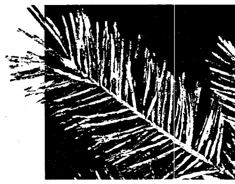
(1) The OESF is DNR's focal point for experimentation. Information gained from the experimentation will be applied to other DNR-managed lands where and when appropriate. DNR will share the information gained with other interested parties in order to ensure that the maximum benefit is achieved through DNR's investment in the Experimental Forest.

(2) In the OESF, DNR will seek to answer questions about integrating conservation and production. DNR will explore the links between management activities and ecological processes and functions at both the landscape and the stand levels.

(3) DNR will acquire knowledge to enhance trust land management through active monitoring, a targeted research effort, and the promotion of cooperative research projects.

(4) Through time, DNR will demonstrate a process by which trust land management activities in the Experimental Forest can respond to new information.

II. Planning Context



II. Planning Context

Trust Duties

DNR has unique obligations in managing the lands covered by the HCP because they are trust lands. The majority of these lands were granted under the Enabling Act and the State Constitution when Washington became a state in 1889. The federally granted lands are to support certain designated beneficiaries in perpetuity. The beneficiaries include public institutions such as public schools, state universities, and charitable, educational, penal, and reformatory institutions.

The state also acquired land from several counties after tax foreclosures and tax delinquencies, as well as through purchases and gifts. The legislature has directed that these lands, known as Forest Board lands, be held in trust and administered and protected by DNR as are other state forest lands. There are 21 counties with Forest Board lands; 19 of them have Forest Board lands within the range of the northern spotted owl.

Out of approximately 3 million acres currently managed in these trusts, about 2.1 million are forest lands. (About 1.6 million acres of the forest lands are within the range of the northern spotted owl and are covered by the HCP. See Map II.1.)

A trust is a relationship in which one person, the trustee, holds title to property which it must keep or use for the benefit of another (Bogert 1987). The relationship between the trustee and the beneficiary is a fiduciary relationship, and it requires the trustee to act with strict honesty and candor and solely in the best interests of the beneficiary. A trust includes a trustee (the entity holding the title), one or more beneficiaries (entities receiving the benefits from the assets), and trust assets (the property kept or used for the benefit of the beneficiaries). In the case of Washington's trust responsibility, the trust assets are the trust lands and the permanent funds.

With the state as trustee, the legislature has designated DNR as manager of the federal grant and Forest Board trust lands. Statutorily, DNR consists of the Board of Natural Resources, the Commissioner of Public Lands as administrator, and the Department Supervisor (RCW 43.30.030). The Board of Natural Resources is required, by statute, to establish "policies to insure that the acquisition, management and disposition of lands and resources within the Department's jurisdiction are based on sound principles designed to achieve the maximum effective development and use of such lands and resources consistent with laws applicable thereto" (RCW 43.30.150). The Board is composed of six members: the Commissioner of Public Lands; the Governor (or a designated representative); the Superintendent of Public Instruction; the Dean of the College of Agriculture, Washington State University; the Dean of the College of Forest Resources, University of Washington; and an elected representative from a county that contains Forest Board land.

As a trust manager, DNR follows the common law duties of a trustee, which include: administering the trust in accordance with the provisions that created it; maintaining undivided loyalty to each of the trusts; managing trust assets prudently; making the trust property productive while recognizing the perpetual nature of the trusts; dealing impartially with beneficiaries; and reducing the risk of loss to the trusts. The department must also comply with all laws of general applicability.

Some of the trust duties have been discussed by the courts specifically in the context of federal land grant trusts. By and large, however, Washington courts have not expounded upon the specifics of how the duties applicable to private trustees apply in the specific, and often unique, circumstances facing the state. A court's analysis of these issues would be informed by the specific trust terms found in the State Constitution and Enabling Act as interpreted in court decisions.

In 1984, the Washington State Supreme Court specifically addressed the state trust relationship in <u>County of Skamania v. State of Washington</u>, 102 Wn.2d 127, 685 P.2d 576. The Skamania decision explicitly addresses only two of a trustee's duties. It found that a trustee must act with undivided loyalty to the trust beneficiaries, to the exclusion of all other interests, and manage trust assets prudently. The Court also cited a series of cases in which private trust principles were applied to land grant trusts. While all but one of these cases are from other states with differently worded Enabling Acts, they generally indicate that a state's duty is to strive to obtain the most substantial support possible from the trust property while exercising ordinary prudence and taking necessary precautions for the preservation of the trust estate. This principle has often been generally referred to as the trust mandate. Although the trust mandate has not been more expressly addressed by the Washington courts, DNR strives to produce the most substantial support possible over the long term consistent with all trust duties conveyed on DNR by the state of Washington.

The 1992 Forest Resource Plan (see section later in this chapter for a discussion of the Forest Resource Plan) contains a succinct discussion of the trust mandate and the common law duties of a trustee as interpreted by DNR and approved by the Board. For example, Board policy indicates that all decisions are to be made with the beneficiaries' interest first and foremost in mind. Board policy also indicates prudence includes managing state lands so as to help prevent the listing of additional species as threatened or endangered.

Board policy indicates that DNR is to manage trust assets to ensure healthy forests that will be productive in perpetuity. Board policies also imply that it is important not to foreclose reasonably foreseeable future options for support. For these reasons, it is important to retain the capacity of the forest to sustain its components and biological relationships.

In short, any management plan for trust lands, including this HCP, should be consistent with the principles of trust management. The following excerpt from the Forest Resource Plan's discussion of DNR's interpretation of its duties as a trust manager helps explain how this HCP ties to trust management obligations:

> <u>The Prudent Person Doctrine</u>
> Trust managers are legally required to manage a trust as a prudent person, exercising such care and skill as a person of ordinary prudence would exercise in dealing with his or her own property. In the department's view, this means, among other things, avoiding undue risk, avoiding tortious acts, etc.

The beneficiaries need a predictable timber sales program that can be executed over several years. Constantly changing regulations often add to administrative overhead. Sales prepared under one set of regulations, for example, may be harvested under a different and more stringent set. These changes (between the time of preparation and the time of harvest) cause contract disputes with purchasers and may force the department to modify planning decisions, thus adding to administrative overhead and causing further delays.

The department believes it is in the best interest of the beneficiaries to manage the trusts in a manner that will avoid the type of controversy that has surrounded forest practices in the past few years. These types of controversies (such as the federal listing of the northern spotted owl as a threatened species) usually result in ever more restrictive regulations. In the department's opinion, public concerns regarding wildlife, fisheries and water quality are likely to escalate and may result in more stringent regulations if the public perceives that the department and other public land managers are not considering nontimber resources.

The department believes it is in the best interests of the trust beneficiaries over the long run to:

- Manage state forest land to prevent the listing of additional species as threatened or endangered.
- Prevent public demand for ever-increasing, restrictive regulations of forest practices.
- Avoid the resulting contract disputes and uncertainty (DNR 1992 p. B-1).

This Habitat Conservation Plan is expected to allow DNR to better fulfill its duties as a trust manager by:

(1) providing certainty and stability in complying with the Endangered Species Act while producing substantial long-term income for trust beneficiaries,

(2) allowing more predictable timber sales levels,

(3) ensuring future productivity of trust lands,

(4) keeping options open for future sources of income from trust lands,

(5) increasing management flexibility, and

(6) reducing the risk of loss to the trusts.

The Endangered Species Act

In 1973, Congress passed the Endangered Species Act (16 U.S.C. 1531 et seq.). The stated purposes of the Act are "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species" (16 U.S.C. 1531(b)), and to act on specified relevant treaties and conventions.

Administration of the Endangered Species Act is overseen by the Secretary of the Interior, with the U.S. Fish and Wildlife Service acting on the Secretary's behalf. The Secretary of Commerce, acting through the National Marine Fisheries Service, is the listing authority for marine mammals and anadromous fish. The Act lists several factors that individually can be the basis for listing a species as endangered or threatened, including "the present or threatened destruction, modification, or curtailment of its habitat or range; . . . the inadequacy of existing regulatory mechanisms; [and] other natural or manmade factors affecting its continued existence" (16 U.S.C. 1533(a)(1)(A),(D),(E)).

Once either Secretary has listed a species of fish or wildlife as endangered, the Act lists several activities that are prohibited, including the "take of any such species" (16 U.S.C. 1538(a)(1)(B)). "The term 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. 1532(18)). The U.S. Fish and Wildlife Service has further defined "harm" to mean "an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 C.F.R. 17.3). Under Section 4 of the Act (16 U.S.C. 1533(d)), the listing Secretary may apply — and usually has applied — the same prohibitions of activities regarding endangered species to threatened species.

If a plant is listed as endangered, activities that are prohibited include to "remove, cut, dig up, or damage or destroy any such species on any [nonfederal] area in knowing violation of any law or regulation of any state" (16 U.S.C. 1538(a)(2)(B)).

In 1982, Congress amended the Endangered Species Act to allow taking of listed species "if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (16 U.S.C. 1539(a)(1)(B)). A nonfederal landowner may apply for an incidental take permit and is required to submit a conservation plan to the Secretary as part of the application. The Act uses the terms "conserve" and "conservation" to mean "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary" (16 U.S.C. 1532(3)).

According to Section 10 of the Act (16 U.S.C. 1539(a)(2)(A)), a conservation plan must specify:

(1) the impact which will likely result from such taking;

(2) what steps the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps;

(3) what alternative actions to such taking the applicant considered and the reasons such alternatives are not being utilized; and

(4) such other measures that the Secretary may require as being necessary or appropriate for purposes of the plan.

The permit can be issued if, "after opportunity for public comment," the Secretary finds that:

(1) the taking will be incidental;

(2) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;

(3) the applicant will ensure that adequate funding for the plan will be provided;

(4) the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

(5) the measures, if any, required [by the Secretary] will be met (16 U.S.C. 1539(a)(2)(B)).

Because granting an incidental take permit is a federal action, a conservation plan is subject to a biological assessment and jeopardy analysis, as set forth in Section 7 of the Act (16 U.S.C. 1536(c) and (a)).

The U.S. Fish and Wildlife Service, acting on behalf of the Secretary of the Interior, has listed as threatened two forest-associated species that occur on DNR-managed land covered by this HCP. In July 1990, the northern spotted owl was listed; in October 1992, the marbled murrelet was listed. In addition, the U.S. Fish and Wildlife Service has listed several other species whose habitat occurs within the range of the northern spotted owl. Although the owl's range is the area covered by the HCP, these other listed species do not occur in great number on DNR-managed forest land. These species are the Oregon silverspot butterfly, the Aleutian Canada goose, the bald eagle, the peregrine falcon, the gray wolf, the grizzly bear, and the Columbian white-tailed deer.

Federal Plans and Rules for Recovery of the Northern Spotted Owl and Marbled Murrelet

Since the listings of the spotted owl and the murrelet, the federal government has published draft recovery plans that target conditions on federal and nonfederal lands for ecological recovery of the listed species. The federal government has also proposed a plan to restore viable populations on federal lands. Because these plans affect DNR's HCP, a brief discussion of the federal plans is included here. In addition, the Secretary of the Interior can issue regulations (called 4(d) rules) regarding conservation of listed species on nonfederal lands. Such a rule has been proposed for the spotted owl; because it would affect DNR-managed lands, a brief discussion of that draft 4(d) rule is included as well.

FINAL DRAFT RECOVERY PLAN FOR THE NORTHERN SPOTTED OWL

The Endangered Species Act requires the Department of the Interior to prepare and implement recovery plans for all listed species, unless the Secretary of the Interior determines that the preparation of a recovery plan would not benefit a species (16 U.S.C. 1533 (f)). Recovery plans generally establish target conditions on federal and nonfederal land for the species or populations in question that would constitute ecological recovery of that species (Rohlf 1989 p. 87). Regulations implementing the Act's requirements for a biological assessment and jeopardy analysis define recovery as "improvement in the status of a listed species to the point at which listing is no longer required under the criteria set out in Section 4(a)(1) of the Act." (50 C.F.R. 402.02). In order to achieve such conditions, not only would the population need to be of satisfactory size, but the factors that led to the species' listing would need to be reduced to the point where they no longer posed a threat to the species (Rohlf 1989 p. 101).

A Draft Recovery Plan for the northern spotted owl was issued in 1992 (USDI 1992a) and revised following the public comment period, but it has yet to receive final approval. As of the approval date of this HCP, the Department of the Interior had not published any further discussion of the Final Draft Recovery Plan, nor had the plan's official status been resolved.

Included in the Final Draft Recovery Plan is an extensive discussion of management recommendations for nonfederal landowners. These recommendations, developed by the federal Northern Spotted Owl Recovery Team, are based on an analysis of where habitat on federal lands alone would be insufficient to achieve recovery objectives for the spotted owl (USDI 1992b). Section A of Chapter IV on spotted owl mitigation contains an explanation of how DNR used the federal recovery team's recommendations in the formulation of DNR's spotted owl conservation strategies.

PRESIDENT'S FOREST PLAN

Because DNR's mitigation for incidental take of spotted owls is designed to complement recovery activities on federal land, a discussion of those activities as proposed in the President's Forest Plan is included here. In response to the controversy surrounding the management of federal forest lands in the Pacific Northwest, the federal government developed the Forest Plan for a Sustainable Economy and a Sustainable Environment, also known as the President's Forest Plan. The main issue leading to the development of the President's Forest Plan was the future of existing old-growth forests.

Since 1989, numerous lawsuits and several court injunctions have severely restricted new and existing timber sales on lands managed by the U.S. Forest Service and the Bureau of Land Management (USDA and USDI 1994). Federal district courts have ruled that these agencies failed to comply with federal law. In particular, separate court decisions have stated that the U.S. Forest Service failed to comply with the National Forest Management Act, the Endangered Species Act, and the National Environmental Policy Act, and that the Bureau of Land Management did not meet its obligations under the National Environmental Policy Act (Thomas et al. 1993; Forest Ecosystem Management Assessment Team 1993).

In western Washington, the U.S. Forest Service has jurisdiction over federal lands available for timber harvest. Since 1960, federal legislation has repeatedly directed the U.S. Forest Service to manage its lands in a manner conducive to healthy populations of fish and wildlife. And, since 1991, several separate rulings in federal courts have reaffirmed this directive.

In April 1993, President Clinton convened the President's Northwest Forest Conference in Portland, Oregon, in order to resolve the conflicting ecological, social, and economic issues surrounding forest management on federal forest lands in Washington, Oregon, and northern California (USDA and USDI 1994). As a result of the conference, the Forest Ecosystem Management Assessment Team, commonly known as FEMAT, was organized by the federal government to develop a management plan for federal lands within the range of the northern spotted owl. FEMAT was asked to identify management alternatives that would attain the greatest economic and social contributions from the forests and also meet the requirements of the applicable laws and regulations, including the Endangered Species Act, the National Forest Management Act, and the National Environmental Policy

Act. FEMAT was also instructed to develop alternatives for long-term management that would maintain or restore:

(1) habitat conditions for the northern spotted owl and marbled murrelet that would provide for the viability of each species,

(2) habitat conditions to support viable populations, well distributed across their current range, of species known to be associated with old-growth forests,

(3) rearing habitat on U.S. Forest Service, Bureau of Land Management, National Park Service, and other federal lands to support the recovery and maintenance of viable populations of anadromous fish species and other fish species considered "sensitive" or "at risk", and

(4) a connected old-growth forest ecosystem on federal lands within the region under consideration (FEMAT 1993).

The options considered varied in four main respects: (1) the quantity and location of land placed in some form of reserve, (2) the activities permitted in reserve areas, (3) the delineation of areas outside of reserves, and (4) the activities permitted outside of reserves.

FEMAT proposed dividing the landscape into different areas according to allowable management activities. They defined two types of reserves: Late successional Reserves and Riparian Reserves. Late successional Reserves encompass old-forest stands, and Riparian Reserves consist of protected-forest zones along rivers, streams, lakes, and wetlands. The Riparian Reserve acts as a buffer between water resources and timber harvest. (For the purposes of this HCP, congressionally reserved areas such as National Parks and Wilderness Areas are considered Late successional Reserves.) Most timber harvesting will occur in the area outside reserves, which is referred to as the Matrix. The forest conditions produced through harvesting are required to meet minimum specifications. Timber harvesting can also occur in Adaptive Management Areas, which are designated to encourage the development and testing of technical and social approaches to achieving desired ecological, economic, and social objectives.

The preferred alternative, known as Option 9, was approved by both the Secretary of the Interior and the Secretary of Agriculture (who oversees the U.S. Forest Service). The Record of Decision for the President's Forest Plan was issued on April 13, 1994, and was to take effect 30 days later. The plan was challenged immediately by both environmental groups and the timber industry. On December 21, 1994, U.S. District Court Judge William Dwyer ruled that the federal agencies responsible for the plan acted within the bounds of the law and that the President's Forest Plan was lawful (Seattle Audubon Society v. Lyons 871 F. Supp. 1291, W.D. Wash. 1994). As of the writing of this HCP, the decision is under appeal in the Ninth Circuit. Section A of Chapter IV on spotted owl mitigation discusses how DNR's conservation strategies relate to the President's Forest Plan.

DRAFT 4(D) RULE FOR THE NORTHERN SPOTTED OWL

Section 4(d) of the Endangered Species Act (16 U.S.C. 1533(d)) authorizes the Secretary of the Interior to issue regulations, commonly referred to as 4(d) rules, that are deemed necessary to provide for the conservation of an endangered or threatened species and can be applied on nonfederal lands. The Department of the Interior initiated the preparation of a 4(d) rule for conservation of the northern spotted owl on nonfederal lands when it proposed FEMAT's Option 9 as the basis for the President's Forest Plan for federal forest lands (Holthausen et al. 1994, Appendix 1, p. 1).

The premise, on which the proposed rule is based, is that federal lands would bear most of the burden for recovery of the spotted owl and that only in a few key areas would contributions from nonfederal lands be needed. Therefore, relief from prohibitions on incidental take could be granted in some portions of the spotted owl's range (Federal Register v. 60, no. 33, p. 9484-9485). However, the U.S. Fish and Wildlife Service has proposed that in particular portions of the spotted owl's range supplemental support from nonfederal lands is still "necessary and advisable" for conservation of the species (Federal Register v. 60, no. 33, p. 9484-9485).

On February 17, 1995, the U.S. Fish and Wildlife Service published a draft 4(d) rule for the northern spotted owl that defines where incidental take restrictions would apply in Washington and California (USDI 1995). The public comment period for the proposed rule ended May 18, 1995.

The proposed 4(d) rule would establish six Special Emphasis Areas in Washington in which incidental take prohibitions would continue to apply. In addition to the lands within the Special Emphasis Areas, any nonfederal lands that fall within a spotted owl circle (see the section in Chapter III on spotted owls for an explanation of owl circles) surrounding a site center located on federal reserves established by the President's Forest Plan (USDA and USDI 1994) would also be subject to take restrictions for two years following adoption of the rule. This provision does not apply to nonfederal lands on the Olympic Peninsula. After two years, the U.S. Fish and Wildlife Service proposes to re-examine the need to maintain habitat on nonfederal lands within federally sited owl circles. All owners of land outside of Special Emphasis Areas and federal owl circles would be required to maintain only 70-acre cores of suitable habitat around spotted owl site centers. Under the proposed 4(d) rule, some DNR-managed trust lands would be included in every Special Emphasis Area. Those lands would not gain relief from current incidental take prohibitions.

However, the draft 4(d) rule also proposes several types of landowner exemptions and opportunities for other kinds of agreements. As a landowner with holdings of more than 5,000 acres of forest land in every Special Emphasis Area, DNR could adopt a habitat conservation plan authorized under Section 10 of the Endangered Species Act (16 U.S.C. 1539(a)(1)(B)) as an alternative to observing incidental take prohibitions. In fact, DNR had already begun preparation of this HCP prior to the publication of the proposed 4(d) rule. Because of the expectation that many large landowners will provide conservation through habitat conservation plans, the U.S. Fish and Wildlife Service is willing to be more lenient under the 4(d) rule (Federal Register v. 60, no. 33, p. 9485).

REANALYSIS REPORT FOR THE NORTHERN SPOTTED OWL ON THE OLYMPIC PENINSULA

There has been a long-standing concern about the viability of the spotted owl on the Olympic Peninsula because the sub-population there is isolated from sub-populations in the western Washington and Oregon Cascades (Thomas et al. 1990; USDA 1988; USDI 1992a). To obtain supporting information for the development of a 4(d) rule under the Endangered Species Act (see above), the U.S. Fish and Wildlife Service requested the analysis of the most recent information about spotted owls on the peninsula in order to assess whether and where it might be appropriate to relax incidental take restrictions on nonfederal lands. A group of six spotted owl ecologists, known as the Federal

Reanalysis Team, was assembled to review existing data and develop a population model to estimate the importance of contributions of varying amounts of habitat from nonfederal lands to the long-term existence of a spotted owl population on the Olympic Peninsula.

The Federal Reanalysis Team used the most current information available for the Olympic Peninsula on spotted owl habitat, population estimates, and demographic rates to re-examine the recommendations made in the Final Draft Recovery Plan (USDI 1992b). Specifically, the Team used these data in a spatially explicit (i.e., sensitive to location and space) spotted owl population model (McKelvey et al. 1992) to simulate the likelihood of persistence of owls on federal lands under various management scenarios and habitat configurations likely to result from the President's Forest Plan and different levels of contributions from nonfederal lands (Holthausen et al. 1994 p. 6).

The Final Draft Recovery Plan had recommended that nonfederal lands on the western side of the Olympic Peninsula be managed to provide demographic support to the population and to maintain connectivity between the coastal strip of the Olympic National Park and the core of federal land on the peninsula (USDI 1992b p. 103). The Final Draft Recovery Plan had also recommended that habitat and population connectivity between the western Washington Cascade Range and the Olympic Peninsula be re-established by providing habitat for breeding clusters of spotted owls in southwest Washington. The reasoning was that re-establishing population connectivity could reduce the risk of extirpation of the Olympic Peninsula sub-population (USDI 1992b p. 105).

The Federal Reanalysis Team made the following conclusions from its work (Holthausen et al. 1994 p. 1-2):

(1) "It is likely, but not assured that a stable population of owls would be maintained on portions of the Olympic National Forest and the core area of the Olympic National Park in the absence of contribution of habitat from nonfederal lands" (Holthausen et al. 1994 p. 1).

(2) It would be unlikely that spotted owls would be maintained on the western coastal strip of the Olympic National Park without a contribution of habitat from nonfederal lands.

(3) There will probably be fewer areas with high occupancy by owls in the Olympic National Forest and the core area of the Olympic National Park without a contribution of habitat from nonfederal lands.

(4) "Retention of nonfederal habitat could result in a biologically significant contribution to the maintenance of a stable spotted owl population distributed evenly across currently occupied portions of the Olympic Peninsula" (Holthausen et al. 1994 p. 1-2).

(5) Retention of nonfederal habitat, while making a significant contribution to the maintenance of the population, will not fully resolve the uncertainties surrounding the long-term persistence of spotted owls on the Olympic Peninsula.

(6) Retention of nonfederal habitat on the western side of the Olympic Peninsula would likely increase the chances of maintaining a population on the coastal strip of the Olympic National Park.

(7) Nonfederal lands may provide the majority of low-elevation habitat on the peninsula. Low-elevation habitat may be of higher quality than high-elevation habitat.

(8) A habitat connection across southwest Washington as suggested in the Final Draft Recovery Plan would have little effect on the status of the owl population on the peninsula if that population were already stable or nearly stable.

The Federal Reanalysis Team was careful to point out in their report that they used considerable professional judgement when drawing conclusions from the results of their modeling efforts. They emphasized that model results do not represent reality, but instead are "repeatable projections of a set of assumptions" (Holthausen et al. 1994 p. 45). The manner in which DNR used the Reanalysis Team's conclusions in the formulation of its spotted owl conservation strategies is discussed in Section A and Section E of Chapter IV. More specific information regarding the biological basis of the report is in Section A on the spotted owl in Chapter III.

DRAFT RECOVERY PLAN FOR THE MARBLED MURRELET

On August 1, 1995, the U.S. Fish and Wildlife Service announced the availability of the federal Draft Recovery Plan (USDI 1995) and a revised proposal for the designation of critical habitat for the marbled murrelet in Washington, Oregon, and California.

Recovery plans are required by Section 4 of the Endangered Species Act (16 U.S.C. 1533(f)) to recommend actions considered necessary to protect or recover species listed by the federal government as threatened or endangered. The Draft Recovery Plan for the Marbled Murrelet was developed by a scientific team established in February 1993, with expertise in seabird ecology, conservation biology, and forest ecology. Assisting the core team were representatives of the affected states and other federal agencies. The draft plan includes information on (a) the biology, including habitat needs, of the species, (b) reasons for population decline and current threats, (c) current management, and (d) recommendations for recovery efforts for Washington, Oregon, and California.

The objectives identified in the Draft Recovery Plan are (a) to stabilize the population at a sustainable level throughout its range, (b) to provide future conditions that support viable, self-sustaining populations, and (c) to gather the scientific information necessary to develop criteria for delisting the species.

The cornerstone of the strategy included in the Draft Recovery Plan is the President's Forest Plan, which specifically addresses marbled murrelets and their habitat on federal lands. The President's Forest Plan identifies and protects large reserve areas that should provide increased habitat for the murrelet over the next 50 to 100 years. Protection is also provided outside of the reserve areas around sites known to be occupied by marbled murrelets. The Draft Recovery Plan includes areas such as nonfederal lands that were not, or could not be, considered in the President's Forest Plan.

Actions identified as necessary to address the objectives of the plan include:

(1) establishing six marbled murrelet conservation zones with specific management strategies for each,

(2) identifying and protecting habitat in each zone through designation of critical habitat or other methods such as habitat conservation plans, and developing management plans for these areas,

(3) monitoring populations and habitat and surveying potential breeding habitat to identify occupied sites,

(4) implementing actions to stabilize and increase the population in the immediate future and increase population growth in the long-term, and

(5) initiating needed research and establishing a regional research coordination body.

PROPOSAL FOR DESIGNATION OF CRITICAL HABITAT FOR THE MARBLED MURRELET

The U.S. Fish and Wildlife Service designates as critical habitat areas that have the physical and biological features necessary for the conservation of a listed species and that require special management. A final rule for designating critical habitat for the marbled murrelet was published in May 1996 (Federal Register v. 61, no. 102, p. 26255-26320).

There are approximately 3.9 million acres of land identified in the final rule in Washington, Oregon, and California, of which 78 percent (3.0 million acres) are federal lands included in the President's Forest Plan. In areas where federal lands alone were thought to be insufficient to support a well distributed population, an additional 870 thousand acres (approximately) of state (812,200 acres), county (9,100 acres), city (1,000 acres), and private (48,000 acres) lands are identified.

The U.S. Fish and Wildlife Service continues to rely on previously existing regulations to protect the marine environment and did not include any marine environment in the final rule.

The final rule includes the following language regarding areas designated as critical habitat that are within an HCP: "Critical habitat units do not include non-federal lands covered by a legally operative incidental take permit for marbled murrelets issued under section 10(a) of the Act."

Other Wildlife Statutes and Regulations

There are other laws and regulations pertaining to wildlife that are applicable, such as the federal Migratory Birds Treaty Act and the federal Bald and Golden Eagle Protection Act. In addition, the state has statutes and regulations governing wildlife. The Washington Department of Fish and Wildlife oversees state listings of endangered and threatened wildlife. DNR's Natural Heritage Program oversees state listings of plants. The Forest Practices Board issues regulations regarding forest practices involving critical wildlife habitat of state-listed species. (See the section in this chapter on the Forest Practices Act.)

If the Washington Department of Fish and Wildlife determines that an animal species is seriously threatened with extinction in the state of Washington, then the agency director may request the State Fish and Wildlife Commission to designate that species as endangered (RCW 77.12.020(6)). The same authority is granted for designating animal species as threatened or sensitive (RCW 77.12.020 (5)). Species designated as endangered are listed under WAC 232-12-014, and those species designated as threatened, sensitive, or protected are listed under WAC 232-12-011. As of the drafting of this HCP, 24 species are listed as endangered and eight species as protected. The complete regulations governing the state listing, delisting, and management of animal species are given in WAC 232-12-297.

The Washington Department of Fish and Wildlife is charged with writing recovery plans for endangered and threatened species that include target population objectives and an implementation plan for attaining the objectives. Such recovery plans may consider various approaches to meeting the objectives, including regulation. To date, the agency has written three recovery plans, for the snowy plover (*Charadrius alexandrinus*) (WDFW 1995a), the upland sandpiper (*Bartramia longicauda*) (WDFW 1995b), and the pygmy rabbit (*Brachylagus idahoensis*) (WDWF 1995c), none of which affect this HCP. (See Section F of Chapter III and Section G of Chapter IV for discussion of plants in the area covered by the HCP.)

RCW 79.70.030 authorizes DNR to establish and maintain a natural heritage program that "shall maintain a classification of natural heritage resources," which, as defined in RCW 79.70.020, includes special plant species. The Natural Heritage Program assigns endangered, threatened, or sensitive status to plants that face varying risks of extinction. As of the drafting of this HCP, the most current list of vascular plants can be found in a report titled Endangered, Threatened & Sensitive Vascular Plants of Washington (DNR 1994). A plant listed by the Natural Heritage Program is not protected through regulations, although the Natural Heritage Program does work with landowners to encourage voluntary protection. (See Section F of Chapter III and Section G of Chapter IV for a discussion of plants in the area covered by the HCP.)

Environmental Laws

In addition to the Endangered Species Act, DNR is required to follow relevant laws of general applicability such as the federal Clean Air Act, the federal Clean Water Act and the state Shorelines Management Act. As part of the process for developing an HCP, DNR is required to adhere to both the National and State Environmental Policy Acts.

NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA, 42 U.S.C. 4321 et seq.) requires full public disclosure and analysis of the environmental impacts of proposed federal actions significantly affecting the quality of the human environment. The issuance of an incidental take permit is a federal action subject to NEPA compliance. Federal actions associated with DNR's proposal involve both the U.S. Fish and Wildlife Service on behalf of the Secretary of the Interior and the National Marine Fisheries Service on behalf of the Secretary of Commerce.

It is important to distinguish between the requirements for an incidental take permit as set forth in the Endangered Species Act (16 U.S.C. 1531 et seq., described earlier in this chapter) and the detailed analysis required under NEPA. To comply with the requirements for an incidental take permit as set forth in the Endangered Species Act, an HCP must explain the potential impacts on federally listed species, the planned measures to minimize and mitigate to the maximum extent practicable those impacts, and other measures as necessary. The HCP must also describe alternatives to the proposed taking and explain why those are not considered feasible. NEPA requires a broader analysis that examines additional environmental impacts of the proposal and considers all reasonable alternatives to the proposed action. As part of the evaluation of reasonable alternatives, the No Action (i.e., no change from current practices) alternative must be analyzed. In this case, the NEPA analysis will compare the effect of issuing the permit to what would occur without the permit (USFWS 1996 p. 45). Please refer to the Draft Environmental Impact Statement for this analysis.

WASHINGTON STATE ENVIRONMENTAL POLICY ACT

The Washington State Environmental Policy Act (SEPA, RCW 43.21C) sets forth requirements for state actions that are similar to those of NEPA for federal actions. These include an analysis of environmental impacts of the proposal and consideration of reasonable alternatives, along with a public disclosure process. DNR is complying with these requirements through the Draft Environmental Impact Statement, a thorough public review effort, and a Final Environmental Impact Statement.

ENVIRONMENTAL IMPACT STATEMENTS AND PUBLIC REVIEW

Both SEPA and NEPA allow a state agency to jointly prepare an environmental impact statement (EIS) with a federal agency. Federal NEPA regulations state that "[f]ederal, [s]tate, or local agencies, including at least one federal agency, may act as joint lead agencies to prepare an environmental impact statement" (40 C.F.R. 1501.5(b)). SEPA rules also allow for the combination of documents where appropriate to comply with both SEPA and NEPA (WAC 197-11-640). In order to improve efficiency, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and DNR have agreed to serve as joint lead agencies for the environmental review of DNR's HCP. The lead agencies have prepared a Draft EIS pursuant to NEPA regulations (40 C.F.R. 1500-1508) and SEPA regulations (WAC 197-11) to fully evaluate DNR's HCP.

To satisfy both federal and state environmental policy act requirements, the U.S. Fish and Wildlife Service and DNR conducted a joint scoping process for the preparation of the Draft EIS. Agencies, tribes and members of the public submitted comments. The Board of Natural Resources also held a series of special public meetings around the state to hear public input. The results of the public scoping process are described in the Draft EIS.

A period of public review and comment followed issuance of the draft HCP and Draft EIS. Another series of public meetings was held around the state. The lead agencies reviewed the comments and the federal agencies conducted a biological assessment and jeopardy analysis of DNR's HCP. A Final EIS and notice of availability were published in October 1995. The Board of Natural Resources considered all reasonable alternatives, benefits and impacts to the trusts, results of the review by the federal agencies, and public input prior to deciding to adopt DNR's HCP. Please refer to DNR's Draft EIS and Final EIS for further information and analysis of the reasonable alternatives examined.

The State Forest Practices Act

In addition to statutes and regulations discussed in previous sections, as a forest land manager, DNR must comply with the Forest Practices Act, Chapter 76.09 RCW, which regulates forest management activity in Washington. The Forest Practices Act expresses the legislature's recognition of the importance of the forest products industry to Washington while finding it in the public's interest that forests be managed in a manner that protects public resources. The legislative finding and declaration includes the statement: "The legislature hereby finds and declares that the forest land resources are among the most valuable of all resources in the state; . . . that coincident with maintenance of a viable forest products industry, it is important to afford protection to forest soils, fisheries, wildlife, water quantity and quality, air quality, recreation, and scenic beauty" (RCW 76.09.010(1)).

The Forest Practices Act created the Forest Practices Board. One of the Board's duties is to promulgate forest practices regulations necessary to implement the purposes, policies, and provisions of the Forest Practices Act. Rules that relate to water quality protection must also be promulgated by the Department of Ecology. One of the legislative findings for the Forest Practices Act is to afford protection to forest soils and public resources (water, fish, wildlife, and capital improvements of the state or its political subdivisions) (RCW 76.09.010(2)(b)). These rules constitute Chapter 222 WAC, which sets minimum standards for forest practices such as road construction, timber harvesting, precommercial thinning, reforestation, fertilization, and brush control. Also included are rules concerning forest practices and habitat for threatened and endangered species. (See WAC 222-16-050(1)(b) and 222-16-080.)

Habitat conservation plans have a special relationship to the forest practices rule regarding critical habitats. When applications for proposed forest practices are submitted, they are assigned to one of four classes established by rule by the Forest Practices Board. Forest practices classified as Class IV-Special are subject to environmental review under the State Environmental Policy Act, Chapter 43.21 RCW (SEPA). Certain practices on "critical wildlife habitats (state) and critical habitat (federal) of threatened and endangered species" require a Class IV-Special designation (WAC 222-16-050(1)(b), 080). However, such habitats are no longer considered critical if the forest practices are "consistent" with a "conservation plan and permit for a particular species [that has been] approved by the U.S. Fish and Wildlife Service" (WAC 222-16-080(7)(a)). Therefore, additional environmental review under SEPA would not be required.

DNR's Forest Resource Plan

In addition to following statutory regulations, DNR is guided in management of state trust lands by policies established by the Board of Natural Resources. (See RCW 43.30.1150(2).) The Forest Resource Plan, adopted by the Board in 1992, is the major policy document currently providing direction for management of forested trust lands.

The Forest Resource Plan reaffirms DNR's commitment to act as a prudent land manager in order to generate income from state forest land to support schools and other beneficiaries. Policies in the various sections of the plan require DNR to analyze and, if necessary, to modify the impact of its activities on watersheds, wildlife habitat, special ecological features, wetlands, and other natural resources to ensure healthy forests that will be productive for future generations. The plan contains general policies and priorities intended to be interpreted within the context of the whole plan, including the following vision statement:

> The department has a clear purpose in caring for state forest land based on stewardship, innovation, commitment and competence. Department employees manage state forest lands and resources in an exemplary manner. Forest land planning is based on early collaboration with land users, neighbors, governments, tribes and the public, with mutual recognition of obligations and responsibilities. When necessary, the trust beneficiaries are compensated for a variety of uses by public and private sources. The department aggressively markets timber and a wide array of nontimber products. The department uses the most appropriate tools and technology. The department recognizes that assets owned by the trusts include the entire ecosystem and manages each site with the entire

> ecosystem in mind. The requirements for the management of timber and nontimber resources are integrated in landscape planning. Finally, the department recognizes the value of its employees, promotes creative thinking at all levels and accepts risk as an element of decisions (DNR 1992 p.1).

The plan divides policies into four general categories: trust asset management, forest land planning, silviculture, and implementation. Trust asset management policies address issues such as forest land transactions, lands available for timber harvest, harvest levels, marketing of special forest products, forest health, fire protection, financial assumptions, and special ecological features. Forest land planning policies describe the process for converting the plan policies into objectives and on-the-ground activities. Silviculture policies set the "sideboards" for individual site prescriptions and activities that effect the establishment, composition, structure, and growth of state forests. Implementation policies describe public involvement, monitoring, research, and plan modification processes.

The HCP is viewed as the major element for complying with the Forest Resource Plan policy on endangered, threatened, and sensitive species on the 1.6 million acres of DNR-managed land that the HCP covers. This policy states:

> The department will meet the requirements of federal and state laws and other legal requirements that protect endangered, threatened and sensitive species and their habitats. The department will actively participate in efforts to recover and restore endangered and threatened species to the extent that such participation is consistent with trust obligations (DNR 1992 p. 39).

In addition, the HCP provides support and direction for applying other Forest Resource Plan policies in regard to riparian management zones, wetlands, landscape planning, wildlife habitat, silviculture, and the Olympic Experimental State Forest.

The Forest Resource Plan articulates the Board's goals and policies in regard to striving to make the trust lands productive while protecting resources. These goals and policies can be implemented in a variety of ways, of which this HCP is one. The HCP does not revisit fundamental decisions made in the Forest Resource Plan. Therefore, the HCP should not be seen as an alternative to the Forest Resource Plan, but rather as a way of providing more substance and detail to existing policies.

III. Biological Data for Species Covered by the HCP

A. Northern Spotted Owl

III. Biological Data for Species Covered by the HCP

A. Northern Spotted Owl

Species Ecology/Literature Review

INTRODUCTION

The northern spotted owl (*Strix occidentals caurina*) occurs in the Pacific coastal region from British Columbia to Marin County, California. Research during the past two decades indicates that spotted owls are strongly associated in much of their range with late successional and old-growth forest habitats. The spotted owl also occurs in some younger forest types where the structural attributes of older forests are present. The U.S. Fish and Wildlife Service listed the spotted owl as a threatened species in June 1990, based on the reduction of the owl's preferred habitat throughout its range (Federal Register v. 55, p. 26114-94). The state of Washington has listed the northern spotted owl as endangered.

The federal Northern Spotted Owl Recovery Team (hereafter referred to as the Recovery Team; for a description of its purposes, see the section in chapter II on the Final Draft Recovery Plan for the Northern Spotted Owl) adopted a modified version of the physiographic provinces described in Franklin and Dyrness (1973) to describe the range of the northern spotted owl. Physiographic provinces are defined by the physical and environmental factors that influence ecological characteristics of the landscape. This section will refer to the Recovery Team provinces for descriptive purposes. (See Map III.1.)

There is a separate discussion on ecology and threats to population for the northern spotted owl on the Olympic Peninsula because a separate conservation strategy is proposed for spotted owls in the Olympic Experimental State Forest Planning Unit on the west side of the Olympic Peninsula and the majority of knowledge of spotted owl ecology and population biology in Washington derives from studies conducted on the Olympic Peninsula. The objectives of that discussion are to review and discuss life history, population ecology, and threats to population persistence of the spotted owl as they relate to its conservation in the Olympic Experimental State Forest.

PHYSICAL CHARACTERISTICS AND BEHAVIOR

The northern spotted owl is a medium-size dark brown owl that has round to elliptical white spots on the head, white mottling on the body and abdomen, and white bars on the tail (Johnsgard 1988). It can be distinguished from other owls by its dark brown eyes surrounded by lighter brown facial disks. It differs from a close relative, the barred owl (*Strix varia*), by the presence of spots on the head and chest as compared to the vertical barring on the chest of barred owls.

Age and Sex Characteristics

Spotted owls have an average life span of eight years (Thomas et al. 1990). Juvenile spotted owls (age one day to five months) can be distinguished from older owls by the presence of pale brown downy feathers (Forsman 1981). As juveniles grow, the amount of down plumage decreases. At approximately five months, juveniles acquire adult-like plumage, but they have white, sharp-tipped tail feathers (Forsman 1981). Subadults between the ages of one and two years retain a downy tuft at the tip of their still-white tail feathers; the tuft is lost sometime after the first year (Moen et al. 1991). Spotted owls are considered adults at 27 months, at which time their tail feathers become rounded and mottled brown.

The easiest way to distinguish males and females is by voice, since their plumage is very similar (Forsman et al. 1984). Male vocalizations are generally lower pitched than female vocalizations. There is also a difference in size, with females being larger than males (reverse sexual dimorphism) (Blakesley et al. 1990 p. 323).

Foraging

Northern spotted owls are adapted to nocturnal hunting through exceptionally good eyesight and hearing and through modified feathers that facilitate silent flight (USDI 1992b p. 18). Spotted owls hunt opportunistically during the day. Typical hunting behavior consists of perching on a branch and locating potential prey by sight or sound, then pouncing on and capturing prey with their talons (USDI 1992b p. 18).

Spotted owls rely on small mammals for most of their diet, although they also eat birds and insects. Significant prey species in terms of biomass (weight) and frequency of capture are flying squirrels (*Glaucomis sabrinus*), wood rats (*Neotoma fuscipies* and *N. cinera*), mice (*Peromyscus* spp.), red tree voles (*Arborimus longicadus*), and rabbits (*Sylvilagus* spp.). Red-back voles (*Clerthrionomys californicus*) can be important south of the Columbia River (Forsman et al. 1984; Thomas et al. 1990; Carey et al. 1992). Two or three small mammal species generally comprise the majority of prey biomass for spotted owls in an area (Solis 1983; Forsman et al. 1984). On the Olympic Peninsula, however, Carey et al. (1992) found that spotted owls depend primarily on flying squirrels. Regional variation in diet is apparently based on habitat and distributional limits of the prey species (Forsman et al. 1984; Thomas et al. 1990, Appendix J; Carey et al. 1992).

Reproduction

Spotted owls form long-term pair bonds. Reproductive activity begins in the late winter when pairs begin to roost together on a regular basis. Commitment to nesting depends on the condition of the female, ability of the male to obtain sufficient food, and availability and abundance of prey. Spotted owls nest in existing structures such as cavities, broken tree tops, or platforms. (See section on habitat characteristics below.) Eggs are laid during early spring. Clutch size in spotted owls is small — one to two eggs is normal. Occasionally a female will lay three eggs. The female incubates the eggs for approximately 30 days, during which time the male's primary responsibility is to provide her with food (Forsman et al. 1984).

Owlets remain in the nest for three to five weeks after hatching (USDI 1992b p. 31). They typically leave before they are able to fly by hopping onto adjacent branches or the ground. Juvenile owls depend on their parents for food until they disperse in September or October. Dispersal of the young signals the end of the reproductive cycle (Gutierrez et al. 1985; Miller and Meslow 1985; Miller 1989). Members of a pair then separate for the winter.

During nesting season, a reproductively active pair of spotted owls defends a functional territory through vocalizations and visual displays. Breeding owls, especially males, are more likely to respond to actual or mimicked owl calls than are non-breeding or single birds (Thomas et al. 1990). A functional territory is the area where habitat conditions are sufficient for survival and reproductive replacement of the pair. Territories are thought to be smaller than home ranges, though the exact relationship is not known (USDI 1992b p. 20).

Nesting Success

Reproductive success for spotted owls varies widely by geographic region and over time (Forsman et al. 1984; Gutierrez et al. 1984; Carey 1985; Franklin et al. 1990; Lutz 1992; LeHaye et al. 1992). Initiation of nesting varies from 40 to 60 percent of pairs (Federal Register, v. 55, p. 7). Success of nesting within a population of sampled individuals can vary from 0 to 100 percent (USDI 1992b p. 31).

Survival

Survival rates for juvenile owls vary, but generally are low (Gutierrez et al. 1985; Miller 1989). Juveniles are vulnerable to predation and starvation during dispersal due to lack of cover when travelling in open areas, inexperience at evading predators, and inexperience in obtaining food (Forsman et al. 1984; Miller 1989). Survival rates for subadults and adults are generally higher than for juveniles. Burnham et al. (1994) summarized survival rates for spotted owls from 11 study sites in California, Oregon, and Washington. Survival rates are estimated from capture/recapture studies of banded animals (Burnham et al. 1987; Lebreton et al. 1992). Estimated mean annual juvenile survival rates for the 11 study areas was 0.258 (standard error[1], se = 0.36) and ranged from 0 to 0.418. Mean annual survival rates for adult spotted owls was 0.844 (se = 0.005) and ranged from 0.821 to 0.868 (Burnham et al. 1994 p. 16).

Home Range

Home range for a species is generally defined as the area used by the animal and to which it exhibits fidelity (USDI 1992b p. 26). Spotted owl home range sizes vary geographically. Median annual home ranges in Washington are largest on the Olympic Peninsula at 14,232 acres (Hanson et al. 1993 p. 19). The Final Draft Recovery Plan reported median annual home ranges in the eastern Cascades and western Cascades provinces as 7,124 acres and 6,657 acres respectively (USDI 1992b p. 27). Hanson et al. (1993) reported median annual home ranges of 6,609 acres and 8,205 acres for the eastern and western Washington Cascades respectively. The smallest observed home range in Washington is 2,969 acres in the western Washington Cascades (Hanson et al. 1993 p. 20).

Gutierrez (in USDI 1992b) summarized the generalizations that can be derived from recent studies about home range characteristics. First, initial observations by Forsman (1980) about the large size of spotted owl home ranges have been confirmed. Second, there is a large degree of overlap between members of the same pair (Forsman et al. 1984; Solis and Gutierrez 1990) and less overlap among adjacent pairs. Carey (1985) speculated that the degree of home range overlap can be affected by forest fragmentation in the landscape. Later research confirmed this hypothesis (Carey et al. 1992). Third, there is much geographic variation in home range size (Thomas et al. 1990; Carey et al. 1992). Fourth, home range size increases as the amount of old-growth forest in the home range decreases

[1]Standard error (se) is a measure of variability. A larger standard error indicates greater variability. Standard error generally decreases with larger sample size.

(Forsman et al. 1984; Carey 1985; Thrailkill and Meslow 1990). Data about the amount of late successional habitat in annual home ranges summarized by Hanson et al. (1993) corroborated this finding for the Olympic Peninsula but not for the western Washington Cascades.

In addition to the above studies on home range characteristics, Lehmkhul and Raphael (1993) found that most measures of spotted owl habitat patterns (total amount, patch size, measures of fragmentation) in home ranges were similar to patterns found in 8,035-acre circles around owl activity centers on the Olympic Peninsula. Measures were less similar for 2,008-acre circles and for 18,080-acre circles. Lehmkhul and Raphael also suggest that 8,035-acre circles contain habitat that is in smaller, more isolated patches than actual home ranges and that circles will more closely approximate home ranges where habitat is distributed across the landscape in regular patterns (Lehmkuhl and Raphael 1993 p. 312).

The variables responsible for geographic differences in home range size are not well understood. Many factors, such as food availability, interspecific competition, and amount and arrangement of suitable habitat, probably contribute to observed variation in home range size (USDI 1992b p. 26).

Dispersal

Juvenile spotted owls must disperse from their parents' home range to establish their own home range and engage in reproductive activity. Adults may also disperse to new home ranges if they have been displaced by logging or by a competing barred owl or if the other member of a pair has died. The dynamics of adult dispersal are much less understood than for juveniles. Successful dispersal of juvenile and displaced adult spotted owls is an important mechanism for recolonizing unoccupied habitat and replacing breeding members of the population, which, in turn, are important for population recovery and maintenance (Thomas et al. 1990 p. 303).

Researchers have used radio telemetry to study patterns of juvenile owl dispersal in Oregon and California. Dispersal generally begins between mid-September and mid-October, and direction of dispersal from the nest area appears to be random (Gutierrez et al. 1985; Miller 1989). Straight-line travel distance for the first autumn was between 9 and 30 miles (Gutierrez et al. 1985; Miller 1989). Guitierrez et al. (in USDI 1992b p. 34) used reobserved banded owls to determine dispersal distance for juveniles that survived to establish their own territories. These distances averaged 4 miles for juvenile males and 12 miles for juvenile females.

Radio-telemetry data for dispersing juveniles in Washington was collected in 1991 and 1992, and comes from three studies, one each on the Olympic Peninsula, the Wenatchee National Forest in the eastern Washington Cascades and the Yakama Indian Reservation. Mean dispersal distance for juveniles on the Olympic Peninsula was 15 miles (number in sample size, n = 31, se = 1.22), maximum distance 36 miles (Washington Forest Practices Board 1995 p. 23). In the eastern Cascades, mean distance was 15.1 miles (n = 80, se = 1.22), and maximum distance was 76 miles. On the Yakama Indian Reservation, mean dispersal distance was 22.2 miles (n = 7, se = 5.29), and maximum dispersal distance was 54 miles (Washington Forest Practices Board 1995 p. 23).

Knowledge of dispersal behavior and habitat is crucial for designing conservation strategies for the spotted owl (Thomas et al. 1990). The distance between areas of suitable nesting, roosting, and foraging habitat should not exceed the distance that most successfully dispersed juveniles are known to have traveled (Thomas et al. 1990). The structure of dispersal habitat is discussed below.

Interspecific Relationships

The spotted owl's main competitor for resources is the barred owl. Barred owls have colonized the Cascade Range and Olympic Mountains in the past 50 years, probably in response to forest fragmentation across the landscape. Barred owls have been reported to be dominant in their interactions with spotted owls and have displaced spotted owls from nests at some sites (USDA 1988; Hamer et al. 1989). Where spotted owls and barred owls co-exist, barred owls reduce the amount of habitat available to spotted owls by using similar structures for nests and pursuing some of the same prey.

Hybridization (breeding between different but related species) is occurring between spotted owls and barred owls. Hamer et al. (1994) reported that a hybrid owl successfully reproduced with a barred owl in at least two breeding seasons. Hybridization appears to be a rare occurrence, given the proportion of known hybrids to known breeding pairs of spotted owls. If hybridization were to become more extensive, however, the genetic integrity of the spotted owl population could be threatened (Thomas et al. 1993; Hamer et al. 1994).

The main predators of spotted owls are thought to be great horned owls (*Bubo virginianus)* and northern goshawks (*Accipiter gentilis)* (Forsman et al. 1984; Miller 1989; USDI 1992b). Spotted owls are known to nest in goshawk territories and to defend their nests against goshawk attacks (USDI 1992b p.21). Great horned owls appear to occupy more fragmented habitats than do spotted owls (Fredrickson et al. 1990; Johnson 1993) and thus probably prey more frequently on spotted owls when the latter's habitat becomes more fragmented or when juvenile spotted owls are dispersing through younger, more open forests (Forsman et al. 1984). The Recovery Team reported that 40 percent of 91 adult or subadult owls and 25 percent of 60 juvenile owls that were radio marked and then died between 1975 and 1991 were killed by other birds (USDI 1992b p. 46).

HABITAT CHARACTERISTICS AND SELECTION

Spotted owls use a variety of forest types and stand structures for nesting, roosting, and foraging throughout their range. Forest types include Douglas fir, western hemlock, mixed conifer, mixed evergreen, redwood, mixed Douglas fir and hardwood, evergreen hardwood, ponderosa pine, and western red cedar.

Spotted owls use existing structures for nests. Nesting habitat is generally found in mature and old-growth stands and contains a high degree of structural complexity. (See discussion below.) In older forests, spotted owls select cavities or broken-top trees more frequently than platforms (mistletoe brooms, abandoned raptor and gray squirrel nests, and debris accumulations) (Forsman et al. 1984; LaHaye 1988). In younger forests, they tend to use platforms more frequently (LaHaye 1988; Buchanan 1991).

Roosting habitat has characteristics similar to nesting habitat, i.e., high canopy closure, a multi-layered canopy, and large diameter trees. In the summer, spotted owls roost in shady spots and near streams. The multi-layered canopy helps owls regulate body temperature by providing various microclimates vertically throughout the canopy (Forsman 1980; Barrows 1981; Solis 1983; Forsman et al. 1984).

Foraging appears to occur in more varied habitat conditions than does nesting and roosting (Thomas et al. 1990). Within these variations however, foraging habitat is still characterized by high canopy closure and complex structure (USDI 1992b p. 24).

Current understanding of characteristics of suitable spotted owl habitat is derived from several types of studies. Bart and Earnst (1992) divide these studies into the following categories:

(1) structural characteristics of utilized habitat,
(2) amount and distribution of suitable habitat within home ranges,
(3) habitat selection for roosting and foraging,
(4) abundance of spotted owls in different habitats,
(5) demographic rates of spotted owls in different habitats, and
(6) studies of different resources needed by spotted owls.

Descriptions of habitat characteristics are best used in combination with correlational studies that determine habitat preference and the survivability of owls in different habitat types, and with functional studies that determine the specific resources of value to spotted owls in their preferred habitats. Any of these types of information in isolation gives an incomplete picture of habitat suitability (Bart and Earnst *in* USDI 1992b, Appendix B, p. 26). Thomas et al. (1990) provide a comprehensive review of spotted owl habitat studies; Bart and Earnst (1992) review new information made available since that 1990 study. The following summary discussion is derived primarily from Bart and Earnst (1992) and Thomas et al. (1990). More recent literature is also discussed.

Structural Characteristics

Spotted owls use sites with a high average canopy cover (greater than 70 percent) and which contain large live trees, down logs and snags (Thomas et al. 1990; Buchanan 1991; Hanson et al. 1993; North 1993). In studies that quantified structural characteristics, the average number of trees that have a specific diameter at breast height (dbh) was consistent, while the number of trees decreased as dbh class increased. Fewer large trees occurred in the eastern Washington Cascades province, eastern California Cascades province and in the western part of the California Cascades province than in other parts of the spotted owl range (Bart and Earnst 1992 p. 38).

Studies summarized in USDI 1992b that compared structural characteristics of utilized sites with those of old-growth forests found average snag density was similar for both. Average values for tree density, snag density, and canopy closure were similar in nesting, roosting, and foraging habitats. Spotted owls use stands dominated by conifers, with hardwood understories present in California, but largely absent in Washington and Oregon. Bart and Earnst (1992) caution that average values should be taken as that and not as a description of each site. Variations in canopy cover, numbers of large trees and snags, and composition of the understory occur in habitat actually used by spotted owls.

Amount of Habitat in Home Ranges

The large size of spotted owl pair home ranges and the amount of late seral stage forest the owls require account for the controversial character of spotted owl conservation. Thomas et al. (1990) summarized the amounts of old-growth and mature forest in spotted owl pair home ranges. (Because there can be extreme outlyers, calculating the median acreage has been found to be more reliable than considering average sizes.) Median acreages of mature and old-growth forest in the Olympic Peninsula and western Cascade province spotted owl home ranges are 4,579 and 3,281 respectively. Hanson et al. (1993) reported the median amount of late successional habitat in spotted owl pair home ranges as 3,827 acres on the Olympic Peninsula and 3,586 acres in the western Washington Cascades. In the eastern Washington Cascades, the median amount of suitable habitat in home ranges was 3,248 acres (Hanson et al. 1993). The median amount of mature and old-growth forest in home ranges varies from 615 acres in the Klamath province to 4,579 acres in the Olympic Peninsula province. Median amounts of old growth in home ranges were less than 1,000 acres in only two studies. Variation also occurred within provinces (Thomas et al. 1990 p. 195; Hanson et al. 1993).

Bart and Earnst (1992 p. 40) point out that the large variation in the amounts of late successional forest within home ranges poses problems for determining what habitat and how much to maintain around individual nest sites to allow for successful replacement of spotted owl pairs. Given that the large cluster reserve concept (Thomas et al. 1990; USDI 1992a and b; FEMAT 1993) is the approach that will be applied on federal lands (USDA and USDI 1994b), how much habitat to conserve around site centers is an issue for land owners and managers attempting to avoid take on nonfederal land by protecting individual nest sites. Some of the uncertainty could be resolved through additional studies that combine estimates of home-range size and amount of old growth within them with analyses of stand structure, viability assessments, and analyses of the functional components of preferred habitat within the home range (Bart and Earnst 1992 p. 41).

Habitat Selection

Gutierrez (in USDI 1992b p. 22-23) discusses habitat use versus selection and preference. Habitat use is determined by observation of an animal in a certain habitat type without defining the context of the observation. Habitat selection is the choice of a habitat or habitats directly available to the animal. Habitat preference is the choice of habitat or habitats that the animal would make if all habitat types were available to it. Several studies have shown that spotted owls select mature and old-growth habitat with a concomitant selection against young stands (Forsman 1980; Carey et al. 1990, 1992; Blakesley et al. 1992).

Several recent studies confirm earlier hypotheses that spotted owls select older stands that have a high degree of structural complexity for their nesting habitat. Most nests located on public land have been found in mature and old-growth forests (Forsman et al. 1984; LaHaye 1988). The proportion of late seral stage forests surrounding nests has been found to be significantly greater than in surrounding random sites in the area (Meyer et al. 1990; Ripple et al. 1991). Lehmkuhl and Raphael (1993) found that spotted owl pair locations had significantly more habitat composed of primarily late successional forest than did random sites. LaHaye (1988) and Buchanan (1991) found that nests were located in stands whose structure was more complex than that of the surrounding areas. Buchanan et al. (1993) also found that nest trees in the eastern Washington Cascades were significantly older than trees at randomly selected sites. These studies suggest that spotted owls select nesting habitat with certain characteristics.

An exception to the generally old age of nesting habitat occurs in eastern Washington where spotted owl nest sites are found in stands that are younger than nest stands in other parts of the spotted owl's range, including western Washington. Buchanan et al. (1995) found that the median age of forest stands in more than half of the 85 nest sites located for their study was 130 years. Median age of actual nest trees in their study area was 137 years (Buchanan et al. 1993). They concluded that the difference in age of the stands and trees between western and eastern Washington was due to regional differences in patterns of disturbance, climate, and tree growth (Buchanan et al. 1993 p. 5).

Spotted owl nest sites have been found in younger managed stands on private land. These sites tend to be in areas where there was some previous uneven-aged management or in areas with rapid tree growth that facilitates habitat development in a relatively short period. Nest sites on managed land retain some structural characteristics of old growth (Thomas et al. 1990). Gutierrez (in USDI 1992b p. 23) pointed out that (1) the health of spotted owl populations found on private ownerships cannot be ascertained because no critical demographic studies have been completed on them, and (2) the presence of breeding owls alone in managed stands does not establish that such habitat is capable of supporting a self-sustaining population.

Thomas et al. (1990) reviewed the literature about selection of habitat for roosting and foraging. Old-growth stands were consistently preferred for both activities in Washington and Oregon west of the crest of the Cascade range. Young stands, pole stands and other stands were consistently avoided. Selection of mature stands was varied. Most studies defined old growth as stands older than 200 years and mature stands as 80-200 years old and containing few canopy layers.

Bart and Earnst (1992) have summarized more recent data. They concluded that the criteria for habitat selection are less clear in California and in the Oregon portion of the Klamath province than in other areas. While Thomas et al. (1990) found that young forests (less than 80 years) were avoided by 55 percent of spotted owls and selected by only 3 percent, Blakesley et al. (1992) and Zabel et al. (1991) found no tendency for owls to avoid stands in the 11- to 21-inch dbh size class (roughly equivalent to the "young" category in Thomas et al. 1990). Blakesley et al. (1992) noted, however, that the small-size class stands in their study areas were produced by natural processes and contained diverse composition and complex structure. Thus selection rates may not apply to even-age managed stands of a similar size class (USDI 1992b, Appendix B, p. 42).

Abundance of Spotted Owls in Different Habitats

Thomas et al. (1990) found that spotted owl density increased with the amount of old growth in a landscape or study plot. Density was very low in landscapes dominated by stands that were 80 years old or less and that lacked old-growth characteristics. Thomas et al. (1990) also recognized studies that indicated the potential for suitable habitat to develop faster in coastal California redwood and mixed Douglas fir forests than in other portions of the spotted owl's range and that more research is necessary in this area. Bart and Forsman (1992) found on both a landscape scale (5,000 - 171,000 acres) and a home range scale (1,000-acre plots) that spotted owl density was significantly higher for areas with greater than 60 percent older forest than for areas with less than 20 percent older forest.

Demographic Rates in Different Habitats

Results of studies analyzing the relation between demographic rates and the amount of old growth in spotted owl nesting territories indicate that the proportion of territories with pairs and reproductive success declined as the amount of old growth declined (Thomas et al. 1990). Bart and Earnst

(1992 p. 47-49) analyzed data from Meyer's and Johnson's unpublished data and found that persistence of spotted owl pairs in territories increased with the amount of forest more than 120 years old. Persistence was defined as the "probability that an owl present in a circle at the start of a year would be found at that site the next year, given that the site was revisited the following year." The authors took persistence as a surrogate measure for adult survival. These results further corroborate the above-mentioned findings of Thomas et al. (1990) on spotted owl density. In contrast, however, Irwin and Fleming (1994) found no correlation between occupancy rates or reproductive success and the amount of late successional habitat within 2.1 miles of spotted owl nests in the eastern Washington Cascades.

In summary, descriptions of habitat used for nesting, roosting, and foraging have shown that these activities take place in older forest; correlational studies have shown that spotted owls prefer older stands for roosting and foraging. Some, though not all, studies have shown that reproductive success is higher for pairs that have more old growth in their home ranges; spotted owl density and adult persistence has also been demonstrated as correlated with increasing amounts of old growth (Bart and Earnst 1992 p. 26).

Dispersal Habitat

In order to disperse successfully, juvenile spotted owls need both sufficient cover to avoid predators and opportunities for foraging. Dispersal habitat as a category distinct from nesting, roosting, and foraging habitat is necessary, given the extent to which older forest habitat has been reduced and fragmented throughout the spotted owl's range. Evidence suggests that juveniles prefer mature and old-growth forests for roosting (Miller 1989) and that risk of predation during dispersal is high in open and fragmented landscapes (Forsman et al. 1984; Johnson 1993). In the current landscape, large areas exist between patches of suitable nesting, roosting, and foraging habitat that juvenile spotted owls need to cross to establish new territories. For the demographic and genetic stability of small sub-populations, juveniles must be able to move between clusters of territories; to do this, they also need to cross large areas of younger forests between large late successional habitat reserves (USDA and USDI 1994b).

The concept of dispersal habitat was first proposed in the Interagency Scientific Committee's report called A Conservation Strategy for the Northern Spotted Owl (Thomas et al. 1990). The idea of establishing specific stand conditions over a large area to facilitate movement of juvenile and non-territorial adults between areas of suitable nesting, roosting, and foraging habitat is based on radio-telemetry data that suggests juvenile owls disperse in random directions (Miller 1989). Thus linear, directional corridors are unlikely to be useful. The Interagency Scientific Committee's report recommended that forested federal lands between designated Habitat Conservation Areas be managed such that 50 percent of every quarter township have forest stands in which trees have an average dbh of 11 inches and at least a 40 percent canopy closure. (This is commonly referred to as the 50-11-40 rule.) The committee proposed this set of specific guidelines as a management hypothesis with the clear understanding that further research was necessary to establish its effectiveness (Thomas et al. 1990, Appendix R). No definitive research on spotted owl dispersal habitat has been published since this recommendation.

POPULATION VIABILITY AND DYNAMICS

Questions of how many spotted owl pairs and how much habitat are sufficient to prevent the species from going extinct are at the center of policy debates and conservation planning involving the northern spotted owl. Addressing these questions involves studies of population dynamics — how birth and death rates contribute to changes in size of the population over time. An understanding of population dynamics can then be used to analyze how large a population needs to be, and how its habitat needs to be distributed across landscapes, to persist over time. This is known as population viability analysis.

A viable population is one that is of sufficient size and distribution to be able to persist for a long period of time in the face of demographic variations, random events that influence the genetic structure of the population, and fluctuations in environmental conditions, including catastrophic events (Meffe and Carroll 1994). The northern spotted owl population currently exists in small sub-population units that are separated in some portions of its range by large areas of unsuitable habitat. The rate at which dispersing juveniles move among these small sub-populations to add to local breeding populations influences the overall likelihood that the whole population will persist. This is called metapopulation dynamics. Metapopulation dynamics are often influenced by the distribution of high quality habitat over the landscape. Areas of lower-quality habitat may function as sinks — areas that need regular immigration of individuals from other sub-populations to survive. Areas of higher quality nesting, roosting, and foraging habitat can often serve as source populations that are self-maintaining and that provide emigrants to sink areas (Harrison 1991; Meffe and Carroll 1994). Viability analyses for spotted owls attempt to take these dynamics into account.

Population modeling also requires data on demographic trends. Studies of recapture or re-observance of banded owls are used to estimate survival rates of juveniles, subadults, and adults (Burnham et al. 1987; Lebreton et al. 1992). These estimates combined with data on the number of females produced by breeding pairs (fecundity) can be analyzed to assess population trends (Anderson and Burnham 1992; Burnham et al. 1994). (For a discussion of the results of recent demographic analyses, see section below on status of and threats to the spotted owl.) Estimates of demographic trends can be used to get a picture of the current situation, but they cannot be used to project population trends into the future (Burnham et al. 1994; USDA and USDI 1994b, Appendix J3). Mathematical and spatial simulation models enhance population viability analyses (USDA and USDI 1994b, Appendix J3, p. 7).

Viability analyses for the spotted owl have used mathematical demographic-based models that do not take spatial arrangement of habitat and territories into account (Lande 1987, 1988), as well as map-based, spatially explicit simulation models (Doak 1989; Lamberson et al. 1992; McKelvey et al. 1993; Holthausen et al. 1994; Lamberson et al. 1994; Raphael et al. 1994).

Modeling efforts have led to several important insights about the factors influencing viability of spotted owl populations[2]. Lande (1987, 1988) used a non-spatial model of dispersal and territory occupancy to estimate the minimum amount of habitat needed to sustain a population of northern spotted owls in a large region. He concluded that if the total landscape (all ownerships) contained less than 21 percent suitable habitat, the population would eventually become extinct. Results from later models that incorporated spatial factors also concluded that sharp thresholds exist in the amount of nesting, roosting, and foraging habitat needed to support a viable spotted owl population (Doak 1989; Lamberson et al. 1992; Carroll and Lamberson 1993).

[2]For a discussion of the differences among these models, see Lamberson et al. (1994) and Appendix J3 in USDA and USDI 1994a.

The analysis by Lamberson et al. (1992) also indicated that another threshold response may occur if population density became too low. When territories become too sparse, the ability of spotted owls to find mates theoretically becomes an insurmountable barrier to maintaining replacement levels of reproduction.

McKelvey et al. (1993) and Lamberson et al. (1994) concluded that in addition to the overall amount of suitable nesting, roosting, and foraging habitat, spatial arrangement of habitat is a very important factor in influencing the persistence of spotted owl populations. These modeling efforts demonstrated that arranging suitable habitat to support large clusters of owls (20-25 pairs) rather than a dispersed arrangement of single territories increased population stability and reduced the potential impacts of random demographic events.

The model described by McKelvey et al. (1993) allows the effects of different management scenarios to be simulated over time. Raphael et al. (1994) used this model to compare the relative differences in effects on spotted owl populations of three alternatives described in the federal Supplemental Environmental Impact Statement (SEIS) on Management of Habitat for Late-Successional and Old Growth Forest Related Species within the Range of the Northern Spotted Owl. They demonstrated that population sizes and occupancy rates that resulted from their model runs were sensitive to assumptions made about juvenile, subadult, and adult survival rates used to set parameters for the model. One set of assumptions or "rule sets" resulted in declining populations for all scenarios modeled (No Cut, SEIS Alternative 1, SEIS Alterative 7, and SEIS Alternative 9, the preferred alternative); use of the other two rule sets resulted in populations that declined and then stabilized. The differences in actual alternatives were swamped by the use of different assumed survival rates for spotted owls (USDA and USDI 1994a, Appendix J3). The fact that results varied depending on assumed demographic rates indicates the need for solid demographic data to use as input in these models in order to achieve more realistic outcomes.

While spotted owl biologists have increased the ability of models to incorporate more realistic assumptions (Lamberson et al. 1994), the results of such models should not be viewed as real predictions of spotted owl population behavior. Holthausen et al. (1994) caution that results of their modeling experiment on the Olympic Peninsula should be viewed as "repeatable projections of sets of assumptions" (p. 45). In USDA and USDI (1994a), the authors view models as "one tool in evaluating wildlife populations and habitat, and do not replace sound professional judgement in decision making" (USDA and USDI 1994a, Appendix J3).

STATUS AND THREATS

The northern spotted owl currently inhabits areas within most of its historic range. However, its distribution has changed markedly from hypothesized historical distributions due to removal or alteration of nesting, roosting, and foraging habitat. Booth (1991) has estimated that more than 80 percent of the old growth that existed prior to European settlement of the Pacific Northwest had been logged by the early 1980s. While not all old growth is suitable habitat, this represents a substantial loss of potential suitable nesting, roosting, and foraging habitat. The Interagency Team responsible for writing the Environmental Impact Statement for the President's Forest Plan estimates that there are 7.4 million acres of suitable habitat left on federal lands throughout the spotted owl's entire range (USDA and USDI 1994a p. 214).

Spotted owl populations are sparse and small in British Columbia, the Oregon Coast Range, the western Washington lowlands province, and other low elevation areas. Local populations have been extirpated from the Puget Trough and Willamette Valley due to habitat loss from urbanization, logging, and agricultural development. Most of the remaining habitat occurs at mid to high elevations (between 2,500 and 5,000 feet) and on federal land.

There are approximately 4.1 million acres of potentially suitable spotted owl habitat on all ownerships in Washington. Approximately 490,000 acres of this is on DNR-managed lands (DNR GIS 1995).

The federal Northern Spotted Owl Recovery Team reported that there are approximately 3,602 known spotted owl pairs in Washington, Oregon, and northern California as of 1992 (USDI 1992 p. 39). Population estimates have been updated for the Olympic Peninsula (Holthausen et al. 1994) (see later discussion on spotted owls on the Olympic Peninsula), but similar efforts have not been undertaken in the rest of the spotted owl's range. The true population size is unknown. There are currently 354 spotted owl site centers that are either on or have a median home range radius (Hanson et al. 1993) that includes DNR-managed lands (WDFW Non-game Database May 1995a).

The Recovery Team identified 10 threats to existing populations of spotted owls. The severity of each threat varies by physiographic province. The most significant factor contributing to the overall decline of the species is loss of nesting, roosting, and foraging habitat to clear-cutting and other even-aged harvest methods (Thomas et al. 1990). Habitat loss also ranks as the most severe future threat to the spotted owl (USDI 1992a p. 41). The following description of threats has been condensed from the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992a p. 41-48) and from the Report of the Scientific Analysis Team (Thomas et al. 1993).

Limited Habitat

Limited habitat poses a threat to spotted owls because productivity levels and occupancy decrease in areas with low proportions of suitable nesting, roosting, and foraging habitat (Bart and Forsman 1992). Areas with less than 20 percent habitat cover do not provide spotted owls with suitable habitat. The Recovery Team considered limited habitat to be a severe threat in provinces that had about or less than 20 percent suitable habitat by area. The northern portion of western Washington Cascades province and the entire western Washington lowlands province fell into this category. A moderate threat exists in provinces with 20 to 60 percent suitable habitat coverage. The rest of the Washington provinces fell into this category.

Population Decline

Rates of population decline are measured by analyzing birth and death rates (see USDI 1992b p. 44 and Appendix C; Thomas et al. 1993) or by using population density studies that examine actual changes in territorial owls per unit area over time (USDA 1992b p. 15). Anderson and Burnham (1992) summarized the results from a demographic analysis from five sites distributed throughout the spotted owl's range. The results indicated that female territorial spotted owls were declining at rates of between 6 and 16 percent per year at individual study sites. The average was 10 percent per year (Anderson and Burnham 1992). A demographic meta-analysis of the complete data set showed that, in addition to populations decreasing at individual study sites, female survival rates were declining at an increasing rate (Anderson and Burnham 1992).

The federal Scientific Analysis Team (Thomas et al. 1993) reported that the Anderson and Burnham (1992) study may have overestimated rates of population decline by assuming that undetected emigrants were dead when they may actually have been alive. The Scientific Analysis Team used a population density method to estimate rates of population decline from 12 study sites. They concluded the overall rate of decline to be 3.2 percent (Thomas et al. 1993 p. 180). Density studies are thought to result in underestimates of rates of population decline. The Scientific Analysis Team (Thomas et al. 1993) concluded that the real annual rates of population decline were somewhere between the results reported in both studies (p. 192).

At the prompting of a group of 14 scientists concerned with the viability of the northern spotted owl, the Clinton Administration directed Anderson, Burnham, and White (Burnham et al. 1994) to conduct an intensive analysis of all existing demographic data, which included new data since Anderson and Burnham's 1992 report. More than 50 specialists undertook the analysis during a 12-day workshop in December 1993 at Fort Collins, Colorado. They analyzed capture-recapture data from 1985-1993 for 11 large study areas. They used estimates of average age-specific survival probabilities and fecundity rates to calculate rates of population change. They estimated the population to be declining at a rate of 4.5 percent per year and found that the rate of population loss is accelerating. They also found that annual survival probabilities for adult females have declined significantly in the six study areas for which they had more than six years of banding data as well as in the other five areas for which they had shorter term records. They concluded that the population of resident territorial female owls is declining at both a biologically and statistically significant rate. This analysis was corrected for undetected emigrants, thus lessening potential underestimations of survival rates.

The discussion of the meaning of the results of this analysis is under way in the scientific community. Bart (1995) argues that Burnham et al. (1994) still underestimate juvenile and adult survival rates by not considering that spotted owls could move to portions of study areas that are inaccessible to researchers and thus go undetected. Holthausen et al. (1994) incorporate unpublished updated data for juvenile emigration from Forsman et al. in their estimates of annual vital rates on the Olympic Peninsula, which results in an estimated annual juvenile survival rate of 0.612 and estimated annual rate of population change of 1.058. Without this readjustment, the estimated rate of annual population change is 0.955. Holthausen et al. (1994) cite Forsman's caution that this adjusted juvenile emigration rate is based on data from only 35 owls and from only two years of study. Estimation of vital rates thus remains inexact and uncertain.

The Recovery Team ranked population decline as a moderate threat in the western Washington Cascades (north and south) and on the Olympic Peninsula. They considered population decline to be a severe threat in the western Washington lowlands and an unknown threat in the eastern Cascades (USDI 1992b p. 42).

Small Populations

Small populations of plants and animals are vulnerable to extinction through random fluctuations in environmental conditions (environmental stochasticity) and in age and sex structure of populations (demographic stochasticity) (USDI 1992b). Small populations can also suffer loss of genetic diversity, which reduces general fitness of the population (USDI 1992b).

The Recovery Team (1992b) considered small populations to be a severe threat in the northern portion of the western Washington Cascades, the Olympic Peninsula, and the western Washington lowlands and a moderate threat in the southern portion of the western and eastern Washington Cascades.

Distributions of Habitats and Populations

Local spotted owl populations and habitat can be unevenly distributed across the landscape. Clusters of spotted owl pairs can become isolated when surrounded by unsuitable habitat. These local populations then are vulnerable to the same fluctuations described above for small populations. Where clusters of spotted owls or patches of suitable habitat are separated by more than 12 miles of poor habitat, persistence of the clusters becomes increasingly unlikely (USDI 1992b p. 45).

Sparse population and lack of habitat distribution is considered a severe threat in the eastern Washington Cascades, western Washington Cascades (northern portion), and western Washington lowlands provinces; they are a a moderate threat in the southern portion of the western Washington Cascades and on the Olympic Peninsula (USDI 1992b p. 42).

Province Isolation

If provinces are separated by physical barriers or lack of suitable habitat, genetic interchange between sub-populations may be blocked. Isolated populations are also vulnerable to genetic, environmental, and demographic fluctuations. Immigration of a few individual spotted owls per generation is necessary for a local population to maintain genetic diversity. A higher rate of immigration may be necessary to counteract demographic imbalance (USDA 1992b).

The Recovery Team identified province isolation as a severe threat in the western Washington Cascades (north), Olympic Peninsula, and the western Washington lowlands provinces, and as a moderate threat in the eastern Cascades and the western Washington Cascades (south) (USDI 1992b). Subsequent analysis by Holthausen et al. (1994) suggests that province isolation may not be as severe a threat to the spotted owl population on the Olympic Peninsula as was previously thought.

Predation

The great horned owl, northern goshawk, red-tailed hawk, and common raven are documented predators of the northern spotted owl. Great horned owls are the most common predator (Miller 1989). This species occurs more frequently in highly fragmented landscapes than does the spotted owl (Anthony and Cummins 1989; Hamer et al. 1989; Johnson 1993). Thus predation by great horned owls is more of a problem in fragmented landscapes than in areas with relatively intact forest cover. Barred owls are starting to share the same range with spotted owls and tend to be dominant in spotted owl/barred owl interactions (Hamer 1988). While barred owls are not a direct predator, they have displaced spotted owls in some areas and are decreasing the amount of habitat available to spotted owls (USDA 1988; Hamer et al. 1989).

The Recovery Team did not feel there was enough information to assess the severity of the predation threat in either the eastern or western Washington Cascades (north and south). They considered predation to be a severe threat in the western Washington lowlands and a moderate threat on the Olympic Peninsula.

Vulnerability to Natural Disturbances

In an unfragmented landscape with abundant suitable habitat, loss of habitat from natural disturbance is generally not a threat to population viability. Given the highly fragmented pattern and reduced amount of the remaining suitable habitat, loss of habitat from fire, windthrow, or insect and disease infestation can pose a significant threat to spotted owls in certain areas. The Recovery Team determined that natural disturbance is a severe threat in the eastern Washington Cascades, a moderate threat in the Olympic Peninsula, and a low threat in the western Washington Cascades (USDI 1992b).

Spotted Owls on the Olympic Peninsula

LIFE HISTORY

Aspects of spotted owl life history that have been well-studied on the Olympic Peninsula and are important to the HCP proposal include reproduction, dispersal of juveniles, and survivorship of both adults and juveniles.

Reproduction

Average annual fecundity rates (numbers of female fledglings produced per female) of adult owls from 11 geographically distinct areas varied from 0.231 to 0.565; the median value was 0.323 (Burnham et al. 1994). Annual fecundity in the Olympic Peninsula study area was 0.380, or 0.76 young per pair per year. There is considerable annual variation in reproductive effort within and among sub-populations of spotted owls, and among individual owl pairs within years. For example, Forsman et al. (1984) observed nesting in 16-89 percent (mean = 62 percent) of pairs during a five-year study in Oregon. Annual variation in fecundity in seven geographically distinct areas with at least five years of study ranged from 0.3-13.4 percent (coefficient of variation, median = 5.6 percent, see Thomas et al. 1993, Table 4-3). Annual variation in fecundity of the Olympic Peninsula sub-population was third highest, c.v. = 10.2 percent. Reproductive rates of spotted owls on the Olympic Peninsula thus seem to be consistent with those observed elsewhere in the species' range, but annual variability in reproduction is relatively high.

Dispersal of Juveniles

Spotted owls leave their natal territories after their first summer. This dispersal appears to be innate (Howard 1960), and may function to maintain the species' distribution in available habitat and maintain genetic diversity among sub-populations (Howard 1960; Greenwood and Harvey 1982). Early studies of dispersing juvenile spotted owls used backpack-mounted radio-transmitters (Forsman et al. 1984; Gutierrez et al. 1985; Miller 1989) or relied on re-observations of owls banded as fledglings (Forsman 1992a) to track their movements and survival. These studies provided information on the directions and distances of movement, habitat associations, and survival. However, there is evidence that the relatively large, backpack-mounted radio-tags influenced survival (Paton et al. 1991) and reproduction (Paton et al. 1991; Foster et al. 1992) of adult owls (with the inference that they may have influenced behavior and survival of juveniles as well), and that emigration of banded owls from study areas causes underestimates of survival (Forsman 1992a). A discussion of juvenile survival is presented in the subsequent section on survivorship.

Dispersing juvenile owls in three study areas from the 1991 (Miller et al. 1992) and 1992 cohorts (Forsman 1992b) were radio-tagged with much smaller transmitters mounted on their tail feathers (a new system with presumably less effect on their behavior). These studies are beginning to provide important, additional information on habitat relationships, dispersal distances, rates of emigration, and survival probabilities. Data from these studies consist of relocations, estimated by triangulation, that were obtained at approximately weekly intervals mostly during the day-time, with less frequent, direct observations. They are probably suitable for descriptions of the general areas traversed and used by dispersing juveniles and descriptions of roost-sites but not for evaluating habitat use for foraging. Analyses are in progress, but it appears that the general trend is for dispersing juveniles to attempt to settle, at least temporarily, in areas that provide good habitat for nesting, foraging, and roosting by adult owls. Further analyses of these data may provide better insights as to cover types that provide habitat for dispersing spotted owls.

Preliminary estimates of first-year dispersal distances (15.12±0.98 miles) of 111 juveniles from the Olympic Peninsula and the east slope of the Cascades Range are similar to those reported by earlier radio-telemetry studies (Gutierrez et al. 1985; Miller 1989). Dispersal distances for 31 juveniles on the Olympic Peninsula ranged from 5.39 to 36.20 miles, and averaged 15.05±1.58 miles. In the four known cases of dispersal to and/or from DNR land in the Olympic Experimental State Forest, owls banded as fledglings were recaptured 9, 14, 18, and 30 miles from their natal sites as adult or subadult members of pairs.

Survivorship

Survival rates are estimated based on annual re-observation of banded spotted owls. Simulation modeling suggests that the survival rate of adult females is the aspect of spotted owl life history that most strongly influences rates of population change (Noon and Biles 1990). Estimates of adult female survival probabilities average 0.844±0.005 across the spotted owl's range, and 0.862±0.017 for the Olympic Peninsula sub-population (Burnham et al. 1994). While their meta-analysis of survival rates across the range of the spotted owl indicated that survival rates were declining, they found that these rates did not change during the study on the Olympic Peninsula. Survival rates for males may be higher; Forsman (1992b) estimated annual survival probabilities for Olympic Peninsula males at 0.893±0.026 for the period 1987-1992.

Estimates of both range-wide and Olympic Peninsula survival probabilities for juvenile birds are much lower (0.258±0.036 and 0.245±0.064 respectively; Burnham et al. 1994). However, those estimates are based solely on re-observations of birds banded as fledglings and are negatively biased because some juveniles emigrate from the study area or to non-monitored sites within the study area and are thus unavailable for re-observation (Burnham et al. 1994; Holthausen et al. 1994; Bart 1995a).

Burnham et al. (1994) used the average emigration rate (0.316±0.053) of 76 juvenile spotted owls that were monitored with radio-telemetry and survived one year to adjust their overall estimate of juvenile survival (averaged over all 11 study areas) to 0.377±0.060. But their analysis did not account for emigration of juveniles to non-monitored sites within the study area (Bart 1995a). Bart (1995b, Table 5) simulated juvenile dispersal to estimate a 21 percent rate of dispersal to non-monitored sites across those study areas and further adjust the juvenile survival estimate of Burnham et al. (1994) to 0.48 (Bart 1995a). Furthermore, Burnham et al. (1994) argued that they did not have area-specific estimates of emigration rates and thus could not derive area-specific, adjusted juvenile survival rates. But the emigration rate they used was derived by averaging over two study areas in which the estimates differ markedly (13/57 = 0.228 Roseburg, Oregon; 11/19 = 0.579 Olympic Peninsula; Burnham et al. 1994). These areas are profoundly different in the degree to which spotted owls are able to disperse from them to areas inaccessible to normal re-observation techniques. Roseburg is entirely commercial forest lands, accessible by road throughout, and surrounded mostly by other study areas. In contrast, almost half of the spotted owl habitat on the Olympic Peninsula study area is in Olympic National Park, which is nearly roadless and extremely difficult to survey for owls. No other study areas border the Olympic Peninsula. Thus, while Holthausen et al. (1994) correctly note that the area-specific emigration and adjusted juvenile survival estimates should be viewed with caution because few data (they studied 35 owls over two years, one of which had an exceptionally mild winter that may have favored juvenile survival) were used to derive them, there are some data and sound logic with which to develop an estimate of emigration (both within and outside of the study area) specific to the Olympic Peninsula. Holthausen et al. (1994) used data additional to that reported by Burnham et al. (1994) to estimate the emigration rate for the Olympics at 0.600±0.083. This results in an adjusted juvenile survival rate of 0.612±0.204, over two times the unadjusted estimate of Burnham et al. (1994). While neither this estimate of juvenile survival in the Olympics, nor Bart's (1995a) metapopulation estimate are conclusive, they suggest that survival rates may be substantially higher than the metapopulation estimate reported by Burnham et al. (1994).

POPULATION ECOLOGY

Trends in the population of spotted owls are extremely important to management decisions relevant to conservation of spotted owl habitat. Thus, analyses and interpretations of ongoing studies of spotted owl populations are closely scrutinized and are subject to considerable controversy. The review and discussion under the subheading Population Decline of these analyses, interpretations, and disagreements provides a good, general overview. A more detailed summary and discussion of findings from the Olympic Peninsula follows.

Population Estimates

The most up-to-date and rigorous estimate of the number of spotted owl pairs on the Olympic Peninsula was provided by Holthausen et al. (1994). They used three sources of data for their estimate: extrapolations from the Washington Department of Fish and Wildlife non-game database for DNR-managed, private, and tribal lands, a nearly complete inventory of territorial owls; extrapolations from nearly complete inventories of territorial owls conducted by the U.S. Forest Service PNW Research Station since 1987 in the Olympic National Forest (Forsman 1992a); and estimates of density for the Olympic National Park based on extrapolating from the density of territories located in randomly selected sample areas (Seaman et al. 1992). The density estimates for the park are the results of preliminary analyses, and await another year of fieldwork and further statistical analysis to refine the point estimate and develop confidence intervals for the estimate. Holthausen et al. (1994) used two sets of assumptions to develop two estimates for the numbers of spotted owl pairs on the Olympic Peninsula: a lower estimate derived by adding the known pairs (and, at least for DNR-managed lands, sites at which pairs had been observed in the past) on DNR-managed and Olympic National Forest lands to the estimated numbers in the Olympic National Park; and a higher estimate derived by adding the known pairs and other sites where spotted owls had been located but pairs not documented on national forest and DNR-managed lands to the estimated numbers in the park. They estimated 282 or 321 pairs of spotted owls on the Olympic Peninsula. These numbers are substantially higher than previously estimated; for example, Thomas et al. (1990) estimated a population of 177 pairs: 40 in the Olympic National Park (Table C2), 131 in the Olympic National Forest (W-38 in Table Q6), and six on state and private lands (W-37, 38 in Table Q6).

Population Trends

Burnham et al. (1994) used the estimates of survival and productivity reviewed above to estimate the rate of change in the population of resident female owls on the Olympic Peninsula. Changes in the population of resident female owls ultimately equate to those of the entire population because the resident females produce the juveniles that maintain the population. They estimated the annual rate of population change (±) for the Olympic Peninsula, using unadjusted estimates of juvenile survival, as 0.9472±0.0255 or an annual loss of 3-8 percent of the resident females (significantly less than ± = 1, a stable population). Their adjusted estimate of juvenile survival results in an estimate of ± = 0.9894, or an annual loss of 1 percent of the resident females (significance needs to be calculated). Holthausen et al. (1994) estimated ± = 1.058±0.065, or an annual change ranging from a 1 percent loss to a 12 percent increase (not significantly different from ± = 1), using their Olympic Peninsula-specific adjustment of juvenile survival rates. They advise that this estimate be interpreted with caution for the reasons noted in the discussions of juvenile survival.

THREATS TO POPULATION PERSISTENCE

This section reviews and discusses recent thoughts on significant threats to the viability of spotted owls on the Olympic Peninsula. Two original discussions are reviewed and compared, that of the interdisciplinary Northern Spotted Owl Recovery Team appointed by the Secretary of the Interior in February 1991 (USDI 1992a) and that of the Reanalysis Team (Holthausen et al. 1994), a team of U.S. Forest Service and National Biological Survey scientists. This review is important because the HCP proposal for the Olympic Experimental State Forest attempts to address the threats identified and discussed in those original reports.

Threats to Owls on the Olympic Peninsula

The Recovery Team (USDI 1992a) identified low population levels, poor population distribution, habitat loss, population isolation, and natural disturbances as major threats to owls on the Olympic Peninsula. Their estimate of population size was 200±25 pairs. They characterized the current distribution of spotted owls as a "doughnut", with owls largely restricted to the mid-elevation forests on mainly federal lands. Over half of the area of the northwestern Olympic Peninsula, 712,000 acres (Table III.1), is in younger forest cover or other open conditions; the great majority of this cover-type is the result of harvests of older forests within the past 40 years. The Recovery Team expected habitat loss to continue at high rates under management regimes then in use. Isolation of the Olympic Peninsula population from other reproductive owls can place the population at risk of extinction or inbreeding if catastrophic or stochastic events caused it to decline severely. Catastrophic fire and/or wind were predicted under a worst-case scenario to reduce the habitat capability up to 30 percent over 100 years (USDI 1992a).

Holthausen et al. (1994) used simulation analyses and other techniques to evaluate the risks to owls on the Olympic Peninsula, and they presented different interpretations of those risks than did the Recovery Team (USDI

Table III.1: Estimates of forest cover types on lands of different ownerships in the Olympic Experimental State Forest area, July 1991

Land cover estimated by supervised classification of Landsat Thematic Mapper scenes taken July 1991 (WDFW 1994c). Land ownership estimated from DNR's digital public lands map (DNR GIS 1995).

Landowner	Cover type	Total area (acres)	Percent of area[1]	Percent of cover type[2]
Olympic National Park	late seral[3]	216,137	16.5	59.1
	mid-seral[4]	16,298	1.2	18.7
	other[5]	143,857	11.0	16.8
Olympic National Forest	late seral	66,325	5.0	18.1
	mid-seral	15,434	1.2	17.7
	other	93,294	7.1	10.9
DNR-managed lands	late seral	52,150	4.0	14.3
in the OESF	mid-seral	20,990	1.6	24.1
	other	197,974	15.1	23.1
Other[6]	late seral	30,983	2.4	8.4
	mid-seral	34,293	2.6	39.4
	other	421,558	32.1	49.2
Total		**1,309,293**	**100**	

[1] The area within the cover type within the ownership class, divided by the total area described.

[2] The area within the cover type within the ownership class, divided by the total area within the cover type.

[3] Late-seral forests include old growth and large sawtimber.

[4] Mid-seral forests include small sawtimber.

[5] Other land cover includes pole, sapling, open canopy/mixed conifer, open areas (clearcuts, high-elevation barrens, towns, etc), water, cloud/shadow cover.

[6] Other lands include all private ownerships, tribal lands, DNR-managed lands outside the OESF.

1992a). They estimated a population size of 282 or 321 pairs, substantially greater than the estimate of the Recovery Team. Their evaluations of risk to the population posed by the spatial and ecological distribution of habitat generally concurred with those of the Recovery Team. Their simulations showed that maintaining all current habitat on all nonfederal lands on the peninsula increased the predicted numbers of pairs occupying sites on both federal and nonfederal lands by about 20 percent over simulations based on no nonfederal habitat, and they concluded that it was unlikely that owls would occupy coastal lowland forests in the Olympic Experimental State Forest area without habitat on nonfederal land.

The current plans for management of the Olympic National Forest have established large reserves in which owl habitat will be maintained and/or restored (USDA and USDI 1994b). In light of these management plans for federal lands, Holthausen et al. (1994) concluded that "...it is likely, but not assured, that a stable population would be maintained on portions of the Olympic National Forest and the core area of the national park in the absence of any nonfederal contribution of habitat." They also analyzed the potential impacts of establishing a significant (370,500 acres of high-quality habitat) connecting corridor between the southern Cascades and the Olympic Peninsula. They concluded that habitat conditions on the Olympic Peninsula were the most important factor determining the stability of the sub-population; in other words, isolation of the sub-population is not as serious a threat as the Recovery Team (USDI 1992a) thought.

Holthausen et al. (1994) evaluated the effects of a worst-case fire by simulating a complete loss of habitat in portions of the eastern and northern Olympic Peninsula that are at high risk of large-scale fires (33 percent of federal land on the peninsula, Holthausen et al. 1994, Figure 5). Their analyses suggested that the total area managed for habitat on federal lands is large enough that an otherwise stable population of spotted owls would be robust to a disturbance of this scale. They discussed but did not analyze the effects of a large-scale windstorm on the western peninsula in combination with the simulated fire loss. They concluded that such a scenario would cause significantly greater impacts to the peninsula owl population, but that the combination was extremely unlikely.

DNR's Survey Data

DNR's spotted owl surveys identify the distribution and presence of northern spotted owls on the landscape and reduce the possibility of violating the Endangered Species Act. Surveys also provide information on the patterns of spotted owl use on both local and statewide scales.

HISTORY

From 1985 through 1987, DNR personnel participated with the Washington Department of Wildlife and Olympic National Park staffs in surveying selected portions of Olympic National Park and DNR's Hoh-Clearwater Block on the Olympic Peninsula. In 1988 and 1989, DNR again conducted surveys on the Hoh-Clearwater Block. The results of these surveys were compiled into a report titled 1988-1989 Hoh-Clearwater Spotted Owl Inventory Project (Anthony and Cummins 1989).

In 1990, inventory surveys were continued in the Hoh-Clearwater Block and were also conducted in the Columbia River Gorge area of southwest Washington.

In 1991, DNR developed an agency protocol for surveying for spotted owls based on draft survey guidelines from the U.S. Fish and Wildlife Service. In the same year, DNR began surveying areas surrounding planned management activities in all DNR regions within the range of the spotted owl.

In 1992, the U.S. Fish and Wildlife Service endorsed the Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls (hereafter referred to as the USFWS Protocol). From 1992 through 1995, DNR conducted surveys according to the USFWS Protocol.

METHODS

The USFWS Protocol includes the Northern Spotted Owl Survey Protocol, which DNR follows strictly with the following EXCEPTIONS:

(1) Prior to the 1994 survey season, DNR surveyed all suitable spotted owl habitat located within a 2.2-mile radius around management activities west of Interstate Highway 5, including the Olympic Peninsula and southwest Washington; elsewhere in the state, DNR surveyed all suitable habitat within a 1.8-mile radius. In 1994, the U.S. Fish and Wildlife Service increased the 2.2-mile radius to 2.7 miles; however, the 1.8-mile radius stayed the same. The 1.8-mile and 2.7-mile radii are based on radio telemetry data showing that spotted owls have larger territories in some parts of the state than in others. In addition, DNR surveys an extra 0.1 mile (1.9 and 2.8 respectively) to allow for management activities that move slightly during the planning stages.

(2) The USFWS Protocol for Spot Calling requires projecting taped calls through a megaphone from predetermined locations (or stations) for 10 minutes per station. DNR has extended this time to 12 minutes per station so as to detect spotted owls that may be slow to respond.

(3) Some surveys may contain spotted owl habitat that cannot be accessed because of difficult terrain or inability to cross private ownership. When these situations arise, DNR and the Washington Department of Fish and Wildlife review each restriction to determine if surveys in the rest of the area will still provide reliable information about spotted owls on the landscape. Because access issues are not addressed in the USFWS Protocol, these restrictions necessitate a protocol departure. In most situations, additional survey efforts compensate for inaccessible habitat by adding extra stations along the edges of the restricted lands, extending calling to 20 minutes instead of 12, and, depending on the amount and shape of the inaccessible habitat, conducting as many as three extra visits within a 0.5- or 1.0-mile wide buffer around the area. These activities can be considered "reasonably consistent" with the USFWS Protocol Standards.

DATA REVIEW

Prior to 1993, the Washington Department of Wildlife reviewed DNR spotted owl surveys on a case-by-case basis as requested by DNR. In 1993, when DNR's spotted owl survey program was expanded significantly, the Washington Department of Fish and Wildlife indicated that DNR should conduct its own data review. DNR established a data review section in its Forest Resources Division, which reviews and evaluates spotted owl surveys using the Washington Department of Fish and Wildlife's Guidelines for Reviewing Spotted Owl Surveys (WDFW 1994a) to determine if individual surveys are reasonably consistent with the USFWS Protocol.

RESULTS

DNR's survey effort has gradually increased, from 53,000 acres of habitat surveyed in 1988 and 1989 to 329,000 acres surveyed in 1993 and 1994.

The Washington Department of Fish and Wildlife tracks all spotted owl detections and uses this information to locate site centers. As of the end of the 1995 survey season, there was a total of 344 site centers on or affecting DNR-managed lands (using the owl circle radii as defined in the USFWS Protocol). (See Table III.2.) Most of these site centers were classified as status 1 (providing habitat for a pair). However, three site centers have been changed to historic status (formerly occupied) according to Washington Department of Fish and Wildlife criteria because surveys for three consecutive years have failed to detect spotted owls at these sites.

Table III.2: Northern spotted owl site centers on or affecting DNR-managed lands as of the end of the 1995 survey season

(Source: WDFW Non-game database October 1995 for site centers; DNR GIS April 1995 for land base)

Status 1 - Pair status	217
Status 2 - Two owls, status unknown	11
Status 3 - Resident single owl	50
Status 4 - Status unknown	63
Status 5 - Historic status (formerly occupied)	3
Total site centers	**344**

B. Marbled Murrelet

Species Ecology/Literature Review

INTRODUCTION
In October 1992, the U.S. Fish and Wildlife Service listed the marbled murrelet, a Pacific seabird, as threatened, due primarily to loss of nesting habitat and secondarily to loss of the bird in gill nets. The state of Washington has also listed the marbled murrelet as threatened.

TAXONOMY
The marbled murrelet belongs to the family Alcidae, which consists of 22 species divided into 12 genera worldwide (DeSanto and Nelson 1995). Other familiar members of this marine family of diving birds include murres, puffins, guillemots, auks, and auklets. There are two subspecies of marbled murrelet, the North American race, *Brachyramphus marmoratus marmoratus,* and the Asian race, *Brachyramphus marmoratus perdix*, commonly known as the long-billed murrelet. Recent evidence indicates that the long-billed murrelet may be a distinct species (Friesen et al. 1994). A related North American murrelet is the Kittlitz's murrelet (*Brachyramphus brevirostris),* whose habitat is strongly associated with glacial ice (Ralph et al. 1995a).

PHYSICAL CHARACTERISTICS
The marbled murrelet is a medium-size seabird (approximately 9.5 inches in length) with a heavy compact body, short tail and neck, and short stubby wings. Males and females have identical plumage, though their plumages vary seasonally (Marshal 1989). Adult marbled murrelets have an alternate plumage in summer and a basic plumage in winter (Carter and Stein 1995). The alternate plumage coincides with the breeding season when the birds are blackish-brown on the upper part of their body with rust coloring at the tips of the back feathers. The sides of their heads, the sides and front of their necks, and their underparts have white feathers with broad dark-brown margins (Kozlova 1957). This pattern gives the murrelet its "marbled" look, which most likely protects breeding birds from detection by predators in forested environments (Binford et al. 1975; Nelson and Hamer 1995a). Adults in the winter have a brownish-gray upper body, a white lower body, and a white band below the neck. Fall juveniles have a brownish mottling on their chest, breast, and sides and are otherwise similar to winter adults. By winter, juveniles are indistinguishable from adults (Marshal 1989; Carter and Stein 1995).

Distinguishing characteristics of murrelets on the water include an upward pointing tail and bill (Marshal 1989; Nelson 1992). The murrelet's body shape facilitates underwater swimming, but its short wings require that it fly faster than 50 miles per hour to avoid stalling.

GEOGRAPHIC DISTRIBUTION
Marbled murrelets occur in North America along 6,500 miles of coastline between the Bering Sea, Alaska, and central California. The geographic center of their distribution is in the northern portion of southeast Alaska, near the Alexander Archipelago (Ralph et al. 1995a; see Map III.2). Populations are fairly large and continuous between the coastline just west of Kodiak Island and the southern edge of British Columbia, with the largest concentrations occurring between the southern part of southeast

Alaska and Prince William Sound (Ralph et al. 1995a). Distribution becomes more disjunct at the southern end of the marbled murrelet's range. In Washington, Oregon, and California, there are distinct gaps between breeding populations. These gaps are thought to be a result of logging activity that has removed nesting habitat, i.e., old-growth and late successional forest (Carter and Erickson 1992; Leschner and Cummins 1992; Nelson et al. 1992; Ralph et al. 1995a). See section below on population status and demography for numbers of murrelets in each portion of their range.

Distribution of the murrelet population at sea during breeding seasons appears to be determined by the distribution and accessibility of adjacent old-growth and late successional forest (Ralph et al. 1995a). The correlation between old-growth and offshore murrelet populations has been circumstantially established between California and southwest Washington. During the breeding season, the largest concentrations of marbled murrelets have been observed at sea adjacent to areas where nesting habitat was available (Sowls et al. 1980; Nelson et al. 1992). The fact that marine productivity is high along this entire coast during the breeding season suggests that foraging habitat is not a limiting factor (Ralph et al. 1995a). The relation between occurrence of murrelets at sea and onshore late successional and old-growth habitat has been more difficult to observe in northern Washington, British Columbia, and Alaska because the coastline is more complex, more old growth remains, and extensive survey efforts have not been made (Ralph et al. 1995a).

Marbled murrelets nest along the coast and in late successional and old-growth forests. The maximum distance inland murrelets have been found is approximately 66 miles in Oregon. In Washington, the detection farthest inland has been at 52.25 miles (Hamer 1995). Most detections of murrelets have been within 40 miles of marine waters (Hamer 1995; Miller and Ralph 1995). However, their inland nesting distribution is not fully known because survey effort is inconsistent in areas greater than 40 miles from saltwater (Hamer 1995; Miller and Ralph 1995; Ralph et al. 1995a).

BEHAVIOR

The following section briefly reviews recently published literature on marbled murrelet behavior and nesting ecology. For a more detailed treatment of foraging behavior and food habits, see Strachen et al. (1995), Burkett (1995), and Hunt (1995). For a more detailed treatment of nesting ecology and behavior, see Nelson and Hamer (1995a).

Foraging

The marbled murrelet feeds in near-shore ocean waters and in inland saltwater bays, sounds, and inland passageways. It also occurs occasionally on large freshwater lakes, though its foraging habits there have not been documented (Marshal 1989). Murrelets feed on marine invertebrates and small fish traveling in schools. Euphasids and mysids (invertebrates) are dominant prey items in the winter and spring, and small fish such as sand lance, herring, anchovy, and sea perch are more important during the breeding season (Burkett 1995). Interannual changes in the marine environment can result in major changes in prey consumption (Burkett 1995).

Marbled murrelets dive to catch prey (Ashmole 1971). They are most often observed to forage singly or in pairs in a band between approximately 328 and 2,200 yards offshore (Strachen et al. 1995). Murrelets have been observed farther than 2,200 yards offshore, but in much lower numbers (Sealy 1975; Ainely et al. 1995; Piatt and Naslund 1995; Ralph and Miller

1995). Strachen et al. (1995) suggest that murrelets dive simultaneously when foraging in pairs for efficiency. Larger foraging flocks occur in the northern part of the murrelet's range than in the southern portion (Carter 1984; Carter and Sealy 1990). Murrelets forage at all times of day but most actively during the morning and late afternoon. They forage at night as well, possibly when there is enough ambient light to allow them to locate prey (Strachen et al. 1995) and to take advantage of fish that feed near the surface at night (Carter and Sealy 1987, 1990). Nelson and Hamer (1995a) hypothesize that adults may forage at night in order to make dawn feeding flights to nestlings.

Marbled murrelets forage in pairs or small single-species flocks in exposed ocean waters but in mixed-species flocks in protected waters. Glaucous-winged gulls (*Larus glaucescens)*, Bonaparte's gulls (*Larus philadelphia)*, pigeon guillemots (C*epus columba)*, common mergansers (*Mergus merganser)*, and pelagic cormorants (*Phalacrocorax pelagicus)* join foraging murrelets after murrelets drive jumping schools of sand lance and herring to the surface (Mahon 1992; Hunt 1995). Mixed-species foraging generally occurs in the northern part of the murrelet's range (Stachen et al. 1995). The reason for mixed-species versus monospecific foraging is unknown (Hunt 1995).

Nesting

Murrelets are the only member of the Alcidae family that nests in trees (Nelson 1992; Nelson and Hamer 1995a). Murrelets do not build nests but use large limbs covered with a thick layer of moss or duff, or use mistletoe brooms or other deformities that create a sufficiently wide and flat space. They nest almost exclusively in inland mature and old-growth coniferous forests. In Alaska, beyond the extent of coastal coniferous forests, they nest on the ground where trees are absent. There is also some ground nesting at or near the tree line (Piatt and Ford 1993).

Courtship occurs at sea. It is believed that pairs visit the nest stand to copulate, form and maintain pair bonds, and select nest sites before laying an egg (Nelson and Hamer 1995a).

The marbled murrelet nesting season varies in length and by starting and ending dates in different parts of its range. Hamer and Nelson (1995a) constructed nesting chronologies based on 86 breeding records from California (n = 25), Oregon (n =1 3), Washington (n = 13), British Columbia (n = 23), and Alaska (n = 12). In Washington, the breeding period is estimated to be 124 days long, with incubation occurring between April 26 and July 30 and nestling (the period after the chick has hatched and before it leaves the nest) occurring between May 26 and August 27. They estimated a 118-day breeding period in British Columbia in which incubation started on May 2 and ended July 4. The nestling period began June 1 and ended by August 30. The breeding season in Alaska was estimated to be only 106 days long. Incubation occurred between May 14 and July 30 and nestling occurred between June 13 and August 27. Hamer and Nelson found the nesting season decreased as they went north in the murrelet's range.

Murrelets have been observed to lay one egg per nesting attempt. Incubation lasts 27-28 days (Sealy 1974, 1975; Simons 1980; Hirsch et al. 1981; Carter 1984). Both the female and the male share incubation responsibilities, with one brooding the egg while the other forages. Incubation shifts can last up to 24 hours. Murrelets will leave the egg unattended for three to four hours (Nelson and Hamer 1995a p. 59). This may be a strategy to maximize forage time and accumulate energy reserves, as similar behavior for these purposes has been observed in other seabirds (Nelson and Hamer 1995a).

Murrelet pairs exchange incubation shifts from 82 minutes before to one minute after dawn in Alaska, Oregon, and California (n = 12 nests), but later on rainy or overcast days (Nelson and Hamer 1995a). No incubation exchanges have been observed in Washington or British Columbia.

Murrelet chicks are born with downy feathers. Juvenile plumage begins to develop under the down before they are 26 days old. The chick removes any remaining down 12-48 hours prior to leaving the nest. Chicks fledge at 30-40 days. Their first flight is believed to be directly to the ocean (Sealy 1975; Quinlan and Hughes 1990; Hamer and Cummins 1991).

Murrelet chicks appear to be inactive for most of the time they are on the nest until two days prior to fledging. Researchers have observed chicks (n = 8 nests) sleeping or remaining motionless 80-94 percent of the time while on the nest (Hamer and Cummins 1991; Naslund 1993; Nelson and Hamer 1995a). Chick activity increases markedly on the two evenings prior to fledging (Hamer and Cummins 1991; Singer et al. in press), when they pace continually and rapidly on the nest platform, flap their wings frequently and vigorously, peer over the edge of the nest platform, move their heads rapidly, and preen constantly (Nelson and Hamer 1995a).

Flight Behavior

Murrelets have distinctive flight behaviors near nest trees and in nest stands. These subcanopy behaviors are associated with nesting and include single or paired birds flying into, through, and out of the canopy and landing in trees (Nelson and Hamer 1995a). Nelson and Hamer (1995a p. 64) report that "landings and departures from trees have been observed at nests, on other branches in nest trees, in trees adjacent to nest trees, and other trees in the nest stand throughout breeding season." Observation of murrelets landing in trees where a nest has not yet been located is a good indication that nesting activity is occurring somewhere in the stand (Ralph et al. 1994). Murrelet researchers have also seen single birds or flocks of murrelets circling above the forest canopy of nesting stands (Gaston 1992; Nelson and Hamer 1995a) and consider this behavior to indicate that the stand is occupied by murrelets (Ralph et al. 1993, 1994). Occupied behaviors suggest, but do not definitively confirm breeding (Paton 1995).

Murrelets follow linear openings such as creeks, roads, or other natural or human-made corridors to directly approach and depart from nest stands (Eisenhawer and Reimchen 1990; Singer et al. 1991, in press; Nelson and Peck in press). Murrelets use similar flight paths to approach and depart from nest trees (Nelson and Hamer 1995a). There appears to be a positive correlation between the direction of approach and departure from nest trees and openings in the canopy around the nest tree, as well as in gaps in horizontal cover around the nest limb (Nelson and Hamer 1995a p. 64).

NESTING SUCCESS AND PREDATION

Seabird nesting success is influenced by a variety of factors such as food availability, habitat quality, physiological condition of breeding females, predation, and climatic conditions (Nettleship and Birkhead 1985; Croxall 1987; Vermeer et al. 1993). However, the relatively low number of known marbled murrelet nests limits current knowledge of the manner in which different factors influence nesting success, and thorough studies have not been conducted (Nelson and Hamer 1995b). Nelson and Hamer (1995b) compiled and analyzed existing information on nest success from records of 65 marbled murrelet nest trees found in North America between 1974 and 1993. Adequate information to determine nest success was available for 32 of the 65 nest tree sites. Of these 32 sites, 72 percent failed (23 of 32). Predation was the cause of egg or chick mortality at 43 percent of the 23 nesting attempts that failed. Predation was the cause of failure for 57 percent, or eight of 14 nests, that failed in Washington, Oregon, and California. These rates of predation are higher than those observed for other alcid species, with the possible exception of those in areas with high numbers of predators or introduced predators (Nelson and Hamer 1995b p. 93). Nelson and Hamer (1995b) also reported that the source of mortality was unknown for 22 percent of the 23 nest sites that failed. Abandonment, the chick falling out of the nest, and the chick dying from other than predation accounted collectively for 34 percent of the 23 nests that failed (Nelson and Hamer 1995b p. 92).

The authors recognized that the high rates of predation reported in their study may have resulted from a biased sample because most of the records came from nests that were in fragmented areas and near forest edges (Nelson and Hamer 1995b p. 94). Nests that were successful were located significantly farther from forest edges than those that failed (Nelson and Hamer 1995b, p. 96). Nests located by researchers may also be more easily located by predators, although information is insufficient to evaluate that source of bias (Nelson and Hamer 1995b p. 94). Other factors believed to affect predation rates are stand size, canopy closure, percent cover over the nest cup, and distance of the nest from the tree trunk (Nelson and Hamer 1995b).

Observed predators of marbled murrelet chicks and eggs are common ravens (*Corvus corax)* and Stellar's jays (*Cyanocitta stelleri)* (Singer et al. 1991; Naslund et al. in press). Other suspected or potential predators are great horned owls (*Bubo virginianus*), other species of forest owls, accipiters such as the northern goshawk, American crows (*Corvus brachyrynchos)*, raccoons (*Procyon lotor),* martens (*Martes americana)*, fishers (*Martes pennati)*, and several species of rodents (Nelson and Hamer 1995b p. 93).

Both the relation between nest predation and distance to an edge and the high rate of nest failure due to predation raise concern for the effects of forest fragmentation on increased predator access to murrelet nest trees and consequently, concern for the effects of forest practices on increased predation of murrelets. Because marbled murrelets produce only one egg per clutch, high rates of nest predation can have a significant negative effect on the murrelet population. This concern is discussed more thoroughly in the section on status and threats.

NESTING HABITAT

Several detailed studies of marbled murrelet nesting habitat have been conducted since 1990. These studies have examined nest stand characteristics (Nelson and Hamer 1992; Hamer and Nelson 1995b), nest tree characteristics (Hamer and Nelson 1995b), inland habitat associations, i.e., landscape, stand, and tree characteristics statistically associated with marbled murrelet occupancy and documented nesting (Hamer and Cummins 1990; Hamer et al. 1994b; Burger 1995a; Grenier and Nelson 1995; Hamer 1995; Kuletz et al. 1995; Miller and Ralph 1995), and larger scale forest landscape patterns associated with murrelet occupancy (Raphael et al. 1995). The results of these studies establish a strong association of marbled murrelet occupancy and known nest sites with old-growth forests or uneven-aged forests with old-growth characteristics. This section summarizes the results of these studies with a focus on data from Washington. Studies are under way to establish habitat associations in younger forest stands. (See the later section in this chapter on DNR's Survey Studies for more discussion of these studies.)

Nest Stand Characteristics

Hamer and Nelson (1995b) compiled published and unpublished information from 61 nest stands and nest trees in North America exclusive of ground nests in Alaska. They defined a nest stand as a contiguous group of trees (including the nest tree) with gaps no larger than 330 feet. They calculated mean, range, and standard deviation for each nest stand characteristic by state or province and also pooled sample statistics for California, Oregon, Washington, and British Columbia. They treated Alaska separately because stand and tree conditions there are different from those further south in the murrelet's range. Results are shown in Table III.3.

Table III.3: Characteristics of nest stands used by the marbled murrelet

The mean, standard deviation, and range, for characteristics of forest stands in North America containing marbled murrelet nest trees (n = 61). Sample sizes for each variable are shown in parentheses. The Pacific Northwest data include nests located in California, Oregon, Washington, and British Columbia. For some characteristics, either no data were available for that state or province, or the sample size was too small to calculate the mean and range.

(Source: Hamer and Nelson 1995b)

Characteristics	California n = 10	Oregon n = 20	Washington n = 6	British Columbia n = 9	Pacific Northwest n = 45	Alaska n = 14
Aspect (degrees)	210±122	147±63	180±121	——	166±92	267±66
	45-352	48-253	39-331	——	35-39	270-360
	(7)	(19)	(5)		(33)	(14)
Elevation (feet)	938±410	1243±499	1142±577	1053±1017	1089±676	315±164
	148-151	200-2119	49-2001	46-3599	46-3599	98-853
	(10)	(10)	(6)	(9)	(35)	(14)
Slope (percent)	18±14	41±27	21±13	3±4	23±23	69±16
	0-41	10-87	0-39	0-11	0-87	47-100
	(7)	(10)	(6)	(7)	(30)	(10)
Slope position[1]	1±0	2.1±0.9	1.3±0.5	1.3±0.7	1.5±0.8	——
	1-1	1-3	1-2	1-3	1-3	——
	(7)	(10)	(6)	(7)	(30)	
Stand size (acres)	871±1070	198±121	877±993	——	510±869	77±64
	248-2725	7-369	12-2452	——	7-2724	10-156
	(4)	(9)	(5)		(16)	(10)

[1] Slope position codes: 1 = lower 1/3, 2 = middle 1/3, and 3 = upper 1/3.

Table III.3: Characteristics of nest stands used by the marbled murrelet *(continued)*

Characteristics	California n = 10	Oregon n = 20	Washington n = 6	British Columbia n = 9	Pacific Northwest n = 45	Alaska n = 14
Stand composition[2] (percent in low-elevation trees)	100±0 100-100 (10)	100±0 100-100 (10)	90±9 78-100 (5)	64±29 20-100 (6)	91±19 20-100 (31)	64±14 39-91 (8)
Total tree density (number/acre)	95±72 37-203 (5)	48±29 19-114 (10)	55±30 34-65 (5)	120±55 60-214 (5)	73±53 19-214 (25)	232±92 119-395 (8)
Canopy height (feet)	289±0 289-2899 (5)	194±26 157-246 (9)	177±16 144-194 (5)	—— ——	210±53 125-289 (20)	75±13 52-98 (14)
Canopy layers (number)	—— ——	2.2±0.4 2-3 (10)	3.4±0.5 3-4 (4)	—— ——	2.5±0.7 2-4 (20)	—— ——
Canopy closure (percent)	39±6 25-48 (7)	43±27 12-99 (8)	69±18 36-88 (5)	—— ——	49±23 12-99 (21)	62±15 40-85 (12)
Distance to coast (miles)	8±5 3-17 (10)	16±6 1-25 (10)	10±18 3-21 (6)	7±2 2-11 (9)	10±7 1-5 (35)	0.3±0.2 0.06-0.7 (14)
Distance to stream (feet)	354±220 998-705 (7)	919±1024 26-328 (10)	230±226 46-656 (5)	328±541 16-1640 (7)	522±735 16-3281 (29)	358±354 7-1066 (9)
Distance to nearest opening (feet)	—— ——	219±230 49-984 (20)	213±108 59-394 (5)	—— ——	302±430 49-2298 (30)	—— ——
Stand age (years)	—— ——	209±48 180-350 (10)	879±606 450-1736 (3)	—— ——	522±570 180-1824 (16)	—— ——

[2] Measure of the percent of western hemlock, Douglas fir, western redcedar, Sitka spruce, and coast redwood in a stand.

Hamer and Nelson (1995b) described both landscape and forest stand characteristics associated with nest trees and stands. Landscape variables included distance to marine waters, elevation, slope, and aspect. The 45 nest stands in the Pacific Northwest were located a mean distance of 10.4 miles from marine waters. The maximum distance was 24.8 miles on the south fork of the Coos River in Oregon (Nelson et al. 1992). In Washington, the mean distance from marine water for six nests was 9.9 miles, and the nest stand farthest inland was 21.2 miles.

The mean elevation of the 35 nest stands (measured from nest tree) in the Pacific Northwest was 1,089 feet. The highest elevation was 3,599 feet in British Columbia. In Washington, the mean nest tree elevation was 1,142 feet and the highest was 2,001 feet. Nests in the Pacific Northwest occurred on slopes averaging 23 percent grade. In Washington, the mean slope was 21 percent, with a range from 0 percent to 39 percent. Eighty percent of nests in the Pacific Northwest were located on the lower two-thirds of slopes. Aspects of the nest varied. (See Table III.3.)

Forest stand characteristics described by Hamer and Nelson (1995b) included age, tree and snag size in stand, tree species composition, canopy height, number of canopy layers and percent canopy cover, stand size, and distance to openings. Ages of stands were determined by using either an increment borer, or stand information data bases from landowners, or by counting rings on nearby stumps. For the Pacific Northwest, mean age of 16 nest stands was 522 years, ranging from 180 years (Oregon) to 1,824 years (mainland coast of British Columbia). In Washington, the mean nest stand age for six nests was 879 years, and the range was 450 years to 1,736 years old. All 61 nest sites reported to date have been in mature or old-growth forests (Hamer and Nelson 1995b p. 72).

Data for tree size (diameter at breast height) in nest stands were available only for Washington and Oregon (Hamer and Nelson 1995b p. 72), where mean tree size was 19 inches dbh (Nelson and Hamer 1992). Tree density in nest stands in the Pacific Northwest was 73 per acre. For five nests in Washington, tree density in nest stands averaged 55 per acre and ranged from 34 to 65 trees per acre.

Nest stands in the Pacific Northwest were largely composed of tree species that occur at low elevations, including Douglas fir, western redcedar, Sitka spruce, western hemlock, and coast redwood (California). Nest stands in Washington had a mean composition of 90 percent low-elevation species.

Forest canopies in nest stands in the Pacific Northwest (no data reported for British Columbia) were characterized by multiple layers — between two and four (n = 20), heights averaging 210 feet (n = 20), and an average canopy closure (n = 21) of 49 percent. In Washington nest stands, there were three to four canopy layers, a mean canopy height of 177 feet, and a mean canopy closure of 69 percent.

Nest stands in the Pacific Northwest (n = 16) averaged 510 acres. The smallest nest stand was 7 acres (Oregon) and the largest was 2,725 acres (California). In Washington, mean nest stand size was 877 acres. The smallest nest stand size was 12 acres and the largest was 2,452 acres.

Nest Tree Attributes

Hamer and Nelson (1995b) described several attributes of nest trees. (See Table III.4.) Nest tree species in the Pacific Northwest (n = 47) were Douglas fir (57 percent), Sitka spruce (15 percent), western hemlock (13 percent), coast redwood (11 percent) and western redcedar (2 percent). One nest was located in an Alaska yellow cedar tree in British Columbia (2 percent). Of six Washington nests, three nests (50 percent) were located in Douglas fir trees, two (33 percent) in western hemlocks, and one nest (17 percent) was located in a western redcedar. Nest trees in the Pacific Northwest had a mean diameter of 83 inches dbh. The smallest nest tree was 34.7 inches dbh, and the largest (in California) was 210 inches dbh (17.5 feet). In Washington, the mean diameter for nest trees was 59.9 inches dbh, with the smallest nest tree measuring 34.7 inches dbh and the largest measuring 86.7 inches dbh.

Data on branch width indicate that murrelets prefer large platforms for nesting. In the Pacific Northwest, mean tree branch diameter measured at the nest was 12.6 inches. The largest branch diameter at the nest was 31.9 inches and the smallest was 3.9 inches. In Washington (n = 4), mean branch diameter was 11.4 inches. The range was 4.3 to 18 inches.

Nest branch height in the Pacific Northwest averaged 147.6 feet above the ground, with a range of 59 feet to 239.5 feet above the ground. The mean nest branch height in Washington was 121.4 feet and the range was 75.4 feet to 173.9 feet.

Murrelets used moss and litter (small twigs, conifer needles, bark pieces) as substrate in their nest platforms. Moss comprised the majority of substrate in 67 percent of nests and litter formed the substrate in 33 percent of nests in the Pacific Northwest. When moss was the substrate, mean depth of moss in or directly adjacent to the nest cup was 1.8 inches. For litter substrate, mean depth was 2 inches.

Nest platforms were formed by large primary branches (32 percent), the fork of two primary branches (23 percent), the juncture between a branch and the bole of the tree (18 percent), dwarf mistletoe brooms (9 percent), large secondary limbs (7 percent), limb damage (2 percent), and an old stick nest (2 percent). Many of the limb nests had natural depressions in which murrelets created a nest cup (Nelson and Hamer 1995b p. 79).

Nests tended to have high canopy closure over them. Mean percent cover over nests in the Pacific Northwest was 85 percent. In Washington, the mean was 90 percent. Most nest trees were within 300 feet of a stream. Many nests were also within 300 feet of clear cuts or roads, but there may be bias in this observation due to ease of access to nest trees by observers (Hamer and Nelson 1995b p. 80).

From the data on 47 marbled murrelet nests and nest stands described to date outside of Alaska, some generalizations can be made about murrelet nesting habitat. Marbled murrelets nest in mature and old-growth trees and stands. No nests have been reported in stands younger than 180 years old, with most nest stands being significantly older. All 61 nest trees located to date have been in mature or old-growth stands. All murrelet nests have been found in low-elevation stands. Nelson and Hamer (1995b p. 80) speculate that low-elevation conifers — Douglas fir, western hemlock, western redcedar, Sitka spruce, and coast redwood — probably have a higher abundance of potential nest platforms than higher elevation stands that are dominated by Pacific silver fir and mountain hemlock.

Table III.4: Characteristics of nest trees used by the marbled murrelet

The mean, standard deviation, and range for platform and tree characteristics of marbled murrelet nest trees (n = 61) located in North America. Sample sizes for each variable are shown in parentheses. The Pacific Northwest data include nests located in California, Oregon, Washington, and British Columbia. For some characteristics, either no data were available for that state or province or the sample size was too small to calculate the mean and range. Calculations were rounded to the nearest inch for measurements except nest substrate depth.

(Source: Hamer and Nelson 1995b)

Characteristics	California n = 10	Oregon n = 22	Washington n = 6	British Columbia n = 9	Pacific Northwest n = 47	Alaska n = 14[1]
Tree species:						
Sitka spruce		1		6	7	5[1]
Douglas fir	4	20	3		27	
western hemlock	1	1	2	2	6	
western redcedar			1		1	
Alaska yellow cedar				1	1	
coast redwood	5				5	
mountain hemlock						7[1]
Tree diameter (inches)	110±54 55-210 (10)	76±19 50-109 (22)	60±18 35-87 (5)	84±30 35-146 (9)	83±36 35-210 (46)	25±7 12-41 (14)
Tree height (feet)	240±26 200-282 (10)	220±36 118-282 (22)	187±23 148-213 (5)	190±49 98-262 (9)	217±43 98-282 (46)	75±13 52-98 (14)
Tree diameter at nest height (inches)	42±19 28-78 (5)	32±9 14-48 (15)	28±8 16-38 (5)	43±24 20-82 (5)	35±15 14-82 (30)	—— ——

[1]This is the data from Hamer and Nelson (1995b). The discrepancy between the 12 trees listed and total of 14 was not explained.

Table III.4: Characteristics of nest trees used by the marbled murrelet *(continued)*

Characteristics	California n = 10	Oregon n = 22	Washington n = 6	British Columbia n = 9	Pacific Northwest n = 47	Alaska n = 14
Branch height (feet)	154±36 108-223 (10)	167±39 59-240 (21)	121±36 75-174 (5)	108±26 59-144 (9)	148±43 59-240 (45)	43±7 33-56 (14)
Branch diameter at trunk (inches)	14±5 8-24 (8)	12±4 6-22 (19)	14±5 6-19 (5)	13±4 7-17 (9)	13±4 4-24 (41)	6±2 4-11 (12)
Branch diameter at nest (inches)	13±5 6-24 (10)	13±7 4-32 (20)	11±5 4-18 (4)	11±4 6-15 (7)	13±6 4-32 (41)	7±2 5-11 (11)
Branch crown position (percent)	64±13 50-91 (10)	74±12 50-92 (21)	63±15 41-81 (5)	58±11 40-74 (9)	68±14 40-92 (45)	59±12 44-79 (14)
Branch orientation (degrees)	203±103 45-360 (10)	173±87 20-360 (20)	233±109 110-342 (4)	187±90 18-341 (9)	189±96 18-360 (43)	—— ——
Distance trunk to nest (inches)	19±24 0-72 (10)	48±63 0.4-300 (21)	10±10 0-22 (4)	53±48 0-134 (9)	35±52 0-300 (44)	24±26 0-88 (13)
Nest platform length (inches)	9±4 3-16 (10)	16±7 5-28 (21)	11±6 4-22 (5)	8±5 5-20 (6)	13±7 3-28 (42)	—— ——
Nest platform width (inches)	6±3 2-9 (10)	11±5 3-20 (21)	9±4 4-15 (5)	5±1 4-7 (6)	9±5 3-20 (42)	—— ——
Nest platform moss depth (inches)	1±1 0.3-3 (5)	2±1 0.2-5 (17)	1±0.3 0.8-1.3 (2)	2±0.5 1-3 (9)	2±1 0.2-5 (33)	2±5 0.8-2 (12)
Nest platform duff and litter depth (inches)	3±3 1-8 (4)	1±0.2 1-1 (2)	1±.3 0.8-1 (3)	—— ——	2±2 0.8-8 (9)	—— ——
Cover above nest (percent)	90±28 5-100 (10)	79±14 40-100 (18)	90±10 70-100 (5)	100±0 100-100 (2)	85±20 5-100 (35)	89±0.5 81-95 (8)

Most nest stands were within 19 miles of marine waters and all of them were within 25 miles. These near distances most likely do not represent the inland distribution of nesting activity for two reasons. First, occupied behavior, which is indicative of nesting, has been observed in many stands located farther than 25 miles from the coast. In Washington, 36 percent of occupied stands are more than 29 miles from marine water, with the farthest occupied stand located 52.2 miles inland. In Oregon, one instance of occupied behavior was observed more than 66 miles inland, though most detections of murrelets have been within 25 miles of the coast (Hamer and Nelson 1995b). Second, survey effort has not been high in areas further than 40 miles from marine waters (Hamer 1995). There are no data on which to assess how much of the population nests farther from, as opposed to closer to, marine waters (Hamer and Nelson 1995b p. 80).

Murrelets appear to nest in stands that have somewhat open canopies. This probably is related to ease of access to the nest tree, which would be important for a bird that approaches the nest at high speeds. The nest itself is well covered, which is probably a predator-avoidance strategy, given the murrelet's apparently high rates of predation (see previous text and Hamer and Nelson 1995b; Nelson and Hamer 1995b). Nests also tended to be close to streams or other openings that facilitate access to the nest tree. Murrelets have been observed using stream and road corridors to travel through forest stands (Nelson and Hamer 1995b).

Nests themselves were located on large branches, in deformities in branch structure or in mistletoe brooms. This suggests that the presence of structure in the stand and the processes that create those structures are important features of murrelet nest habitat (Hamer and Nelson 1995b; Grenier and Nelson 1995). Large, old trees without the structural attributes of nest platforms would probably not constitute nesting habitat. A study by Nelson et al. (in press) in which 15 nest trees were compared to randomly located trees within the same nest stand showed that nest trees had significantly more platforms than the other trees. In addition, murrelets selected trees that had four or more platforms and avoided trees that had three or fewer platforms. Naslund et al. (in press) also showed that nest trees in Alaska had more platforms than random trees surrounding the nest trees. Nest trees also had higher percentages of epiphyte cover, which likely contributes hiding cover for nests.

The data suggest strong associations between murrelet nesting habitat and old, structurally complex, low-elevation forests. Further evidence in Burger (1995a), Grenier and Nelson (1995), and Miller and Ralph (1995) corroborate these observations. In addition, occupancy of stands and abundance of murrelets appear to be correlated with the amount of old-growth habitat available (Hamer and Cummins 1990; Hamer 1995; Miller and Ralph 1995; Raphael et al. 1995; Kuletz et al. in press). Generalizations of nest stand, nest tree, and nest attributes should be viewed cautiously in light of the small sample size from which they were drawn. Furthermore, nest tree and nest stand characteristics describe what birds are using, but do not indicate habitat quality. Habitat quality will need to be assessed by correlating habitat attributes with reproductive success (Hamer 1995; Nelson and Hamer 1995b; Ralph et al. 1995a). In addition, more extensive surveys of non-old-growth habitat will help determine if, and the extent to which, murrelets use younger and smaller trees.

Inland Habitat Associations in Washington

As of 1993, murrelet occupancy had been verified in 1,107 stands in California, Oregon, and Washington (Washington Forest Practices Board 1995). In Washington, occupied behavior has been verified in 229 stands (WFPB 1995). Occupied behavior is indicative of nesting activity in a stand (Ralph et al. 1994; Paton 1995). Thus, the number of documented occupied stands provides a larger sample from which to draw conclusions about murrelet nesting habitat than is available from the six known nest tree stands in Washington. Hamer (1995) used logistic regression analysis to compare characteristics of 62 occupied stands with characteristics of 87 unoccupied stands. Starting with 38 forest stand variables, he found that the probability of occupancy of an old-growth stand increased with an increase in the total number of potential nest platforms, percent moss coverage on limbs of trees greater than 32 inches diameter at breast height, percent slope, stem density of dominant trees (dominant trees are greater than or equal to 32 inches dbh), and the mean dbh of western hemlock. At the same time, he found that the probability of occupancy of a stand decreased with an increase in the percent coverage of lichens on the branches of dominant trees, stand elevation, and canopy closure. (See WFPB 1995 and Hamer 1995 for a complete description of the model and variables used.)

Hamer (1995) also analyzed detection rates and number of surveyed stands that were verified as occupied against elevation and distance inland. He found that mean detection rate and number of stands verified as occupied declined sharply above 3,500 feet and at distances greater than 39 miles from marine waters. More than 98 percent of all murrelet detections were from forest stands below 3,500 feet, and 98.5 percent of all detections were from areas less than 40 miles inland.

Statistical models such as described by Hamer (1995) can be useful for predicting what forest types are potentially occupied murrelet nesting habitat, for determining what forest management activities would degrade potentially occupied or suitable habitat, and for designing silvicultural prescriptions that could accelerate the development of habitat from currently unsuitable stands. As discussed above, descriptions of nesting habitat associations need to be augmented by a more thorough understanding of how these associations relate to reproductive success of murrelets. Statistical models based on occupancy versus non-occupancy are only an interim step until habitat quality can be defined in terms of reproductive success.

ESTIMATES OF MURRELET ABUNDANCE, POPULATION DEMOGRAPHY, AND TRENDS

Population Estimates

Marbled murrelet population is currently estimated by surveys done at sea, from both planes and boats. Total population based on the most current information is 300,000 individuals. Approximately 85 percent of this estimated population is concentrated along the Gulf of Alaska and Prince William Sound. The total Alaska population is estimated to be 220,900 birds (Piatt and Naslund 1995: Klosiewski and Laing 1994). At the edge of the murrelet's range, in the Aleutian Islands, the population is less than 5,000 (Piatt and Naslund 1995). The British Columbia population is estimated to be between 45,000 and 50,000 birds (Rodway et al. 1992). The Washington population is estimated at approximately 5,500 birds (Speich and Wahl 1995; Varoujean and Williams 1995). Two estimates have been derived for Oregon: Varoujean and Williams (1995) used aerial surveys to derive an estimate of 6,600 individuals, and Strong et al. (1995) arrived at an estimate of between 15,000 and 20,000 using boat surveys. For California, Ralph and Miller (1995) estimated 6,450 individuals.

The use of at-sea surveys for murrelets is a recent technique whose accuracy is currently being assessed (Ralph et al. 1995a). Well-established methods for determining population sizes of other alcid species are ineffectual for marbled murrelets because they have secretive nesting habits and consequently are virtually inaccessible for banding. Census survey results have varied between years, locations, and methods. Ralph et al. (1995a) identified aspects of surveys that can affect accuracy and suggested ways to reduce sources of error.

Population Trends

Keeping in mind these limitations for population estimates, researchers still think there is enough evidence to suggest that the murrelet population is declining. Circumstantial evidence of population decline includes observations that murrelets are abundant offshore of areas where extensive old-growth stands still exist (the Gulf of Alaska), while distribution is disjunct in areas where most of the old growth has been harvested (Washington, Oregon, and California), with murrelets found offshore along remaining stands of older forest (Ralph et al. 1995a). More quantitative assessments are available from Alaska and British Columbia for trends over the past 20 years. In Alaska, Piatt and Naslund (1995) concluded from comparing small-boat survey counts from 1972-1973 and 1989-1991 and Christmas bird counts that populations have decreased on the order of 50 percent in the past 20 years. In British Columbia, Burger (1995b) also concluded that populations have decreased by 50 percent in Clayquot Sound, based on density estimates made from surveys between 1979 and 1993. However, Burger (1995b) found that survey results in Barclay Sound indicated populations there decreased in 1992 and 1993, but doubled or tripled the following year, in 1994. He speculates that the low numbers in 1992 and 1993 may have been due to El Niño factors.

Data for quantitative assessment of long-term population trends is lacking in many parts of Washington, Oregon, and California. Speich et al. (1992) and Speich and Wahl (1995) report that qualitative accounts of murrelet abundance in the Puget Sound from early this century suggest that numbers are lower now than they were then. These authors indicate that further analysis of recent census data is needed to assess the role that spatial and temporal variation in census results plays in the low numbers that have been observed in recent years. Speich and Wahl (1995) also report that no early qualitative assessments of murrelet populations on the outer Pacific coast of Washington are available, but census data collected over the last 23 years from nearshore waters off Grays Harbor, Washington, indicate that murrelet abundance has decreased there since 1989, with especially low numbers observed in 1993. Their 1993 observations were confirmed by aerial surveys done along the Washington outer coast by Varoujean and Williams (1995). Speich and Wahl (1995 p. 323) suggest that overall changes in marine carrying capacity may be contributing to observed population declines in the past two years because other oceanic bird species with various foraging strategies have been observed the past two years to have the lowest recorded abundances since 1971.

Historic anecdotal accounts of murrelet occurrence in Oregon reported that murrelets were “common” or “abundant” near the Columbia River and offshore of Tillamook County in the northern half of the state and near the mouth of the Yaquina River in central Oregon (Taylor 1921; Strong et al. 1995). Onshore sightings of murrelets in these areas have been infrequent in recent years, suggesting a population decline in the northern half of Oregon (Nelson et al. 1992; Strong et al. 1993; Strong et al. 1995). Historical accounts of murrelet abundance in California also suggest that the population has declined (Carter and Morrison 1992). The presence of two small disjunct populations in California, one off the coast of central California and the other off the coast of northern California, coincides with the existence of remnant old-growth stands onshore and suggests that populations may be declining as the availability of nesting habitat is declining (Ralph et al. 1995a p. 12). Incidental killing in gill nets and by oil spills and other marine pollution is also thought to reduce murrelet populations (see below).

Demography

Long-term data on the vital rates of marbled murrelet sub-populations are unavailable. This information is crucial for determining rates of population change and what segments of the population (i.e., juveniles or adults) contribute most to population stability and for predicting what rates of decline the population can sustain and for how long before extinction thresholds are crossed. (See discussion of population viability analysis in the spotted owl ecology literature review in the preceding section of this chapter.) Understanding these aspects of murrelet population ecology is necessary to design adequate long-term conservation plans. Preliminary research on nesting success (Nelson and Hamer 1995b) indicates that marbled murrelets may have one of the lowest juvenile survival rates of alcid species (DeSanto and Nelson 1995). Observations of ratios of juveniles to adults at sea indicate that the adult reproductive rate is low (Ralph and Long 1995; Varoujean and Williams 1995; but see below). Low rates of juvenile survival and annual reproduction in any species mean that high rates of adult survival are necessary for a stable population. If high rates of juvenile mortality are the result of human management activity and not a part of natural demographic processes in the population (see above and Hamer and Nelson 1995a), a change in management practices that reduce juvenile mortality rates could significantly improve long-term prospects for the species.

Preliminary demographic modeling indicates that the marbled murrelet population is declining at between 4 and 6 percent per year (Beissinger 1995). This assessment is based on juvenile to adult ratios observed at sea and from inferences of possible adult survival rates made from other alcid species. Ralph et al. (1995a) caution that there are several potential sources of error in counting juveniles at sea and that the years in which these data were taken were characterized by unusually warm sea temperatures. Counts of juveniles at sea assume that observers can accurately distinguish adults from juveniles. In addition, nesting chronology data (Hamer and Nelson 1995a) indicate that in some areas, murrelet chicks may not fledge until September. By this point in the season, adults have molted and are not distinguishable from juveniles; the result is a potential low estimate of the number of juveniles. Warm ocean conditions can reduce prey availability and result in adults forgoing breeding or in chicks starving (Ainley and Boekelheide 1990), which may have adversely affected reproductive rates and thus given a non-representative picture of long-term demographic trends.

Knowledge of population dynamics in general and of demographic data from other alcid species allows for identification of some factors that affect demography of marbled murrelets. These factors include age at first breeding, the proportion of the adult population that breeds, the number of young that survive to breeding age, adult mortality rates, and subadult mortality rates (Ralph et al. 1995a p. 13). Conditions that affect the proportion of the adult population that breeds include limitations of the amount of suitable nesting habitat that is not already occupied by other murrelets and prey availability offshore of suitable nesting habitat (Ralph et al. 1995a). Loss of nesting habitat is occurring and is very likely limiting the proportion of adults that can breed. Evidence (discussed earlier) of large local concentrations of murrelet populations offshore of extensive old-growth forest, smaller populations where old growth is limited, and no murrelet activity at sea where old growth is absent supports this hypothesis.

Food availability will be affected by oceanic conditions and the degree to which prey species of murrelets are over-fished by humans. El Niño events have decreased the availability of food for seabirds (Ainley and Boekleheide 1990). Long-term changes in marine productivity have had major effects on seabirds in the Bering Sea (Ralph et al. 1995a). Fisheries exist for some prey species of the murrelet — primarily Pacific herring, rockfish, and northern anchovy. These fish populations are currently depressed due to overfishing (Ainley et al. 1994). However, Ralph et al. (1995a) do not think that food availability is currently a limiting factor affecting murrelet populations, though El Niño events could have short-term effects on the number of adults breeding.

Predation appears to have a large influence on reproductive success. Thirty-one percent of all nests discovered thus far have failed due to predation, and 43 percent of all nests that have failed for any reason have failed due to documented predation (Nelson and Hamer 1995b). Nelson and Hamer (1995b) also found that successful nests were located significantly further from stand edge than those that failed. (See earlier discussion on predation.) This suggests that forest fragmentation could have an adverse effect on reproductive success of marbled murrelets.

Adult mortality is affected by predation in transit between foraging areas and nests. It may also be affected by predation at sea, but no predator takings of murrelets at sea have been recorded (Ralph et al. 1995a p. 16). Adult and subadult mortality rates are increased by deaths due to human activities such as gill-netting (Carter et al. 1995; Fry 1995), pollution, and oil spills (Carter and Kuletz 1995).

Currently, demographic analyses cannot distinguish the relative effects of habitat loss from other factors affecting population trends (Ralph et al. 1995a). It is generally known, however, that populations that do not produce enough young to replace adults eventually become extinct. Thus, the extent to which murrelet nesting habitat has been lost will certainly have a negative effect on the size of the murrelet population. In addition, because murrelets only produce one egg per clutch, they will not recover quickly from higher adult mortality. Increased adult mortality at sea from human activities will also have a large negative effect on the overall population.

Collecting demographic data for murrelets is difficult because of their inaccessibility. Traditional banding and re-observation techniques of both adults and juveniles are not practical, given the difficulties in locating murrelet nests. Alternative methodologies such as refinement of at-sea observation techniques and completely new techniques suitable to murrelet biology will need to be developed to assess accurately demographic trends and determine the relative contribution of different influences on population viability (Ralph et al. 1995a).

HABITAT STATUS IN WASHINGTON

Estimates of the amount of potential marbled murrelet nesting habitat in Washington have been made using satellite data developed by the Washington Department of Fish and Wildlife and modified by DNR (see Raphael et al. 1995; WFPB 1995 based on data developed by Eby and Snyder 1990 and updated by Collins 1993). These estimates were based on broad definitions of old-growth and large-saw forests. The amount of potential nesting habitat by ownership based on these estimates is shown in Table III.5.

Table III.5: Old-growth, large-saw, and small-saw forests below 3,500 feet and less than 66 miles from marine waters, by ownership

(Source: DNR GIS, November 1994)

Ownership	Old growth (acres)	Large saw (acres)	Small saw (acres)
Federal	798,231	710,347	352,853
State	62,950	64,656	173,131
Local	1,162	3,227	2,659
Tribal	3,607	1,302	5,614
Private	67,154	100,656	335,232
Total	**933,104**	**880,188**	**869,489**

Status of Habitat on DNR-managed Lands

From data in Hamer et al. (1994b), DNR derived another estimate of potentially suitable nesting habitat for the lands it manages, assuming that (1) marbled murrelets would use a stand that contains at least eight trees per acre that are equal to or greater than 32 inches dbh; (2) at least 40 percent of such trees are Douglas fir, western hemlock, western redcedar, or Sitka spruce; and (3) the stand contains at least two nesting platforms per acre. This definition was derived from minimum conditions of occupied murrelet stands in Washington. Using forest growth models incorporating site index and assumptions of how managed stands versus unmanaged stands grow, DNR estimated the age at which a stand would develop eight trees greater than or equal to 32 inches dbh. Data from Hamer et al. (1994b) indicate that in unmanaged low-elevation stands, three trees per acre that are greater than or equal to 30 inches dbh would produce at least two platforms per acre. The platform per acre criterion is thus captured by the tree size and density criteria.

DNR's computerized geographic information system data base was queried to assess how many acres of DNR-managed land met this minimum definition of murrelet habitat within 66 miles of marine waters. The estimate was between 55,773 and 63,614 acres, depending on whether growth was assumed to be for a managed stand or a natural stand. This represents 3.4 percent to 3.8 percent of all DNR-managed forest lands in the area covered by the HCP. However, combining old-growth and large-saw estimates from the Washington Department of Fish and Wildlife results in an estimate of 126,606 acres of potential murrelet habitat on DNR-managed land.

The two-year murrelet habitat relationship study currently under way on DNR-managed lands will result in the most accurate picture yet of how much actual potential nesting habitat exists. This study is explained in more detail later in this chapter.

Habitat trends

The amount of available murrelet nesting habitat has been decreasing. Murrelets have been found thus far to nest almost exclusively in low-elevation old-growth and mature forests within 40 miles of marine waters, although they have been observed as far as 66 miles inland. About 10 percent of pre-settlement old growth remains in western Washington (Norse 1990; Booth 1991). Logging, urbanization, and agricultural development have all contributed to the loss of this habitat.

Management under the President's Forest Plan is expected to result in retention of 97 percent of the remaining 980,000 acres of potential murrelet habitat on federal lands in Washington (USDA and USDI 1994a; Perry 1995). Although there are currently no federal restrictions on logging of murrelet nesting habitat on nonfederal lands, landowners are still liable for take of murrelets under the Endangered Species Act. To avoid risk of taking, DNR began a voluntary deferral of timber harvesting in potential murrelet habitat in 1992. The Forest Practices Board is developing a rule for murrelet habitat on state and private lands under the State Forest Practices Act.

THREATS

Habitat Loss and Fragmentation

In its listing decision, the U.S. Fish and Wildlife Service identified habitat loss as the major factor causing the decline of marbled murrelet populations (Federal Register v. 57, p. 45328-37). Threats associated with loss of nesting habitat are (1) a decrease in the proportion of the population that is able to reproduce through reduced availability of nest sites; (2) decrease in reproductive rate of population due to inability of displaced adult breeders to locate new nest sites after their previous sites have been destroyed; (3) packing, i.e., an increased density of birds nesting in the habitat that is available; and (4) fragmentation of existing habitat, which increases the accessibility of nest sites to predators and isolates portions of the population, leading to increased vulnerability to genetic and environmental changes (Divoky and Horton 1995; Ralph et al. 1995a; WFPB 1995).

A decrease in the proportion of the population breeding threatens the species because it could lead to rates of population decline from which the species could not recover. In other words, an extinction threshold could be reached. Current knowledge of murrelet demography is not sufficient to determine where this threshold lies (Beissinger 1995; Ralph et al. 1995a).

The ability of adult breeders to disperse to new nesting stands is not well understood. Drawing from a comparative study of other alcids and knowledge of murrelet nesting habits, Divoky and Horton (1995) suggest that murrelet adults may not be well adapted to disperse to new nest stands once their natal stand has been destroyed. If this is true, it may be difficult for displaced adults to be able to breed, thus reducing the reproductive output of local populations.

Packing is problematic for at least two reasons. First, when all high-quality nest sites are occupied, murrelets may be forced to nest in lower quality habitat or at the edge of suitable stands. Either of these cases could result in a lower likelihood of nesting success. For instance, if a nest is established on a smaller limb or platform than would otherwise be chosen, there could be a higher risk of a chick falling out of the nest. Dead chicks that have fallen out of nests have been documented (Nelson and Hamer 1995b). Nesting on the edge of a stand increases likelihood of nest failure due to predation (Nelson and Hamer 1995b). Second, a high density of nest sites in a stand provide more opportunities for predators to form search images of murrelets as they approach or depart from the nest stand (Ralph et al. 1995).

Forest fragmentation in general increases the number of smaller forest patches (Harris 1984; Forman and Godron 1986). Forests in the Pacific Northwest have experienced a high degree of fragmentation due to clearcut harvest practices in this century (Harris 1984; FEMAT 1993; Thomas et al. 1993). The relation between increased bird nest predation and forest fragmentation has been established in several studies. Bryant (1994) demonstrated that artificial ground and shrub nests located within 328 feet of a forest clearcut edge suffered higher rates of predation than did nests located between 328 feet and 1,804 feet from an edge. Paton (1994) summarized data that demonstrated that songbirds had reduced nesting success when their nests were located near a forest edge. Populations of corvids (jays, ravens, and crows) have been observed to increase in forest edges in British Columbia (Bryant, personal communication, cited in Burger 1995a p. 158) and in the west in general (Marzluff 1994). Densities of great horned owls are also higher in fragmented forests as compared to areas with more contiguous stands (Johnson 1993). Corvids are known predators of marbled murrelets, and great horned owls are suspected predators of murrelets (Nelson and Hamer 1995b).

In addition to the above evidence, Nelson and Hamer (1995b) found that successful murrelet nests were farther from an edge than nests that failed due to predation. Stand size was greater and amount of canopy closure near the nest was higher for successful than for unsuccessful nests; however, the difference was not significant between nests that failed due to predation and nests that failed due to other reasons. Finding these characteristics of successful nests led Nelson and Hamer (1995b) to conclude that changes in configuration of habitat, such as amount of edge, may significantly affect nesting success.

Forest fragmentation also poses the risk of isolation of small sub-populations of murrelets. Small sub-populations that do not interact to a high degree with other sub-populations are susceptible to extirpation through a variety of mechanisms: inbreeding depression, which reduces the fitness of the population (Frankle and Soule 1981; Saunders et al. 1991); random demographic fluctuations, i.e., an unfavorable ratio of males to females or breeding adults to non-breeding adults or subadults; and random environmental catastrophes. (See discussion of spotted owl demography in Section A of this chapter.)

Evidence discussed in this review suggests that the amount of nesting habitat is a limiting factor for murrelet populations at this time (See also Ralph et al. 1995a.). In addition, marbled murrelet nests are extremely vulnerable to loss through predation (Nelson and Hamer 1995a, b). Loss of a chick through predation in turn appears to be influenced by the distance of the nest from forest edge (Nelson and Hamer 1995b). Thus, the overall amount, size, and contiguity of suitable nesting stands are important factors in murrelet conservation.

The U.S. Fish and Wildlife Service has designated critical habitat for the marbled murrelet (Federal Register v. 61, no. 102, p. 26255-26320). Most of this habitat designation includes lands that are to be managed as Late successional Reserves under the President's Northwest Forest Plan (USDA and USDI 1994 a and b). Some nonfederal land has been included, the vast majority of which is DNR-managed land. Most of this land occurs in southwest Washington and on the Olympic Peninsula. The U.S. Fish and Wildlife Service conducted an assessment of the effects of the HCP strategies on designated critical habitat on DNR-managed lands, the results can be found in the Biological Opinion.

Mortality at Sea

High rates of adult survivorship are necessary to maintain population stability in species with low reproductive output. Marbled murrelets are particularly sensitive to adult mortality because they only produce one egg per nesting attempt (Beissinger 1995; Ralph et al. 1995a). Thus, human-caused mortality of adult murrelets above natural levels can have significant negative impacts to the murrelet population. Large oil spills, chronic oil pollution, organochlorine pollution, and entanglement in gill nets are significant sources of mortality for marbled murrelets at sea.

Oil spills destroy the ability of feathers to regulate a bird's body temperature; oil also affects most of a bird's physiological systems (Burger and Fry 1993). The 1989 *Exxon Valdez* oil spill directly killed approximately 5,000 marbled murrelets and 3,000 unidentified murrelets, which included marbled murrelets, Kittlitz's murrelets, and ancient murrelets in Prince William Sound, Alaska (Carter and Kuletz 1995); this was the largest recorded single mortality event for marbled murrelets in North America (Carter and Kuletz 1995). Indirect effects on murrelets from the spill included sub-lethal levels of oil that reduced prey populations, disturbance from increased human activity in Prince William Sound during clean-up and monitoring after the spill, and reduced reproductive output of the local population in the vicinity of the spill (Irons 1992; Oakley and Kuletz 1994; Oakley et al. 1994; Kuletz in press; Piatt and Anderson in press; Carter and Kuletz 1995).

Oil spills also pose a significant threat to murrelets in Washington, Oregon, and California, where there is a high volume of commercial shipping, and barge and oil tanker traffic along the Pacific coast (Fry 1995). Several medium to large oil spills have occurred along the Pacific coast within the range of the murrelet since the late 1800s. Collection of systematic records of seabird carcass recovery did not begin until recently. Seven major spills have occurred in Washington since 1971. Oiled murrelet carcasses were recovered at the 1985 *Arco Anchorage* spill near Port Angeles and the 1988 *Nestucca* spill off Grays Harbor. Approximately 45 murrelet carcasses were recovered at the site of the 1991 *Tenyo Maru* spill off Willapa Bay, and estimates suggested that a total of 200-400 murrelets actually died. This represents a large portion of the local breeding population (Carter and Kuletz 1995) and is the largest recorded loss of murrelets to an oil spill on the U.S. Pacific coast south of Alaska (WFPB 1995). Thus, small murrelet populations could potentially be eliminated in a single oil spill event.

Chronic oil pollution, including small spills, bilge seeps, dumping, and undetected slow leaks from coastal tanks, pumps, and pipelines, can also pose a threat to the murrelet population. This type of oil pollution is poorly documented, making an assessment of the level of threat difficult. However, retrieval of dead oiled murrelets on beaches in times that did not coincide with medium to large oil spills indicates that chronic oil pollution does kill (Carter and Kuletz 1995). Murrelet populations in the Puget Sound and the Columbia River/Grays Harbor areas of Washington are highly susceptible to oil pollution from tanker traffic. Because the Puget Sound area is highly industrialized, the likelihood of murrelet exposure to chronic oil pollution from small spills is also increased.

Fry (1995) identified organochlorine compounds as a prevalent non-oil pollution threat within the range of the murrelet. Specifically, polychlorinated dibenzo-dioxins (PCDD) and polychlorinated dibenzo-furans (PCDF), which are contained in pulp-mill discharges, cause significant injury to fish, birds, and estuarine environments (Elliot et al. 1989; Whitehead 1989; Colodey and Wells 1992; Fry 1995). PCDDs and PCDFs bioaccumulate in marine sediments, fish, and fish-eating birds and impair bird production (Elliot et al. 1989; Bellward et al. 1990). There has been no record of bioaccumulated residues or breeding impairment in marbled murrelets to date, although murrelets that feed in areas of historic or current discharge from bleached paper mills could be at risk from eating fish with bioaccumulated organochlorine compounds (Fry 1995). Active chlorine bleach mills in Washington are located in Port Angeles, Bellingham, Everett, and Grays Harbor.

Mortality to murrelets from gill net fisheries is well documented in Alaska and British Columbia, but not in Washington (Carter et al. 1995). Results of several seabird observer programs initiated in 1993 are still preliminary. The U.S. Fish and Wildlife Service estimated a total take of 10 murrelets from all-citizen fisheries programs and tribal fisheries for 1993, which they did not judge to put the species in jeopardy (Carter et al. 1995 p. 281). However, Carter et al. (1995) estimate that there is significant mortality from gill and purse seine nets in the northern Puget Sound and San Juan Islands because of the high concentration of fishing activities and coincidence of a large portion of the murrelet breeding population there. They estimate that take is on the order of tens to hundreds of birds and recommend continuation and augmentation of observer programs in order to assess more accurately the impact of gill nets to murrelets in Washington.

DNR's Forest Habitat Relationship Studies

DNR is conducting a marbled murrelet forest habitat relationships study in each of the HCP planning units within the murrelet's Washington range. The objective of the habitat relationships studies is to determine the influences of distance from marine waters and habitat type on murrelet occupancy of DNR-managed forest lands. Results will be used to formulate a threshold definition of murrelet habitat for DNR-managed forest lands and to develop a long-term murrelet conservation strategy.

DESIGN

Two years of murrelet surveys will be conducted in each of the five west-side HCP planning units and the Olympic Experimental State forest. Each planning unit will contain 54 survey areas on DNR-managed lands. These survey areas will be stratified by two factors: (1) distance from marine waters and (2) habitat type (Table III.6). Habitat descriptions of the survey areas will characterize forest conditions, nesting opportunities, and topography.

In each planning unit, 18 survey areas will be selected in each of three distance bands (near, mid, and far). Band width will be based on the distribution of DNR-managed lands from marine waters, each band containing a third of the DNR-managed lands within the planning unit. Thus, actual band width will differ within and among planning units.

Within each distance band, six survey areas will be located in each of three habitat classes: old-forest habitat with an average density of at least two suitable nesting platforms per acre, young-forest habitat with an average density of at least two suitable nesting platforms per acre and young-forest habitat with at least one suitable nesting platform. For the purposes of these studies, old forest will be defined as old-growth forests or mature forests where most of the co-dominant trees are more than 120 years old. Young forest will be defined as sub-mature forests where most of the co-dominant trees are less than 120 years old. A suitable nesting platform is a horizontal limb, tree structure, or deformity at least 7 inches in diameter and a minimum of 50 feet above the ground.

Table III.6: Allocation of survey areas in each planning unit, by habitat type and distance from marine waters

Habitat type	Distance of area from marine waters		
	Near band	Mid band	Far band
Old forest, ≥2 platforms/acre	6	6	6
Young forest, ≥2 platforms/acre	6	6	6
Young forest, at least 1 platform	6	6	6

In each planning unit, survey areas will be selected to ensure consistency within each habitat class. Consistency will be sought in terms of landscape context, forest type, elevation, stand origin, stand size, and distribution of platforms in the survey area. To ensure that each survey area represents an independent sampling unit, survey areas will be at least one-half mile apart.

Each survey area will be surveyed from two, three, or four stationary survey stations. Theoretically, one survey station can cover up to 30 acres of habitat, allowing for a maximum survey area size of 120 acres. However, because in many places actual station coverage will be less than 30 acres, we will select survey areas between 40 and 80 acres in size will be selected. This assumes an actual station coverage of about 15 acres per station, half the theoretical maximum. Stands less than 20 acres will not be considered as survey areas.

Each planning unit will be surveyed for two consecutive years. In year 1, each survey area will be visited on at least four mornings. Survey areas where murrelet presence is detected will receive two additional survey visits, for a total of six visits. In year 2, each survey area will again be

Table III.7: Prescribed number of visits for each survey area for both years of the DNR marbled murrelet forest habitat relationships studies

Year-1 status	Year-2 status	Number of year-1 visits	Number of year-2 visits	Number of total visits
No detections	No detections	4	4	8
	Presence	4	10	14
	Occupancy	4	6-10*	10-14*
Presence	No detections	6	10	16
	Presence	6	10	16
	Occupancy	6	6-10*	12-16*
Occupancy	No detections	6	6	12
	Presence	6	6	12
	Occupancy	6	6	12

*The number of year-2 survey visits and total visits depends on when occupancy is determined in year 2.

Definitions

detection: The sighting or hearing of one or more murrelets acting in a similar manner.

presence: A stand of potential habitat where one or more murrelets have been seen or heard.

occupancy: A stand of potential habitat where (1) an active nest or recent nest site has been discovered as evidenced by a fecal ring or eggshell fragments, (2) a chick or eggshell fragments have been discovered on the forest floor, or (3) murrelets have been observed exhibiting subcanopy behaviors. See discussion titled Flight Behavior earlier in this section for examples of subcanopy behaviors.

visited on at least four mornings. Survey areas where murrelet presence was detected in year 1 or is detected in year 2 but occupancy has not been confirmed will be surveyed until (a) occupancy is confirmed and six year-2 survey visits have been completed or (b) ten year-2 survey visits have been completed, whichever comes first. Survey areas where murrelet occupancy was determined in year 1 will receive six year-2 survey visits (Table III.7).

Observations will be made and data recorded according to procedures described in Methods for Surveying Marbled Murrelets in Forests: A Protocol for Land Management and Research (Ralph et al. 1994) and its 1995 supplement (Ralph et al. 1995b) and any subsequent updates or modifications as required by the U.S. Fish and Wildlife Service. Data will also be mapped for input into an ARC/INFO coverage on DNR's geographic information system.

The habitat of each survey area will be accurately described with respect to forest conditions, nesting opportunities, and topography. This information will be used to determine the influences of these factors on murrelet occupancy of DNR-managed forest lands. Habitat descriptions will:

(1) be made using objective, scientifically accepted methods that can be repeated with the same results,

(2) be made in a manner that allows comparison with results of other studies of murrelet habitat relationships,

(3) describe forest conditions within the entire survey area, and

(4) be limited to those variables that might reasonably influence murrelet occupancy of DNR-managed forest lands.

STUDIES IN PROGRESS

In 1994, marbled murrelet forest habitat relationships studies were initiated in the South Coast and most of the Olympic Experimental State Forest HCP planning units. This work was carried out by the Washington Department of Fish and Wildlife through an interagency agreement with DNR.

In 1995, year 2 of murrelet surveys in the South Coast and most of the Olympic Experimental State Forest planning units were again conducted by the Washington Department of Fish and Wildlife, which completed the habitat relationships studies for these planning units. Also in 1995, habitat relationships studies were initiated in the Columbia and Straits (including the rest of the Olympic Experimental State Forest) planning units; this work is being carried out by DNR. Year 1 of marbled murrelet surveys and habitat descriptions of survey areas will be completed in the Straits and Columbia Planning Units.

C. Other Federally Listed Species Within the Range of the Northern Spotted Owl

Nine wildlife species within the range of the northern spotted owl are listed by the federal government as threatened or endangered: the northern spotted owl, marbled murrelet, Oregon silverspot butterfly, Aleutian Canada goose, bald eagle, peregrine falcon, gray wolf, grizzly bear, and Columbian white-tailed deer. Discussions of species ecology for the spotted owl and marbled murrelet are found in Sections A and B of this chapter, respectively. Habitat needs of the other seven species are reviewed below, followed by Table III.8, which lists for each of the nine species its federal and state status and in which HCP planning unit each could potentially occur.

Oregon Silverspot Butterfly

The Oregon silverspot butterfly (*Speyeria zerene hippolyta*) is the only federally listed species of arthropod that is found in Washington (WDW 1993a). This butterfly is currently listed by the federal government as threatened and by the state as endangered. However, no critical habitat in Washington has been designated under the Endangered Species Act (WDW 1993b).

The Oregon silverspot is found only in habitats that support its larval host plant, western blue violet (*Viola adunca*). Such habitats include coastal salt-spray meadows and open fields. In Washington, potential habitat for the Oregon silverspot is limited to the coastal grasslands on the Long Beach peninsula near Loomis Lake (WDW 1993b; WDW 1991). Adult butterflies are thought to rest and feed in adjacent open spruce/shoreline pine forest glades, where they are protected from wind and can feed on nectar available from a number of plant species. (WDW 1993b; WDW 1991). The presence of heavy grass thatch and woody plant invasion threatens the silverspot butterfly habitat. DNR manages accreted lands on the Long Beach peninsula that could contain Oregon silverspot habitat.

Aleutian Canada Goose

The Aleutian Canada goose (*Branta canadensis leucopareia*), a subspecies of the Canada goose, was downlisted by the federal government from endangered to threatened in 1990 (Federal Register v. 55, no. 239, p. 51112). The subspecies is listed as endangered by the state. The subspecies is distinguished from the other locally ubiquitous species by a broad white ring at the base of the neck. A major cause of the early decline of the Aleutian Canada goose was predation by foxes and other small mammals in the subspecies' nesting areas which are located on Buldir and Chagulak islands in the Aleutian Archipelago and on Kaliktagik in the Semidi Islands in Alaska. In the early 1800s, foxes were introduced onto the Aleutian islands and neighboring islands as a fur supply and some rodents were inadvertently introduced with the landing of ships. The winter range was not defined until the early 1970s. Wintering areas extend from Alaska to California and into parts of Japan. From less than 800 individuals in 1975, their numbers have increased to 12,000-14,000 individuals in 1994. The most recent counts indicate about 20,000 individuals. Currently the San Joaquin Valley, northern California coast, and Sacramento Valley form the subspecies' main wintering area, but they also winter in western Oregon and southwestern Washington. They regularly stop in the Willamette Valley of Oregon in September or October. Their winter range is expanding as the population increases. The species may occur in the area covered by the HCP but only as a migrant or winter resident. Habitat used during migration or winter residency includes lakes, ponds, wetlands, grasslands, and agricultural fields. Control of foxes, use of seasonal Canada goose hunting closures to reduce incidental take, and conversion to nontoxic shot have all contributed to the recovery of the subspecies.

Bald Eagle

The bald eagle *(Haliaeetus leucocephalus)* is listed by both the federal government and the state as threatened (WDW 1993a). Throughout Washington, the bald eagle typically occurs along the coasts, major rivers, lakes, and reservoirs (USDI 1986). Potential habitats are riparian areas along rivers, streams, lakes, sloughs, and reservoirs; coastal estuaries and beaches; freshwater beaches; and mature and old-growth forest stands within 1 mile of water (Brown 1985).

Washington supports the largest population of nesting bald eagles in the seven-state area covered by the Pacific States Bald Eagle Recovery Plan (USDI 1986). Most nesting in Washington occurs on the San Juan Islands and along the Olympic Peninsula coast; however, nesting territories are also found along Hood Canal, on the Kitsap Peninsula, in Island, Pierce, and Thurston counties, along the Columbia River in southwestern Washington, in the Cascade Range, and in eastern Washington (USDI 1986). Bald eagles typically nest near water, usually on prominent features overlooking aquatic foraging areas (Stalmaster 1987; Anthony and Isaacs 1988). In western Washington, distance between nest sites and water averages 282 feet (Grubb 1976); within the seven-state recovery area, nest sites are generally within 1 mile of water (USDI 1986). The average territory radius ranges from 1.55 miles in western Washington to 4.41 miles along the lower Columbia River, where reproduction rates are low (Grubb 1980; Garrett et al. 1988). The three main factors affecting distribution of nests and territories are:

(1) proximity to water and food,

(2) suitable nesting, perching, and roosting trees, and

(3) the number of breeding eagles (Stalmaster 1987).

Nest sites in western Washington are found most commonly in Douglas fir and Sitka spruce trees. Nest trees average 116 feet tall and 50 inches dbh and typically exceed the U.S. Forest Service's minimum diameter-at-breast-height specifications for old-growth inventory (Anthony et al. 1982).

Washington also supports the largest population of wintering bald eagles in the seven-state recovery area. Primary wintering areas include the Olympic Peninsula, the San Juan Islands (particularly Cypress Island), Puget Sound and its tributaries, Hood Canal, and the Cowlitz and Columbia rivers. The Skagit River supports one of the largest concentrations of wintering bald eagles in the contiguous United States, with as many as 553 individuals counted during peak periods. At least six bald eagle winter communal roost sites occur along the North Fork of the Nooksack River, all at least partially on DNR-managed land. Food availability is the major factor that attracts bald eagles to wintering locations (Stalmaster 1987). Many areas that have abundant populations of overwintering waterfowl or salmon runs also support large concentrations of wintering eagles (Biosystems Analysis, Inc. 1984; Keister et al. 1987).

Bald eagles use perches during nesting, hunting, feeding, territorial maintenance, and behavioral displays (Stalmaster 1987). Eagles select perches that provide a good view of the surrounding territory; typically, the tallest perch tree available is preferred (Stalmaster 1987). Along the Nooksack River, dead trees are strongly preferred as daytime perches during the winter; tree species commonly used are black cottonwood, big leaf maple, or Sitka spruce (Stalmaster and Newman 1979). Because of its relatively low height, red alder is used less often (Stalmaster 1976).

Wintering bald eagles often roost communally in single trees or large forest stands. Most of these areas are near a rich winter food source (typically anadromous fish and water fowl) and in forest stands that are of uneven ages and have some old-growth characteristics (Anthony et al. 1982). Many roost sites are in ravines and draws that protect eagles in bad weather (Hansen 1978; Keister 1981). Roost sites are generally positioned in the tallest, most dominant trees that provide unobstructed views of the surrounding landscape (Anthony et al. 1982). In western Washington, communal roost sites have been documented in black cottonwood, Douglas fir, western redcedar, western hemlock, and other tree species (Hansen et al. 1980; Anthony et al. 1982).

Anthony and Isaacs (1988) recommend that habitat alterations not occur within 1,312 feet of bald eagle nests and that disturbance activities within 2,625 feet of nests be restricted between January 1 and August 15. The Pacific States Bald Eagle Recovery Plan (USDI 1986) recommends temporary buffers of 1,312 feet around screened roosts and 2,625 feet around visible roosts. Timber harvests can occur, but only between November 1 and April 1. Along foraging areas, a 164- to 326-foot wide strip of tall perch trees should be maintained. Stalmaster (1987) recommends that a buffer zone of 820 to 984 feet be maintained where little screening cover is present. Under WAC 232-12-292, the Washington Department of Fish and Wildlife works with landowners to design site-specific management plans that provide flexible land use instead of setting standard buffer distances.

Peregrine Falcon

The peregrine falcon (*Falco peregrinus*) is listed by both the federal government and the state as endangered (WDW 1993a). In Washington, three subspecies occur: *F. p. anatum, F. p. peali,* and *F. p. tundrius* (Allen 1991), but only *F. p. anatum* is believed to nest here (Peregrine Falcon Recovery Team 1982; Johnsgard 1990). Fifteen nesting pairs of peregrine falcons were recorded along the outer coast, in the San Juan Islands, and along the Columbia River Gorge in 1990 (Allen 1991). Washington primarily provides important migratory and wintering habitat for peregrines, including estuaries such as Skagit River flats, Grays Harbor, and Willapa Bay, where falcons prey on large concentrations of waterfowl and shorebirds. *F. p. peali* and *F. p. tundrius* are present as winter migrants.

Most peregrine nests are on cliffs or high escarpments that dominate the nearby landscape, although office buildings, bridges, and river cutbanks have also been used for nesting (PFRT 1982; Craig 1986). Most preferred nesting cliffs are at least 150 feet high and can be found from sea level to 11,000 feet (PFRT 1982). Foraging habitat includes marshes, lakes, river bottoms, croplands, and meadows where peregrines prey primarily on songbirds, waterfowl, and shorebirds (Porter and White 1973). During the breeding season, peregrine falcons will travel as far as 17 miles from the aerie to hunt, although a hunting range of 10 miles is considered typical (Porter and White 1973; PFRT 1982).

Human disturbance during the nesting season can greatly inhibit peregrine falcon nesting success. Guidelines for protection of falcon nest sites include prohibition of land-use activities that alter or eliminate characteristics of hunting and prey habitat within 10 miles of aeries and of nesting habitat within 1 mile of a nest cliff. Disturbances and human activities should also be restricted from February 1 through August 1 within 0.5 mile of a nest cliff (PFRT 1984).

Gray Wolf

The gray wolf *(Canis lupus)* is listed by both the federal government and the state as endangered in Washington (WDW 1993a). This species ranges over large areas (Laufer and Jenkins 1989) and potentially occurs throughout the same range as that of the grizzly bear (see below), as well as the Washington Cascade mountains south to the Columbia River.

The gray wolf uses virtually any type of forest and natural opening as long as the level of human activity is low and there is an ungulate prey base (Laufer and Jenkins 1989). Because the wolf is currently becoming re-established throughout many parts of Washington and little data have been collected on its habitat use, all naturally vegetated lands should be considered potentially suitable habitat for this species. Vegetation types used include quaking aspen, mixed conifer, ponderosa pine, white or grand fir, alpine meadows, shrublands, riparian zones, marshes, bogs, and swamps (Thomas 1979). Wolf dens are normally located under logs or in rock outcrops.

The species is wide-ranging. On Vancouver Island, in temperate conifer forests similar to those in the area covered by HCP, two home ranges for wolf packs were 40 and 47 square miles (Scott 1979).

Grizzly Bear

The grizzly bear *(Ursus arctos)* is listed by the federal government as threatened in Washington (USDI 1993) and by the state as endangered (WDW 1993a). This species potentially occurs throughout the Cascade Range, from Canada south to near Yakima, and across the northern third of the state from the Okanogan Highlands to the Idaho border (Almack et al. 1993). The federally designated North Cascades Grizzly Bear Ecosystem extends through this region at elevations from about 492 to 10,778 feet. In the east- and west-side planning units of the HCP, DNR manages 122,300 acres in the North Cascades Grizzly Bear Recovery Area. The grizzly bear ranges over large areas and typically uses many vegetation types to fulfill its life requisites. Of special importance to bears are wet meadows, swamps, bogs, streams, and conifer, subalpine, and lodgepole pine forests, as well as alpine meadows and parklands (Brown 1985). However, these habitats alone would not be sufficient for supporting this species. Areas with little human disturbance may be preferred as habitat; many studies have shown the potential negative effect of human disturbance on grizzly bears (McLellan and Shackleton 1988; Kawsorn and Manley 1989; Mace and Manley 1993).

All naturally vegetated land types are considered suitable grizzly bear habitat. Den sites of grizzly bears can be found in nearly any type of forest, but are typically in coniferous forests. Bears normally select den sites on steep slopes near the tree line (Almack 1986). Bears forage in many vegetation types in order to obtain sufficient plant and animal foods. Their diet includes 124 species of plants, winter-killed ungulates, small mammals, and anadromous fish (Almack et al. 1993). Some DNR-managed parcels of land within the federally designated North Cascades Grizzly Bear Recovery Area could potentially provide lower elevation spring habitat for grizzly bears.

Grizzly bears are wide-ranging. Knight et al. (1988 as discussed in USDI 1993) estimated a density of one bear per 16 square miles in the U.S. portion of the Selkirk Ecosystem (northeast Washington and northwest Idaho). Assuming a circular home range, a territorial bear would range over a distance of 4.5 miles, the home-range diameter. Ten miles is thought to be the minimum "long distance movement" for grizzlies in the Selkirk Mountains. (Almack 1986).

Columbian White-tailed Deer

The Columbian white-tailed deer (*Odocoileus virginianus leucurus*) is listed by both the federal government and the state as endangered in Washington. The deer's current range is limited to areas less than about 10 feet above sea level (USDI 1983). Approximately 700 to 1,000 Columbian white-tailed deer occur along the Columbia River (USDI 1983). They are found only in bottomlands and on several islands in an 18-mile reach of the Columbia River near Cathlamet, Washington, and in an area near Roseburg, Oregon (USDI 1983). In Washington, these deer occur in the Julia Butler Hansen Columbian White-tailed Deer National Wildlife Refuge, and on Puget, Brown, Jackson, Ryan, Little, and Hunting Islands, which are owned privately or managed by DNR. Several DNR parcels of land in the refuge and on Puget Island are leased to the U.S. Fish and Wildlife Service and private landowners. Some of the deer's range is within the Columbia Planning Unit of this HCP.

Potential habitat for the Columbian white-tailed deer includes Columbia River bottomland riparian forests (alder, cottonwood, and spruce), grassland, pastures, and farmland not occupied by black-tailed deer (WDW 1991). Columbian white-tailed deer are primarily grazers, feeding in active and abandoned farm fields and pastures within 750 feet of forest cover and forest parks (WDW 1991). The deer's historical habitats include tidal spruce swamps, park forest, open-canopy forest, sparse rush, and wetlands (USDI 1983). Spruce, alder, cottonwood, and willow are common tree and shrub species used by deer for foraging, resting, and thermal cover (USDI 1983).

Although the population of Columbian white-tailed deer is apparently doing well (i.e., down- or de-listing this population has been considered), range expansion has not occurred, primarily because black-tailed deer have taken over other suitable habitat along the Columbia River, precluding white-tailed deer from using these areas.

Table III.8: Federally listed wildlife, their state status, and their potential occurrence in HCP planning units

SE = state endangered, ST = state threatened (WDW 1993a); OESF = Olympic Experimental State Forest.

		Planning Unit								
Species	**State Status**	**Klickitat**	**Columbia**	**South Coast**	**South Puget**	**Yakima**	**Chelan**	**North Puget**	**Straits**	**OESF**
Federally listed as threatened:										
Northern spotted owl	SE	X	X	X	X	X	X	X	X	X
Marbled murrelet*	ST	X	X	X	X	X	X	X	X	X
Oregon silverspot butterfly	SE			X						X
Bald eagle	ST	X	X	X	X	X	X	X	X	X
Grizzly bear	SE				X	X	X	X		
Aleutian Canada goose	SE		X	X	X			X		X
Federally listed as endangered:										
Peregrine falcon	SE	X	X	X	X	X	X	X	X	X
Gray wolf	SE	X	X		X	X	X	X		
Columbian white-tailed deer	SE		X							

*Potential habitat for the marbled murrelet exists in the east-side planning units. However, at this time, the marbled murrelet is not known to inhabit the east-side planning units.

D. Salmonids and the Riparian Ecosystem

Introduction

Salmon are one of the most important natural resources for the economy of the state of Washington. The resource is exploited by three main fishing groups: nontreaty commercial, treaty (Indian) commercial, and recreational fishers. From 1981 to 1990, the total marine and freshwater salmon catch for Washington averaged 7.2 million fish per year (Palmisano et al. 1993). According to historical records, the peak harvests between 1961 and 1979 were 57 percent lower than those between 1864 and 1922 (The Wilderness Society 1993). This large reduction in the productivity of the Pacific Northwest salmon fishery has been attributed to many factors, including large-scale water projects (dams), poor fisheries management (overfishing and hatchery practices), urbanization, agriculture, and detrimental forest practices (Palmisano et al. 1993; Nehlsen et al. 1991). As a consequence, some stocks east of the area covered by the HCP have been listed by the federal government as threatened, and several stocks in the area covered by the HCP are candidates for federal listing.

Bull trout (*Salvelinus confluentus*) and seven species of anadromous salmonids inhabit the rivers and streams of western Washington: sockeye salmon (*Oncorhynchus nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), and sea-run cutthroat trout (*O. clarki*). Anadromous fish spend part of their life at sea and return to freshwater to reproduce. During the portion of their life cycle spent in rivers and streams, these fish are vulnerable to forest practices that affect the integrity of riparian ecosystems (Hicks et al. 1991).

The life cycles of anadromous salmonids and bull trout are reviewed separately below, followed by a discussion of general salmonid habitat needs and the riparian ecosystem. The section ends with a review of current status and distribution of these species.

Anadromous Salmonid Life Cycle

Sockeye, pink, chum, chinook, and coho salmon and steelhead and sea-run cutthroat trout each have unique geographical distributions, life cycles, and habitat requirements. But from the perspective of forest land management, the similarities among the anadromous species of the family Salmonidae far outweigh the differences. There are few significant differences in the ways that forest practices impact each species. Therefore, in the following discussion, distinctions among the life cycles of these species are not emphasized. For additional information, the natural history and habitat requirements of salmonids are thoroughly reviewed by Groot and Margolis (1991) and Meehan (1991). The effects of forest management on salmonid freshwater habitat are reviewed by Salo and Cundy (1987), Meehan (1991), and Naiman (1992).

The salmonid life cycle consists of seven principal stages: egg, alevin, fry, parr, smolt, subadult, and adult. Eggs are laid in a nest, or redd, constructed by an adult female in a gravel streambed. After the eggs are laid and fertilized, the female covers them with gravel. Alevins hatch from the eggs after about three months of incubation (Meehan and Bjornn 1991). This larval stage is characterized by the presence of a yolk sac. Alevins can reside in the gravel for several months and emerge upon becoming fry, the next stage in their development (Meehan and Bjornn 1991). Because fry are small and weak, they are highly susceptible to predation. They are unable to swim against strong currents and therefore tend to stay along the stream margins in channel pools and eddies. Pink and chum juveniles remain in freshwater for a short period (0 to 30 days). Other species, in particular coho, steelhead, and cutthroat, remain in freshwater for 1 to 4 years (Palmisano et al. 1993). As fry become larger and stronger, they develop dark vertical bars on their sides called parr marks, and hence are known as parr. Parr venture away from the stream margins into swifter currents where larger prey are more prevalent. The juveniles of coho, steelhead, and cutthroat spend the summer months competing for food and space (Chapman 1966). Juveniles of some species (particularly coho) overwinter in tributaries, sloughs, and side channels (Emmett et al. 1991). Depending on the species, these juvenile freshwater stages end a few days to four years after leaving the redd and are marked by migration toward the sea (Meehan and Bjornn 1991).

Parr become smolts as they migrate to estuaries, where they remain until they complete the physiological changes needed to survive in the marine environment. Subadults spend one to four years in the ocean (Meehan and Bjornn 1991). During this time, individuals undertake long migrations, some traveling more than 1,000 miles. The path and distance are affected by ocean currents and abundance of prey. Some salmonid species migrate as far as the western portions of the Gulf of Alaska (Emmett et al. 1991). The vast majority of subadults return to the stream of their origin, but some natural straying into non-natal streams does occur (Waples 1991). The timing of this upstream migration varies among species and stocks.

Just prior to entering freshwater, individuals begin a dramatic metamorphosis to the adult or spawning stage. Most species develop a noticeable difference between sexes (sexual dimorphism). Spawning typically occurs in shallow riffle areas of a stream. Both sexes may mate with several partners before dying. In some species, females may guard the redd. Trout species can survive after spawning, migrate back to the ocean, and return to spawn one or two more years (Emmett et al. 1991). Chemical nutrients released through the decay of adult carcasses may be critical to the health of riparian ecosystems and probably sustain the productivity of the next generation of juvenile salmon (Willson and Halupka 1995). Some differences among life cycles of western Washington anadromous salmonids are summarized in Table III.9.

Bull Trout Life Cycle

The bull trout is a candidate for federal listing. The genus *Salvelinus*, also known as charr, belongs to the family Salmonidae. One other member of this genus is native to Washington, the Dolly Varden (*S. malma*). Until 1978, when it was recognized by Cavender (1978) as a separate species, bull trout was considered to be Dolly Varden. The separate classification was officially recognized in 1980 (Mongillo 1993). However, the geographic range of the two species overlaps in Washington and British Columbia (Goetz 1989), and the two species use the same freshwater habitat (Mongillo 1993; Brown 1994), have similar life histories, are known to hybridize (Mongillo 1993; Goetz 1989), and are difficult to distinguish. Information on geographical distribution and population status developed by the Washington Department of Fish and Wildlife is recorded as bull trout/Dolly Varden (Mongillo 1993; WDFW 1994b).

Bull trout populations exhibit anadromous, adfluvial, fluvial, and resident behaviors. Anadromous forms mature at sea, adfluvial in lakes, and fluvial in the main stem of rivers. The life cycle and freshwater habitat of bull trout are similar to that of salmon (genus *Oncorhynchus*). (See the preceding discussion of salmon life cycle and the following discussion of habitat needs.)

Table III.9: Life cycles of western Washington anadromous salmonids in freshwater, by species and run

(Source: Palmisano et al. 1993)

Species (Run)	Age at return (years)	Time of return	Spawning season	Area of juvenile develop-ment	Time in freshwater	Place of origin
Chinook salmon (Spring)	2 - 6	Mar - May	Early fall	streams, rivers, estuaries	90 days to 1 yr	hatchery & wild
Chinook salmon (Summer)	2 - 5	Jun - Jul	Late Sep - Nov	streams, rivers, estuaries	90 - 180 days	hatchery & wild
Chinook salmon (Fall)	2 - 5	Aug - Sep	Fall	streams, rivers, estuaries	90 - 180 days	hatchery & wild
Sockeye	3 - 5	Mar - Jul	Sep - Jan	lakes	1 - 2 years	wild in lakes
Coho salmon	2 - 3	Aug - Nov	Oct - Dec	streams, rivers, lakes	1 year	hatchery & wild
Chum salmon	3 - 5	Sep - Mar	Sep - Mar	estuaries	0 - 30 days	hatchery & wild
Pink salmon	2	Aug - Sep	Sep - Oct	estuaries	0 - 7 days	wild
Steelhead trout[1] (Winter)	4 - 6	Nov - Apr	Jan - Jun	streams, rivers	2 - 3 years	hatchery & wild
Steelhead trout[2] (Summer)	3 - 5	May - Oct	Jan - Jun	streams, rivers	2 years	hatchery & wild
Cutthroat trout[1] (Sea-run)	2 - 6	Jul - Dec	Dec - Jun	streams, rivers	1 - 4 years	hatchery & wild

[1]Less than 5 percent of returning fish are repeat spawners.

[2]Less than 1 percent of returning fish are repeat spawners.

Adults spawn in September and October (Brown 1994). Typically, redds are built by a single pair. Eggs incubate until about March (Brown 1994), when fry emerge from the gravel and become free-swimming (Goetz 1989). Juveniles are territorial. They are found immediately above, on, or within the stream bed (Pratt 1992), often in pockets of slow water formed by cobbles and woody debris. Individuals less than about 4.3 inches long feed on aquatic insects, and their diet includes more fish as they become larger. Anadromous, adfluvial, and fluvial juveniles migrate downstream at age two or three (Brown 1994). Adfluvial bull trout mature for two to three years before they are ready to spawn (Brown 1994).

Adult bull trout move upstream beginning in April, and the majority reach tributary streams in August. The strength of homing to natal streams may vary with each population (Goetz 1989). Once there, they seek cover in deep pools, large woody debris, and undercut banks until it is time to spawn. Males may spawn more than once in a single season (Goetz 1989), and both males and females, can spawn in either successive or alternate years (Brown 1994). After spawning, adults return to the sea, lake, or mainstem river, depending on their life history.

Bull trout are a cold-water species; they are often found near cold perennial springs. The development of eggs and alevins requires very cold water, optimally between 35.6° and 39.2° F (Goetz 1989). In Washington, the most intense spawning occurs in water that is 41° to 42.8° F (Brown 1994). Adults prefer deep pools of cold water and are seldom found in streams warmer than 64.4° F (Brown 1994).

Eggs, alevins, and fry require clear water. The embryonic stages remain in the redd for about 223 days (Goetz 1989), and this prolonged period makes them highly susceptible to the deposition of fine sediments, which can reduce the flow of oxygenated water through the redd or can entomb emerging fry (Pratt 1992). Fry are bottom dwellers and prefer small pockets of slow water formed by cobbles and large woody debris. When sediment fills these pockets, they become less suitable as rearing habitat. Juvenile densities decline as this occurs (Pratt 1992).

Habitat complexity provided by woody debris affects stream carrying capacity and survival rates. Population densities increase or decrease with the amount of woody debris (Rieman and McIntyre 1993) that provides protection from predators and enhances overwinter survival (Rieman and McIntyre 1993).

Bull trout are adversely affected by human activities in the same ways that salmon are. Removing riparian vegetation can lead to higher water temperatures, increased sediment loads, and decreased amounts of instream large woody debris (Ratliff and Howell 1992; Murphy and Meehan 1991). The requirements of the eggs and alevins make them highly susceptible to habitat degradation. Juvenile rearing habitat may be an ecological bottleneck that affects the viability of populations (Brown 1994). Of the 46 bull trout/Dolly Varden populations identified within the five west-side planning units and the Olympic Experimental State Forest, 56 percent are impacted by forest management (Mongillo 1993).

Bull trout populations have also been harmed by dams, overfishing, and agriculture as well as by exotic species. Dams block or delay migration, affecting 21 percent of the 77 bull trout/Dolly Varden populations in Washington (Mongillo 1993). Overharvesting by sports fishermen (Mongillo 1993) affects 27 percent of the populations. Agriculture, including grazing, affects 25 percent of the populations. Through competition and hybridization, brook trout (*S. fontalis*), a closely related species introduced to Washington from the eastern United States, poses a threat to 31 percent of the populations (Mongillo 1993).

Salmonid Habitat Needs and the Riparian Ecosystem

Because the life cycles and freshwater habitat needs are similar for the various western Washington anadromous salmon species and bull trout, the following discussion applies to all of them. All freshwater life stages of salmonids require moderate stream flows; cool, well-oxygenated, unpolluted water; low suspended-sediment load; adequate food supply; and structural diversity provided by submerged large woody debris (Cederholm 1994). Well-functioning riparian ecosystems are necessary to satisfy these habitat needs.

The riparian ecosystem is where aquatic and terrestrial ecosystems interact. From water's edge to upland, there exists a continuum of physical and biological characteristics. Nevertheless, the riparian ecosystem can be effectively modeled as three unique zones: an aquatic zone, a riparian zone, and a zone of direct influence (Naiman et al. 1992; see Figure III.1). The aquatic zone is the location of aquatic ecosystems. Adjacent to the aquatic zone is the riparian zone, a narrow band of moist soils and distinctive vegetation. Beyond the riparian zone lie upland areas, and the spatial extent of upland influences on aquatic ecosystems delineates the direct influence zone. The health of the aquatic ecosystems is affected by terrestrial products and processes, most notably shade, soil erosion, litter (e.g., fallen leaves, twigs, and conifer needles), and large woody debris (e.g., tree trunks) (Cederholm 1994). Salmonids inhabit the aquatic zone, but, in effect, their habitat encompasses the entire riparian ecosystem.

THE AQUATIC ZONE

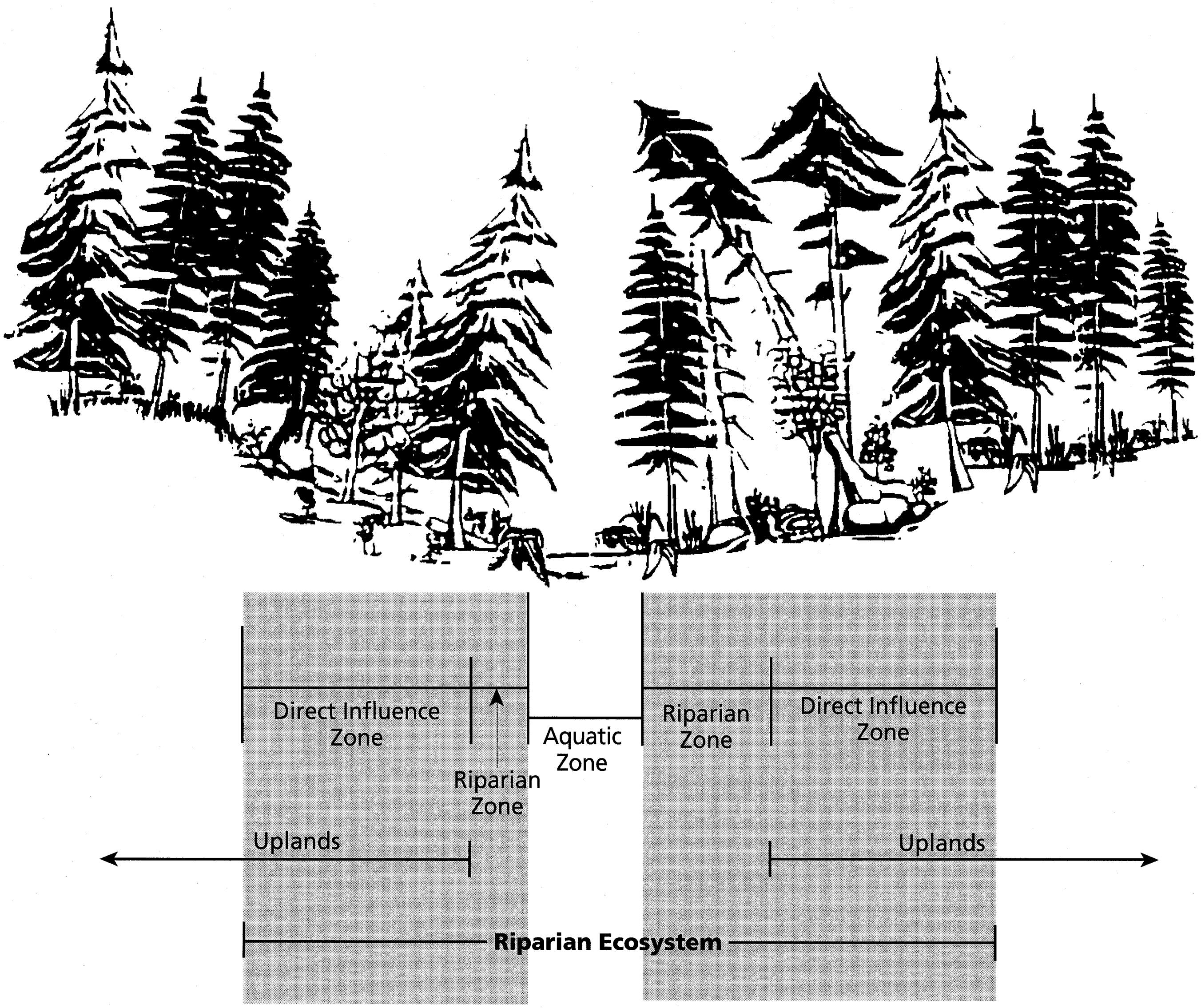
Each salmonid life stage has slightly different critical habitat requirements, and a lack of suitable habitat for a single life stage could affect the viability of an entire stock. Eggs incubating in a redd require a high concentration of dissolved oxygen, which is a function of several environmental variables: water temperature, biological oxygen demand, stream flow, and sediment load (Bjornn and Reiser 1991). High water temperatures decrease the solubility of oxygen in water. High biological oxygen demand, caused by microbial decomposition of organic materials, also decreases the amount of oxygen available to the developing egg. Inadequate streamflow reduces the circulation of fresh oxygenated water through the gravel to the redd as well as the removal of the egg's metabolic wastes (Bjornn and Reiser 1991). Fine sediments settle into the spaces between gravel, which also impedes the flow of water to the eggs (Everest et al. 1987). Excessive streamflow (floods) can destroy redds.

Alevins reside in the redd and have similar needs for clean, cool, well-oxygenated water. Sediment load can affect alevins in an additional way. If the spaces between gravel are blocked by fine sediments, then emerging individuals may be entombed within the redd (Everest et al. 1987).

The survival of fry and parr is determined by water quality (temperature, dissolved oxygen, and suspended sediment), food, cover, and space (Bjornn and Reiser 1991). Water temperature affects the rate of growth and development — all cold-water fish cease growth at temperatures above 68.5° F (Reiser and Bjornn 1979). Salmonids are cold-water fish, and their preferred temperature range is between 50° and 57° F (Bjornn and Reiser 1991).

Figure III.1: The riparian ecosystem

Although the riparian ecosystem is a continuum from water's edge to upland, the lines approximate the natural zonation of a riparian forest landscape, i.e., the extent of the riparian ecosystem and the zones within the ecosystem. (Adapted from: Sedell et al. 1989)



The upper lethal temperature limit lies between 73.4° and 78.4° F (Reiser and Bjornn 1979), and the lower lethal temperature limit is near 32° F (Bjornn and Reiser 1991).

Large amounts of small organic material, high temperatures, and low flows can reduce dissolved oxygen to harmful levels (Bjornn and Reiser 1991). High loads of suspended sediment may abrade and clog fish gills (Reiser and Bjornn 1979). Too much fine sediment may indirectly affect juveniles by destroying their food supply (Reiser and Bjornn 1979).

Stream productivity and riparian vegetation are two factors that affect the density of insects, the principal prey of juveniles. The amount of small organic material, or detritus, present in a stream is an important variable affecting stream productivity (Bjornn and Reiser 1991). High stream productivity leads to high densities of herbivorous aquatic insects. Terrestrial insects enter streams by falling or being blown off vegetation; this input has been found to be an important component of the prey base (Reiser and Bjornn 1979).

Depending on the species, juveniles exhibit varying degrees of territorial behavior (Emmett et al. 1991). Territoriality limits the amount of space shared among individuals of the same species, and therefore, as species become more territorial, stream carrying capacity becomes more a function of space. In addition to habitat complexity, space is a function of streamflow and water depth (Bjornn and Reiser 1991). Off-channel areas function as essential over-wintering habitat for juveniles. Side-channels and wetlands are used by juveniles to escape high flows in the main channel.

Juveniles are highly susceptible to predation by other fish and terrestrial animals. Riparian vegetation, undercut banks, submerged boulders and logs, turbulent water, and aquatic vegetation create places where fish can avoid predators (Bjornn and Reiser 1991). Cover also creates shaded areas that provide the preferred microclimatic conditions of many juvenile salmonids (Reiser and Bjornn 1979).

The survival of smolts is affected by many factors. Smolts require stream flows adequate to direct their migration (Bjornn and Reiser 1991). Relatively high temperatures may interfere with the parr-to-smolt transition (Bjornn and Reiser 1991). Smolts use pools to rest and cover to reduce the threat of predation.

Stream flow, barriers, and water quality are the main factors that can affect the upstream migration of returning adults. If the environment along the migration route is too stressful, then adults may not survive the migration or possess sufficient energy for spawning. Adults may halt migration if water is too warm, too turbid, or poorly oxygenated (Bjornn and Reiser 1991). Barriers (dams, culverts, log jams) and inadequate stream flows may impede or completely block the movement of adults upstream. Adults use pools for resting and the security of cover. Because adults feed infrequently or not at all during their spawning migration, the prey base is less important during this stage of the life cycle.

Suitable spawning habitat requires the proper substrate and adequate cover, stream flow, and water quality. The different species of salmonid typically spawn in different parts of the stream network. Cutthroat trout and coho generally use small tributaries, while steelhead trout, pink, and chinook salmon use larger tributaries and the upper reaches of mainstream stems. Sockeye use stream areas linked to lakes. Bull trout use cold water tributaries. The size of preferred spawning gravel and the depth and velocity of water at spawning sites is related to adult size. Lengths of adult salmonid species range from about 8 inches for cutthroat to 58 inches for chinook (Emmett et al. 1991). This results in preferred spawning conditions ranging from sand and pebbles (for cutthroat) to cobble (for chinook), as well as the occurrence of redds in nearly all fishbearing streams containing suitable habitat. Most species spawn in gravel between 0.5 inches and 4 inches in diameter. The area utilized for spawning also varies across species. A single pair of chinook requires about 24 square yards; a trout pair needs about 2 square yards.

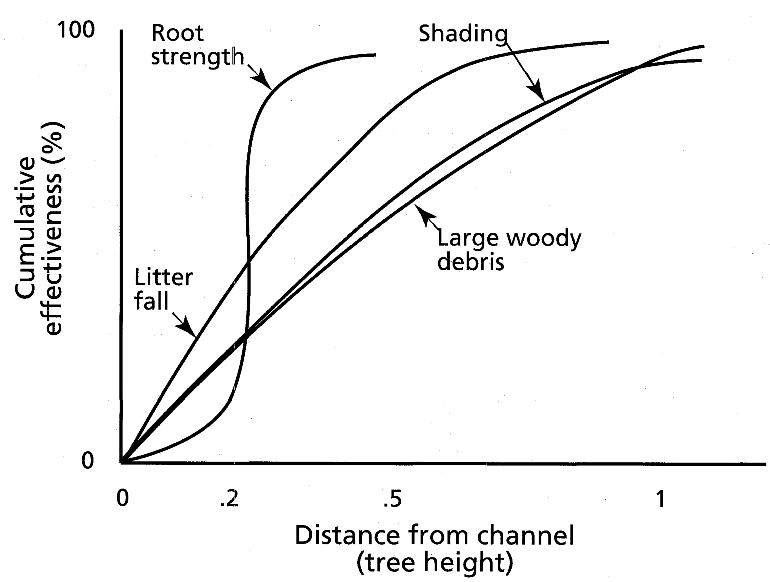
Salmonids benefit in each stage of their life cycles from high structural complexity. High structural complexity corresponds to high diversity in the size, location, and variety of physical, hydrological, and biological elements. A variety of gravels, pools of various depths, riffles, eddies, side channels, undercut banks, boulders, aquatic vegetation, amount of cover, and large woody debris are among the elements that contribute to structural complexity. The most important of these is large woody debris (Cederholm 1994). For streams coursing through intact riparian ecosystems, large woody debris continually influences the physical and biological processes affecting salmonid habitat. The importance of large woody debris to riparian ecosystems is discussed below.

THE DIRECT INFLUENCE ZONE

The degree to which aquatic ecosytems and terrestrial ecosystems interact decreases as the distance from surface water increases (FEMAT 1993; Cederholm 1994) (Figure III.2). The finite width of the riparian ecosystem is a result of this inverse relation. The terrestrial ecosystem principally affects water temperature, stream bank stability, sediment load, and detrital nutrient load of the aquatic ecosystem, and it is the source of large woody

Figure III.2: Relation between effectiveness of terrestrial elements of salmonid habitat and distance from stream channel

Root strength influences stream bank stability. Litter fall contributes organic nutrients to the aquatic food chain. Large woody debris performs many physical and biological functions essential to habitat quality. (See text.) (Modified from FEMAT 1993)



debris (Cederholm 1994; FEMAT 1993). Suitable salmonid habitat exists within ranges of variability for each of these key habitat elements and is best described by the natural regime under unmanaged conditions. From the perspective of forest management, the demonstrable effects of the direct influence zone on these key elements of salmonid habitat provide a guide for the development of riparian conservation strategies.

Water Temperature

Water temperature is principally a function of vegetative cover. Over-stream riparian vegetation moderates energy flow into and out of aquatic ecosystems (Chamberlin et al. 1991). Removing riparian vegetation and the shade it provides increases summer water temperatures. Lower winter water temperatures may also occur because removing riparian vegetation (Chamberlin et al. 1991) allows heat to escape. Steinblums et al. (1984) found that local topography (slope) and forest stand density (basal area) were the most statistically significant variables determining the amount of stream shading (angular canopy density). In general, riparian buffer widths are not a good predictor of shade protection (Steinblums et al. 1984; Beschta et al. 1987). Nevertheless, Beschta et al. (1987) claim that buffer widths of 100 feet or more will provide the same level of shading as that of an intact old-growth forest stand, whereas Steinblums et al. (1984) showed that in some cases buffer widths of 125 feet or more may be necessary to achieve this level of shading.

The degree to which water temperature is affected by riparian vegetation is a function of stream size (Chamberlin et al. 1991). For example, the temperature of shallow water bodies responds more quickly to changes in air temperature, and the temperature of small streams is more sensitive to changes in riparian vegetation because the forest canopy covers a higher proportion of the stream's surface (Chamberlin et al. 1991).

Stream Bank Stability

Riparian vegetation stabilizes stream banks. Therefore, removing vegetation leads to increased mass wasting (such as landslides) and sediment loading (amount of suspended and deposited sediments). The strength and density of the root network play a critical role in stream bank stability. Root strength declines appreciably at distances greater than one-half a tree crown diameter (FEMAT 1993). Therefore, the most important trees for bank stability lie within one-half a tree crown diameter from the stream bank. Likewise, the size and density of trees growing along a stream should be key variables determining bank stability, but no studies have investigated the relationship between relative density and stream bank stability.

Sediment Load

Sediment load can be increased by natural mass-wasting processes, timber harvesting, and roads (Cederholm 1994; Chamberlin et al. 1991). Riparian buffers can intercept sediments flowing from upland human-caused disturbances. Studies (Lynch et al. 1985; Moring 1982) have found that buffer strips of approximately 100 feet are effective in intercepting sediments from clearcuts. Broderson (1973) suggested that on slopes less than 50 percent (27 degrees), a riparian buffer at least 50 feet wide is needed to control the overland flow of sediments. On steep slopes greater than 50 percent, he suggested that buffers as wide as 200 feet would be effective in protecting water quality. Further discussion of sediments appears in the subsection titled Upland Influences on Salmonid Habitat.

Nutrient Load

The amount of instream small organic material, or detritus, affects stream productivity (Bjornn and Reiser 1991). Higher stream productivity leads to higher densities of herbivorous aquatic invertebrates. In forested small- and medium-order streams, riparian vegetation is the primary source of detritus (Gregory et al. 1987; Richardson 1992). Removal of vegetation along headwaters will lessen this input and may significantly affect stream productivity throughout a watershed. For a watershed in eastern Quebec, estimates showed that approximately 23 percent of the annual particulate organic load collected at the bottom of the watershed was contributed by first-order streams (comparable to Types 4 and 5 streams as defined in WAC 222-16-030) (Conners and Naiman 1984). This finding suggests that upper headwater areas without fish contribute detrital input to downstream segments that support fish. However, the importance of this upstream contribution to detrital input is not known.

Stand age and canopy cover significantly influence detrital input to a stream system. Old-growth forests contribute approximately five times as much detritus to streams as clearcut forests (Bilby and Bisson 1992). Richardson (1992) found that old-growth forests contributed approximately twice as much detritus as either 30- or 60-year-old forests. However, even though streamside timber harvest reduces detrital input, the resulting reduction in forest canopy in the riparian zone leads to increased light levels and algae production in the aquatic zone, which in turn produces detritus in the stream (Bilby and Bisson 1992).

Richardson (1992) estimated that 70 to 94 percent of all leaves that enter a stream segment are transported downstream. Some detritus added to streams originates from beyond the immediate streamside area. The maximum source distance of instream detritus is not known, but it has been estimated that 14 to 25 percent of the total litter input is blown in (Richardson 1992).

Erman et al. (1977) found that the composition of invertebrate communities in streams with riparian buffers wider than 100 feet was indistinguishable from those of unlogged streams. From this result, FEMAT (1993) inferred that riparian buffers at least 100 feet wide delivered sufficient small organic material to maintain a diverse aquatic community (Figure III.2).

Large Woody Debris

Large woody debris is the most important link between terrestrial and aquatic ecosystems, acting on stream flows to create essential elements of salmonid habitat — pools, riffles, side channels, and undercut banks (Swanston 1991; Maser et al. 1988). Large woody debris causes lateral migration of the stream channel, creating backwaters along stream margins and increasing variations in depth (Maser et al. 1988). Large woody debris also serves as cover from predators and competitors (Bjornn and Reiser 1991), and this cover may create preferable microclimatic conditions as well. Large woody debris moderates the energy of stream flows, thereby decreasing streambed scour and bank erosion. Dams formed by logs perform at least three functions:

(1) They store fine sediments in Types 4 and 5 streams that would adversely affect downstream spawning areas and invertebrate populations.

(2) They retard the flow of nutrients down the channel, thus increasing stream productivity.

(3) They retain gravel of various sizes essential to spawning (Bisson et al. 1987).

Gravel and nutrients retained by large woody debris are the substrate for the growth of some aquatic vegetation.

During floods, large woody debris in the riparian zone is important for the maintenance and development of riparian soils. Large woody debris performs at least three functions during floods:

(1) it moderates the energy of stream flows,

(2) it stabilizes soils, and

(3) it traps suspended sediments and organic nutrients.

The saturated soils of some riparian zones may impede the regeneration of conifer species. Large woody debris enhance conifer regeneration by acting as nurse trees.

Through stream bank erosion, windthrow, tree mortality, and beaver activity (Bisson et al. 1987), the riparian zone supplies nearly all large woody debris. The probability that a falling tree will enter a stream is a function of distance from the channel and tree height (Van Sickle and Gregory 1990). For a riparian forest stand of uniform height, mathematical models demonstrate that large woody debris input to streams is theoretically maximized when the riparian buffer width is equal to the height of the forest stand (Van Sickle and Gregory 1990). The same models show that the function relating input of large woody debris to buffer width is nonlinear. Ninety percent of the theoretical maximum is reached when a buffer width equals approximately 40 percent of the forest stand height (Van Sickle and Gregory 1990).

In old-growth forests of southeastern Alaska, Murphy and Koski (1989) found that the sources of 90 percent of instream large woody debris were within approximately 50 feet (slope distance) of the stream bank. The approximate average height of trees along the streams in this study area was 130 feet. In effect, Murphy and Koski (1989) showed that riparian buffer widths equal to 40 percent of an average tree height will recruit almost all potential large woody debris. Measurements from sites in western Washington and Oregon indicate that in old-growth conifer forests (average tree height 189 feet, range 164 to 262 feet) riparian buffers 120 feet wide (slope distance) would be 90 percent effective in delivering large woody debris to aquatic ecosystems, and that in mature conifer forests (average tree height 157 feet, range 131 to 213 feet) the same level of effectiveness would be provided by buffer widths of 90 feet (McDade et al. 1990). In terms of tree height, McDade et al. (1990) show that 90 percent of the potential large woody debris lies within a zone whose width is about 60 percent of the height of the average tree in the riparian ecosystem.

To date, studies making forest management recommendations for the recruitment of large woody debris have not considered the lateral migration of the stream channel (Murphy and Koski 1989; Robison and Beschta 1990; McDade et al. 1990; WFPB 1994). Stream channels are dynamic, and static riparian buffers, which today provide adequate large woody debris, may fail to do so after decades of stream migration. For long-term protection of larger streams (Types 1, 2, and 3) in low-gradient unconfined channels, riparian buffers may need to exceed the recommended minimums.

Instream stability and longevity of large woody debris are assumed to be important for its ecosystem function (Bisson et al. 1987). Stability is a function of size, with debris length relative to stream width having the greatest effect (Bisson et al. 1987). Instream longevity of large woody debris is a function of both size and species: larger pieces are more resistant to breakage, and conifers are more resistant to fragmentation and decomposition than red alder (Bisson et al. 1987), a hardwood often associated with riparian areas. Short harvest rotations in managed forests along streams produce trees that are too small to function properly as instream large woody debris.

UPLAND INFLUENCES ON SALMONID HABITAT

Hydrology and geomorphology link upland areas with the riparian ecosystem. Upland areas contribute water and sediment to the riparian ecosystem, and forest practices alter the physical processes that control delivery rates.

Water Quantity

Water quantity, or stream flow, can be modeled as annual precipitation minus annual evapotranspiration (Swanston 1991). The model is a useful approximation of real hydrological processes and has an important implication: there is a strong causal link between forest cover and stream flow. Within a watershed, the fraction of land that is forested is one of the most important variables affecting annual runoff (Chamberlin et al. 1991; Hicks et al. 1991). Forest harvest reduces the amount of both intercepted precipitation and evapotranspiration. In some cases, this produces an increase in annual water yield and stream flow during seasons of low flow, which is thought to have a short-term beneficial effect for some aquatic resources (Cederholm 1994). In other cases, a reduction in fog interception and drip may decrease water yield and summer low flows (Harr 1982).

Excessive peak flows can produce dramatic changes in stream channel form and function. Forest management that significantly increases the magnitude or frequency of peak-flow events can result in long-term damage to riparian ecosystems and the loss of salmonid habitat. Peak-flow events can destabilize and transport large woody debris, fill pools with sediments, and destroy salmon redds. Structurally complex channels containing large woody debris and composed pools, riffles, and side channels can be transformed to simple uniform channels with limited habitat value to salmonids.

After timber harvest, annual water yield in a watershed changes. When annual water yield returns to pre-harvest levels, the forest stand is said to be “hydrologically mature” with respect to those processes (principally interception and evapotranspiration) that affect annual water yield. In other words, when a given hydrologic variable (e.g., annual water yield, low and peak flow levels) for a young forest stand is similar to that of a mature forest stand, then the young stand is said to be hydrologically mature with respect to those processes that affect that variable.

Forest practices that affect winter snow accumulation and melt can have significant long-term detrimental impacts on aquatic resources. Basin-wide cumulative effects of reducing mature forest cover may lead to peak flows that damage stream beds when the windy and warmer conditions associated with large rainstorms cause the quick melting of shallow snowpacks that have accumulated during the winter. These are known as rain-on-snow events. The initiation of many landslides is linked to rain-on-snow events. For example, Harr (1981) reported that 85 percent of all landslides in small watersheds in western Oregon were associated with rain-on-snow events. In western Washington, rain-on-snow events are most common and most severe between 1,200 feet and 4,000 feet in elevation — the rain-on-snow zone (WFPB 1994). Forest canopy density is the principal feature determining the hydrologic maturity of a forest stand with respect to rain-on-snow discharge (Harr 1981; Coffin and Harr 1992). Young conifer forests reach hydrological maturity with respect to rain-on-snow peak flows between ages 25 and 35. The state Forest Practices Board (WFPB 1994) defines maximum rain-on-snow hydrological maturity as a forest stand with greater than 70 percent crown closure and less than 75 percent of the crown in hardwoods or shrubs.

Wetlands are a primary part of the permanent soil and ground water hydrology of forests in many watersheds. Their influence on stream flow has been repeatedly demonstrated (Winter 1988; Waddington et al. 1993). Wetlands also moderate storm flow and store the water for future discharge (Richardson 1994). Specifically, wetlands augment low flows by releasing stored water to streams or ground water. Modification of wetlands through channelization or timber harvest can increase storm discharge, produce more frequent channel eroding flows downstream, and reduce water storage and discharge during summer low-flow periods.

Water quality is also influenced by wetland function. Because wetlands slow water flow, they allow sediments to precipitate or adhere to vegetation. Oberts (1981) found that watersheds with less than 10 percent wetlands had suspended-solid loading rates per unit area that were as much as 100 times greater than those of watersheds with more than 10 percent wetlands.

Sediments

Sediments are delivered naturally from uplands to riparian ecosystems primarily through landslides. These large-scale random events add large quantities of material to the stream network rapidly. In undisturbed watersheds, the concentration of sediments increases substantially during storms, and much of this increase is the direct result of soil mass-wasting (landslides) (Swanston 1991). Mass-wasting occurs when gravitational force overcomes the strength of soil materials. Slope stability is strongly affected by the steepness and form of the slope, thickness of the soil layer, and amount of moisture in the soil. Typically, landslides occur where local changes in the water table increase soil saturation, which in turn decreases the friction between soil particles to the point that they slide down the slope under the force of gravity. Three groups of general mass-wasting processes affect riparian ecosystems: slumps and earth flows, debris avalanches, and debris torrents. Slumps are deep-seated failures that generally develop as a result of long-term water accumulation. Earth flows typically begin with a slump and are slow moving — from 1 inch to 90 feet per year (Swanston 1991). Debris avalanches are shallow rapid landslides and constitute some of the most common soil mass movements (Swanston 1991). Debris torrents are large quantities of soil, rock, and large woody debris suspended in a slurry that rapidly flows down steep stream channels. Debris torrents are typically a consequence of the flood outburst when dams created by debris avalanches fail.

The presence of clearcut units in a watershed increases the likelihood of mass-wasting events (Swanson and Dyrness 1975; Swanson et al. 1987). Timber harvest affects the landsliding process in four ways. First, transpiration is decreased with tree removal. Decreased transpiration increases soil moisture and tends to raise water-table levels, thus increasing the risk of slope failure. Second, the forest canopy can intercept significant quantities of precipitation, and its removal leads to increases in soil moisture. Third, timber harvest may disturb the soil in such a way as to create macropores in the soil; these macropores act as conduits that facilitate soil saturation. Fourth, tree harvest results in stump roots that decay, which decreases soil strength and can increase the frequency of landsliding until new root systems are established. This period of decreased stability lasts for approximately 5 to 20 years after harvest (Sidle et al. 1985).

Roads in upland areas have significant detrimental impacts on salmonid habitat. In few locations can roads be built that have no negative effects on streams (Furniss et al. 1991). Landslides resulting from road construction are considered a significant source of sediment input into streams (Wu and Swanston 1980; Chesney 1982; Everest et al. 1987; Sidle 1985). In the Pacific Northwest, roads appear to contribute more to landslides than clearcutting, although this association varies substantially with location (Sidle et al. 1985) and seems to be highly dependent on watershed hydrology and geomorphology (Duncan and Ward 1985). Cederholm et al. (1981) reported a significant positive correlation between fine sediment in spawning gravels and the percentage of basin area covered by roads.

Status and Distribution

In western North America, anadromous salmonids range from mid-California to the Arctic Ocean (Meehan and Bjornn 1991). Their historic distribution included southern California and Mexico (Wilderness Society 1993). Freshwater salmonid habitat extends eastward into Idaho, i.e., the Snake River and its tributaries. All species from the Pacific Northwest migrate out into the Pacific Ocean, some traveling as far north as the Bering Sea. Anadromous salmonids occupy all of Washington except the area north of the Snake River drainage and east of the Columbia River in central Washington and the area east of the Okanogan Highlands in northeastern Washington (WDF 1993).

Bull trout are found in the Rocky Mountains, Cascade Range, and Olympic Mountains of the northwestern United States and southwestern Canada (Meehan and Bjornn 1991). Populations exist in Washington, Oregon, Idaho, western Montana, northern California, northern Nevada, British Columbia, and Alberta.

STOCKS AND EVOLUTIONARILY SIGNIFICANT UNITS

Fisheries management of salmon is normally done according to runs, which are aggregations of stocks. A stock is a discrete breeding population. The Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993) has defined stock to be:

> The fish spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season (p. 10).

The spatial or temporal reproductive isolation required by this definition is reflected in the names given to stocks, e.g., "Nisqually River winter steelhead" or "Snohomish River fall chinook". Stocks may possess distinct biological characteristics (e.g., physical appearance, habitat preferences, genetics, or population demography), but not necessarily. As noted by Meehan and Bjornn (1991), "stock" can be considered synonymous with "subspecies."

The Endangered Species Act defines species as "any distinct population-segment of any species of vertebrate fish or wildlife which interbreeds when mature" (16 U.S.C. 1532(15)). For purposes of the Endangered Species Act, salmon stocks are grouped into populations known as Evolutionarily Significant Units (ESU). If conditions warrant federal listing of a salmon, it is the stated intention of National Marine Fisheries Service to list ESUs, rather than an entire salmon species or individual stocks (Federal Register v. 56, p. 58612-8). (Bull trout have not been separated into ESUs.)

An ESU is a population that (1) is substantially reproductively isolated from other population units of the same species and (2) represents an important component in the evolutionary legacy of the species (Waples 1991). The first criterion is essentially the same as the Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993) definition of a stock. The second criterion requires that sub-populations in separate ESUs possess significant genetic or other biological differences. As a result, many stocks are lumped into a single ESU. For example, agencies in Washington, Oregon, and California have identified more than 200 distinct stocks of coho salmon. These stocks have been grouped into six ESUs. Washington contains at least 90 stocks of coho (WDF et al. 1993), and these are distributed among three ESUs.

SALMONID STATUS IN THE PACIFIC NORTHWEST

Nehlsen et al. (1991) assessed extinction risks for 214 native naturally spawning salmonid stocks occurring in Idaho, Washington, Oregon, and northern California. They defined three risk categories: high risk of extinction, moderate risk of extinction, and special concern. Stocks with a high or moderate risk of extinction have likely attained the threshold for listing under the Endangered Species Act. Stocks with a moderate risk have a larger number of spawning adults each year than do stocks with a high risk. Stocks of special concern have not attained the threshold for listing, but do face some risk of extinction or possess some unique characteristic that requires attention. Nehlsen et al. (1991) estimated that 101 stocks in the Pacific Northwest had a high risk of extinction, 58 had a moderate risk, and 54 were of special concern.

Under the Endangered Species Act, the National Marine Fisheries Service regulates salmon, and it has declared several different salmonid populations as threatened or endangered. The agency listed Sacramento River winter chinook as threatened in 1990 (Nehlsen et al. 1991) and Snake River sockeye as endangered in 1991 (Federal Register v. 56, no. 224, p. 58619-24). Spring/summer and fall runs of Snake River chinook were listed as threatened in 1992 (Federal Register v. 47, no. 78, p. 14653-5). In March 1995, the steelhead populations in the Klamath Mountain of northern California were proposed for listing as threatened (Federal Register v. 60, no. 51, p. 14253-61).

The National Marine Fisheries Service initiated status reviews for west coast steelhead trout in May 1993 and coho salmon in October 1993 (Federal Register v. 58, no. 206, p. 57770-1; v. 59, no. 102, p. 27527-8). The status review for steelhead is expected to be completed in 1996. The status review for coho, completed in July 1995, proposed that the species be federally listed in Oregon and California, but not in Washington (Federal Register v. 60, no. 142, p. 38011-30).

The federal government initiated coastwide status reviews for the other five anadromous salmonids in September 1994 (Federal Register v. 59, no. 175, p. 46808-10). The first of these reviews, for pink salmon, was to be completed in 1995. Completion of the status reviews for chum, sockeye, and chinook salmon, and sea-run cutthroat will probably occur in 1996. The federal listing of salmonid species could be followed by federal regulations pertaining to forest practices on nonfederal lands.

The bull trout is regulated by the U.S. Fish and Wildlife Service and was made a category 2 candidate for federal listing in 1985 (Federal Registery, v. 50, no. 181, p. 37958-67). In response to petitions, the U.S. Fish and Wildlife Service began a rangewide status review in May 1993. This review, completed in June 1994, concluded that the status of the bull trout warranted its listing as a threatened species, but listing was precluded by other higher priority actions. At that time, the species was assigned a listing priority number of 9 (on a scale of 1 to 12, with 1 being the highest priority) and made a category 1 candidate. In April 1995, the species was moved up to a listing priority number of 3. Dolly Varden is not a federal candidate.

SALMONID STATUS IN WASHINGTON

The Washington State Salmon and Steelhead Stock Inventory (WDF et al. 1993) identified 435 distinct salmonid stocks in Washington. Information for 322 stocks was adequate to assess their status, and of these, 38 percent were classified as depressed, 4 percent as critical, and 58 percent as healthy (WDF et al. 1993). A depressed stock is one "whose production is below expected levels based on available habitat" (WDF et al. 1993 p. 30), and a critical stock is one for which "permanent damage to the stock is likely or has already occurred" (WDF et al. 1993 p. 30).

Nehlsen et al. (1991) compiled a list of Pacific Northwest salmon stocks threatened with extinction. For stocks in Washington, their list describes 47 as having a high risk of extinction, 18 as having moderate risk, and 27 as being of special concern. A partial list of extinct stocks (Nehlsen et al. 1991) includes 42 stocks from Washington.

Using a different definition, Williams et al. (1989) listed the bull trout as a species of special concern. In Washington, 77 separate bull trout/Dolly Varden populations have been identified (Mongillo 1993). Information was adequate to determine the status of only 34 populations. Of these, nine were considered to have a high risk, six a moderate risk, and 13 a low risk of extirpation.

SALMONID STATUS IN THE AREA COVERED BY THE HCP

The riparian conservation strategies proposed under this HCP will be applied to only the HCP planning units west of the Cascade crest. Therefore, the discussion of stock status in the area covered by the HCP is confined to those planning units. There are 387 distinct salmonid stocks in these HCP planning units (WDF et al. 1993). The status of these stocks is summarized in Table III.10. For those 277 stocks for which a status could be determined, 32 percent were depressed, 4 percent were critical, and 64 percent were healthy (WDF et al. 1993). Nehlsen et al. (1991) rated 40 stocks as having a high risk of extinction and 12 as having a moderate risk. Bull trout and Dolly Varden were not included in either the Washington State Salmon and Steelhead Stock Inventory or Nehlsen et al.

DISTRIBUTION ON DNR-MANAGED LANDS IN THE FIVE WEST-SIDE AND THE OLYMPIC EXPERIMENTAL STATE FOREST PLANNING UNITS

To determine the distribution of species of anadromous salmonids on DNR-managed lands covered by the HCP, DNR staff performed an analysis using the agency's computerized geographic information system with input from

Table III.10: Status of salmonid stocks in the five west-side planning units and the Olympic Experimental State Forest

Species[1]	Status (Source: WDF et al. 1993)				Extinction risk (Source: Nehlsen et al. 1991)		
	Healthy	Depressed	Critical	Unknown	High	Moderate	Special Concern
Coho	37	33	1	18	7	0	1
Chinook	46	17	4	14	15	0	1
Chum	48	3	2	18	4	3	0
Sockeye	1	4	1	1	1	1	0
Pink	9	2	2	2	2	1	0
Steelhead	36	30	1	57	9	7	10
Sea-run cutthroat[2]	—	—	—	—	2	1	8
Total stocks	**177**	**89**	**11**	**110**	**40**	**12**	**21**

[1]Bull trout and Dolly Varden were not included in the WDF et al. (1993) or Nehlsen et al. (1991) studies

[2]Species not included in WDF et al. (1993)

the Washington Department of Fish and Wildlife's Washington Rivers Information System, which identifies all streams that salmonids are known or expected to inhabit. Digital data are to the 1:100,000 scale, and the presence of fish species is recorded by river reach.

Using this database, all Watershed Administrative Units (WAUs) that are known or thought to contain salmonids were tabulated. Over 80 percent of DNR-managed lands west of the Cascade crest in the area covered by the HCP are in WAUs that contain coho, chinook, and steelhead (Table III.11). Smaller percentages of DNR-managed lands are in WAUs that contain the other four anadromous salmonids and bull trout/Dolly Varden. All DNR-managed lands in the Olympic Experimental State Forest are in WAUs that contain coho and steelhead (Table III.11). With the exception of the South Puget Planning Unit, all west-side planning units have at least 80 percent of their DNR-managed lands within WAUs that contain a salmonid species.

WAUs range in size from 10,000 to 50,000 acres. Given the relatively small area of WAUs compared to HCP planning units, DNR staff assumed that all fishbearing streams (Types 1, 2, and 3) in a WAU identified as containing a salmonid species are actually inhabited by that species. Using this extrapolation, the assessment shows that more than 1,000 miles of fishbearing streams on DNR-managed forest land in the five west-side and Olympic Experimental State Forest planning units potentially contain coho, steelhead, chinook, chum, and sea-run cutthroat (Table III.12). On the basis of stream miles, the density and distribution of salmonids vary widely among planning units. For example, the DNR analysis shows that the Olympic Experimental State Forest has more than 400 stream miles occupied by anadromous salmonids, whereas the North Puget Planning Unit has about 250 miles. All the fishbearing stream miles on DNR-managed land in the Olympic Experimental Forest and South Coast planning units contain at least one species of anadromous salmonid. At least 90 percent of fishbearing streams on DNR-managed land in the Straits, North Puget, and Columbia planning units contain a species of anadromous salmonid.

To estimate the potential impacts of forest practices activities on DNR-managed land, DNR staff assumed that (1) all managed land within a WAU affects salmonid habitat, and (2) impacts by individual landowners are proportional to the amount of land they manage within a WAU. For some WAUs, these assumptions may be weak. For example, DNR may manage 10 percent of a WAU, but that 10 percent affects 90 percent of the salmonid spawning habitat in that WAU. Nevertheless, this analysis provides a useful estimate of DNR's potential impacts on salmonid populations. DNR staff calculated the total area of WAUs identified as containing salmonid species as well as the total area of DNR-managed land within these WAUs. The ratio of these two numbers is the proportion of DNR-managed land that could affect salmonids. This proportion suggests the magnitude of the potential impact that DNR forest management may have on these species. For example, in the Olympic Experimental State Forest, on average, about 26 percent of all land that could impact salmonids is managed by DNR (Table III.13). For the five west-side planning units, on average, about 11 percent of all land that could affect salmonids is managed by DNR.

Differences in impacts by individual planning units among species reflect their geographical distribution (Table III.13). For example, pink salmon generally spawn in the lower reaches of coastal rivers (Emmett et al. 1991), and therefore, planning units with DNR-managed lands near the coast have a greater impact on this species. In the OESF, 33 percent of all land that could impact pink is managed by DNR, but in the South Puget Planning Unit, only 2 percent is managed by DNR.

Table III.11: Percent of DNR-managed forest land west of the Cascade crest in Watershed Administrative Units that contain salmonids

The five west-side planning units consist of South Coast, Straits, North Puget, South Puget, and Columbia. OESF is the Olympic Experimental State Forest. Each HCP planning unit contains several WAUs. (For more information on this, see the section in Chapter I titled Organization of the Planning Area.)

(Source: DNR GIS April 1995)

Planning Unit	Coho	Chinook	Chum	Sockeye	Pink	Steelhead	Sea-run Cutthroat	Bull Trout/ Dolly Varden	Total DNR-managed acres
South Coast	100	97	91	3	1	97	96	5	238,700
Straits	98	93	93	18	67	90	98	26	111,700
North Puget	82	80	77	48	62	81	37	74	396,400
South Puget	73	73	63	9	18	71	52	23	145,500
Columbia	81	67	39	25	0	78	81	23	289,300
Total for five west-side planning units	86	80	70	26	29	83	67	37	1,181,600
OESF	100	94	52	74	13	100	98	33	267,000
Total five west-side and OESF planning units	**88**	**83**	**67**	**35**	**26**	**86**	**73**	**36**	**1,448,600**

Table III.12: Estimated miles of fishbearing streams on DNR-managed lands west of the Cascade crest

Only Types 1, 2, and 3 waters are considered. OESF is the Olympic Experimental State Forest.

(Source: DNR GIS April 1995)

Planning Unit	Coho	Chinook	Chum	Sockeye	Pink	Steelhead	Sea-run Cutthroat	Bull Trout/ Dolly Varden	Total stream miles
OESF	418	388	232	326	63	418	410	121	418
South Coast	240	236	222	33	2	240	230	15	240
Straits	94	70	91	22	71	91	94	24	95
North Puget	258	239	245	138	198	258	84	233	284
South Puget	89	89	84	3	15	88	73	17	117
Columbia	236	208	144	76	0	227	230	91	263
Total	**1,335**	**1,230**	**1,018**	**598**	**349**	**1,322**	**1,121**	**501**	**1,416**

Table III.13: Percent of total land area west of the Cascade crest that impacts salmonids and is managed by DNR

DNR-managed lands in the Columbia Planning Unit have no pink salmon. The five west-side planning units consist of the Straits, North Puget, South Puget, South Coast, and Columbia. OESF is the Olympic Experimental State Forest.

(Source: DNR GIS April 1995)

Planning Unit	Coho	Chinook	Chum	Sockeye	Pink	Steelhead	Sea-run Cutthroat	Bull Trout/ Dolly Varden
South Coast	13	15	15	4	5	13	13	3
Straits	15	15	15	11	13	15	15	8
North Puget	13	14	15	14	13	13	15	14
South Puget	5	5	5	1	2	5	6	3
Columbia	14	13	13	16	—	14	13	15
Total for five west-side planning units	12	12	12	10	10	12	13	10
OESF	25	25	23	28	33	25	24	22

E. Other Species of Concern in the Area Covered by the HCP

For the purposes of this HCP, species of concern are defined as those wildlife species that are (a) listed by the federal government as threatened or endangered, (b) listed by the state as threatened, endangered, or sensitive, or (c) proposed as candidates for listing by the federal or (d) state government. Previous sections of this chapter discuss habitat needs of the federally listed species and of anadromous salmonids and bull trout. This section provides information on habitat needs of other federal candidate species and state-listed and state candidate species that have no federal status. The species are organized in the following taxonomic groups: mollusks, arthropods, fish, amphibians, reptiles, birds, and mammals. The section starts with Table III.14, which lists for each species its federal and state status and in which HCP planning unit each could potentially occur.

At the time of writing the draft HCP and the draft EIS, the U.S. Fish and Wildlife Service used a system of classifying species that were candidates for listing as threatened or endangered into separate categories. Category 1 species were those for which the Service had sufficient information to issue a proposal for listing. Category 2 species were those for which existing information indicated that listing was possibly appropriate but sufficient data did not exist on the biological status of the species or threats to that species to warrant the issuance of a proposed rule. Both category 1 and category 2 species were considered as species of concern in the draft HCP and Draft EIS. On February 28, 1996, the U.S. Fish and Wildlife Service published an updated list of candidate species using a revised categorization system (Federal Register v. 61, no. 40, p. 7596). Former category 1 species are now referred to simply as candidates for listing. Former category 2 species are no longer considered candidates for listing, though most of them have been retained on a list of federal species of concern (Federal Register v. 61, no. 40, p. 7596). There are now two species in the HCP Planning Area that are candidate species - the spotted frog and bull trout. This section reflects the change in federal candidate status of unlisted species of concern as of the date of HCP approval and issuance of the Incidental Take Permit. Descriptions of former category 2 taxa are retained and still considered species of concern for the purposes of this HCP. Additionally, there are six species that were formerly listed as federal category 2 that are considered sensitive but have no official state or federal status.

Table III.14: Other species of concern by federal and state status and their potential occurrences in the HCP planning units

Federal candidate - Substantial data support listing the species as endangered or threatened; listing proposals are either under way or delayed.

Federal species of concern - Data point to listing species but not conclusively; additional data are being collected.

Other sensitive species - formerly listed as federal category 2.

Under state status, S = state; E = endangered; T = threatened; C = candidate; M = monitor; G = game; Sen = sensitive.
OESF = Olympic Experimental State Forest.

		Planning Unit								
Species	**State status**	**Klickitat**	**Columbia**	**South Coast**	**South Puget**	**Yakima**	**Chelan**	**North Puget**	**Straits**	**OESF**
Federal candidate										
spotted frog	SC	X	X		X	X	X	X		
Federal species of concern										
Newcomb's littorine snail	SM			X						
California floater	—	X	X			X	X			
great Columbia River spire snail	SC	X	X							
Beller's ground beetle	SC				X			X		
Hatch's click beetle	SC				X			X		
Fender's soliperlan stonefly	—		X		X					
river lamprey	—		X	X	X			X	X	X
Pacific lamprey	—	X	X	X	X			X	X	X
Larch Mountain salamander	SSen	X	X							
tailed frog	SM	X	X	X	X	X	X	X	X	X
Cascades frog	—	X	X		X	X		X	X	X
northwestern pond turtle	SE	X	X		X			X		
northern goshawk	SC	X	X	X	X	X	X	X	X	X
olive-sided flycatcher	—	X	X	X	X	X	X	X	X	X
long-eared myotis	SM	X	X	X	X	X	X	X	X	X