Endangered Species Act - Section 7 Consultation

INTRA-SERVICE BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
01EWFW00-2015-F-0882

For the Issuance of an Enhancement of Survival Permit for the Safe Harbor Agreement for the City of Everett's Forestry on the Lake Chaplain Tract

Snohomish County, Washington

Federal Action Agency:
U.S. Fish and Wildlife Service

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

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Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

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Appendices

ACRONYMS AND ABRREVIATIONS

C	Celsius
CFR	Code of Federal Regulations
DNR	Washington Department of Natural Resources
ESA	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)
Everett	City of Everett
F	Farenheit
FR	Federal Register
g	grams
HCP	Habitat Conservation Plan
IA	Implementation Agreement
LCT	Lake Chaplain Tract
murrelet	marbled murrelet
Opinion	Biological Opinion
Permit	Enhancement of Survival Permit
PNT	Potential Nest Tree
Service	U.S. Fish and Wildlife Service
SHA	Safe Harbor Agreement
SOSEA	Spotted Owl Special Emphasis Area
spotted owl	northern spotted owl
WAC	Washington Administrative Code

INTRODUCTION

This document is the U. S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) based on our review of the proposed issuance of an Enhancement of Survival permit by the Service to the City of Everett, Washington, (Everett) for implementation of the Everett's Safe Harbor Agreement (SHA) for the Lake Chaplain Tract located in Snohomish County, Washington, and its effects on northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and gray wolf (*Canis lupus*), in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA).

This Opinion is based on information provided in the July, 2015, Safe Harbor and Cooperative Habitat Enhancement Agreements for the Lake Chaplain Tract, draft Categorical Exclusion, field investigations, and other sources of information as detailed below. A complete record of this consultation is on file at the Service's Washington Fish and Wildlife Office in Lacey, Washington.

CONSULTATION HISTORY

On April 4, 2013, the Service received a letter from Everett's Department of Public Works requesting assistance in developing a SHA to enhance and restore habitat benefitting the northern spotted owl (spotted owl) and marbled murrelet (murrelet) and to provide certain regulatory assurances to Everett.

From April 2013 to April 2015, the Service met with, and provided technical assistance to, Everett in the development of the SHA. The application for an Enhancement of Survival Permit (Permit) was received on December 10, 2014 The draft SHA, draft Implementation Agreement (IA), and NEPA categorical exemption were made available for a 30-day public comment period on May 5, 2015 (80 FR 25709). At the same time, a news release was sent to State and Federal elected officials, State and Federal agencies, Native American Tribes, non-governmental organizations, and the media. The Service initiated internal consultation on June 5, 2015

The following is a summary of important events associated with this consultation:

- Site visit(s) were conducted on May 28, 2013 and July 16, 2013
- The draft SHA was received on April 20, 2015
- Additional information necessary to initiate consultation was received on 4/23/2015
- Formal consultation was initiated on June 19, 2015
- Clarifying information on the acreage of riparian areas per Forest Practice rules was received on July 1, 2015
- Clarifying information on the scope of proposed road maintenance was received on July 10, 2015

CONCURRENCE

The Service proposes to issue a Permit to Everett to implement the SHA for the Lake Chaplain Tract (Lake Chaplain SHA). Under the Lake Chaplain SHA, Everett will manage forestland and forest roads to enhance and maintain habitat for murrelets and spotted owls while continuing to generate revenue from forest management operations. The SHA describes forest retention and harvest patterns, silvicultural prescriptions, and species-specific conservation measures related to forest and road management.

The Lake Chaplain Tract (LCT) encompasses approximate 3,729 acres used for timber and drinking water production since the beginning of the twentieth century. Forested portions of the project area total 3,014 acres. The entire project area is in the foothills west of the North Cascades.

The Lake Chaplain SHA strategy prioritizes timber harvest from young forest stands, defers timber harvest on 1,066 acres in areas of mature forest and areas adjacent to sensitive sites (e.g., wetlands, unstable slopes). Forest management practices will accelerate development of mature forest conditions, compared to baseline management strategies, by planting and maintaining lower tree densities, creating and/or retaining snags in harvest units, protecting decaying large-diameter woody debris in harvest units, and monitoring forest conditions. The SHA details the locations of timber harvest activities, harvest deferrals, and sensitive sites. Additional sensitive sites (e.g., unstable slopes) will be identified and not-harvested as a part of ongoing operations.

Baseline conditions include commercial forest management activities and strictly limited public access. Baseline forest management is largely an even-age, commercial system designed to comply with the Washington State Forest Practice rules (refer to Forest Practices Habitat Conservation Plan (HCP) and Biological Opinion 1-3-06-FWI-0301 for more information), which are primarily focused on protection of water quality, fish habitat, and public safety during timber and road management activities. The project area is not used for hunting, fishing, hiking, off-road vehicle use or any other public commercial or recreational activities; the area is managed primarily for production of drinking water. Forest and road management on forested portions of the LCT is the subject of this consultation.

The Lake Chaplain SHA is designed to provide increasing amounts of suitable nesting habitats for murrelets and spotted owls during the permit term. The Service determined that any potentially adverse effects on other listed, proposed, or candidate species as a result of this action, including the threatened gray wolf (*Canis lupus*) are extremely unlikely.

Gray Wolf

Currently, confirmed packs of federally listed wolves occur in the North Cascades Wolf Recovery Region (Wiles et al 2011, p. 22). When writing of this document began, all confirmed observations of wolves in this area were east of the crest of the Cascade Mountains, whereas the action area for the proposed Lake Chaplain SHA is located in the western foothills, more than 30 miles from the Cascade crest. In the meantime, the Service confirmed that one individual wolf was struck by a car and found in western Washington approximately 30 miles south of the action area. The wolf was found along the interstate highway that crosses the Cascade crest at the pass nearest to known wolf packs in eastern Washington. There are currently no known individuals or packs in western Washington. Given the wide-ranging nature of wolves, connectivity of suitable habitats between the action area, and the occupied areas of the eastern North Cascades, and the long duration of the proposed permit, it is possible that transient individuals will occasionally occur in the project area.

Primary management considerations to protect wolves include reducing the likelihood of encounters with humans or livestock and maintaining adequate prey populations (Wiles et al. 2011. p. 9). In the action area, this is achieved by limiting public access, not raising livestock, and maintaining a range of forest stand conditions that promote both ungulate (prey) production and complex land cover. Most roads in the project area are not publicly accessible and already exist. The project will not significantly increase road density, traffic volumes, or recreational use of the action area.

The project is timber and road management activities that employ heavy equipment. Equipment operation will generate noise and associated activity that would likely temporarily displace any transient wolves or wolf prey species (e.g., deer and elk) from the treatment units. However, this effect would be temporary and highly localized. Temporary displacement from a small area would not significantly alter a transient wolf's behaviors due to the species' wide-ranging habits and the availability of suitable habitat and prey in adjacent areas. Additionally, moderate-density plantings in regeneration harvests and thinning treatments designed to promote understory vegetation will maintain and enhance forage for deer and elk, so habitat effects to the gray wolf and wolf prey species are considered to be insignificant. There is no evidence to indicate that resident, breeding, or denning wolves are present in this part of Washington, so there would be no disruption of wolf breeding or denning behaviors. The potential for project activities to disrupt wolf denning behavior is extremely unlikely, and is therefore considered to be discountable.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

A Federal action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas (50 CFR 402.02).

The Service proposes to issue a Permit in accordance with their authority and responsibility under section 10(a)(1)(A) of the ESA. Everett, as the permit applicant, prepared and submitted an application based on the document, *Safe Harbor and Cooperative Habitat Enhancement Agreements for the Lake Chaplain Tract* (City of Everett, 2015). Using the same planning document, Everett is seeking a similar agreement with Washington State Department of Natural Resources (DNR) under the State's forest practice rules for Cooperative Habitat Enhancement Agreements.

SHAs are voluntary agreements between the Service and cooperating non-Federal landowners. Each SHA is designed to benefit federally endangered or threatened species by having landowners implement voluntary conservation measures that are reasonably expected to provide a net conservation benefit to the species. SHAs provide assurances to non-Federal landowners interested in using their lands to benefit ESA-listed species, but who also want to avoid future restrictions on land use, in particular for ESA-listed species.

In a SHA, the landowner agrees to maintain, create, restore, or improve habitat for endangered or threatened species. The Service, working with the landowner, establishes a baseline condition for each species and determines whether the proposed actions are reasonably expected to result in a net conservation benefit (64 FR 32717). The SHA Policy defines the "baseline condition" as "population estimates and distribution and/or habitat characteristics and determined area of the enrolled property that sustain seasonal or permanent use by the covered species at the time the Safe Harbor Agreement is executed." Thus, only those areas occupied by the species at the outset of the SHA must contribute to the baseline. The negotiated baseline can exceed the current condition in some cases. SHAs also allow two categories of take (50 CFR 17.32(c)(1)(ii)): one is a result of adverse effects of management activities on covered species incidental to the enhancement of their survival, and the other is a result of returning the lands to the baseline at the end of the permit term. For this SHA, the baseline is negotiated to be 447 acres in four blocks that include all areas likely to be occupied by the murrelet or the spotted owl immediately prior to SHA implementation (City of Everett, 2015, Figure 4-1).

The Lake Chaplain SHA covers an area at the edge of the Puget Lowland ecoregion and the North Cascades ecoregion in Snohomish County, Washington (Omernik 1987). These correspond to the Western Washington Lowlands and Western Washington Cascades Provinces in the spotted owl recovery plan (USFWS, 2011, p. A-3). The 3,729 acres of covered lands are forestland surrounding a municipal drinking water reservoir. The lands are located around Lake Chaplain and downstream from Lake Chaplain to and along the Sultan River. The covered lands consist of 3,014 acres of forest across a variety of stand ages, reflecting past management practices. Approximately half of the forested areas are over 80 years old. Non-forest acreage, including Lake Chaplain, is 715 acres.

Everett's objective in implementing the SHA is to contribute to the conservation of murrelets and spotted owls while continuing long-term forest management activities. The species covered by the Lake Chaplain SHA are the spotted owl and murrelet; no other species are under consideration for an ESA section 10 Permit. If approved, the SHA would replace existing Washington State Forest Practice Rules for spotted owls and murrelets on the SHA area. It is important to note that the only proposed changes from forest practices are for rules addressing these two species; all other Forest Practices Rules will remain in effect. For example, riparian zones would continue to be managed under the HCP (City of Everett, 2015, Section 4.1.4), even though the SHA commits Everett to retain additional forest area outside the Forest Practices riparian buffers. The Lake Chaplain SHA borders Washington DNR forestlands and private forestlands (City of Everett, 2015, Figure 3-3).

The covered activities include forest management activities according the current Forest Practices Rules modified as described in Section 4 of the SHA. The SHA describes areas where timber harvest will and will not occur based, in part, on the spatial distribution of the stands contributing to the negotiated baseline. Covered activities are 1) timber harvest, 2) (pre)commercial forest thinning, and 3) road construction, maintenance, and decommissioning. Reservoir operations are not covered by this SHA.

In addition to protecting the baseline habitat (447 acres containing 394 acres of currently suitable habitat for murrelets and owls), SHA implementation will defer harvest during the permit duration on 619 acres through special management areas adjacent to active harvest units and through designated set-asides (City of Everett, 2015, Sections 4.1.2 and 4.1.3). Including the baseline habitat, a total of 1,066 acres (35 percent of the LCT) will not be harvested during the permit term. Forest stands that will not be harvested range from 40 to 164 years old. During the 50-year permit term, these stands will continue developing the mature forest structures typical of both murrelet and owl habitats.

Active forest management under the SHA will implement conservation measures designed to accelerate tree growth, promote understory shrub growth, and create snags. Compared to standard silvicultural practices employed on the LCT without SHA implementation, the SHA silvicultural prescriptions are intended to develop larger trees and more diverse forest structure through longer rotations and prescriptions described in Section 4.1.6 of the SHA. Measures include lower-density tree planting in regeneration units, tree density triggers for pre-commercial and commercial thinning, and long-term planning for regeneration harvests and road management. By implementing occupied site provisions (City of Everett, 2015, Section 4.1.7), Everett will provide for nesting opportunities, particularly for murrelets, throughout the LCT, not limited to the designated baseline, set-asides, and special management areas. Everett anticipates their active silviculture will develop nesting habitat for murrelets, as well as foraging and dispersal habitat for spotted owls. Under the SHA, Everett will also build on existing information about habitat conditions through monitoring.

Issuance of the Permits removes the section 9 take prohibition related to owls and murrelets during the permit term, supplanting the specific Forest Practice Rules that aim to avoid the risk of take through identification and buffering of occupied habitats, or through seasonal restrictions on operations (WAC 222) and subject to the limits described in the SHA and this document. Following the permit term, forest management on the Lake Chaplain Tract will be subject to the Forest Practice rules and section 9 take prohibitions in place at that time.

No actions are known to be interrelated or interdependent to the proposed SHA.

Conservation Measures

The primary conservation measures in the proposed SHA are harvest deferrals for areas that are or are reasonably likely to become suitable nesting habitat for either covered species during SHA implementation. Everett designated 1,066 acres for harvest deferrals for the entire permit duration.

Additional conservation measures include:

1. Lengthening timber harvest rotations.
2. Incorporating (pre)commercial thinning prescriptions into standard timber management regimes.
3. Replanting prescriptions that embrace low-density and high diversity to develop more diverse forest stands compared to the plantation-style approach common in commercial timber management.
4. Occupied Site Provisions intended to minimize disturbance or delay habitat removal should either covered species occupy managed stands.

Conservation measures are described in detail in Section 4 of the SHA.

Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. The action area for this proposed Federal action was initially based on the geographic extent of in-air sounds and habitat alteration resulting from proposed actions, as depicted in Figure 1. The action area includes the entire LCT, plus forestland within a quarter-mile of areas proposed for active forest management. In addition, we considered as part of the action area, lands that may be eligible for inclusion as covered lands under clause 11.2 of the Implementation Agreement.

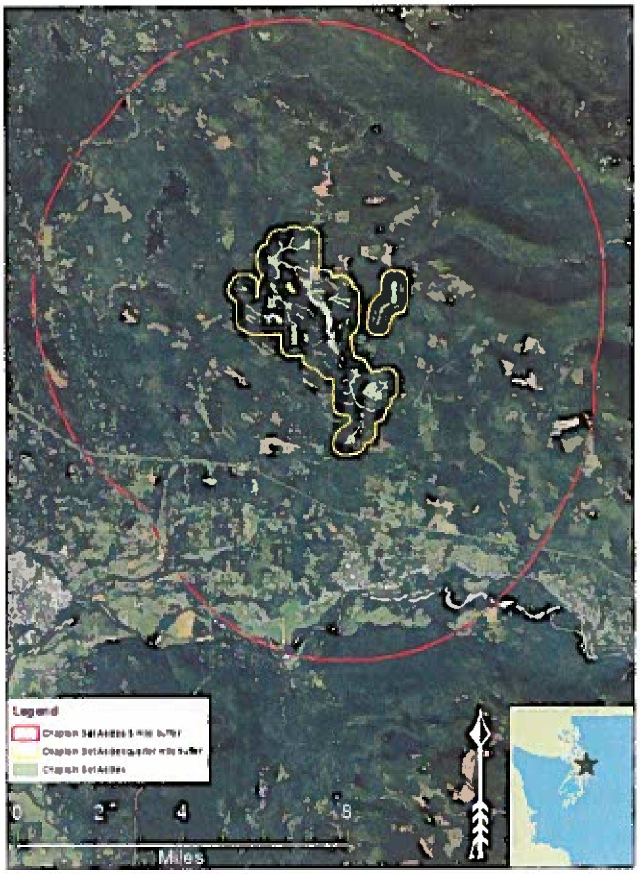

Figure 1. Action area

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

The following analysis relies on the following four components: (1) the *Status of the Species*, which evaluates the rangewide condition of the listed species addressed, the factors responsible for that condition, and the species' survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the species' current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of listed species in the wild.

The jeopardy analysis in this Opinion emphasizes the rangewide survival and recovery needs of the listed species and the role of the action area in providing for those needs. It is within this context that we evaluate the significance of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

STATUS OF THE SPECIES: NORTHERN SPOTTED OWL

For a detailed account of northern spotted owl biology, life history, threats, demography, and conservation needs, refer to Appendix A: Status of the Species: Northern Spotted Owl.

ENVIRONMENTAL BASELINE: NORTHERN SPOTTED OWL

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of state and private actions which are contemporaneous with the consultation in progress.

The action area is in a rural area of Snohomish County with neighboring land uses are in forestry and a small amount of low-density residential sites. The LCT lands are situated around Lake Chaplain, approximately three miles north of Sultan, Washington, at the western edge of the Cascade Mountain Range. State-owned forest lands managed under the DNR HCP—the HCP incorporates conservation strategies for spotted owls and murrelets—account for the majority of the LCT perimeter (approx. 80 percent). Private lands are interspersed around the LCT perimeter, including residential and forestlands. The surrounding forest lands are generally managed for commercial timber production. The core of the action area is Everett's drinking-water reservoir and associated water-supply facilities.

A small amount of Mt. Baker-Snoqualmie National Forest lands abuts the LCT's perimeter at the Diversion Dam. Lands managed by the US Forest Service in the action area are not designated as critical habitat for the spotted owl. As such, there is no designated critical habitat for spotted owls in the action area.

The LCT is characterized by Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) forests. Other tree species common in the LCT include western red cedar (*Thuja plicata*) and red alder (*Alnus rubra*). Nearly all of the LCT was previously clearcut for timber harvest, starting as early as the mid- to late-19th century. In recent years, most of the LCT forest lands were actively managed according to a wildlife habitat management plan that incorporated a noxious weed management plan and murrelet habitat protections (Snohomish PUD 1988). The plan was reviewed by the Service (Biological Opinion 13410-2010-F-0609), but is no longer in effect.

As a result of all past forest management on the LCT, approximately half of the forest area is in an immature seral state that will not be suitable as spotted owl nesting habitat during the permit term. Of the remaining area, most is even-aged forest with some large trees, but large trees with cavities suitable for spotted owl nesting are currently rare across the LCT. Areas designated as set-asides and special management areas (including the poorly named "old-growth management areas") do not currently contain suitable habitat for spotted owls.

Forest Practices Rules designate 10 spotted owl special emphasis areas (SOSEAs) in Washington, comprising over 1.5 million acres of state and private lands where spotted owl habitat protection on non-Federal lands would be emphasized. The LCT is between, not in, two SOSEAs: the Finney Block SOSEA and the I-90 West SOSEA.

Current Condition of the Species in the Action Area

No spotted owls are currently known to occupy the action area. A single resident spotted owl site was documented over five miles east-northeast of the LCT in 1994, outside of the action area. The status of that owl is unknown. Surveys for spotted owls in potential suitable habitat in the LCT were conducted in 2007 and 2008. No spotted owls have been detected within the action area. Barred owls (*Strix varia*) which can outcompete and can have other negative interactions with spotted owls (Wiens et al 2012), were detected on the LCT.

The spotted owl was listed as threatened throughout its range "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USFWS 1990, p. 26114). Within the action area, two factors are considered to be significantly responsible for the current condition of the species: habitat loss and adverse interactions with barred owls.

First, nearly all suitable habitat in the action area was removed through prior timber harvest. The condition of forests on the LCT includes more diverse stand ages than most commercially managed landscapes, in part, because Everett has maintained a moderate harvest rate to protect water quality in the basin. The current age structure includes 1,535 acres beyond 80 years of stand age, 545 acres between 40 and 80 years, and 934 acres under 30 years (no stands on the LCT are between 30 and 40 years). A small portion of the stands beyond 80 years have large trees with large cavities, complex canopies, and other features of high-quality nesting habitat for spotted owls. Likewise, a portion of the stands beyond 40 years have suitable structure to serve as foraging and dispersal habitats for spotted owls.

More than half of the forest area is currently in an immature seral state. Whereas spotted owls nest in complex forests with wide-ranging tree sizes, accumulations of large dead wood, and multi-layered forest canopies, the forests in the action area are primarily even-aged forests with a simple canopy layer. Additional time is necessary for most forest stands in the action area to develop the complex structures characteristic of spotted owl nesting habitat. Because lands in the action area remain forested, the degraded habitat is likely capable of becoming suitable habitat with time. All of the stands with potential nesting habitat in the action area in 2015 are contained within the 447-acre area defined as "baseline habitat." The Service conservatively estimated that 394 acres within the baseline are suitable for the spotted owls' nesting, roosting, and foraging behaviors (City of Everett, 2015, appendix C). With little information about snag frequency on the LCT, or more specifically, about the availability of suitable cavities for nesting, we tried to overestimate the area of suitable nesting habitat. Regardless of the precision of habitat estimates, old forest areas suitable for owl nesting are significantly rarer than they were historically.

The second significant factor within the action area is the 20th century influx of barred owls (Taylor and Forsman 1976, entire). Barred owl presence negatively influences spotted owl occupancy through competition, aggressive interactions, and displacement (Gutierrez et al 2007, entire).

The combined effects of barred owl interactions and landscape-level loss of suitable nesting habitat limit spotted owls to very low densities throughout the action area (Sovern et al 2014, entire), if they still occur in the action area at all.

Conservation Role of the Action Area: Northern Spotted Owl

The 2011 Revised Recovery Plan for the Northern Spotted Owl (Spotted Owl Recovery Plan) recommends conserving occupied sites and unoccupied, high-value spotted owl habitat on non-Federal lands wherever possible (USFWS 2011, pp. III-51). The Service's primary expectation for SHAs is to provide a net conservation benefit, even if the benefit is limited to the permit duration, by recruiting spotted owl habitat where improved distribution of spotted owls would improve long-term recovery potential.

In the context of this SHA, the nearest high-quality old-forest habitat that is important for spotted owl demographics is located on Federal lands outside the action area. The conservation role of the action area is primarily to serve as foraging and dispersal habitat, connecting to suitable nesting habitat across a larger landscape. Over time, suitable nesting habitat may develop on some adjacent State lands in the action area, providing potential demographic support to the spotted owls.

In the Environmental Baseline, the primary conservation role of the LCT is to provide foraging and dispersal habitat for connectivity for spotted owls dispersing across the landscape. With SHA implementation, the LCT lands also have a role in spotted owl demographic support through development of habitat suitable for nesting, roosting, and foraging. However, we assume this role is minimal due to the ongoing occupancy of the site by barred owls.

Climate Change

Climate change, combined with effects from past forest management practices, is influencing current forest ecosystem processes and dynamics by increasing the frequency and magnitude of wildfires, insect outbreaks, drought, and disease (USFWS 2011, pp. III-5 - 11). In the Pacific Northwest, mean annual temperatures rose 0.8 °C (1.5 °F) in the 20th century and are expected to continue to warm from 0.1 °C to 0.6 °C (0.2 °F to 1 °F) per decade (Mote and Salathe 2010, p. 29). Climate change models generally predict warmer, wetter winters and hotter, drier summers and increased frequency of extreme weather events in the Pacific Northwest (Salathe et al. 2010, pp. 72-73).

Predicted climate changes in the Pacific Northwest have implications for forest disturbances that affect the quality and distribution of spotted owl habitat. Both the frequency and intensity of wildfires and insect outbreaks are expected to increase over the next century in the Pacific Northwest (Littell et al. 2010, p. 130). One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration, and severity. Westerling et al. (2006, pp. 940-941) analyzed wildfires and found that since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period from 1970-1986. The total area burned is more than 6.5 times the previous level and the average length of the fire season during 1987-2003 was 78 days longer compared to 1978-1986 (Westerling et al. 2006, p. 941). The area burned annually by wildfires in the Pacific Northwest is expected to double or triple by the 2080s (Littell et al. 2010, p. 140). Wildfires are now the primary cause of spotted owl habitat loss on Federal lands, with over 236,000 acres of habitat loss attributed to wildfires from 1994 to 2007 (Davis et al. 2011, p. 123).

Potential changes in temperature and precipitation have important implications for spotted owl reproduction and survival. Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Olson et al. 2004, p. 1039, Dugger et al. 2005, p. 863), survival (Franklin et al. 2000 pp. 576-577, Olson et al. 2004, p. 1039, Glenn et al. 2011, p. 1279), and recruitment (Glenn et al. 2010, pp.2446-2547). Cold, wet weather may reduce reproduction and/or survival during the breeding season due to declines or decreased activity in small mammal populations so that less food is available during reproduction when metabolic demands are high (Glenn et al. 2011, pp. 1288-1289). Cold, wet nesting seasons may increase the mortality of nestlings due to chilling and reduce the number of young fledged per pair per year (Franklin et al. 2000, p.557, Glenn et al. 2011, p. 1286).

Drought or hot temperatures during the summer have also been linked to reduced spotted owl recruitment (Glenn et al. 2010, p. 2549). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals that spotted owls prey upon (Glenn et al. 2010, p. 2549).

In summary, climate change is likely to exacerbate some existing threats to the spotted owl such as the projected potential for increased habitat loss from drought-related fire, tree mortality, insects and disease, as well as affecting reproduction and survival during years of extreme weather.

EFFECTS OF THE ACTION: NORTHERN SPOTTED OWL

The effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The SHA describes voluntary conservation actions that are expected to lead to net conservation benefits to spotted owls. To issue an enhancement of survival permit under section 10(a)(1)(A) of the ESA, there needs to be a reasonable expectation of net conservation benefits that contribute directly, or indirectly, to the recovery of the covered species (64 FR 32717). In this case, the benefits are associated with the landscape condition, including protection of the best available habitat and development of additional habitat areas. There can also be adverse effects associated with SHA implementation. Significant adverse effects are primarily anticipated from potential noise and visual disturbance associated with equipment operation for timber harvest and road construction near suitable spotted owl habitat.

In this analysis of landscape-level habitat conditions, we analyze the effects on habitat conditions resulting from SHA implementation and the significance to spotted owls. We consider the benefits of the Permit and the potential adverse effects of implementing the SHA. We also analyze the resulting habitat conditions to determine the effect of the action on the spotted owls and the spotted owl population. In this analysis we assume that all commercial forestlands which can be managed feasibly and for which management is allowed under the SHA and under other regulations would be managed in order to meet commitments and objectives.

Management under the Permit

The management regime under the Permit will defer 1,066 acres from harvest, including 447 acres designated as the SHA baseline. Some of the baseline areas contain currently suitable habitat (likely overestimated at 447 acres of suitable habitat). Some deferred areas have good potential to develop characteristics of submature or old forest habitat; they contain large trees but currently have a low frequency of snags or other cavity-bearing trees (i.e., baseline and old growth management areas). Areas designated as "permanent mixed forest" or riparian are also deferred from harvest during the permit term. These stands are simple-structured stands (i.e., even-age trees, single canopy layer) that have good potential to develop into young forest marginal habitat (i.e., foraging and dispersal habitat) during the permit term. In total, 35 percent of the LCT is deferred from harvest during the permit term, and 15 percent is designated as baseline habitat.

The terms of the SHA require retention of all habitat areas currently suitable for spotted owl nesting, roosting, and foraging. The terms also protect those areas already on trajectory to become habitat—either old forest or submature— from harvest during the permit term. In addition, the SHA thinning prescriptions and longer harvest rotations promote development of a matrix of foraging and dispersal habitat through much of the LCT (see USFWS 2011, p. III-15 for a discussion of thinning effects on spotted owl habitat). Stands not deferred from harvest are subject to clearcut timber harvesting. Thus, the areas actively managed under the SHA will serve as a shifting mosaic that eventually includes foraging and dispersal habitat, as well as early seral forest. As a whole, the SHA will protect and expand the amount of suitable habitat for all life history phases of the spotted owl.

All together, the SHA prescriptions will retain increasing amounts of suitable habitat by, protecting the stands most likely to provide suitable nesting, roosting, and foraging habitat in the coming decades through harvest deferrals, and developing foraging and dispersal habitat in managed stands through silvicultural prescriptions for thinning.

Contribution to Demographic Support

Concentrations of owl suitable habitat, especially habitat that can support nesting, are anticipated to occur primarily on Federal and State lands outside the action area. In the baseline, no portion of the action area is designated for demographic support of spotted owls. By protecting concentrations of suitable habitat, the SHA is expected to provide opportunity for demographic expansion of spotted owls in an otherwise degraded action area.

Bart and Forsman (1992) and Bart (1995, p. 944) found a statistically significant relationship between amount of suitable habitat and spotted owl survival and reproduction. Although riparian areas and unstable slopes protected from harvest in the baseline are approximately 10 percent of the LCT, many of those areas are currently young dense stands that are not suitable for any life history phase of the spotted owl. SHA harvest deferrals and silviculture will develop additional mature forest suitable for spotted owls nesting, roosting, and foraging in the baseline blocks and in the old growth management area. Likewise, the SHA prescriptions will develop additional areas suitable for foraging and dispersal in the permanent mixed forest and riparian areas (the SHA designates larger riparian zones than required in the baseline). The SHA protects habitat and promotes additional habitat development concentrated around Lake Chaplain. Based on the habitat trajectory under SHA prescriptions and the positive association between habitat extent and owl demographics, the SHA creates a potential for the action area to provide demographic support to spotted owls where this would not otherwise exist.

Contribution to Dispersal and Connectivity

Whether habitat is distributed sufficiently to provide connectivity depends on the species, their home range, mobility, and other habitat needs. Likewise, whether habitat fragmentation is too severe for a species depends on whether the species uses interior conditions and/or edge habitat and how they disperse. In general, as the amount of contiguous natural habitat decreases below 60 to 80 percent of the landscape, connectivity between the remaining habitat patches becomes increasingly important for many species (McComb 1999, p. 296).

Dispersal failure leads to population declines. A review of published literature suggests connectivity for spotted owls deteriorates once late-successional habitat is fragmented and constitutes less than 50 percent of the landscape (Davis et al 2011, p. 40). Juvenile spotted owls dispersing across clearcuts or open-canopy forests move shorter distances and have an increased probability of mortality (Miller et al. 1997). Herter and Hicks (1995) also found dispersal distances traveled by successful dispersers to be farther than those of unsuccessful dispersers (18.8 vs. 15.3 miles). Decreasing dispersal can reduce local populations while habitat loss simultaneously reduces population viability and exacerbates the effects of stochastic events. These factors, when combined, may increase the risk of local extirpations. The success of juvenile dispersal in a fragmented landscape is likely a primary factor determining the future existence of spotted owls in the Pacific Northwest (Meyer et al. 1998).

Before SHA implementation, the LCT is managed for commercial timber, not for spotted owl foraging and dispersal habitat, nor for habitat connectivity. Outside the baseline habitat, dispersal habitat is sparsely distributed on the LCT because densely-planted stands harvested at a young age typically do not have the open space below the canopy needed for owls to hunt and fly (Miller et al 1997, p. 145). Where stands suitable for dispersal do occur they are relatively isolated.

While portions of the areas deferred from harvest under the SHA are suitable for foraging and dispersal, deferring harvest throughout the baseline habitat, set-asides, and special management areas will combine with the longer harvest rotations and thinning prescriptions in managed areas to result in a substantial increase in foraging and dispersal habitat connectivity on the LCT. Based on 78-year clearcut cycles in managed stands (City of Everett, 2015, P. 25) and an estimated 40 years to develop foraging and dispersal habitat from a clearcut with a thinning regime (pre-commercial and commercial thinning), long-term SHA implementation will maintain, at most, 35 percent of the LCT in non-dispersal conditions. This represents a substantial improvement in within-LCT connectivity of suitable habitat and reduced fragmentation.

We are confident that the SHA commitments will expand suitable foraging and dispersal habitat even though absence of a specific schedule for thinning and final-harvest of discrete management units means we cannot quantify the precise amount of foraging and dispersal habitat by year. The conclusion that habitat will expand can be reached qualitatively by contrasting the management approaches with and without the SHA, as described in detail in the SHA (Table 4-2).

The designated baseline, set-asides, and special management areas are, at a broad landscape scale, clustered tightly around Lake Chaplain. At a finer scale, the deferred harvest areas are distributed throughout the LCT. The SHA provides a cohesive planning approach for habitat distribution on the LCT, reducing the isolation of each stand of suitable habitat at all scales. Under the SHA, Everett will thin managed stands, improving their condition as foraging and dispersal habitat. Clearcuts will still occur, but at a lower density due to longer harvest rotations. Thinnings, longer harvest rotations, and designation of harvest deferrals adjacent to baseline habitat will result in improved connectivity between habitat patches on the LCT.

The SHA will not change forest management outside the LCT, so connectivity among the LCT and occupied habitats (outside the action area) will not change as a result of SHA implementation. The LCT will be a relatively isolated concentration of suitable habitat amid the larger ecoregions. This is, however, an improvement that will benefit spotted owls over the existing conditions for dispersal and connectivity because of improved habitat connectivity within the LCT.

Effects to Spotted Owls Associated with New Owl Sites

There is a possibility that new owl nest sites could become established during the term of the SHA. If a new spotted owl site is discovered on SHA lands within the LCT, the terms of the SHA will allow for continued LCT management per SHA. Washington State may designate a new owl site center on the LCT to affect management on non-covered lands nearby the LCT. In that situation, a new activity center (70 acres) may be identified but will not condition management under the SHA. Instead, management under the SHA would trigger Occupied Site Provisions (City of Everett, 2015. Section 4.1.7), establishing a 5-year term of habitat protection.

After the Occupied Site Provisions expire, occupied habitat that is both on the LCT and outside the harvest-deferred areas could be harvested. In the unlikely event that a new nest site on SHA lands is discovered in the managed matrix, the spotted owl(s) in question would eventually be forced to disperse away from the site due to the direct loss of the nest patch, but not until the Occupied Site Provisions expire as described in the SHA (Section 4.1.7). This scenario includes eventual harvest of the occupied habitat occurring outside of the nesting season. It is important to note that the SHA provides conservation measures to ensure that benefits are accrued prior to harvest occurring. Benefits result both from additional habitat development and from delaying harvest of some occupied sites to allow for reproductive opportunities (i.e., Occupied Site Provisions).

Disturbance of nest sites in the managed matrix is not reasonably certain to occur because we consider it extremely unlikely that such a site would be used by spotted owls for nesting or roosting. The stands in the managed matrix represent degraded habitats. The stands that are on trajectory to develop nest-site characteristics during the permit term are deferred from harvest. Surveys for spotted owls were conducted throughout the LCT and no spotted owls were detected, even in the highest quality habitat. If owls occupy the LCT in the future, it is most likely that the Occupied Site Provisions would be used to limit noise and visual disturbance during the nesting season to protect owls nesting near, but not in, managed stands.

Barred Owls

Because barred owls compete with spotted owls for habitat and resources for breeding, feeding, and sheltering, ongoing loss of habitat has the potential to intensify their competition by reducing the total amount of these resources available to the spotted owl and bringing barred owls into closer proximity with the spotted owl (USFWS 2011, p. I-9). A recent study in Oregon found that both species use patches of older conifer forest for roosting and foraging, both species relied on similar prey associated with these forest types, and the survival of both species was associated with the amount of old forest in their home ranges (Wiens 2012, p. 64). These findings highlight the significance of old forest as a potential limiting factor resulting in the competitive relationship between the two species. In order to reduce or not increase this competitive pressure, the Spotted Owl Recovery Plan recommends conserving and restoring older, multi-layered forests across the range of the spotted owl while the threat from barred owls is being otherwise addressed (USFWS 2011, pp. I-8).

In the context of this SHA, the older forests that are currently essential for demographic support of spotted owls are provided outside of the action area, primarily by Federal lands and secondarily by State lands. There is little habitat that would be classified as "high quality" old forest habitat on the SHA lands. The area around the Diversion Dam may be the only high-quality habitat for owl nesting on the LCT at SHA initiation. If suitable habitat occurs elsewhere on the LCT, it is in the designated baseline, and the near-term effects of the SHA implementation (10 to 20 years) may continue to result in competition between barred owls and spotted owls associated with ongoing fragmentation adjacent to suitable habitat on the LCT. Dugger et al (2011, p. 2463) found that the amount of old forest habitat at the core of spotted owl home ranges most strongly influenced the probability of spotted owl occupancy over time. The likelihood that a site would be abandoned by spotted owls increased with decreasing amounts of old forest at the core, and this effect was compounded where barred owls were detected, indicating that as suitable habitat decreases within a home range, the likelihood for negative competitive interactions between the two species increases (Dugger et al. 2011, p. 2463).

As described above, none of the anticipated effects of habitat loss are expected to occur in baseline habitat, nor are expected to result in a loss of habitat below the baseline condition. As habitat-adjacent stands are harvested, it is reasonable to expect that the potential for competition within remaining habitat areas will increase. However, considering that the SHA will result in significantly more areas of suitable habitat than would exist without the Permit, the risk to spotted owls from competition with barred owls as a result of the Permit is expected to be minimal.

Over the long-term (20 to 50 years), as more of the SHA lands outside the designated baseline and deferred-harvest areas transition to dispersal, or Young Forest Marginal habitats, the effects of the SHA on barred owl-spotted owl interactions are likely to be neutral, because such habitats are not likely to support resident, territorial spotted owls or barred owls. Although both owl species are known to use younger, less structurally complex forests for limited foraging and roosting opportunities, such forests are not a significant factor in either adult survival or reproductive rates for either spotted owls or barred owls (Dugger et al., 2005, p. 863; Wiens 2012, pp.60-61).

Effects to Spotted Owls from Disturbance and Habitat Loss

In previous analyses of the potential for disturbance to spotted owls (USFWS, 2013, pp. 74-83; USFWS 2006, entire), we concluded that the noise and activity associated with the use of excavators, chainsaws, and other motorized equipment can disrupt normal spotted owl nesting behaviors in some situations. In those analyses, we concluded that significant disturbance (disruption of nesting behaviors) can occur when noise or project activity occurs in close proximity (i.e., from 65 yards to 0.25 mile depending on the activity) to an active spotted owl nest during the early nesting season (March 15 to July 15). Early nesting season behavior includes nest site selection, egg laying, incubation and brooding of nestlings to the point of fledging (Forsman et al. 1984, pp. 32-38). Disruption of normal nesting behaviors during the early nesting season is significant due to the potential for reduced hatching success, fitness, or survival of nestlings.

Noise and visual disturbance associated with forest management activities during the early spotted owl nesting season could result in flushing a spotted owl adult or juvenile away from a nest. Flushing from a nest site is considered a significant disruption of normal behavior because flushing a nesting owl increases the risk of predation to the eggs or nestlings. The greatest risk to spotted owls from disturbance is causing a pre-fledged juvenile to flush. It is common for pre-fledged owlets to leave the nest and perch on adjacent branches before they can fly (Forsman et al. 1984, p. 36). Owlets in this stage of development are vulnerable because if they fall to the ground before they are able to fly, they have a higher risk of mortality. Forsman et al. (1984, p. 36) notes that seven of nine owlets that fell or jumped from the nest prematurely were killed by the fall or disappeared before reaching the flying stage.

A flush response creates the likelihood of injury by increasing the risk of predation through the advertisement of the nest's location, advertisement of the adult and juvenile, or the premature departure of a nestling from a nest. Predation mortality of juvenile spotted owls is common, and is the leading cause of death of fledglings (Forsman et al. 2002, p. 18). Spotted owls are preyed on by great horned owls (*Bubo viginianus*) (Forsman et al. 1984, p. 38; 2002, p. 18), and they are likely preyed on by northern goshawks (*Accipiter gentilis*), and red-tailed hawks (*Buteo jamaicensis*) (Forsman et al. 2002, p. 27). It is likely that flushing a spotted owl from its nest or causing a nestling to flush from the nest prematurely would increase the chances of juveniles being predated. However, adult spotted owls are protective and have been observed defending themselves and their young from potential avian predators (e.g., hawks and ravens) (Forsman et al. 1984, p. 36). Female spotted owls exposed to disturbance are reluctant to leave the nest during the early stages of the breeding cycle (Delaney et al. 1999, p. 71; Delaney and Grubb 2003, p.22), so the risk of causing an incubating spotted owl to abandon a nest is somewhat reduced.

SHA management activities (road construction and timber harvest) are reasonably certain to cause noise and visual disturbance to spotted owls nesting in adjacent areas. The SHA restricts timber harvest and road construction to avoid forest management activities on covered lands during the early nesting season in proximity to a stand with documented spotted owl occupancy. Spotted owl surveys are more likely to occur in stands scheduled for timber management than in the baseline habitat or in designated set-asides, so owls nesting outside of harvest units may not be detected before nearby disturbances. Therefore, the effects of disturbance are most likely to result when timber management or road construction occurs in close proximity to areas designated as baseline habitat. Because spotted owls do occasionally choose alternate nest locations in their core areas (Forsman et al. 1984, p. 32), we used all baseline habitat within 65 yards of stands to be managed under the SHA to represent the areas where noise and visual disturbance to spotted owls is most likely to occur (see USFWS 2013, p. 4 for source of effects distances). There are a total of four blocks of baseline habitat; the block located near the Diversion Dam is not adjacent to areas with proposed timber management or road construction under the SHA (note, activities conducted by other nearby landowners are not covered by the SHA and must meet the Forest Practice Rules for limiting disturbance to spotted owls or their habitat, so such activities are not considered as effects of permitting the SHA). The three blocks of baseline habitat located around the Lake are each adjacent to areas where equipment operation for forest management will generate noise and visual disturbance. The portions of those stands within 65 yards of harvest units or proposed roads total approximately 77 acres, or 17 percent of the baseline habitat. Based on silvicultural prescriptions and rotation timing described in the SHA, we anticipate that these 77 acres will be exposed to noise and visual disturbance for up to three nesting seasons during the SHA.

In addition to forestry work, road construction, road maintenance, and Diversion Dam maintenance will also generate noise and visual disturbance where they occur within 65 yards of baseline habitat for an extended duration. However, noise and visual disturbance from road maintenance will be transitory, never resulting in extended exposure beyond a few minutes at any one location. As a result, road maintenance activities are likely to generate insignificant noise and visual disturbance. By contrast, road construction and diversion dam maintenance will generate significant noise and visual disturbance, each lasting no more than a single nesting season. The area within 65 yards of road construction and Diversion Dam maintenance activities is a total of 12 acres of baseline habitat, of which 4 acres overlap with the 77 acres described above. Noise and visual disturbance resulting from road construction or Diversion Dam maintenance activities will persist for one nesting season each at two locations during the SHA.

Noise and visual disturbance associated with SHA implementation will disrupt nesting behaviors of spotted owls across 85 acres of baseline habitat. Noise and visual disturbance will be associated with the following temporary activities that will occur in each location for up to an entire nesting season at a time: road construction, timber harvests, and Diversion Dam maintenance. Transitory maintenance activities that will occur for up to an hour at any location are not expected to result in measureable effects because the brief passing of a grader or mower is consistent with the environmental baseline and does not generate significant disturbances. For up to three nesting seasons, noise and visual disturbance from forestry will occur in 77 acres of baseline habitat; and from road construction or dam maintenance in 12 acres of baseline habitat. Throughout an area totaling 4 acres of baseline habitat, these activities will all occur in the same locations resulting in four nesting seasons with noise and visual disturbance. Covered activities will generate noise and visual disturbance at different locations each year, so smaller areas of habitat will be exposed in any given year.

Because noise-generating activities may occur year-round in areas where spotted owl occupancy is not detected, we anticipate that this type of disturbance will be ongoing at the start of the nesting season in a portion of the above-described 85 acres. Thus, we do not anticipate direct effects on juveniles, but rather disturbance of nesting adults that will cause adults to not reproduce that year or to seek other nesting opportunities. Because the effects of noise and visual disturbance are temporary, any affected nest site would become suitable again following cessation of the noise-generating activity.

Neither individual spotted owls, nor spotted owls pairs are believed to occur in the action area at the time of this writing. The conclusion that individuals would be exposed to noise and visual disturbance is based on the expectation that SHA implementation will benefit spotted owls by facilitating their expansion into the LCT. Because it is not plausible to predict the timing of future re-occupancy of the LCT by spotted owls, this analysis simply reflects the likelihood that individuals will be exposed to noise and visual disturbance from SHA implementation in the area described above. Because any owls in the 85 acres will be exposed to noise and visual disturbance for up to four nesting seasons during SHA implementation, a portion of which we expect to become occupied by spotted owls during SHA implementation, it is reasonable to conclude that one instance of nest abandonment will result from noise and visual disturbance. Temporally, at the beginning of SHA implementation, spotted owls are not expected to occupy the LCT at the outset of the SHA, so some noise-generating activities may occur without exposure to owls.

In addition to the potential for noise and visual disturbance, the temporary loss of foraging habitat in the LCT through timber harvest will reduce prey availability to spotted owls during their critical summer nesting period, when they are most dependent upon the nearby foraging habitat (Forsman et al. 1984, p. 21). Even where habitat levels remain above viability thresholds, habitat removal during the nesting season will likely disrupt normal foraging behaviors during years that timber harvest activities occur near nest sites. Despite the expectation of disrupted foraging, the effect is immeasurably small, due to the continued availability of sufficient foraging habitat in the immediate landscape. We do not expect the temporary reduction in foraging habitat associated with ongoing timber harvests to result in missed feedings to nestlings, but we do expect adequate feeding for any nestlings in areas adjacent to regeneration harvests. This is because foraging adults may need to search another stand, but would be expected to forage successfully in and around the LCT. If feedings are routinely delayed, the effects would include slow juvenile development and smaller, less fit fledglings. However, the alteration of foraging habitat by timber harvest at the scale of the SHA is likely to cause only small changes in foraging behaviors. SHA implementation will concurrently enhance the quality of managed stands for spotted owl foraging through silvicultural thinnings. As a result of temporary reductions in and active enhancement of foraging and dispersal habitat for spotted owls, any feeding delays would be brief delays, overall foraging effectiveness will remain stable; effects on juveniles would be immeasurably small and insignificant.

In conclusion, due to the limited number of acres expected to be harvested each year (i.e., less than 1.5 percent of the LCT), deferral of harvest on most areas currently suitable for foraging, implementation of Occupied Site Provisions, thinning prescriptions in simple-structured stands, and the lack of known nest sites on or near the covered lands, we do not expect noise or visual disturbance to result in an outright nest failure, nor reduced fitness or survival of adult spotted owls. However, we do anticipate the pre-breeding abandonment of a nest by one adult pair of spotted owls within the 103 acres exposed to increased noise and visual disturbance. Because spotted owls are more likely to nest in a stand interior than along a stand edge where noise and visual disturbance will occur, we expect that no more than one pair of spotted owls will abandon a nest during the permit term as a result of noise and visual disturbance.

When a spotted owl pair abandons a nest site as a result of SHA implementation, the effects will include failed or delayed breeding for that nesting season. Over the 50-year term of SHA implementation, one instance of failed or delayed breeding will marginally delay establishment of additional spotted owls. Because reproduction is irregular over time (Noon and Biles 1990, p. 20), and there are uncertainties about how soon owls may occupy the LCT, the duration of such a delay in reproduction is uncertain, and we assume that any individuals that temporarily abandon a nest site in response to disturbance will renest within two years.

Indirect Effects to spotted owl Habitat on SHA Lands

Indirect effects to suitable spotted owl habitat from windthrow are anticipated when timber harvest creates new openings in or adjacent to stands of suitable habitat. For this analysis, we assume such effects are likely to occur within 200 feet of a clearcut boundary.

Windthrow is a natural phenomenon affecting forests throughout the Pacific Northwest. Catastrophic windthrow can knock over entire stands, sometimes destroying spotted owl habitat. More commonly, winds knock down individual trees along a stand edge in the first few years after a change in the wind exposure. The factors that influence windthrow include individual tree characteristics, stand characteristics, root zone soil characteristics, topographic exposure, and meteorological conditions (Stathers et al. 1994; Harris 1999). Windthrow usually occurs in the first few years after adjacent harvesting, particularly where less windfirm trees are exposed to stronger winds by harvesting. Trees become more windfirm after a few years of exposure as they develop reaction wood in response to swaying (Stathers et al 1994). Windthrow damage can extend into adjacent stands for hundreds of feet, although most damage is usually concentrated in the first 30 to 60 feet of the cutting boundary edge (Stathers et al. 1994).

Edge effects associated with clearcut timber harvests on the SHA lands will temporarily alter windthrow risks, resulting in the potential removal of individual trees and scattered patches of trees on the edges of existing suitable nesting or dispersal habitats in and adjacent to the SHA lands. The Service anticipates that the scattered loss of individual trees or patches of trees from windthrow could occur for distances up to 200 feet into stands of habitat adjacent to harvest units. However, the total area of baseline habitat within 200 feet of proposed harvest units would overstate the extent of this effect because windthrow will only occur in some of the areas adjacent to harvest units and primarily in the first few years following harvest if that period has strong wind events. The exact locations and the thoroughness of windthrow cannot be predicted. Where green tree areas (City of Everett, 2015, Section 4.1.3.1), riparian areas (City of Everett, 2015, Section 4.1.4), unstable slopes (City of Everett, 2015, Section 4.1.3.2), limited fetch, or otherwise stable trees occur adjacent to suitable habitat, the effects of windthrow will be minimized or avoided.

Because the SHA commits to protecting the baseline habitat, windthrow is likely to result in the loss or degradation of minor amounts of suitable habitat along new clearcut edges. In most cases, the loss of individual trees or small groups of trees would result in only a minor alteration of habitat at the site scale, not necessarily degradation. As an effect of SHA implementation, windthrow is not reasonably certain to result in a significant or quantifiable loss of suitable habitat.

Effects of Future Land Acquisitions within the SHA Areas

The SHA includes a provision for land acquisition within 5 miles of the LCT. The land addition boundary overlaps with the Wilson Creek-Pilchuck site center, the nearest site with a spotted owl detection. We have no estimate at this time as to which parcel may be acquired and incorporated into SHA management or whether future land acquisitions will contain suitable owl habitat.

If Everett acquires any additional lands within five miles of the LCT and such lands are not inhabited or regularly visited by any covered species, Everett may request a Minor Modification to include such lands under the Permit per the Implementation Agreement. Because of the requirement that lands acquired and covered under the Permit are not initially used as nesting or foraging habitat by spotted owls, the potential effects of SHA implementation in those areas, including temporary habitat loss or disturbance as described above, would be insignificant to the spotted owl. Benefits to spotted owls of including such lands would result from the timber management prescriptions under the SHA, which are likely to expand foraging and dispersal habitat over time, as described above. We do not anticipate development or acquisition of additional nesting habitat for spotted owls during the permit term outside the LCT.

Effects of Early Termination

Everett can implement the SHA for its full 50-year term and then return to baseline, or they can decide to terminate the SHA at any time and return to baseline. Depending on timing of an early termination, there could be different amounts of habitat in the SHA area. As long as they have at least the designated habitat to meet the agreed-upon baseline, they are in compliance with that aspect of the SHA. If habitat levels go below the specified baselines, they are not in compliance with the SHA. We assume that Everett will implement the SHA for the full permit term and that habitat levels will always be at or above the elevated baseline conditions specified in the SHA.

The baseline is defined as four specific polygons, totaling 447 acres (City of Everett, 2015, Figure 4-1), and containing all suitable habitat (City of Everett, 2015, Appendix C). With the exception of the area around the Diversion Dam, the baseline habitat is not protected from harvest by Forest Practice rules. Thus, even if Everett returns to baseline, it will retain significantly more suitable habitat than it would without the SHA.

In a worst-case scenario, Everett would intensively manage forests under the SHA, marginally reducing the total area of foraging and dispersal habitat in the managed matrix, and then the SHA would be terminated early. Under the SHA, intensive management would include regeneration harvests, plantings, and thinnings. Together, these actions could have moderate positive or minor negative effects on the total extent of foraging and dispersal habitats depending on the balance of activities and the response to thinning. Depending on the initial stand condition, thinning will temporarily reduce the value of the site for foraging owls by reducing canopy closure, or it will enhance foraging habitat by increasing mid-story openness and stimulating understory development, which improves movement, prey detection, and prey production. In the long-term, the SHA thinning prescriptions are likely to result in increased areas of foraging and dispersal habitat.

Because all suitable habitat for nesting, roosting, and foraging is designated as the baseline and the vast majority of foraging and dispersal habitat is deferred from harvest during the permit term, even the most intensive management under the SHA could only reduce the extent of foraging and dispersal habitat by a very small proportion. By implementing thinning prescriptions (City of Everett, 2015, Sections 4.1.6.3 and 4.1.6.4), we anticipate an expansion of foraging and dispersal habitat, even with concurrent clearcut harvest of such habitat (City of Everett, 2015, Section 4.1.6.5). If the balance of activities produces any negative changes in foraging and dispersal habitat, the reduction will be fine-scale, localized, and temporary. Moreover, this SHA creates a shifting mosaic of foraging and dispersal habitat and protects otherwise unprotected habitat for nesting, roosting, and foraging.

The SHA specifies voluntary conservation actions that lead to net conservation benefits. There are other requirements already in place under the Forest Practices HCP that will not be changed with this SHA. An important example of this is the riparian prescriptions implemented under the Forest Practices HCP. The riparian prescriptions will not be modified by the proposed SHA, and we are not analyzing those riparian management zones as part of the requirement to achieve a net conservation benefit. However, we acknowledge there will be some habitat contributions to the owl from riparian management zones, particularly later in the permit term.

Beneficial Effects of the SHA

The SHA applies to an area that is not otherwise expected to support dispersal or demography of spotted owls. With SHA implementation, the action area will develop a role in dispersal and demographic support of spotted owls by maintaining functional habitat. Implementation of the SHA is expected to provide increasing areas of spotted owl habitat in the action area over the permit term and beyond. While individual nest sites or foraging habitat could be impacted over time, the enhancement of habitat quantity and quality on the LCT, described above, is expected to contribute to the conservation needs of spotted owls in the zone including the Western Washington Lowlands and Western Washington Cascades Provinces (UFWS, 2011, p.A-3).

The benefits to spotted owls are achieved through consistency of the SHA with the Revised 2011 Spotted Owl Recovery Plan as described below.

Recovery Action 6: *In moist forests managed for spotted owl habitat, land managers should implement silvicultural techniques in plantations, overstocked stands and modified younger stands to accelerate the development of structural complexity and biological diversity that will benefit spotted owl recovery* (USFWS 2011, p. III-19).

The proposed SHA contains prescriptions for reforestation, pre-commercial thinning, and commercial thinning that promote accelerated development of structurally complex forests. Moderate-density tree planting (City of Everett, 2015, Section 4.1.6.2) is intended to achieve rapid forest establishment while also promoting understory shrub production, which corresponds to prey production (Carey 1995). Pre-commercial (City of Everett, 2015, Section 4.1.6.3) and commercial thinning prescriptions (City of Everett, 2015, Section 4.1.6.4) are designed to achieve multiple canopy layers, increased canopy depth, and to enlarge tree crowns. One of the benefits to spotted owls from implementing the SHA is the good potential for the proposed silviculture to develop spotted owl prey habitat suitable for spotted owl foraging behaviors.

Recovery Action 10: *Conserve spotted owl sites and high value spotted owl habitat to provide additional demographic support to the spotted owl population.* (USFWS 2011, p. III-43).

The covered lands likely do not contain any sites occupied by spotted owls. The covered lands do contain sites with complex forest stands that are suitable for owl nesting, or that will become suitable during the permit term. The SHA is in a landscape characterized by intensively managed forests where spotted owl habitat for every life history phase was historically more abundant than it currently is. The SHA will protect from harvest the highest value spotted owl habitat in the action area, which is essential to providing additional demographic support to the spotted owl population in the long-term.

***Recovery Action 14:** Encourage applicants to develop Habitat Conservation Plans and Safe Harbor Agreements that are consistent with the recovery objectives.* (USFWS 2011, p. III-52).

Everett is entering into this SHA voluntarily to receive regulatory assurances for management of their forest lands (City of Everett, 2015, p. 4). Spotted owl habitat in the SHA likely does not support any occupied spotted owl territories at the SHA initiation. However, areas on the SHA contain dispersal, submature, and mature forest stands capable of supporting spotted owls. Everett is interested in regulatory assurances provided by the SHA that allow ongoing forest management without risk of prohibited take. They developed the SHA to provide a net conservation benefit to the spotted owl. The SHA is consistent with Recovery Action 14 because the SHA will provide habitat for spotted owls across life history phases that is complimentary to existing conservation strategies provided by the Northwest Forest Plan and DNR State Lands HCP.

Summary of the Effects of the Action

The existing nesting, roosting, and foraging habitat for spotted owls in the action area is within the 447 acres of designated baseline. During SHA implementation, harvest deferrals on 1,066 acres will result in increased areas of suitable nesting, roosting, and foraging habitat for spotted owls. The deferrals include approximately 97 acres of buffers on narrow streams. While we do not expect nesting, roosting, and foraging habitat to develop in 50-foot wide stream buffers, suitable nesting habitat may develop in any other area deferred from harvest. This means 522 acres of suitable habitat are likely to develop from SHA implementation.

In considering the effects of the SHA on the status of the species, we must consider the likelihood that spotted owls do not occur in the action area prior to SHA implementation based on past owl surveys of the LCT. Therefore, the potential for adverse effects to the species relies on the achievement of beneficial effects first. That is, before any direct adverse effects may result from the action, owls will first have to re-colonize the action area. Expanding into the LCT would, on its own, be considered a significant improvement to the status of spotted owls in the action area and will rely, in large part, on the habitat conditions in the LCT.

The significant adverse effects that are likely to result from SHA implementation are limited to the effects of noise and visual disturbance after owls establish territories on covered lands. Noise and visual disturbance will disrupt normal behaviors. Forest management activities will disrupt normal nesting and foraging behaviors of all adult spotted owls associated with 77 acres of habitat exposed to noise and visual disturbance over three non-consecutive nesting seasons during the 50-year permit term. Likewise, road construction will disrupt normal nesting, and foraging behaviors of all adult spotted owls in 12 acres of habitat (4 of these acres are within the 77 acres above) exposed to noise and visual disturbance over one nesting season. Finally, tree removal for maintenance activities at the Diversion Dam will disrupt normal nesting and foraging behaviors of all adult spotted owls in 4 acres exposed to noise and visual disturbance during one nesting season.

We concluded above that there is a likelihood that, during the Permit term, one spotted owl nest site will be abandoned due to noise and visual disturbance at the outset of the nesting season. We also concluded that owls abandoning a nest site will be able to locate additional nest sites within the action area due to landscape conditions resulting from SHA prescriptions. We estimate that this would result in up to two years of reduced reproduction for one pair of spotted owls due to the need to establish a new nesting site prior to successful breeding. However, even considering a potential displacement from a nest site, the long-term effect of SHA implementation will enhance the status of the species in the action area because reproductive adult spotted owls are not currently using the action area at all.

Overall, we expect that the short-term, adverse effects of the action will be offset by the long-term benefits to the species. The plan will provide demographic support for spotted owls in an area that currently lacks regulatory protections for unoccupied spotted owl habitat and is not currently occupied by spotted owls. This results in a significant improvement in the role of the action area for spotted owl distribution.

CUMULATIVE EFFECTS: NORTHERN SPOTTED OWL

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

The action area is predominately forested land managed for timber production. The overwhelming majority of forestland in the action area is under non-Federal ownership and forestry activities are covered under federally-approved HCPs. Any significant changes to any of those HCPs require Federal actions that are unrelated to the proposed action. Other land uses in the action area include reservoir management and some residential parcels. We expect the area to remain in low-density residential mixed with forestry for the full permit duration. Reservoir management is subject to future Federal actions that are unrelated to the proposed action.

There are no known State, Tribal, local, or private actions that are reasonably certain to occur in the action area.

INTEGRATION AND SYNTHESIS OF EFFECTS: NORTHERN SPOTTED OWL

Many spotted owl populations are declining. Declines are especially severe in the northern parts of the species' range, where populations dropped by 40 to 60 percent from 1992 to 2006 (Forsman et al. 2011, p. 45). The action area is within this northern range. The factors that influence spotted owl demography are not fully understood, but habitat quality and quantity, annual weather patterns, and the presence of barred owls are all factors that affect spotted owl survival, reproduction, and local population trends (Formsan et al. 2011, p. 75).

Over the past decade, it has become apparent that competition with the barred owl poses a significant threat to the spotted owl. Past habitat loss and current habitat loss are also threats to the spotted owl, even though loss of habitat due to timber harvest has been greatly reduced on

Federal lands for the past two decades (USFWS 2011, p. vi). Conservation strategies for the spotted owl emphasize the importance of maintaining large blocks of suitable habitat to support clusters of spotted owl territories by providing for demographic exchange (dispersal) between these local populations (USFWS 2011, p. II-3), and reducing impacts associated with barred owl competition (USFWS 2011, p. II-4).

Under the SHA, additional habitat will develop compared to management without the permit. Spotted owl distribution is expected to expand marginally as forests in the action area mature to provide better nesting, roosting, and foraging habitat with increased foraging and dispersal habitat. Silvicultural prescriptions to create and maintain additional dispersal habitat are expected to contribute to improved connectivity for spotted owls dispersing across or within the action area. This, in turn, will provide connectivity between the Western Washington Cascades physiographic province and the Western Washington Lowlands physiographic province (USFWS 2011, p. A-3). While an individual owl nest site will be negatively impacted by noise and visual disturbance over the permit duration, the SHA will protect all existing nesting, roosting, and foraging habitat from harvest and increase the overall amount and quality of foraging habitat in the action area. This enhancement of habitat quantity and quality on a landscape scale within the action area will contribute to meeting the conservation needs of the spotted owls in these provinces.

Forest management under the SHA will maintain larger blocks of suitable habitat for spotted owls than without the SHA due to set-asides for baseline habitat and other harvest restrictions. This reduced level of habitat fragmentation is expected to directly improve habitat conditions for spotted owls while also providing any spotted owls present with less competition from barred owls (Sovern et al 2014, p. 1439).

Although the SHA will result in habitat improvements and will not increase exposure of spotted owls to competition from barred owls, spotted owls will be disturbed by project activities. Disturbance to spotted owls will result from noise-generating activities that may occur year-round in areas where spotted owl occupancy is not detected. This type of disturbance will be ongoing at the start of the nesting season and will expose 85 acres of suitable nesting habitat to noise and visual disturbance over 3 to 4 nesting seasons over 50 years (3 seasons of exposure to 77 acres and 4 seasons of exposure to 12 acres, of which 4 acres overlap with the 77 acres). The result of exposure to noise and visual disturbance is anticipated to be the abandonment of one nest site at the onset of the breeding season once in the 50-year permit term, and in the event that spotted owls eventually occupy the LCT.

If a spotted owl pair abandons a nest sites as a result of SHA implementation, the effects would likely include failed or delayed breeding for that nesting season. Over the 50-year term of SHA implementation, one instance of failed or delayed breeding will marginally delay establishment of additional spotted owls. Because reproduction is irregular over time (Noon and Biles 1990, p. 20), and there are uncertainties about how soon owls may occupy the LCT, we cannot quantify the duration of such a delay in reproduction. By contrast, without the SHA, we would not expect any spotted owls to occupy the LCT, perpetually prohibiting establishment of additional spotted owls. Effects of a single delayed or failed breeding in a 50-year period will not be measurable at a population scale, especially if the population is expanding in a manner that enables future establishment of breeding pairs in the action area. However, even considering an expected nest abandonment resulting from noise and visual disturbance, the overall effect of SHA implementation is enhancement of the status of the spotted owls in the action area because reproductive adult spotted owls are expected to re-occupy portions of the action area that they are not currently using.

The action area is not expected to contain any occupied spotted owl sites at the time of SHA initiation, so there is no potential for reductions in spotted owl survival and reproduction associated with implementation of the SHA prescriptions.

The SHA uses active forest management to create or enhance dispersal habitat through planting and (pre)commercial thinning prescriptions that encourage understory development and appropriate tree density for dispersal habitat. Combined with protections for suitable nesting habitat, the SHA will benefit spotted owls through habitat improvements at the scale of the action area in excess of the protected baseline habitat. The effects of noise and visual disturbance on spotted owls will include disturbance of an undetected pair at the onset of the breeding season after benefits of SHA implementation result in establishment of spotted owls in the action area. Overall, with the SHA, the action area will contribute to the demographic support of spotted owls by protecting, creating, and enhancing suitable nesting, roosting, and foraging habitat. The adverse effects of SHA implementation after owls begin to occupy the LCT —up to four episodes of disturbance and one instance of reduced reproduction from pre-breeding nest abandonment—are insignificant to the spotted owl population, especially in light of the long-term benefits of SHA implementation. In order for the adverse effects to occur, the benefits of SHA implementation must be partially realized through occupancy of the LCT by spotted owls.

CONCLUSION: NORTHERN SPOTTED OWL

After reviewing the current status of northern spotted owl, the environmental baseline for the action area, the effects of the proposed SHA and the cumulative effects, it is the Service's Opinion that the SHA, as proposed, is not likely to jeopardize the continued existence of the northern spotted owl.

No critical habitat has been designated in the action area for this species; therefore, none will be affected.

STATUS OF THE SPECIES: MARBLED MURRELET

For a detailed account of marbled murrelet biology, life history, threats, demography, and conservation needs, refer to Appendix B: Status of the Species: Marbled Murrelet.

ENVIRONMENTAL BASELINE: MARBLED MURRELET

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of state and private actions which are contemporaneous with the consultation in progress.

The action area is in a rural area of Snohomish County. Neighboring land uses are mostly forestry and a small amount of low-density residential sites. The LCT lands are situated around Lake Chaplain, a drinking water reservoir approximately three miles north of Sultan, Washington, at the western edge of the Cascade Mountain Range. State-owned forest lands managed under the DNR HCP account for the majority of the LCT perimeter (approx. 80 percent). The private lands dotting the LCT perimeter include residential and forestlands. The surrounding forest lands are generally managed for commercial timber production.

A small area of Mt. Baker-Snoqualmie National Forest abuts the LCT's perimeter at the Diversion Dam. Lands managed by the U.S. Forest Service in the action area are not designated critical habitat for murrelets. Likewise, the majority of the LCT's eastern boundary border State Lands managed by Department of Natural Resources that is not designated critical habitat.

The LCT is characterized by forests with Douglas-fir, western hemlock forests, western red cedar, and red alder. Nearly all of the LCT was previously clearcut for timber harvest, starting in the mid- to late-19th century. During past forest management on the LCT, almost all the forest has been cut for timber.

For SHA development, the Service and Washington Department of Fish and Wildlife biologists evaluated the LCT forests for suitable murrelet nesting platforms (City of Everett, 2015, Appendix C). At the time of writing, suitable habitat for murrelets occurred in four patches contained within the 447-acre SHA baseline (City of Everett, 2015, Appendix C). Areas designated for other set-asides (e.g., old-growth management areas) were also reviewed, and were determined to not be suitable nesting habitat. The remaining stands on the LCT were reviewed using Everett's inventory data and aerial photos.

Current Condition of the Species in the Action Area

Murrelet detections in and around the action area vary among surveys, though suitable habitat was surveyed only sporadically. Murrelets were observed over Lake Chaplain and over the forest on the west-northwest shore of the Lake in three years during the mid-1990's (City of Everett, 2015, p. 19), though behaviors indicating nesting were not documented. Surveys from 1993 to 1995 may not have been done according to the PSG survey protocols (Ralph et al 1994). Murrelets were not detected during audio/visual PSG protocol surveys (Mack et al, 2003) along a portion of the mature forests on the eastern shore of Lake Chaplain in 2007 and 2008 (City of Everett, 2015, p 19). Murrelet occupancy (i.e., nesting) was determined near the Diversion Dam during a 2014 survey (City of Everett, p. 19). Most of the LCT was never surveyed for murrelets. Taken together, survey results indicate that murrelets use the action area, and at least one site was determined occupied.

The action area is within Conservation Zone 1 (USFWS 1997, p. 114), where murrelets occur at low density and are exhibiting a 5.4 percent annual decline (Lance and Pearson 2015, p. 5). Threats to murrelets in Conservation Zone 1 include habitat loss or degradation and reduced prey quality (USFWS 2009, p. 22). These threats are compounded by exposure of nests to predators in managed forests (USFWS 1997, pp. 47-54; Malt and Lank 2009, entire).

The primary factor of the action area affecting murrelets and murrelet populations is the availability of high quality nesting habitat. Historically, nesting habitat in the action area was much more abundant. Due to intensive timber management, stands containing large trees with adequate nesting platforms are currently fragmented and rare, so each remaining nest site is important to the current population of murrelets. In the context of the species' extremely low productivity (measured by juvenile/adult ratio at sea) and widespread habitat losses, the loss of nesting sites is considered a primary mechanism for the species' continued decline.

Compounding the effects of habitat loss, where occupied habitat is fragmented or anthropogenic activity is common, avian predators, such as corvids (e.g., crows and ravens) are likely to exert increased pressures on murrelets by harassing adults or feeding on murrelet eggs (Raphael 2002). Mammalian predators, such as squirrels and mice, are also likely to prey on murrelet eggs and chicks. Mammalian responses to habitat fragmentation and human disturbance likely vary by species and degree of habitat alteration. Information on mammalian predation of murrelets in the action area and elsewhere is scant (Bradley and Marzluff 2003; Flaherty et al. 2000).

In addition to predators, habitat fragmentation exposes nest sites to noise and visual disturbance from human activities. Because recreation is limited on the LCT and forestry is the dominant land use, increased noises and visual disturbances usually result from heavy machinery used for forest management activities.

Murrelet responses to potential predators and to noise and visual disturbances include abandoning a feeding mission (Hamer and Nelson 1998, pp. 8-17; Appendix C–Revised Disturbance Analysis for Marbled Murrelets). When these stressors are common in the action area, murrelets must expend extra energy making return trips to foraging territories to maintain feedings for chicks. The action area is located approximately 18 miles east of the nearest marine waters, though individuals probably travel even farther to forage. When adults have to make additional foraging trips, or if a feeding is missed, these can represent a developmental delay for the chick or increased risk of predation from "advertising" nest locations (Hull et al 2001, p 1036; Kuletz 2005, pp 43-45).

Based on limited habitat availability in the action area, intense habitat fragmentation, and the moderate distance to marine foraging areas, we conclude that the current condition of murrelets in the action area is consistent with the species' dramatic declines across Conservation Zone 1 measured since listing (Lance and Pearson 2015, p. 5).

Conservation Role of the Action Area

The action area is located in the middle of Conservation Zone 1, as defined in the Marbled Murrelet Recovery Plan (USFWS 1997, p. 114). The covered lands have at least one occupied nesting stand near the Diversion Dam, approximately two miles east of Lake Chaplain, and three patches of currently suitable habitat (City of Everett, 2015, Figure 4-1) without documented occupancy. No other occupied sites are known in the action area.

"Because of loss of late-successional forest habitat and its replacement with urban development in the Puget Trough, remaining suitable nesting habitat for marbled murrelets on the eastern shore of Puget Sound is a considerable distance from the marine environment (more than 32 kilometers [more than 20 miles]), lending special importance to remaining nesting habitat that is closest to Puget Sound" (USFWS 1997, p. 125). The Puget Sound is approximately 18 miles west of the action area; dense residential and urban areas fill in from 5 miles west of the action area to the Puget Sound shoreline. In the vicinity of the action area, suitable habitat on the LCT is likely among the nearest to the Puget Sound (i.e., foraging territory). The LCT is located between the Puget Sound and large blocks of Federal forestlands in the Cascades where suitable nesting habitat is currently concentrated. Given its relative proximity to marine foraging areas, the LCT is among the "first" habitat that murrelets will encounter when flying from the Puget Sound toward the Cascades. Murrelets that may utilize suitable habitat in the LCT could experience lower energetic demands for marine foraging trips than is experienced by murrelets using the further Federal lands. Even with declining population numbers, murrelets nesting on, or fledged from, nearby Federal lands may provide a source population for the action area, so suitable habitat in the action area has a likelihood of becoming occupied during the permit term.

Suitable habitat in the action area is within the four forest patches designated as baseline habitat under the SHA. The patches total 447 acres. While it remains an important habitat for murrelets, the action area can provide only a relatively minor contribution to the regional carrying-capacity base for murrelets (Raphael et al. 2008). The LCT has only 0.0006 percent of the 675,000 acres of suitable habitat estimated to remain in Conservation Zone 1 (McShane et al. 2004, p. 4-9).

Unoccupied habitats can also be important for murrelet conservation in that they provide potential nesting opportunities for displaced breeders and/or first-time breeding adults if they disperse away from their natal breeding habitat seeking nesting habitat to colonize. The conservation role of the LCT is to continue providing nesting opportunities to murrelets within the context of a highly fragmented and intensively managed landscape where other nesting opportunities may be limited. Given that rangewide productivity is extremely low and habitat loss is considered a primary mechanism for the continued decline of the species, any nest site in the action area has conservation value to the species.

<u>Climate Change</u>

In the Pacific Northwest, mean annual temperatures rose 0.8 °C (1.5 °F) in the 20th century and are expected to continue to warm from 0.1 °C to 0.6 °C (0.2 °F to 1 °F) per decade (Mote and Salathe 2010, p. 29). Climate change models generally predict warmer, wetter winters and hotter, drier summers and increased frequency of extreme weather events in the Pacific

Northwest (Salathe et al. 2010, pp. 72-73). Predicted climate changes in the Pacific Northwest have implications for forest disturbances that affect the quality and distribution of murrelet habitat. Both the frequency and intensity of wildfires and insect outbreaks are expected to increase over the next century in the Pacific Northwest (Littell et al. 2010, p. 130).

One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration, and severity. Westerling et al. (2006, pp. 940-941) analyzed wildfires and found that since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period from 1970-1986. The total area burned is more than 6.5 times the previous level and the average length of the fire season during 1987-2003 was 78 days longer compared to 1978-1986 (Westerling et al. 2006, p. 941). The area burned annually by wildfires in the Pacific Northwest is expected to double or triple by the 2080s (Littell et al. 2010, p. 140). Wildfires are now the primary cause of murrelet habitat loss on Federal lands, with over 56,000 acres of habitat loss attributed to wildfires from 1994 to 2007 (Raphael et al. 2011, p. 31). Climate change is likely to further exacerbate some existing threats such as the projected potential for increased habitat loss from drought related fire, mortality, insects and disease, and increases in extreme flooding, landslides and windthrow events in the short-term (10 to 30 years).

Within the marine environment, effects on the murrelet food supply (amount, distribution, quality) provide the most likely mechanism for climate change impacts to murrelets. Studies in British Columbia (Norris et al. 2007) and California (Becker and Beissinger 2006) have documented long-term declines in the quality of murrelet prey, and one of these studies (Becker and Beissinger 2006, p. 475) linked variation in coastal water temperatures, murrelet prey quality during pre-breeding, and murrelet reproductive success. These studies indicate that murrelet recovery may be affected as long-term trends in ocean climate conditions affect prey resources and murrelet reproductive rates. While seabirds such as the murrelet have life-history strategies adapted to variable marine environments, ongoing and future climate change could present changes of a speed and scope outside the adaptive range of murrelets (USFWS 2009, p.46).

EFFECTS OF THE ACTION: MARBLED MURRELET

The effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The SHA describes voluntary conservation actions that are expected to lead to net conservation benefits to murrelets. To issue an enhancement of survival permit under section 10(a)(1)(A) of the ESA, there needs to be a reasonable expectation of net conservation benefits that contribute directly, or indirectly, to the recovery of the covered species (64 FR 32717). In this case, the benefits are associated with the area of suitable nesting habitat. There can also be adverse effects associated with SHA implementation. Significant adverse effects on murrelets are anticipated from exposure to the following stressors (1) noise and visual disturbance associated with equipment operation for timber harvest, road construction, and road maintenance near suitable murrelet nesting habitat and (2) exposure of potential nest sites to new forest edges that attracts avian predators into murrelet habitat. These stressors are addressed in more detail below.

Beneficial Effects

Everett, in coordination with Service, identified 447 acres in 4 discrete patches ranging from 53 acres to 177 acres per patch of potential murrelet nesting habitat as their baseline. This likely overestimates the amount of suitable habitat. Over the duration of the SHA, additional areas within the baseline stands will mature into suitable nesting habitat through forest growth and maturation. Beyond baseline habitat, we also anticipate development of potential nest trees (PNT) in the set-asides (SHA section 4.1.2) and special management areas (SHA section 4.1.3) at variable rates based, in part, on current stand development phases. The set-asides and special management areas are delineated to include all stands that are on trajectory to develop suitable nesting habitat during the permit term, though other areas are also included in these categories for other reasons. Set-asides designated as unstable slopes and larger riparian buffers are likely to develop PNTs during the permit term, as are special management areas designated as Old Growth Management Areas. The Permanent Mixed Forest and Green Tree Areas will be more variable regarding habitat suitability during the permit term. Together, special management areas and set-asides defer harvest on 619 acres during the permit term; in these areas, up to 522 acres have good potential to become suitable nesting habitat during SHA implementation (see analysis below, including implementation uncertainties). The likelihood of murrelets nesting on the LCT will increase overtime due to habitat expansion and maturation resulting from SHA implementation.

Implementation Uncertainties

The Service identified specific uncertainties with the SHA. One topic of uncertainty is what portion of set-aside stands will develop into suitable murrelet habitat during the life of the SHA. The Service assumes that set-asides and special management areas will grow PNTs during the permit term, but the narrow riparian buffers associated with non-fish-bearing streams will not provide functional habitat due to the minor amounts of interior forest condition, if any, that occur in those areas. Suitable habitat will occur in portions of the set-asides and special management areas, but will not occur in all such areas at any given time.

A second topic of uncertainty is whether any stands scheduled for active management with (pre)commercial thinning regimes would provide suitable murrelet nesting habitat during the permit term. The Service expects that development of suitable nesting platforms in managed stands is unlikely to occur during the permit term. This assumption is based on the low likelihood of such stands developing numerous large platforms with moss cover during the first few decades after treatment.

Another area of uncertainty is the possibility of future murrelet occupancy. As forests in set-aside areas and special management areas mature over the 50-year Permit term, we anticipate that trees will grow large limbs adequate for nesting, stands will increase in habitat capability, and the LCT will develop additional suitable murrelet habitat. Therefore, the chance of occupancy increases later in the Permit term. However, the chance of occupancy is good throughout the permit term, as evidenced by the prior detection of murrelets on the LCT. Lastly, we cannot estimate the future murrelet population's rate of colonizing newly developed habitats on the covered lands.

Effects of Tree Removal

Adverse effects on murrelets will result from the covered management activities. This includes normal forest management operations, and construction of a road segment along baseline habitat. Due to forest management patterns and current stand conditions that preclude development of murrelet nesting habitat on the overwhelming majority of forestlands adjacent to the LCT, the negative effects would all occur on covered lands. We identified the following stressors that will result from the proposed activities: 1) removing potential habitat outside the nesting season; 2) noise and visual disturbance; and 3) increased risk of avian predation associated with construction of a new road along baseline habitat.

Removal of Trees from Suitable Habitat on City of Everett Lands

Because murrelets exhibit nest site fidelity (Burger et al 2009, p. 217 & 222), felling of PNTs can adversely affect murrelets. Even if the tree is felled outside the nesting season, the murrelets returning to that tree in a subsequent season would be forced to locate an alternate nest site. This behavior is energetically costly, and increases risk of adult predation. In areas where nesting habitat is highly fragmented or otherwise limited, relocating to a new nest site could result in a delay in the onset of nesting, nest site abandonment, or failed nesting due to higher predation risk at a marginal nesting location (Divoky and Horton 1995, p. 83; Raphael et al 2002, p. 232).

Murrelets are likely to maintain fidelity to their nesting sites as long as the habitat stand retains some suitable nesting structures and the birds are able to successfully nest at the site (Divoky and Horton 1995, pp. 83-84). Birds seeking a new nesting location may prospect for nest sites. Prospecting for nest sites is a well-documented murrelet behavior involving individuals or pairs flying near and landing on tree limbs in the early spring and midsummer. Murrelets also visit nesting areas during the winter and may select nest sites during this time (Nelson 1997, p. 7). Research in Oregon (Meyer et al 2002, p. 110) and in British Columbia (Zharikov et al 2006, p. 117) indicates that murrelets do not immediately abandon fragmented or degraded habitats. Murrelets may prospect on the LCT prior to their first nesting season or in response to tree removal in previously used nesting habitat. Because thinning prescriptions applied under the SHA are not likely to develop murrelet nesting habitat in managed stands during the permit term, we do not expect any removal of suitable habitat as a result of timber management operations. However, under the SHA, removal of trees from suitable nesting habitat may occur during road construction and maintenance of the Diversion Dam.

Tree Removal Due to Road Construction and Diversion Dam Maintenance

Adjacent to the northwestern patch of baseline habitat, Everett proposes, under the SHA, to construct a segment of new road to accommodate future timber management in an adjacent stand. The road construction will remove approximately 0.9 acre of existing forest adjacent to designated baseline habitat based on an estimated 750 feet of road length and 50 foot of corridor width (50 feet exceeds the actual road width to include the entire construction footprint). PNTs are located near the proposed road segment in a stand without known murrelet occupancy; protocol surveys were not completed in this stand. The PNTs in the adjacent stand are not immediately adjacent to the proposed road corridor, so neither the PNTs in the baseline, nor the neighboring tree crowns that provide cover to potential nesting platforms will be removed. During a recent site visit, the Service confirmed that there are not currently any PNTs in the proposed construction footprint (City of Everett, 2015, Appendix C). Figure 4-1 in SHA shows the location of the proposed road. Figure 2 in SHA, Appendix C shows a "position checkpoint" in the proposed road corridor, so we confirmed that this does not indicate the location of a PNT as did most of the other points shown in Figure 2.

In a similar action, Everett will remove non-PNTs adjacent to the baseline habitat at the Diversion Dam. In contrast to the new road segment, murrelets are known to occupy the stand at the Diversion Dam. By our own estimate, the Diversion Dam maintenance project will remove up to a half-acre of trees that do not contain nesting platforms. The trees are adjacent to existing infrastructure for dam operations.

Trees in the 0.9-acre road corridor and 0.5-acre Diversion Dam maintenance area contribute to stand integrity by minimizing habitat fragmentation (e.g., Raphael et al 2002, entire). Effects of fragmentation on murrelets can be significant (e.g., Burger et al 2004, entire), particularly when habitat alteration extends to adjacent nest trees. The proposed road corridor is not adjacent to known occupied sites, though the Diversion Dam is. Neither of these proposed actions will remove PNTs. Trees currently providing cover to PNTs will also remain unaltered. The removed trees may have become suitable nest trees or could have eventually provided cover to suitable nest trees during the permit term; however, their removal will not actually reduce the number of suitable nesting sites on the LCT. Therefore, we do not expect physical impacts to individual murrelets from this activity. In following sections, we evaluate the potential effects of this removal as it pertains to noise and visual disturbance, as well as predation.

Effects to Murrelets from Removal of Non-Nest Trees in a Nesting Stand

Removal of non-nesting trees will occur in a stand that is otherwise suitable for murrelet nesting when the road corridor is constructed. In effect, this will create a gap in the canopy of a suitable nesting stand. The project will not remove any PNTs, or any trees providing cover to PNTs along the 750-foot long route, totaling 0.9 acre. Contiguous suitable murrelet nesting habitat extends across 99 acres at this location in the northwest corner of the Lake.

Removal of non-nesting trees in a nesting stand will also occur for a small maintenance project at the Diversion Dam. This project will remove up to a half-acre of trees that do not contain nesting platforms adjacent to existing infrastructure for dam operations. Similar to the above-described road construction, this work will not remove PNTs or trees providing cover directly to PNTs.

Tree removal for these two projects will marginally reduce the suitability of some existing PNT in the adjacent stands by generating greater predation risks than are found in interior forest conditions. Reduced amounts of interior forest could result in increased predation risk, fewer nesting attempts, and the eventual abandonment of the site by murrelets, although this outcome is not certain. Because additional nesting habitat would remain in the immediately adjacent areas, it is highly likely that a displaced breeding pair would attempt to find another nest tree within the remaining habitat.

The proposed actions will create additional areas of edge effects in the forest. Research in the Pacific Northwest has also identified up to 15 mammalian and avian species that potentially prey on murrelet nests (Marzluff and Neatherlin 2006, p. 308). The risk of predation on murrelet nests by avian predators—especially corvids—appears to be highest in close proximity to forest edges (including roads), campgrounds, and settlements (Raphael et al. 2002, Marzluff and Neatherlin 2006). As the ratio of edge to interior habitat increases, nesting patch size decreases, or murrelets simply use nesting habitat with higher predation risks. Raphael et al (2002, p. 226) reviewed the few available studies and records of predation at murrelet nest sites and observed that predation caused most nest failures within 55 yards of forest edges. Habitat alteration and periodically increased levels of human activity will attract avian predators, so we expect the tree removal to extend existing predation risks 55 yards into the forest at these sites.

Information is not available to describe existing predation risks at each of these two sites, though it is reasonable to consider the action area a moderate-risk landscape for predation resulting from existing habitat fragmentation. Current predation risks are highest near stand edges, particularly where there is a substantial difference in stand conditions across the stand edge, or where anthropogenic infrastructure exists adjacent to murrelet nesting habitat. Tree removal at these two locations will expand this effect into the forest within 55 yards of the new edges.

To estimate the area of this effect, we must know the size and orientation of the projects. Because this information is not available for maintenance work at the Diversion Dam, we assumed a reasonable worst case scenario in which the 0.5-acre project area is arranged parallel to the river and is 50 feet wide and 435 feet long. Other likely arrangements of the impact area produce a less linear impact area that would result in a smaller effect-area, so we consider this assumption to be a reasonable worst case, resulting in 3.2 acres where murrelets will be exposed to increased predation risks.

The road construction project area is approximately 50 feet wide by 750 feet long, or 0.9 acre. Most of the forest area around this project is designated as baseline habitat, though areas of non-habitat are present west of and southeast of the project footprint. The area of suitable habitat within 55 yards of the project footprint where we expect murrelets will be exposed to increased predation risk is 4.8 acres.

In total, tree removal adjacent to suitable habitat will expose murrelets to increased predation risks in eight acres of suitable nesting habitat. This effect is likely to persist as long as the forest edge remains pronounced, conservatively estimated as a permanent impact.

Increased predation risk may result in individuals nesting in other locations within the action area or nesting with this risk. Pairs nesting in other nearby locations are likely to find suitable habitat within the action area. Of the pairs nesting within 55 yards of the new clearings, lower productivity is expected, but some nests may successfully fledge young. Because the effects of the action of the action will increase predation risks in less than two percent of the baseline habitat, or less than 1 percent of the areas where suitable nesting habitat may occur by the end of the SHA term, we do not expect the change in predation risks over these two small areas to measurably alter murrelet productivity in the action area.

Noise and Visual Disturbance in Occupied Murrelet Habitat

Background Information Regarding Disturbance to Murrelets from Project Noise and Activity

The use of excavators, chainsaws, graders, and other motorized equipment will introduce increased levels of sound and human activity into project areas during SHA implementation and the subsequent return-to-baseline. Over the 50-year permit duration, road construction, road maintenance, and timber management will expose murrelets in adjacent stands to noise and visual disturbance. These activities will coincide with the murrelet nesting season (April 1 to September 23) in un-surveyed habitats where the Occupied Site Provisions are not implemented.

The noise and visual disturbances associated with the proposed action have the potential to affect murrelets in the action area. To minimize the likelihood and magnitude of effects, equipment operation during the nesting season will abide by daily and seasonal timing restrictions when operating adjacent to known-occupied sites, subject to conditions of the Occupied Site Provisions (City of Everett, 2015, Section 4.1.7). Noise and visual disturbance is also minimized by the arrangement of set-asides adjacent to potentially suitable habitats (e.g., see City of Everett, 2015, Map 4-1 and Section 4.1.3.1), and by the conservative designation of baseline habitat. During the Permit term, limitations on equipment operation will minimize but not completely avoid noise and visual disturbance to murrelet habitat.

We previously analyzed the effects of noise and visual disturbance to murrelets (e.g., USFWS 2013, pp. 101-11 and Appendix A; USFWS 2014, pp. 13-21) and concluded that these types of project noises or activities can disrupt normal murrelet nesting behaviors in some situations. Significant disturbance occurs when project-generated noise or activity causes a murrelet to avoid or delay nest establishment, flush away from an active nest site during incubation or brooding, abort a feeding attempt to nestlings, or maintain increased vigilance (USFWS 2006, p. 123). A flush from a nest site includes movement out of an actual nest, off of the nest branch, and away from a branch of a tree within suitable habitat during the nesting season. Such events are considered significant because they have the potential to result in reduced hatching success, fitness, or survival of juveniles and adults.

Appendix C (*Revised Disturbance Analysis for Marbled Murrelets*) provides a literature review that informs our analysis of disturbance effects to murrelets. Acknowledging that the effects of noise and general disturbance in the terrestrial habitat of the murrelet only result in significant effects during the nesting season, the analysis groups potential exposures of nesting murrelets to noise and human activity into three categories: (1) aircraft noise (helicopters and planes); (2) ground-based continuous noise and human activity (e.g., chainsaws, heavy equipment); and, (3) impulsive noise (pile-driving and blasting). We concluded that under certain scenarios these activities could result in significant disruptions of normal behaviors that result in a likelihood of injury to murrelets. The following behavioral responses are considered a significant disruption of normal behavior: (1) an adult murrelet avoiding or delaying nest establishment; (2) an adult flushing from a nest or perch within the vicinity of a nest site; and (3) an adult murrelet delaying or aborting one or more feedings of nestlings. The proposed action includes ground-based activities that will occur during the nesting season and will produce continuous noises (category 2), but the action will not include aircraft noise (category 1) or impulsive noises during the nesting season (category 3).

We expect that disturbances resulting in the above-described behaviors are likely to result from ground-based activity during the nesting season (April 1 to September 22) within 110 yards of a nest site.

Exposure of Murrelets to Noise and Visual Disturbance

Murrelets will be exposed to noise and visual disturbance within nesting habitat as a result of road construction, road maintenance, and forest management activities. Exposure will result where these activities are conducted adjacent to stands that are occupied and unsurveyed, or adjacent to occupied stands not meeting the Occupied Site Provisions.

Road maintenance activities will occur on all roads within the LCT during SHA implementation. According to Everett, road maintenance includes grading every three years and annual mowing (Hitchcock, 2015). Although equipment-generated noises will exceed the murrelet disturbance threshold in suitable habitat within 110 yards of road maintenance, the activity will be transient, not staying in any one location for an extended duration. Noises and visual disturbances generated by transient road maintenance activities will be extremely brief duration at any single location, so increased noise and visual disturbance is not reasonably certain to overlap with the delivery of prey items to nestlings within the disturbance zone (Appendix C, p. 10). Road maintenance activities generating continuous sounds at any one location are not proposed under the SHA. Therefore, road maintenance activities are likely to generate noise and visual disturbance that does not significantly alter murrelet behavior or nesting success.

Road construction activities will occur once during the SHA in one location, adjacent to a baseline habitat block in the northwest portion of the LCT. Minimization measures include daily operating restrictions that prohibit noise-generating activities within a quarter-mile of an occupied site except between two hours after sunrise and one hour before sunset. No blasting will occur during the nesting season. Ground-based equipment will produce continuous noise and has associated human activity. Equipment-generated noises will exceed the murrelet disturbance threshold in the portions of baseline habitat within 110 yards of the 750-foot long road segment, totaling totals 12.4 acres of potentially suitable nesting habitat, for up to one nesting season.

Forest management activities occurring adjacent to murrelet nesting habitat during the nesting season will also result in exposure of murrelets to noise and visual disturbance. Minimization measures include implementation of the Occupied Site Provisions and the placement of green tree areas between harvest units and suitable habitat to serve as a physical buffer. Under the

SHA, Everett will implement up to 30 acres of clearcut harvest per year, or up to 150 acres per five-year period. Everett will also thin forests at 8 to 10 years and 30 to 40 years of stand age. There remain too many management uncertainties (e.g., shape and location of harvest units) to specify exactly how many acres of suitable habitat will be exposed to noise and visual disturbance as a result of forest management activities. We can, however, estimate a worst-case scenario.

A worst-case scenario of noise and visual disturbance from forest management activities will expose all areas designated as set-asides or special management areas (areas where murrelet nesting habitat may develop during the SHA) to noise and visual disturbance. This exposure will last for an entire nesting season at a time. Without consideration of potential green tree areas, the Service mapped the areas of baseline habitat and active management areas; Out of 447 acres of baseline habitat, approximately 175 acres of the baseline habitat are more than 110 yards from forest stands that will be managed under the SHA, meaning these 175 acres of baseline habitat will never be exposed to noise and visual disturbance from forest management activities. The remaining 272 acres of baseline habitat will be exposed to noise and visual disturbance from forest management activities during at least one nesting season unless the Occupied Site Provisions are implemented. This exposure will occur in different years at different locations.

Noise and visual disturbance from forest management activities will occur at each location up to three times during the 50-year term of the SHA. Even-aged management areas will have up to three harvest activities: pre-commercial thinning, commercial thinning, and a regeneration harvest. At most locations, only two of these three steps will be implemented in a 50-year period. However, a stand subject to regeneration harvest in the early years of SHA implementation will be ready for pre-commercial and commercial thinning within the permit term. Likewise, for uneven-aged stands, management will occur three times during the permit term only in those stands actively managed in the early years of SHA implementation. Because we cannot accurately estimate the locations of management activities by year, this analysis assumed all areas that may be exposed to increased noise and visual disturbance by forest management activities are exposed for the full duration of two to three non-consecutive nesting seasons during the SHA. With these assumptions, we conclude that 272 acres of baseline habitat will be exposed to noise and visual disturbance from forest management activities throughout three nesting seasons. Similarly, all 522 acres of set-asides and special management areas, where murrelet nesting habitat may develop during the permit term, will also be exposed to noise and visual disturbance from forest management activities. However, in the set-asides and special management areas, nesting habitat will take additional time to develop, so we estimate that this effect will be limited to two nesting seasons over the 50-year permit term.

There are no data detailing the specific locations of murrelet nests in the action area. Covered activities will occur in areas with periodic human activity and high levels of habitat fragmentation. The project area is nearer to marine foraging areas than most of the available habitat in the Cascades portion of Conservation Zone 1 (USFWS 1997, p. 114). It is reasonable to expect that murrelets will be nesting in the suitable habitat on the LCT and will be exposed to project-generated disturbances from road construction and forest management that significantly disrupt normal behaviors, as described below.

Response of Murrelets to Noise and Visual Disturbance

The action includes a conservation measure requiring that certain activities scheduled to occur during the murrelet nesting season will start at least two hours after sunrise and cease two hours prior to sunset. This restriction reduces the potential to disrupt murrelets during their daily peak activity periods for establishing nest sites, feeding, and incubation exchanges, but it does not eliminate exposure under all circumstances. Activities not triggering the Occupied Site Provisions will likely disrupt some adult nesting behaviors, including nest establishment, incubation exchanges, and feeding of nestlings, and will increase the time spent vigilant. Such events are considered a significant disruption of normal behavior that creates a likelihood of injury because they can result in reduced productivity (e.g., if nest establishment was avoided or delayed), fitness, or survival of juveniles and adults. Noise and visual disturbance creates a likelihood of injury in three ways: (1) by delaying nest establishment; (2) by increasing the risk of predation to adults or nestlings; and (3) by increasing energetic cots to adults and nestlings. We address these outcomes below.

Delayed Nest Establishment

Increased disturbance during the onset of the nesting season could delay nest establishment. Noise and visual disturbance at a site previously used for nesting would potentially displace the murrelet pair that would have returned to the same tree in a subsequent year. Nesting murrelets will use the same platform, branch, or tree in multiple years (Bloxton and Raphael 2009, p 11-12; Golightly and Schneider 2009, entire). A recent study on the reuse of nest trees in British Columbia reported that 26 of 143 nest trees (18 percent) showed evidence of re-nesting (Burger et al. 2009, p. 217). Fidelity to individual nest trees for nesting was more common in landscapes with highly fragmented nesting habitat, and less common in large tracts of suitable nesting habitat (Burger et al. 2009, p. 222).

Because murrelets exhibit nest site fidelity, increased disturbance around PNTs can adversely affect murrelets. The murrelets returning to that tree in a subsequent season would be forced to locate an alternate nest site. In areas where nesting habitat is highly fragmented or otherwise limited, relocating to a new nest site could result in a delay in the onset of breeding, nest site abandonment, or failed breeding due to higher predation risk at a marginal nesting location (Divoky and Horton 1995, p. 83; Raphael et al. 2002, p. 232).

Prospecting for nest sites is a well-documented murrelet behavior. Prospecting involves individuals or pairs flying near and landing on tree limbs in the early spring and midsummer. Murrelets also visit nesting areas during the winter and may select nest sites during this time (Nelson 1997, p. 7). Research in Oregon (Meyer et al. 2002, p. 110) and in British Columbia (Zharikov et al. 2006, p. 117) indicates that murrelets do not immediately abandon degraded habitats. Murrelets are likely to maintain fidelity to their nesting sites as long as the habitat stand retains some suitable nesting structures and the birds are able to successfully nest at the site (Divoky and Horton 1995, pp. 83-84). Increased disturbance will reduce the overall quality of suitable nest platforms at the stand scale, but is not expected to result in the loss of nesting habitat functions, nor substantially reduce nesting opportunities for murrelets in the action area.

When noise and visual disturbance delays nesting, murrelets may elect to nest in a different part of the stand or may nest in the same location, but at a later date. Depending on the timing within the nesting season, delays in nesting would likely preclude a re-nesting attempt. For these reasons, we consider the increased noise and visual disturbance over three non-consecutive nesting seasons within 272 acres of baseline habitat to create a likelihood of injury by significantly disrupting normal behaviors.

Increased noise and visual disturbance will also delay nest establishment, thereby disrupting normal behaviors, in 522 acres of potential nesting habitat within the areas deferred from harvest during the SHA. Because murrelets do not occupy the set-asides and special management areas at the initiation of the SHA and we cannot predict the timing of habitat development or murrelet occupancy, delayed nest establishment is not reasonably certain to occur in response to all forest management activities. Therefore, we conservatively conclude that forest management will disrupt normal nesting behaviors in 522 acres of set-asides and special management areas throughout two non-consecutive nesting seasons during SHA implementation.

Increased Predation Risk and Energetic Costs

Murrelets have evolved several mechanisms to avoid predation; they have cryptic coloration, are silent around the nest, minimize movement at the nest, and limit incubation exchanges and chick feeding to occur primarily during twilight hours (Nelson 1997, p. 14). The relationship between human activities and predators, and their potential impact on murrelet nesting success, has been identified as a significant threat to murrelets (Peery and Henry 2010, p. 2414). Losses of eggs and chicks to avian predators have been determined to be an important cause of nest failure (McShane et al. 2004, p. 4-109). The risk of predation by avian predators appears to be highest in close proximity to forest edges and human activity, where many corvid species (e.g., jays, crows, ravens) are in highest abundance (McShane et al. 2004, p. 4-109).

Murrelets appear to be most sensitive to noise and visual disturbances when they are approaching a nest site or delivering fish to a nestling. There are several documented instances where ground-based activities caused adult murrelets to abort or delay feedings of nestlings, caused adults to divert their flight paths into nesting habitat, or caused murrelets to vacate suitable habitat (Hamer and Nelson 1998, pp. 8-17; Appendix C – *Revised Disturbance Analysis for Marbled Murrelets*). Disturbances that cause a murrelet to flush can advertise the nest's location, thereby creating a likelihood of predation of the eggs or nestlings (USFWS 2006, p. 27). Noise and visual disturbance is likely to significantly disrupt the murrelets normal nesting behaviors. Potential murrelet responses to disturbance include flushing from a nest or branch within nesting habitat, aborted or delayed feeding of juveniles, or increased vigilance/alert behaviors at nest sites with implications for reduced individual fitness and reduced nesting success. These behavioral disruptions create a likelihood of injury by increasing the risk of failed nesting attempts due to predation of nestlings, or through reduced fitness of nestlings caused by missed feedings. Murrelet predation is not reasonably certain to occur in every year because activities generating noise and visual disturbance will not actually occur in every year, and because active murrelet nests will not occur in every portion of suitable habitat exposed to increased disturbance. Because we lack information about the number or frequency of murrelets nesting in the affected areas, the best available metric to describe the intensity of this effect is a habitat surrogate:

- Forest management activities will expose
  - 272 acres of baseline murrelet nesting habitat to increased predation risks and energetic costs during three nesting seasons[1] as a result of increased noise and visual disturbance;
  - 522 acres of murrelet nesting habitat that will develop in set-asides and special management areas during the SHA to increased predation risks and energetic costs during two nesting seasons[3] as a result of increased noise and visual disturbance;
- Road construction activities will expose 12.4 acres of baseline murrelet nesting habitat within the above-mentioned 82.5 acres above will to increased predation risks and energetic costs during one nesting season as a result of increased noise and visual disturbance.

Positive detections of murrelet occupancy that trigger the Occupied Site Provisions will reduce the extent and duration of the above-described exposures, but we cannot predict the magnitude of that reduction.

Noise and visual disturbance that causes an adult murrelet to abort a prey delivery also creates a likelihood of injury for the adult through increased energetic cost, and by exposing the adult to an increased risk of predation. Hull et al. (2001, p. 1036) report that murrelets spend 0.3 to 3.5 hours per day (mean 1.2 ± 0.7 hours per day) commuting to nests during the breeding season. The distance traveled between the nest site and foraging areas ranged up to 102 km, and required substantial energy demands for the adults. Each flight to the nest is energetically costly, increases the risk of predation from avian predators, and detracts from time spent on other activities such as foraging (Hull et al. 2001, p. 1036). Increases in prey capture and delivery efforts by adults degrades the adult body condition by the end of the breeding season, and increases the predation risks to adults and chicks as more trips inland are required (Kuletz 2005, pp. 43-45).

If the adult aborts a single feeding and returns with another prey item that same day, the time the adults spends commuting will increase by 100 percent, and on those days when the adult would make two feeding roundtrips, commuting time will increase by 50 percent. Ralph et al. (1995, p. 16) state, "Predation on adult murrelets by raptors occurs in transit to nest sites. Given the small number of nest sites that have been monitored, observations of the taking of adult murrelets by predators raise the possibility that this is not a rare event." They proceed to list several observations of raptors killing adult murrelets and of murrelet wings and bones being found in

[1] To clarify, the disturbances from forest management activities will occur during separate nesting seasons in separate locations. Any location within this area will be exposed to disturbances from forest management for two or three non-consecutive nesting seasons.

peregrine falcon nests. The significantly increased time airborne due to an aborted feeding creates a likelihood of injury from predation to the adult. Given the 50-year duration of effects, we believe this outcome is reasonably certain to occur as described in the above bullets in this sub-section

Effects of Reduced Feedings to Nestlings

Murrelets are most sensitive to noise and visual disturbances when they are approaching a nest site or delivering fish to a nestling. Murrelet nestlings are fed primarily during dawn and dusk periods, but also may be fed throughout the day (Nelson 1997, p.18). Even with morning and evening timing restrictions in place, murrelets exposed to noise or visual disturbances are susceptible to missed feedings during the day. Nelson and Hamer (1995, p. 62) reported that relatively few feedings take place during the daytime. However, in some areas, 31 to 46 percent of feedings take place during the mid-day hours (Appendix D – *Murrelet Nesting Season*).

Missed feedings can reduce the fitness of nestlings. During chick rearing, adults feed the young 1 to 8 times per day (mean = 3.2 ±1.3 SD) (Nelson and Hamer 1995, p. 61). If we assume an average of 4 feedings per day, a single aborted feeding would constitute a loss of 25 percent of that day's food and water intake for the nestling. Such a loss is considered to be a significant disruption of normal behavior given that, "murrelet chicks grow rapidly compared to most alcids, gaining 5 to 15 g/day during the first 9 days after hatching" (Nelson and Hamer 1995, p. 60). With such a fast growth rate and a low average number of daily feedings, it is reasonable to assume a single missed feeding may disrupt normal growth and create the likelihood of injury by presenting a developmental risk to the chick. Young murrelets that receive multiple daily feedings grow faster and fledge earlier than those with lower provisioning rates. Early fledging helps minimize nest mortality (Nelson and Hamer 1995, p. 66).

Fish-eating alcids (e.g., murrelets, *Brachyramphus spp.*; and puffins, *Fratercula spp.*) exhibit wide variations in nestling growth rates. The nestling stage of murrelet development can vary from 27 to 40 days before fledging (DeSanto and Nelson 1995, p. 45). The variations in alcid development are attributed to constraints on feeding ecology, such as specialized foraging behaviors, unpredictable and patchy food distributions, and great distances between feeding and nesting sites (Oyan and Anker-Nilssen 1996, p. 830). Food limitation often results in poor growth, delayed fledging, increased mortality of chicks, and nest abandonment by adults (Oyan and Anker-Nilssen 1996, p. 836). Growth rates of body mass and skeletal elements in alcids are strongly affected by rates of food intake; and low rates of daily food intake result in a significant increase in the duration of chick development time (Kitaysky 1999, p. 466). Some alcids respond to reduced provisioning by slowing their metabolic rates and allocating growth to the head and wings to facilitate successful fledging (Oyan and Anker-Nilssen 1996, p. 830, Kitaysky 1999, p. 470). Murrelets also exhibit this adaptive behavior by prioritizing wing and bill growth in the nest and delaying the development of fat stores to post-fledging development (Janssen et al. 2011, p. 859). This is believed to be an adaptive strategy to reduce the length of the nestling period while maintaining a high probability of successful fledging and survival immediately after fledging (Janssen et al. 2011, p. 866).

Contemporary studies of murrelet diets in the Puget Sound–Georgia Basin region indicate that Pacific sand lance (*Ammodytes hexapterus*) (sand lance) now comprise the majority of the murrelet diet (Gutowsky et al. 2009, p. 251). Historically, energy-rich fishes such as herring and northern anchovy *(Engraulis mordax)* comprised the majority of the murrelet diet (Becker and Beissinger 2006, p. 470, Gutowsky et al. 2009, p. 247). This is significant because sand lance have the lowest energetic value of the fishes that murrelets commonly feed on. For example, a single northern anchovy has nearly six times the energetic value of a sand lance of the same size (Gutowsky et al. 2009, p. 251), so a chick would have to eat six sand lances to get the equivalent energy of a single anchovy. This illustrates the significance that a single feeding can represent for a murrelet nestling. Assuming nestlings receive an average of three single-fish feedings per day (Nelson and Hamer 1995, p. 61), a nestling being fed a low-quality diet comprised primarily of sand lance may be on the edge of its energetic needs for successful development. Nestlings have minimum daily energetic demands to sustain life and development, and mortality from starvation occurs when nestlings do not receive sufficient food (Kitasky 2009, p. 471). A recent study of 158 radio-tagged murrelets in Washington found that of 20 confirmed nesting attempts, only 4 nests were successful, indicating a very low nesting rate and low nesting success (Bloxton and Raphael 2009, p. 8). The majority of the nest failures were attributed to nestling starvation or adults abandoning eggs during incubation (Bloxton and Raphael 2009, p. 11).

The findings from Bloxton and Raphael (2009, entire) indicate that murrelets in Washington are not initiating nesting or are abandoning their nests during incubation or chick rearing, most likely in response to poor foraging conditions. For those murrelets that do initiate nesting and begin chick rearing, the implications of missed feedings due to noise and visual disturbance could be significant, because each missed feeding represents a delay in the development of the chick, prolonging the time to fledging and increasing the risk of predation, accidental death from falling off the nest, or abandonment by the adults. If the disturbance at a nest site is prolonged, each successive day of disturbance represents an increasing risk that multiple missed feedings will trigger a significant delay in their growth and development processes, cause permanent stunting, or result in the mortality of a nestling due to malnourishment.

When implementation of covered activities triggers Occupied Site Provisions, noise- and disturbance-generating activities are restricted to mid-day hours, meaning that murrelet nestlings are likely to receive a minimum of one or more feedings during the dawn or dusk hours. Exposure of murrelets to prolonged noise and visual disturbance during peak feeding hours will occur when Occupied Site Provisions are not triggered due to undetected murrelet occupancy or detection of murrelet occupancy at multiple sites in a single year. Given access limitations for workers on the LCT (the entire watershed is gated and access is carefully controlled), it is not likely that work will occur during the dawn/dusk hours. As previously established in the status of the species section, we know that the majority of daily feedings occur during dawn and dusk hours. Depending on the quality of prey delivered, as discussed above, these feedings may or may not be sufficient to sustain the development of the chick. If the quality of prey is poor, the chick may suffer from reduced fitness and low fledging weight depending on the quality of the diet the nestling is provided and the proportion of mid-day feedings that are missed. Kuletz (2005, p. 85) developed a model to examine the relationship between the energy requirements of murrelet chicks and the number of daily feedings required for fledging. Depending on the energy content of the fish delivered, minimum daily feedings range from approximately two herring to eight sand lances per day (Kuletz 2005, p. 85). Over the course of the 27 to 40 day nestling period, the estimated feedings required for successful fledging range from 38, age1+, herring to 204 sand lances (Kuletz 2005, p. 85). We assume that murrelet nestlings that experience missed mid-day feedings due to noise and visual disturbance will still fledge, but fledgling weights may be low and the development time to fledging may be increased significantly. Such situations create a likelihood of injury through reduced survival and fledgling success.

For the proposed SHA, the habitat areas exposed to disruptive activities are of a significant size relative to the action area. Exposure durations will be prolonged throughout the nesting season in the years that exposures occur. However, activities generating significant noise and visual disturbance will occur only a few times at any given location during the 50-year SHA term. As described above, the sources of significant noise and visual disturbance will be forest management and road construction. A worst-case scenario is that a single location will be exposed to noise and visual disturbance during road construction and three rounds of forest management, all in separate years. In this worst-case scenario, the affected habitat area will be exposed to significant noise and visual disturbance for four seasons and will be free from such disturbances during 46 nesting seasons during the permit term. A more realistic scenario is that forestry or maintenance activities are completed in a significantly more contracted time period, resulting in noise and visual disturbance affecting a given location for a fraction of the nesting season over three years during the 50-year SHA.

Although we recognize that prolonged disturbance at a site (multiple missed feedings over days or weeks) has the potential to result in the death of a nestling due to malnourishment, we conclude that the death of an individual is not reasonably certain to occur within any given nesting season. This is due to the fact that peak feeding period is during dawn/dusk hours when project activities will be minimized by Occupied Site Provisions or by access logistics. This is further informed by the proximity of the action area to foraging habitat that enables murrelets to forage at moderate energy costs compared to murrelets nesting further inland. Due to the variable nature of the murrelet diet, we cannot currently predict with reasonable certainty the number of missed feedings that are likely to result in injury or death of a nestling, or the number of years such risks must be incurred before an injury or death is reasonably certain to occur. However, given the likelihood that disturbances will be persistent during the nesting season in which they occur, noise and visual disturbance is reasonably certain to increase the likelihood of injury through reduced fledging weights of an unknown number of individuals. Although we cannot quantify the number of individuals that may be affected, a reasonable approximation of the extent of effects can be described as (1) the 272 acres of baseline habitat and the 522 acres of set-asides and special management areas where forest management will increase noise and visual disturbance. The 12.4 acres where road construction will have the same effects are entirely within those 272 acres.

Summary of Noise and Visual Disturbance Effects

In summary, exposure of murrelet nesting habitat to noise disturbance during the nesting season will result from the initial construction of a road segment and from forest management. Exposure will result in significant effects when project-generated noise or activity causes a murrelet to avoid or delay nest establishment, flush away from an active nest site during incubation or brooding, abort a feeding attempt to nestlings, or maintain increased vigilance. These behaviors will result from forest management activities within 110 yards of a nest during the nesting season (April 1 to September 23), totaling 272 acres of baseline habitat over three nesting seasons during the 50-year permit and 522 acres of set-asides and special management areas over two nesting seasons. One road construction project will result in the same effects across 12.4 acres that are contained within the 272-acre area. Disturbances that cause a murrelet to flush are expected to increase the likelihood of predation of eggs or nestlings. Noise and visual disturbance is reasonably certain to cause adult murrelets to alter their flight behavior (i.e., abort or delay feedings), creating a likelihood of injury for the adult through increased energetic cost, and by increased exposure to predation. Noise and visual disturbance is expected to cause adults to abort or delay feedings to chicks, creating a likelihood of injury to the chick in the areas describe in this paragraph.

Allocation of Green Tree Areas between suitable habitat and forest management activities will reduce the overall noise and visual disturbance in the suitable habitat within the action area, but the reduction is not likely to result in full avoidance of the effects described above.

Summary of the Effects of the Action

The existing murrelet nesting habitat in the action area is approximately 447 acres in size. During SHA implementation, harvest deferrals on 1,066 acres will result in increased areas of suitable nesting habitat for murrelets. The deferrals include approximately 97 acres of buffers on narrow streams. While we do not expect functional nesting habitat to develop in 50-foot wide stream buffers, suitable nesting habitat may develop in any other area deferred from harvest. This means 522 acres of suitable habitat are likely to develop from SHA implementation.

During SHA implementation, approximately 1.5 acres of habitat removal for Diversion Dam maintenance and road construction will expose 8 acres of murrelet nesting habitat to increased predation risk. Increased predation risk will not alter murrelet productivity in the action area, in part because SHA implementation will enhance long-term murrelet productivity in the action area by providing more nesting habitat through set-asides and special management areas. However, we expect that increased predation risk will result in a likelihood of injury to adult murrelets from exposure to avian predators and the extra energy spent making additional prey delivery and foraging trips.

Also during SHA implementation, noise and visual disturbance from forest management will result in a likelihood of injury by significantly disrupting normal murrelet behaviors in 272 acres of nesting habitat during three nesting seasons. Similarly, all 522 acres of set-asides and special management areas where habitat is likely to develop during the SHA, will also be exposed to noise and visual disturbance from forest management activities. However, in the set-asides and special management areas, nesting habitat will take additional time to develop, so this effect will be limited to two nesting seasons over the 50-year permit term. Portions of the same habitat will be also exposed to noise and visual disturbance resulting from road construction (12.4 acres). Significant disturbances from road construction are expected to occur during one nesting season in baseline habitat. No single location will be exposed to noise and visual disturbance from SHA implementation for more than four nesting seasons during the 50-year permit term (12.4 acres), and most locations will have substantially lower exposure.

Noise and visual disturbance from SHA activities will delay nest establishment, increase predation risks and thereby increase energetic costs of normal behaviors, and result in reduced feedings to nestlings. Concurrently, Everett will minimize exposure to noise and visual disturbance through implementation of the Occupied Site Provisions under the SHA, and expand habitat through harvest deferrals.

CUMULATIVE EFFECTS: MARBLED MURRELET

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

The action area is predominately forested land managed for timber production. The overwhelming majority of forestland in the action area is under non-Federal ownership and forestry activities are covered under federally-approved HCPs. Any significant changes to any of those HCPs require Federal actions that are unrelated to the proposed action. Other land uses in the action area include reservoir management and some residential parcels. Reservoir management is subject to future Federal actions that are unrelated to the proposed action.

There are no known state, tribal, local, or private actions that are reasonably certain to occur in the action area.

INTEGRATION AND SYNTHESIS OF EFFECTS: MARBLED MURRELET

Murrelet populations across the range of the species and within Conservation Zone 1 are declining. At the scale of the Conservation Zone, significant recent annual declines in murrelet numbers were measured at 1.6 to 9.1 percent (Lance and Pearson 2015, p. 5). The primary factor of the action area affecting murrelets and murrelet populations is the availability of high quality nesting habitat containing PNTs. Compounding the effects of habitat loss, where occupied habitat is fragmented or anthropogenic activity is common, avian predators, such as corvids prey on and harass adults and feed on murrelet eggs and chicks. Habitat fragmentation also exposes nest sites to noise and visual disturbance from human activities.

The known locations of suitable in the action area are located on the covered lands in four patches ranging from 53 to 177 acres and totaling 447 acres, or 0.0006 percent of the 675,000 acres of suitable habitat estimated to remain in Conservation Zone 1 (McShane et al. 2004, p. 4-9).

Implementation of the SHA will protect existing habitat, conservatively delineated as 447 acres of baseline habitat; develop up to 522 acres of additional nesting habitat through harvest deferrals in set-asides and special management areas; and accelerate maturation of managed stands by extending harvest rotations and thinning prescriptions. During the SHA, the Occupied Site Provision and the strategic allocation of Green Tree Areas will minimize noise and visual disturbances to murrelets resulting from adjacent forest practices.

Disturbances to murrelets from covered activities will result from road construction and forest management. Throughout the permit duration, forest management activities will expose approximately 272 acres of nesting habitat to noise and visual disturbance for 3 non-consecutive nesting seasons. Road construction will also expose 12.4 acres contained within the 272 acres to an additional nesting season of noise and visual disturbance. Two nesting seasons of additional exposure to noise and visual disturbance will occur in 522 acres of set-asides and special management areas from forest management activities once those stands are sufficiently mature to provide suitable nesting habitat. Noise and visual disturbance will be concentrated in midday hours, providing opportunities for dawn and dusk feedings on a regular basis. Silvicultural prescriptions will result in the disturbances being dispersed spatially and temporally, not exposing 272 contiguous acres or 522 contiguous acres to noise and visual disturbance in consecutive years. All areas of suitable habitat will be free of noise and visual disturbance for at least 46 years of the 50-year permit term.

Habitat alteration of from tree removal adjacent to baseline habitat will result from road construction and Diversion Dam maintenance during SHA implementation. Suitable nesting trees will not be removed. Approximately 1.5 acres of forest adjacent to suitable habitat will be removed. The effects of this removal are most pronounced when considering the response of avian predators to changes in forest edges.

Murrelets nesting within 55 yards of the edges of suitable habitat will be exposed to increased predation risks. This results in a total of approximately 8 acres of suitable habitat with increased predation risks. Increased risk alters behaviors of individual murrelets; they spend more time vigilant and may abandon certain feeding trips, increasing energetic costs of feeding nestlings. Increased predation risk is not a guarantee of a predation event. It is unlikely that increased predation risks across 8 acres will result in a measurable change in murrelet productivity in the action area or at the scale of the Conservation Zone. Any reductions in reproductive success resulting from exposure to noise and visual disturbance, habitat alteration, or increased predation risks are expected to be minor, extremely localized, and offset within the LCT through increased amounts of suitable habitat.

The SHA will protect existing habitat and develop additional habitat. Areas with good potential to develop suitable habitat during the SHA are contained within the set-asides and special management areas, totaling 619 acres.

With long-term increases in the amount of suitable habitat on the LCT, and existing evidence to show that murrelets already use portions of the LCT, it is reasonable to conclude that the SHA will increase the likelihood and abundance of murrelets nesting on the LCT. Amounts of suitable habitat in the action area will increase through protection of set-asides and special management areas that are on trajectory to develop habitat during the permit term. Habitat fragmentation will decrease through allocation of green tree areas during timber harvest. These factors will have positive effects on murrelet reproduction and distribution in the action area (Zharikov et al 2007, entire), resulting in a net conservation benefit for the species in the action area from SHA implementation.

CONCLUSION: MARBLED MURRELET

After reviewing the current status of marbled murrelet, the environmental baseline for the action area, the effects of the proposed SHA and the cumulative effects, it is the Service's Opinion that the SHA, as proposed, is not likely to jeopardize the continued existence of the murrelet.

Critical habitat for this species has been designated primarily on Federal land, and to a lesser extent on State, county, City, and private lands. However, this action does not affect that area and no destruction or adverse modification of that critical habitat is anticipated.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. *Harm* is defined by the Service as an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). *Harass* is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The proposed SHA and its associated documents clearly identify the anticipated adverse effect to covered species likely to result from the proposed action and the measures that are necessary and appropriate to minimize those adverse effects. All conservation measures described in the SHA, together with the provisions described in the associated Implementation Agreement and section 10(a)(1)(A) Permit, are hereby incorporated by reference as reasonable and prudent measures and terms and conditions within this Incidental Take Statement pursuant to 50 CFR § 402.14(i). Such terms and conditions are non-discretionary and must be undertaken by the Service so that they become binding conditions of the permit issued to the Applicants, as appropriate, for the exemptions under section 10(a)(1)(A) and section 7(o)(2) of the ESA to apply.

The Service has a continuing duty to regulate the activity covered by this incidental take statement. If Everett (1) fails to assume and implement the terms and conditions; or (2) if the Permittee fails to adhere to the section 10(a)(1)(A) permit conditions, the protective coverage of the Permit and section 7(o)(2) may lapse. The amount or extent of incidental take anticipated under the proposed SHA and associated reporting requirements are as described in the SHA and its accompanying section 10(a)(1)(A) permit.

In order to monitor the impact of incidental take, the Service's Washington Fish and Wildlife Office must report the progress of the action and its impact on the species as specified in the incidental take statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

Northern Spotted Owl

The Service anticipates that incidental take, in the form of harassment, of spotted owls is reasonably certain to occur over the 50-year term of the SHA.

The Service anticipates incidental take of northern spotted owl will be difficult to detect for the following reason(s): (1) there is a low likelihood of finding affected individuals due to one or more of the following factors: relatively low population density, secretive behavior and cryptic coloration, concealing habitat, and sporadic distribution over a large portion of the landscape; (2) the large area associated with implementation of the proposed activities covered by the Permit; (3) the take may manifest itself outside the portions of the covered lands where activities are being conducted; and (4) affected individuals may suffer sub-lethal effects that are difficult to detect. For these reasons, we have used the amount of habitat removed or degraded as a surrogate for expressing the anticipated amount of incidental take in the form of harass. Changes in habitat conditions are a reasonably good indicator of such take.

Take is anticipated in the form of harassment (i.e., a significant disruption of normal nesting behaviors that creates a likelihood of injury) resulting from noise and visual disturbance that disrupts nesting and foraging behaviors. The anticipated amount or extent of take is described below, based on the amount of occupied habitat where proposed activities are reasonably certain to cause incidental take:

1. Forest management activities will disrupt normal nesting and foraging behaviors of all adult spotted owls associated with 77 acres of habitat exposed to noise and visual disturbance over three non-consecutive nesting seasons between 2015 and 2065.

2. Road construction will disrupt normal nesting, and foraging behaviors of all adult spotted associated with 12 acres of habitat exposed to noise and visual disturbance over one nesting season between the 2015 and 2065. Four of these acres overlap with the 77 acres identified above, but the effects will occur at different times.

3. Tree removal from maintenance at the Diversion Dam will disrupt normal nesting and foraging behaviors of all adult spotted owls associated with 4 acres of exposed to noise and visual disturbance during one nesting season between the years of 2015 and 2065.

Marbled Murrelet

The Service anticipates that incidental take, in the form of harassment, of murrelets is reasonably certain to occur over the 50-year term of the SHA.

The Service anticipates that this incidental take of murrelets will be difficult to detect for the following reason(s): (1) there is a low likelihood of finding affected individuals due to one or more of the following factors: their relatively low population density, secretive behavior and cryptic coloration, concealing habitat, small size, and sporadic distribution over a large portion of the landscape; (2) the large area associated with implementation of the proposed activities covered by the Permit; (3) the take may manifest itself outside the portions of the covered lands where activities are being conducted; and (4) affected individuals may suffer sub-lethal effects that are difficult to detect. For these reasons, we have used the amount of habitat removed or degraded as a surrogate for expressing the anticipated amount of incidental take in the form of harass. Changes in habitat conditions are a reasonably good indicator of such take.

Noise and Visual Disturbance

Noise and visual disturbance is expected to significantly disrupt the murrelets' normal nesting behaviors. Expected murrelet responses to this noise and visual disturbance include adults flushing from a nest or branch within nesting habitat, aborted or delayed feeding of juveniles, or increased vigilance/alert behaviors at nest sites with implications for reduced individual fitness and reduced nesting success. These responses create a likelihood of injury through failed nesting attempts due to predation of nestlings, reduced fitness of nestlings caused by missed feedings, and/or through increased predation risk and reduced fitness of adults that make additional flights in response to noise and visual disturbance.

Incidental take of all adult and juvenile murrelets, in the form of harassment, is associated with approximately 272 acres of nesting habitat that will be exposed to noise and visual disturbance associated with forest management activities over three non-consecutive years and 522 acres of murrelet nesting habitat that will be exposed to noise and visual disturbance associated with forest management activities over two non-consecutive years during the murrelet nesting season (April 1 to September 23) between 2015 and 2065.

Incidental take of all adult and juvenile murrelets, in the form of harassment, associated with approximately 12.4 acres of baseline habitat that will be exposed to noise and visual disturbance from road construction and Diversion Dam maintenance during one nesting season (April 1 to September 23) within 110 yards of these activities, between the years of 2015 and 2065.

Tree Removal

Tree removal adjacent to habitat is associated with road construction and Diversion Dam maintenance activities. Tree removal adjacent to habitat will degrade habitat quality and create edge conditions that increase predation risk of nesting murrelets, leading to reduced reproductive success.

Incidental take in the form of harassment associated with tree removal that will occur with road construction adjacent to baseline habitat. This incidental take will occur within 55 yards of the road construction footprint which totals 4.8 acres within baseline habitat, over one year during the murrelet nesting season (April 1 to September 23).

Incidental take in the form of harassment associated with Diversion Dam maintenance adjacent to baseline habitat. This incidental take will occur within 55 yards of the road construction footprint which totals 3.2 acres within baseline habitat, over one year during the murrelet nesting season (April 1 to September 23).

The Service will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-711), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein.

EFFECT OF THE TAKE

In the accompanying Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the northern spotted owl or the marbled murrelet.

REASONABLE AND PRUDENT MEASURES

The conservation measures negotiated in cooperation with the Service and included as part of the SHA (see pages 3-5 of this document) constitute all of the reasonable and prudent measures necessary to minimize the impacts of incidental take. On that basis, no RPMs except for monitoring and reporting requirements are included in this Incidental Take Statement. The monitoring and reporting plans described in section 4.4 of the SHA include, but are not limited to, commitments to monitor and report on the implementation of covered activities as well as the conditions of designated baseline habitat and species occurrences. The monitoring plan will provide the best available data to monitor and report on the amount or extent of take, per 50 CFR 402.14(i)(1)(iv).

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, Everett must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. Implement the monitoring and reporting plans described in Section 4.4 of the SHA

2. Educate appropriate City staff or contractors on the terms of the SHA to ensure Everett's ongoing capacity to implement the SHA and its monitoring/reporting requirements.

The Service believes that no more than 85 acres of habitat likely to contain northern spotted owls and 794 acres of habitat likely to contain marbled murrelet will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service any need for possible modification of the reasonable and prudent measures.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Minimize corridor width for the proposed road adjacent to baseline habitat.

2. Minimize "daylighting" of any roads or skid trails in or adjacent to the baseline habitat.

3. Minimize the footprint of the Diversion Dam maintenance project adjacent to baseline habitat.

4. Minimize vehicular traffic and equipment operation in or adjacent to baseline habitat during the nesting seasons for northern spotted owl or marbled murrelet.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the (request/reinitiation request). As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) the amount or extent of incidental take is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; 4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

LITERATURE CITED

Bart, J. 1995. Amount of suitable habitat and viability of northern spotted owls. Conservation Biology 9(4):943-946.

Bart, J., and E.D. Forsman. 1992. Dependence of northern spotted owls Strix occidentalis caurina on old-growth forests in the western USA. Biological Conservation 62:95-100.

Becker, B.H., and S. R. Beissinger. 2006. Centennial decline in the trophic level of an endangered seabird after fisheries decline. Conservation Biology 20(2):470-479.

Bloxton, T.D. and M.G. Raphael. 2009. Breeding ecology of the marbled murrelet in Washington State. Five year project summary (2004-2009). Unpublished agency report. USDA Forest Service, Pacific Northwest Research Station. Olympia, Washington. 44p.

Bradley, J.E., and J.M. Marzluff. 2003. Rodents as nest predators: Influences on predatory behavior and consequences to nesting birds. The Auk. 120(4):1180-1187.

Burger, A.E., M.M. Masselink, A.R. Tillmanns, A.R. Szabo, M. Farnholtz, and J.J. Krkosek. 2004. *In* Hooper, T.D. (editor). Proceedings of the Species at Risk 2004 Pathways to Recovery Conference. March 2-6, 2004. Victoria, British Columbia.

Burger, A.E., I.A. Manley, M.P. Silvergieter, D.B. Lank, and others. 2009. Re-use of nest sites by marbled murrelets (Brachyramphus marmoratus) in British Columbia. Northwestern Naturalist 90:217-226.

Carey, A.B. 1995. Sciurids in Pacific Northwest managed and old-growth forests. Ecological Applications 5(3):648-661.

City of Everett. 2015. Safe harbor and cooperative habitat enhancement agreements: Lake Chaplain Tract. Prepared in support of a Safe Harbor Agreement request to US Fish and Wildlife Service. July, 2015.

Davis, R.J., K.M. Dugger, S. Mohoric, L. Evers, W.C. Aney. 2011. Northwest Forest Plan—the first 15 years (1994–2008): status and trends of northern spotted owl populations and habitats. Gen. Tech. Rep. PNWGTR- 850. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 147 p.

Delaney, D.K., and T.G. Grubb. 2003. Effects of off-highway vehicles on northern spotted owls: 2002 Results. A report to the State of California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division under Contract No. 439129-0-0055. USDA Rocky Mountain Research Station, May 2003. 38 pp.

Delaney, D.K., T.G. Grubb, P. Beier, L.L. Pater, and M.H. Reiser. 1999. Effects of helicopter noise on Mexican spotted owls. Journal of Wildlife Management 63(1):60-76.

De Santo, T.L., and S.K. Nelson. 1995. Comparative reproductive ecology of the Auks (Family Alcidae) with emphasis on the marbled murrelet. pp. 33-47. *In* Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt (eds.). Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152. Pacific Southwest Experimental Station, U.S. Forest Service. Albany, California. 420p.

Divoky, G.J. and M. Horton. 1995. Breeding and natal dispersal, nest habitat loss and implications for marbled murrelet populations. pp. 83-87 *In* Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt (eds.). Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152. Pacific Southwest Experimental Station, U.S. Forest Service. Albany, California. 420p.

Dugger, K.M., F. Wagner, R.G. Anthony, and G.S. Olson. 2005. The relationship between habitat characteristics and demographic performance of northern spotted owls in Southern Oregon. Condor 107(4):863-878.

Dugger, K.M., R.G. Anthony, and L.S. Andrews. 2011. Transient dynamics of invasive competition: barred owls, spotted owls, habitat, and the demons of competition present. Ecological Applications 21(7) pp. 2459-2468.

Flaherty, E.A., S.A. Dubay, J. Bradley, J. Marzluff, and G.D. Hayward. 2000. The northern flying squirrel (Glaucomys sabrinus) as a potential predator of marbled murrelet (Brachyramphus marmoratus) eggs. Northwest Science. 74(4):335-339.

Forsman, E.D., E.C. Meslow, and H.M. Wight. 1984. Distribution and biology of the spotted owl in Oregon. Wildlife Monographs 87:3-64.

Forsman, E.D., R.G. Anthony, J.A. Reid, P.J. Loschl, S.G. Sovern, M. Taylor, B.L. Biswell, A. Ellingson, E.C. Meslow, G.S. Miller, K.A. Swindle, J.A. Thrailkill, F.F. Wagner, and D.E. Seaman. 2002. Natal and breeding dispersal of northern spotted owls. Wildlife Monographs 149(1):35.

Frankliln, A.B., D.R. Anderson, R.J. Guitiérrez, and K.P. Burnham. 2000. Climate, habitat quality, and fitness in northern spotted owl populations in northwestern California. Ecological Monographs, 70(4):539-390.

Glenn, E.M., R.G. Anthony, and E.D. Forsman. 2010. Population trends in northern spotted owls: Associations with climate in the Pacific Northwest. Biological Conservation 143:2543-2552.

Glenn, E.M., R.G. Anthony, E.D. Forsman, and G.S. Olson. 2011. Reproduction of northern spotted owls: The role of local weather and regional climate. The Journal of Wildlife Management 75(6):1279-1294.

Golightly, R.T., and S.R. Schneider. 2009. Observations of incubation in year 8 of a long-term monitoring effort at a marbled murrelet nest in northern California. Humboldt State University, Department of Wildlife. Arcata, California. 39p.

Gutierrez RJ, M Cody, S Courtney, and AB Franklin. 2007. The invasion of barred owls and its potential effect on the spotted owl: a conservation conundrum. Biological Invasions. 9:181-196.

Gutowsky, S., M.H. Janssen, P. Arcese, T.K. Kyser, D. Ethier, M.B. Wunder, D.F. Bertram, L. McFarlane Tranquilla, C. Lougheed, D. Ryan Norris. 2009. Concurrent declines in nestling diet quality and reproductive success of a threatened seabird over 150 years. Endangered Species Research 9:247-254.

Hamer, T.E. and S.K. Nelson. 1998. Effects of disturbance on nesting marbled murrelets: summary of preliminary results. An unpublished report prepared for U.S. Fish and Wildlife Service, Portland, Oregon. January, 1998. Hamer Environmental, Mount Vernon, Washington and Oregon State University, Corvallis, Oregon. 24p.

Harris, R.B. 1999. Abundance and characteristics of snags in western Montana forests. Gen Tech. Rep. RMRS-GTR-31. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 19 p.

Herter, D.R. and L.L. Hicks. 1995. Northern spotted owl surveys and demography in the Plum Creek Cascades Habitat Conservation plan (HCP) area. Plum Creek Timber Co., L.P., Tech. Rept. No. 1. Seattle, Washington. 79 p.

Hull, C., G.W. Kaiser, C. Lougheed, L. Lougheed, S. Boyd, and F. Cooke. 2001. Intraspecific variation in commuting distance of marbled murrelets (*Brachyramphus marmoratus*): Ecological and energetic consequences of nesting further inland. The Auk 118(4):1036-1046.

Janssen, M.H., P. Arcese, T.K. Kyser, D.F. Bertram, and D.R. Norris. 2011. Stable isotopes reveal strategic allocation of resources during juvenile development in a cryptic and threatened seabird, the marbled murrelet (Brachyramphus marmoratus). Canadian Journal of Zoology 89:859-868.

Kitaysky, A.S. 2009. Metabolic and developmental responses of alcid chicks to experimental variation in food intake. Physiology and Biochemical Zoology 27(4):462-473.

Kuletz, K.J. 2005. Foraging behavior and productivity of a non-colonial seabird, the marbled murrelet (Brachyramphus marmoratus), relative to prey and habitat. Ph.D. dissertation, University of Victoria. Victoria, British Columbia. 195p.

Lance, M.M., and S.F. Pearson. 2015. 2014 Washington at-sea marbled murrelet population monitoring: Research progress report, April, 2015. Washington Department of Fish and Wildlife, Wildlife Science Division. Olympia, Washington. 23p.

Littell, J.S., E.E. Oneil, D. McKenzie, J.A. Hicke, J.A. Lutz, R.A. Norheim, and M.M. Elsner. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change 102:129-158.

Mack, D.E., W.P. Ritchie, S.K. Nelson, E. Kuo-Harrison, P. Harrison, and T.E. Hamer. 2003. Methods for surveying marbled murrelets in forest: A revised protocol for land management and research. Prepared for the Pacific Seabird Group, Marbled Murrelet Technical Committee. 81p.

Malt, J.M., and D.B. Lank. 2009. Marbled Murrelet nest predation risk in managed forest landscapes: dynamic fragmentation effects at multiple scales. Ecological Applications 19(5):1274-1287.

Marzluff, J.M. and E. Neatherlin. 2006. Corvid response to human settlements and campgrounds: Causes, consequences, and challenges for conservation. Biological Conservation 130:301-314.

McComb, W. C. 1999. Forest fragmentation: wildlife and management implications synthesis of the conference. *In* Rochelle, J.A., L.A. Lehman, and J. Wisniewski (eds.). Forest Wildlife and Fragmentation Management Implications. Koninklijke Brill NV, Leiden, The Netherlands. pp. 296-301.

McShane, C., T.E. Hamer, H.R. Carter, R.C. Swartzman, V.L. Friesen, D.G. Ainley, K. Nelson, A.E. Burger, L.B. Spear, T. Mohagen, R. Martin, L.A. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation reports for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. EDAW, Inc. Seattle, Washington. 370p.

Meyer J.S., L.L. Irwin, and M.S. Boyce. 1998. Influence of habitat abundance and fragmentation on northern spotted owls in western Oregon. Wildlife Monographs 139:1-51.

Meyer, C.B., S.L. Miller, and C.J. Ralph. 2002. Multi-scale landscape and seascape patterns associated with marbled murrelet nesting areas on the U.S. west coast. Landscape Ecology 17:95-115.

Miller, G.S., R.J. Small, E.C. Meslow. 1997. Habitat selection by spotted owls during natal dispersal in western Oregon. Journal of Wildlife Management 61(1):140-150.

Mote, P., E. Salathe, V. Duliere, and E. Jump. 2008. Scenarios of future climate for the Pacific Northwest. A report for the Climate Impacts Group, University of Washington, Seattle, Washington. 12p.

Nelson, S.K. 1997. The birds of North America, No. 276 - Marbled Murrelet (Brachyramphus marmoratus). *In* Poole, A., and F. Gill (eds.). The birds of North America: life histories for the 21st century. 32p.

Nelson, S.K. and T.E. Hamer. 1995. Nesting biology and behavior of the marbled murrelet. Pp. 57-67. *In* Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt (eds.). Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152. USDA Forest Service, Pacific Southwest Experimental Station. Albany, California. 420p.

Noon B.R., and C.M. Biles. 1990. Mathematical demography of spotted owls in the Pacific Northwest. The Journal of Wildlife Management 54(1):18-27.

Norris, D.R., P. Arcese, D. Preikshot, D. F. Bertram, and T. K. Kyser. 2007. Diet reconstruction and historic population dynamics in a threatened seabird. Journal of Applied Ecology 44, pp. 875-884.

Olson, G.S., E.M. Glenn, R.G. Anthony, E.D. Forsman, J.A. Reid, P.J. Loschl, and W.J. Ripple. 2004. Modeling demographic performance of northern spotted owls relative to forest habitat in Oregon. The Journal of Wildlife Management 68(4):1039-1053.

Omernik, J.M. 1987. Ecoregions of the conterminous United States; map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1):118-125.

Oyan, H.S. and T. Anker-Nilssen. 1996. Allocation of growth in food-stressed Atlantic puffin chicks. The Auk 113(4):830-841.

Peery, M.Z., and R. W. Henry. 2010. Recovering marbled murrelets via corvid management: A population viability approach. Biological Conservation 143:2414-2424.

Ralph, C.J., G.L. Hunt Jr., M.G. Raphael, J.F. Piatt (eds). 1995. Ecology and conservation of the marbled murrelet. US Department of Agriculture, US Forest Service, Pacific Southwest Research Station. PSW-GTR-152. 420 p.

Raphael, M.G., D. Evans Mack, J.M. Marzluff, and J. Luginbuhl. 2002. Effects of forest fragmentation on populations of the marbled murrelet. Studies in Avian Biology 25:221-235.

Raphael, M.G., S.K. Nelson, P. Swedeen, M. Ostwald, K. Flotlin, S. Desimone, S. Horton, P. Harrison, D. Prenzlow-Escene, and W. Jaross. 2008. Recommendations and supporting analysis of conservation opportunitites for the marbled murrelet long-term conservation strategy. Washington State Department of Natural Resources. Olympia, Washington. 337p.

Raphael, M.G., G.A. Falxa, K.M. Dugger, B.M. Galleher, D. Lynch, S.L. Miller, S.K. Nelson, and R.D. Young. 2011. Northwest Forest Plan – the first 15 years (1994-2008): status and trend of nesting habitat for the marbled murrelet. PNW-GTR-848. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 52p.

Salathe, E.P., L.R. Leung, Y. Qian, and Y. Zhang. 2010. Regional climate model projections for the state of Washington. Climatic Change 102 (1-2):51-75.

Snohomish PUD. 1988. Wildlife habitat management plan for the Henry M. Jackson hydroelectric project Federal Energy Regulatory Commission poject number 2157: Volume I, main plan and appendices A - E. Prepared by Snohomish County Public Utility District 1, and the City of Everett, Washington. May, 1988. Accessed online July 15, 2015: http://www.snopud.com/PowerSupply/hydro/jhprelicense/jhprdoch/jhprhisttr.ashx?p=1533

Sovern SG, ED Forsman, GS Olson, BL Biswell, M Taylor, and RG Anthony. 2014. Barred owls and landscape attributes influence territory occupancy of northern spotted owls. The Journal of Wildlife Management. 78(8):1436-1443.

Stathers, R.J., Rollerson, T.P., and Mitchell, S.J. 1994. Windthrow handbook for British Columbia forests. Victoria, B.C: B.C. Ministry of Forestry. Research Working Paper 9401.

Taylor Jr. AR, and ED Forsman. 1976. Recent range extensions of the barred owl in western North America, including the first records for Oregon. Condor. 78.4:560-561.

USFWS (US Fish and Wildlife Service). 1990. Endangered and threatened wildlife and plants: Determination of threatened status for the spotted owl. Federal Register Volume 55. 123:26114-26194. June 26, 1990.

USFWS (US Fish and Wildlife Service). 1997. Recovery plan for the threatened marbled murrelet (Brachyramphus marmoratus) in Washington, Oregon, and California. Portland, Oregon. 203 pp plus appendices.

USFWS (US Fish and Wildlife Service). 2006. Transmittal of guidance: Estimating the effects of auditory and visual disturbance to northern spotted owls and marbled murrelets in Northwestern California. Unpublished agency document. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office. July 31, 2006. 12p. plus 2 appendices.

USFWS (US Fish and Wildlife Service). 2009. Marbled murrelet (Brachyramphus marmoratus) 5-year review. Washington Fish and Wildlife Office. Lacey, Washington. June 12, 2009. 108 pp.

USFWS (US Fish and Wildlife Service). 2011. Revised recovery plan for the northern spotted owl (Strix occidentalis caurina). U.S. Fish and Wildlife Service. Portland, Oregon. xvi + 258 pp.

USFWS (US Fish and Wildlife Service). 2013. Biological opinion for effects to northern spotted owls, critical habitat for northern spotted owls, marbled murrelets, critical habitat for marbled murrelets, bull trout, and critical habitat for bull trout from selected programmatic forest management activities March 25, 2013 to December 31, 2033 on the Olympic National Forest Washington. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office. Lacey, Washington. 13410-2009-F-0388. March 25, 2013. 404p.

USFWS (US Fish and Wildlife Service). 2014. Biological opinion for the North Head Light Lighthouse multi-use trail and parking lot improvements, Pacific County, Washington. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office. Lacey, Washington. 01EWFW00-2014-F-0207. 91pp.

Westerling, A. L., H. Hidalgo, D.R. Cayan, and T. Swetnam. 2006. Warming and earlier spring increases Western US forest wildfire activity. Science 313: 940-943.

Wiens JD. 2012. Competitive interactions and resource partitioning between northern spotted owls and barred owls in western Oregon. PhD dissertation. Oregon State University. March 2, 2012. 156 pp.

Wiles, G.J., H.L. Allen, and G.E. Hayes. 2011. Wolf conservation and management plan for Washington. Washington Department of Fish and Wildlife. Olympia, Washington. 297 pp.

Zharikov, Y., D.B. Lank, F. Huettmann, R.W. Bradley, N. Parker, P. P.-W. Yen, L.A. Mcfarlane-Tranquilla, and F. Cooke. 2006. Habitat selection and breeding success in a forest-nesting Alcid, the marbled murrelet, in two landscapes with different degrees of forest fragmentation. Landscape Ecology 21:107-120.

Zharikov, Y., D.B. Lank, and F. Cooke. 2007. Influence of landscape pattern on breeding distribution and success in a threatened Alcid, the marbled murrelet: model transferability and management implications. Journal of Applied Ecology 44:748-759.

APPENDIX A
STATUS OF SPECIES: NORTHERN SPOTTED OWL

Appendix A
Status of the Species: Northern Spotted Owl

Legal Status

The northern spotted owl (spotted owl) was listed as threatened on June 26, 1990, due to widespread loss and adverse modification of suitable habitat across the spotted owl's entire range and the inadequacy of existing regulatory mechanisms to conserve the owl (55 FR 26114 [June 26, 1990]). The U.S. Fish and Wildlife Service (Service) recovery priority number for the spotted owl is 12C (USFWS 2011, p. I-6) on a scale of 1C (highest) to 18 (lowest). This number reflects a moderate degree of threat, a low potential for recovery, the spotted owl's taxonomic status as a subspecies and inherent conflicts with development, construction, or other economic activity given the economic value of older forest spotted owl habitat. A moderate degree of threat equates to a continual population decline and threat to its habitat, although extinction is not imminent. While the Service is optimistic regarding the potential for recovery, there is uncertainty regarding our ability to alleviate the barred owl impacts to spotted owls and the techniques are still experimental, which matches our guidelines' "low recovery potential" definition (48 FR 43098 [1983]). The spotted owl was originally listed with a recovery priority number of 3C, but that number was changed to 6C in 2004 during the 5-year review of the species (USFWS 2004, p. 55) and to 12C in the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, p. I-6).

Life History

Taxonomy

The northern spotted owl is one of three subspecies of spotted owls currently recognized by the American Ornithologists' Union. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990, pp. 741-742; Barrowclough et al. 1999, p. 928; Haig et al. 2004, p. 1354), morphological (Gutierrez et al. 1995, p. 2), and biogeographic information (Barrowclough and Gutiérrez 1990, pp. 741-742). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutierrez et al. 1995, p. 2). Recent studies analyzing mitochondrial DNA sequences (Barrowclough et al. 2005, p. 1117; Chi et al. 2004, p. 3; Haig et al. 2004, p. 1354) and microsatellites (Henke et al. 2005, p. 15) confirmed the validity of the current subspecies designations for northern and California spotted owls. The narrow hybrid zone between these two subspecies, which is located in the southern Cascades and northern Sierra Nevada, appears to be stable (Barrowclough et al. 2005, p. 1116).

Physical Description

The spotted owl is a medium-sized owl, approximately 18 to 19 inches (46 to 48 cm) in length and approximately 1.1 to 1.9 lbs. (490 to 850 gm) in weight (Gutierrez et al. 1995, p. 2), and is the largest of the three subspecies (Gutierrez et al. 1995, p. 2). It is dark brown with a barred tail and white spots on the head and breast, and has dark brown eyes that are surrounded by prominent facial disks. Three age classes can be distinguished on the basis of plumage characteristics (Moen et al. 1991, p. 493). The spotted owl superficially resembles the barred owl (*Strix varia*), a species with which it occasionally hybridizes (Kelly and Forsman 2004, p. 807). Hybrids exhibit characteristics of both species (Hamer et al. 1994, p. 488).

Current and Historical Range

The current range and distribution of the spotted owl extends from southern British Columbia through western Washington, Oregon, and California as far south as Marin County (55 FR 26115 [June 26, 1990]). The southeastern boundary of its range is the Pit River area of Shasta County, California. The range of the spotted owl is partitioned into 12 physiographic provinces (provinces), based upon recognized landscape subdivisions exhibiting different physical and environmental features (Figure 1) (USFWS 1992, p. 31). These provinces are distributed across the range as follows:

- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands

- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath

- Three provinces in California: California Coast, California Klamath, California Cascades

The spotted owl has been extirpated or is uncommon in certain areas. Timber harvest activities have eliminated, reduced, or fragmented spotted owl habitat and decreased overall population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (USFWS 1992, p. 1799).

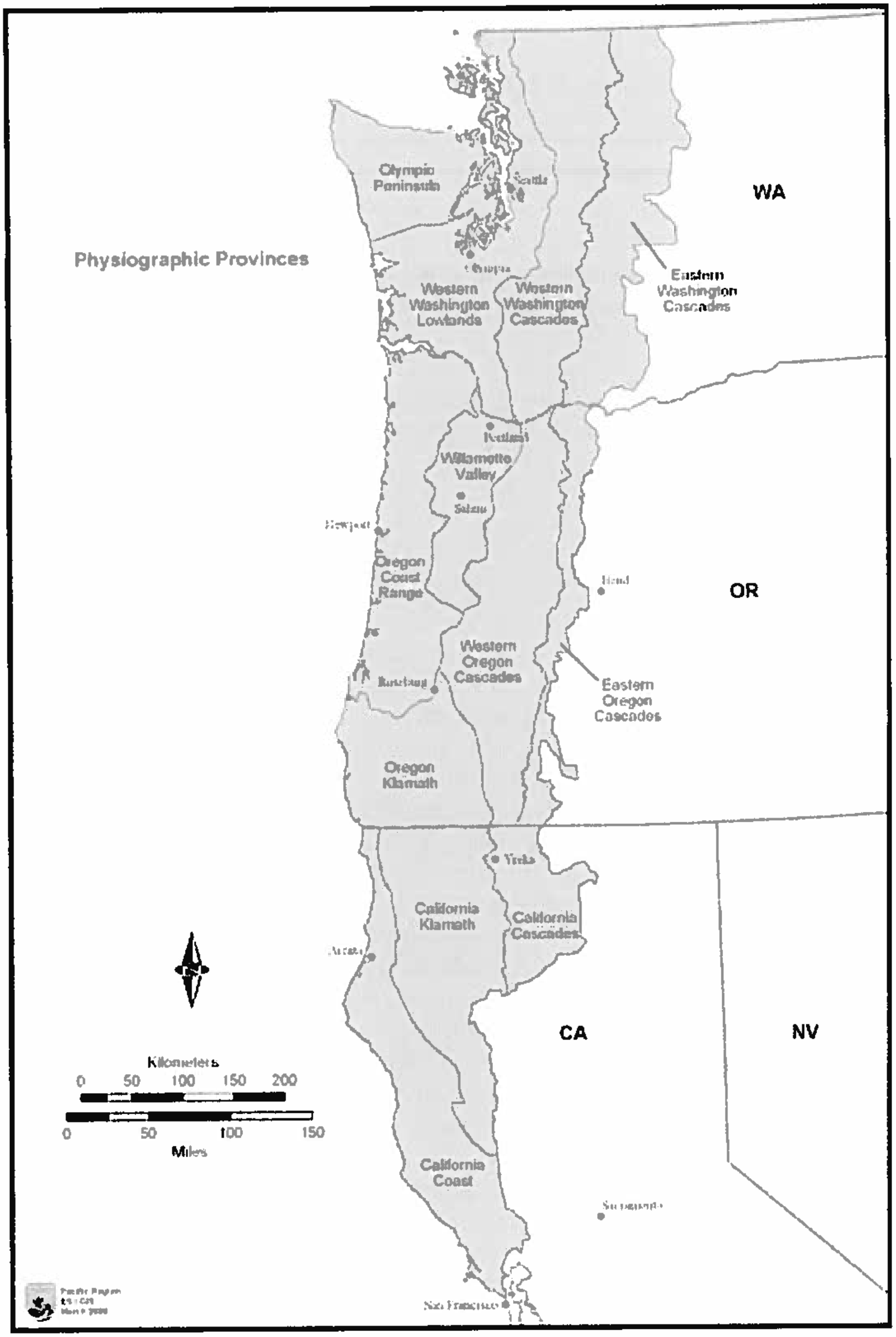

Figure 1. Physiographic provinces in the range of the spotted owl in the United States.

Behavior

Spotted owls are territorial. However, home ranges of adjacent pairs overlap (Forsman et al. 1984, p. 22; Solis and Gutiérrez 1990, p. 746) suggesting that the area defended is smaller than the area used for foraging. Territorial defense is primarily effected by hooting, barking and whistle type calls. Some spotted owls are not territorial but either remain as residents within the territory of a pair or move among territories (Gutierrez 1996, p. 4). These birds are referred to as "floaters." Floaters have special significance in spotted owl populations because they may buffer the territorial population from decline (Franklin 1992, p. 822). Little is known about floaters other than that they exist and typically do not respond to calls as vigorously as territorial birds (Gutierrez 1996, p. 4).

Spotted owls are monogamous and usually form long-term pair bonds. "Divorces" occur but are relatively uncommon. There are no known examples of polygyny in this owl, although associations of three or more birds have been reported (Gutierrez et al. 1995, p. 10).

Habitat Relationships

Home Range

Home-range sizes vary geographically, generally increasing from south to north, which is likely a response to differences in habitat quality (55 FR 26114:26117 [June 26, 1990]). Estimates of median size of their annual home range (the area traversed by an individual or pair during their normal activities (Thomas et al. 1993, p. IX-15) vary by province and range from 2,955 acres in the Oregon Cascades (Thomas et al. 1990, p. 194) to 14,271 acres on the Olympic Peninsula (USFWS 1992, p. 23). Zabel et al. (1995, p. 436) showed that these provincial home ranges are larger where flying squirrels are the predominant prey and smaller where wood rats are the predominant prey. Home ranges of adjacent pairs overlap (Forsman et al. 1984, p. 22; Solis and Gutiérrez 1990, p. 746), suggesting that the defended area is smaller than the area used for foraging. Within the home range there is a smaller area of concentrated use during the breeding season (~20 percent of the home range), often referred to as the core area (Bingham and Noon 1997, pp. 133-135). Spotted owl core areas vary in size geographically and provide habitat elements that are important for the reproductive efficacy of the territory, such as the nest tree, roost sites and foraging areas (Bingham and Noon 1997, p. 134). Spotted owls use smaller home ranges during the breeding season and often dramatically increase their home range size during fall and winter (Forsman et al. 1984, pp. 21-22; Sisco 1990, p. iii).

Although differences exist in natural stand characteristics that influence provincial home range size, habitat loss and forest fragmentation effectively reduce habitat quality in the home range. A reduction in the amount of suitable habitat reduces spotted owl abundance and nesting success (Bart and Forsman 1992, pp. 98-99; Bart 1995, p. 944).

Habitat Use

Forsman et al. (1984, pp. 15-16) reported that spotted owls have been observed in the following forest types: Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), Shasta red fir (*Abies magnifica shastensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), and redwood (*Sequoia sempervirens*). The upper elevation limit at which spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather(Forsman 1975, p. 27; Forsman et al. 1984, pp. 15-16).

Roost sites selected by spotted owls have more complex vegetation structure than forests generally available to them (Barrows and Barrows 1978, p. 3; Forsman et al. 1984, pp. 29-30; Solis and Gutiérrez 1990, pp. 742-743). These habitats are usually multi-layered forests having high canopy closure and large diameter trees in the overstory.

Spotted owls nest almost exclusively in trees. Like roosts, nest sites are found in forests having complex structure dominated by large diameter trees (Forsman et al. 1984, p. 30; Hershey et al. 1998, p. 1402). Even in forests that have been previously logged, spotted owls select forests having a structure (i.e., larger trees, greater canopy closure) different than forests generally available to them (Buchanan et al. 1995, p.1402; Folliard 1993, p. 40; Hershey et al. 1998, p. 1404).

Foraging habitat is the most variable of all habitats used by territorial spotted owls (USFWS 1992, p. 20). Descriptions of foraging habitat have ranged from complex structure (Solis and Gutiérrez 1990, pp. 742-744) to forests with lower canopy closure and smaller trees than forests containing nests or roosts (Gutierrez 1996, p. 5).

Habitat Selection

Spotted owls generally rely on older forested habitats because they contain the structures and characteristics required for nesting, roosting, foraging, and dispersal. These characteristics include the following: 1) a multi-layered, multi-species canopy dominated by large overstory trees, 2) moderate to high canopy closure, 3) a high incidence of trees with large cavities and other types of deformities, especially dwarf mistletoe brooms, 4) numerous large snags, 5) an abundance of large, dead wood on the ground, and 6) open space within and below the upper canopy for spotted owls to fly (Thomas et al. 1990, p. 19). Forested stands with high canopy closure also provide thermal cover, as well as protection from predation (Weathers et al. 2001, p. 686).

Foraging habitat for spotted owls provides a food supply for survival and reproduction. Foraging activity is positively associated with tree height diversity (North et al. 1999, p. 524), canopy closure (Courtney et al. 2004, pp. 5-15; Irwin et al. 2000, p. 180), snag volume, density of snags greater than 20 in (50 cm) dbh (Courtney et al. 2004, p. 5-15; Irwin et al. 2000, pp. 179-180; North et al. 1999, p. 524), density of trees greater than or equal to 31 in (80 cm) dbh (North et al. 1999, p. 524), volume of woody debris (Irwin et al. 2000, pp. 179-180), and young forests with some structural characteristics of old forests (Carey et al. 1992, pp. 245-247; Irwin et al. 2000, pp. 178-179). Northern spotted owls select old forests for foraging in greater proportion than their availability at the landscape scale (Carey et al. 1992, pp. 236-237; Carey and Peeler 1995, p. 235; Forsman et al. 2005, pp. 372-373), but will forage in younger stands with high prey densities and access to prey (Carey et al. 1992, p. 247; Rosenberg and Anthony 1992, p. 165; Thome et al. 1999, pp. 56-57).

Dispersal habitat is essential to maintaining stable populations by filling territorial vacancies when resident spotted owls die or leave their territories, and to providing adequate gene flow across the range of the species. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities. Dispersal habitat may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding for dispersing juveniles (USFWS 1992, p. 1798). Forsman et al. (2002, p. 222) found that spotted owls could disperse through highly fragmented forest landscapes. However, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004, p. 1341).

Spotted owls may be found in younger forest stands that have the structural characteristics of older forests or retained structural elements from the previous forest. In redwood forests and mixed conifer-hardwood forests along the coast of northwestern California, considerable numbers of spotted owls also occur in younger forest stands, particularly in areas where hardwoods provide a multi-layered structure at an early age (Diller and Thome 1999, p. 275; Thomas et al. 1990, p. 158). In mixed conifer forests in the eastern Cascades in Washington, 27 percent of nest sites were in old-growth forests, 57 percent were in the understory reinitiation phase of stand development, and 17 percent were in the stem exclusion phase (Buchanan et al. 1995, p. 304). In the western Cascades of Oregon, 50 percent of spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands of less than 40 years old (Irwin et al. 2000, p. 41).

In the Western Washington Cascade Mountains, spotted owls used mature/old forests dominated by trees greater than 20 inches (50 cm) diameter-at-breast height with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season and used young forest trees 8 to 20 inches (20 to 50 cm) diameter-at-breast height with greater than 60 percent canopy closure) less often than expected based on availability (Herter et al. 2002, p. 437).

In the Coast Ranges, Western Oregon Cascades and the Olympic Peninsula, radio-marked spotted owls selected for old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Carey et al. 1990, pp. 14-15; Forsman et al. 1984, pp. 24-25; Forsman et al. 2005, pp. 372-373). Glenn et al. (2004, pp. 46-47) studied spotted owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use is influenced by prey availability. Ward (1990, p. 62) found that spotted owls foraged in areas that had lower variance in prey densities (prey were more predictable in occurrence) within older forests and near ecotones of old forest and brush seral stages. Zabel et al. (1996, p. 436) showed that spotted owl home ranges are larger where flying squirrels are the predominant prey and, conversely, are smaller where woodrats (*Neotoma* spp.) are the predominant prey.

Recent landscape-level analyses in portions of Oregon Coast and California Klamath provinces suggest that a mosaic of late-successional habitat interspersed with other seral conditions may benefit spotted owls more than large, homogeneous expanses of older forests (Franklin et al. 2000, pp. 573-579; Meyer et al. 1998, p. 43; Zabel et al. 2003, p. 1038). In the Oregon Klamath and Western Oregon Cascade provinces, Dugger et al. (2005, p. 876) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center (within 730 meters) (2,395 feet). Survival decreased dramatically when the amount of non-habitat (non-forest areas, sapling stands, etc.) exceeded approximately 50 percent of the home range (Dugger et al. 2005, pp. 873-874). The authors concluded that they found no support for either a positive or negative direct effect of intermediate-aged forest—that is, all forest stages between sapling and mature, with total canopy cover greater than 40 percent—on either the survival or reproduction of spotted owls.

It is unknown how these results were affected by the low habitat fitness potential in their study area, which Dugger et al. (2005, p. 876) stated was generally much lower than those in Franklin et al. (2000) and Olson et al. (2004), and the low reproductive rate and survival in their study area, which they reported were generally lower than those studied by Anthony et al. (2006). Olson et al. (2004, pp. 1050-1051) found that reproductive rates fluctuated biennially and were positively related to the amount of edge between late-seral and mid-seral forests and other habitat classes in the central Oregon Coast Range. Olson et al. (2004, pp. 1049-1050) concluded that their results indicate that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in their study area.

Reproductive Biology

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Gutierrez et al. 1995, p. 5). Spotted owls are sexually mature at 1 year of age, but rarely breed until they are 2 to 5 years of age (Forsman et al. 2002, p. 17; Franklin 1992, p. 821; Miller et al. 1985, p. 93). Breeding females lay one to four eggs per clutch, with the average clutch size being two eggs; however, most spotted owl pairs do not nest every year, nor are nesting pairs successful every year(Anthony et al. 2006, p. 28; Forsman et al. 1984, pp. 32-34), and renesting after a failed nesting attempt is rare (Gutierrez 1996, p. 4). The small clutch size, temporal variability in nesting success, and delayed onset of breeding all contribute to the relatively low fecundity of this species (Gutierrez 1996, p. 4).

Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Forsman et al. 1984, p. 32). After they leave the nest in late May or June, juvenile spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (Forsman et al. 1984, p. 38). During the first few weeks after the young leave the nest, the adults often roost with them during the day. By late summer, the adults are rarely found roosting with their young and usually only visit the juveniles to feed them at night (Forsman et al. 1984, p. 38). Telemetry and genetic studies indicate that close inbreeding between siblings or parents and their offspring is rare (Forsman et al. 2002, p. 18; Haig et al. 2001, p. 35).

Dispersal Biology

Natal dispersal of spotted owls typically occurs in September and October with a few individuals dispersing in November and December (Forsman et al. 2002, p. 13). Natal dispersal occurs in stages, with juveniles settling in temporary home ranges between bouts of dispersal (Forsman et al. 2002, pp. 13-14; Miller et al. 1997, p. 143). The median natal dispersal distance is about 10 miles for males and 15.5 miles for females (Forsman et al. 2002, p. 16). Dispersing juvenile spotted owls experience high mortality rates, exceeding 70 percent in some studies (Miller 1989, pp. 32-41). Known or suspected causes of mortality during dispersal include starvation, predation, and accidents (Forsman et al. 2002, pp. 18-19; Miller 1989, pp. 41-44). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Forsman et al. 2002, pp. 18-19; Gutierrez 1989, pp. 616-617; Hoberg et al. 1989, p. 249). Successful dispersal of juvenile spotted owls may depend on their ability to locate unoccupied suitable habitat in close proximity to other occupied sites (LaHaye et al. 2001, pp. 697-698).

There is little evidence that small openings in forest habitat influence the dispersal of spotted owls, but large, non-forested valleys such as the Willamette Valley apparently are barriers to both natal and breeding dispersal (Forsman et al. 2002, p. 22). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear although radio telemetry data indicate that spotted owls move around large lakes rather than cross them (Forsman et al. 2002, p. 22). Analysis of genetic structure of spotted owl populations suggests adequate rates of gene flow may occur across the Puget Trough between the Olympic Mountains and Washington Cascades and across the Columbia River between the Olympic Mountains and the Coast Range of Oregon (Haig et al. 2001, p. 35).

Breeding dispersal occurs among a small proportion of adult spotted owls; these movements were more frequent among females and unmated individuals (Forsman et al. 2002, pp. 20-21). Breeding dispersal distances were shorter than natal dispersal distances and also apparently random in direction (Forsman et al. 2002, pp. 21-22).

Food Habits

Spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman et al. 1984, p. 51; Sovern et al. 1994, p. 202). The composition of the spotted owl's diet varies geographically and by forest type. Generally, flying squirrels (*Glaucomys sabrinus*) are the most prominent prey for spotted owls in Douglas-fir and western hemlock (*Tsuga heterophylla*) forests (Forsman et al. 1984, pp. 40-41; Hamer et al. 2001, p. 224) in Washington and Oregon, while dusky-footed wood rats (*Neotoma fuscipes*) are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal provinces (Forsman et al. 1984, pp. 40-42; Forsman et al. 2004, p. 218; Ward et al. 1998, p. 84). Depending on location, other important prey include deer mice (*Peromyscus maniculatus*), tree voles (*Arborimus longicaudus, A. pomo*), red-backed voles (*Clethrionomys* spp.), gophers (*Thomomys* spp.), snowshoe hare (*Lepus americanus*), bushy-tailed wood rats (*Neotoma cinerea*), birds, and insects, although these species comprise a small portion of the spotted owl diet (Forsman et al. 1984, pp. 40-43; Forsman et al. 2004, p. 218; Hamer et al. 2001, p. 224; Ward et al. 1998, p. 84).

Other prey species such as the red tree vole (*Arborimus longicaudus*), red-backed voles (*Clethrionomys gapperi*), mice, rabbits and hares, birds, and insects) may be seasonally or locally important (Courtney et al. 2004, p. 4-27). For example, Rosenberg et al. (2003, p. 1720) showed a strong correlation between annual reproductive success of spotted owls (number of young per territory) and abundance of deer mice (*Peromyscus maniculatus*) (r2 = 0.68), despite the fact they only made up 1.6±0.5 percent of the biomass consumed. However, it is unclear if the causative factor behind this correlation was prey abundance or a synergistic response to weather (Rosenberg et al. 2003, p. 1723). Ward (1990, p. 55) also noted that mice were more abundant in areas selected for foraging by spotted owls. Nonetheless, spotted owls deliver larger prey to the nest and eat smaller food items to reduce foraging energy costs; therefore, the importance of smaller prey items, like *Peromyscus*, in the spotted owl diet should not be underestimated (Forsman et al. 2001, p. 148; Forsman et al. 2004, pp. 218-219).

Population Dynamics

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Gutierrez 1996, p. 5). The spotted owl's long reproductive life span allows for some eventual recruitment of offspring, even if recruitment does not occur each year (Franklin et al. 2000, p. 576).

Annual variation in population parameters for spotted owls has been linked to environmental influences at various life history stages (Franklin et al. 2000, p. 581). In coniferous forests, mean fledgling production of the California spotted owl *(Strix occidentalis occidentalis)*, a closely related subspecies, was higher when minimum spring temperatures were higher (North et al. 2000, p. 805), a relationship that may be a function of increased prey availability. Across their range, spotted owls have previously shown an unexplained pattern of alternating years of high and low reproduction, with highest reproduction occurring during even-numbered years (e.g., Franklin et al. 1999, p. 1). Annual variation in breeding may be related to weather (i.e., temperature and precipitation) (Wagner et al. 1996, p. 74; Zabel et al. 1996, pp. 437-438) and fluctuation in prey abundance (Zabel et al. 1996, pp. 437-438).

A variety of factors may regulate spotted owl population levels. These factors may be density-dependent (e.g., habitat quality, habitat abundance) or density-independent (e.g., climate). Interactions may occur among factors. For example, as habitat quality decreases, density-independent factors may have more influence on survival and reproduction, which tends to increase variation in the rate of growth (Franklin et al. 2000, pp. 581-582). Specifically, weather could have increased negative effects on spotted owl fitness for those owls occurring in relatively lower quality habitat (Franklin et al. 2000, pp. 581-582). A consequence of this pattern is that at some point, lower habitat quality may cause the population to be unregulated (have negative growth) and decline to extinction (Franklin et al. 2000, p. 583).

Olson et al. (2005, pp. 930-931) used open population modeling of site occupancy that incorporated imperfect and variable detectability of spotted owls and allowed modeling of temporal variation in site occupancy, extinction, and colonization probabilities (at the site scale). The authors found that visit detection probabilities average less than 0.70 and were highly variable among study years and among their three study areas in Oregon. Pair site occupancy probabilities declined greatly on one study area and slightly on the other two areas. However, for all owls, including singles and pairs, site occupancy was mostly stable through time. Barred owl presence had a negative effect on these parameters (see barred owl discussion in the New Threats section below). However, there was enough temporal and spatial variability in detection rates to indicate that more visits would be needed in some years and in some areas, especially if establishing pair occupancy was the primary goal.

Threats

Reasons for Listing

The spotted owl was listed as threatened throughout its range "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (55 FR 26114-26194). More specifically, significant threats to the spotted owl included the following: 1) low populations, 2) declining populations, 3) limited habitat, 4) declining habitat, 5) distribution of habitat or populations, 6) isolation of provinces, 7) predation and competition, 8) lack of coordinated conservation measures; and (9) vulnerability to natural disturbance (57 FR 1796-1838). These threats were characterized for each province as severe, moderate, low, or unknown. Declining habitat was recognized as a severe or moderate threat to the spotted owl in all 12 provinces, isolation of provinces within 11 provinces, and declining populations in 10 provinces. Together, these three factors represented the greatest concern range-wide to the conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations a severe or moderate concern in eight provinces, suggesting that these factors are a concern throughout the majority of the range. Vulnerability to natural disturbances was rated as low in five provinces.

The degree to which predation and competition might pose a threat to the spotted owl was unknown in more provinces than any of the other threats, indicating a need for additional information. Few empirical studies exist to confirm that habitat fragmentation contributes to increased levels of predation on spotted owls (Courtney et al. 2004, pp. 11-8 to 11-9). However, great horned owls (*Bubo virginianus*), an effective predator on spotted owls, are closely associated with fragmented forests, openings, and clearcuts (Johnson 1992, p. 84; Laidig and Dobkin 1995, p. 155). As mature forests are harvested, great horned owls may colonize fragmented forests, thereby increasing spotted owl vulnerability to predation.

<u>New Threats</u>

The Service conducted a 5-year review of the spotted owl in 1994 (USFWS 2004), for which the Service prepared a scientific evaluation of the status of the spotted owl (Courtney et al. 2004). An analysis was conducted assessing how the threats described in 1990 might have changed by 2004. Some of the key threats identified in 2004 are:

- "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects...In their questionnaire responses...6 of 8 panel member identified past habitat loss due to timber harvest as a current threat, but only 4 viewed current harvest as a present threat" (Courtney et al. 2004, p. 11-7)

- "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small (a total of 2.3 percent of the range-wide habitat base over a 10-year period)" (Courtney et al. 2004, p. 11-8)

- "Although the panel had strong differences of opinion on the conclusiveness of some of the evidence suggesting [barred owl] displacement of [spotted owls], and the mechanisms by which this might be occurring, there was no disagreement that [barred owls] represented an operational threat. In the questionnaire, all 8 panel members identified [barred owls] as a current threat, and also expressed concern about future trends in [barred owl] populations." (Courtney et al. 2004, p. 11-8)

Barred Owls

With its recent expansion to as far south as Marin County, California (Gutierrez et al. 2004, pp. 7-12 to 7-13), the barred owl's range now completely overlaps that of the spotted owl. Barred owls may be competing with spotted owls for prey (Hamer et al. 2001, p. 226) or habitat (Dunbar et al. 1991, p. 467; Hamer et al. 1989, p. 55; Herter and Hicks 2000, p. 285; Pearson and Livezey 2003, p. 274). In addition, barred owls physically attack spotted owls (Pearson and Livezey 2003, p. 274), and circumstantial evidence strongly indicated that a barred owl killed a spotted owl (Leskiw and Gutiérrez 1998, p. 226). Evidence that barred owls are causing negative effects on spotted owls is largely indirect, based primarily on retrospective examination of long-term data collected on spotted owls (Kelly et al. 2003, p. 46; Olson et al. 2005, p. 921; Pearson and Livezey 2003, p. 267). It is widely believed, but not conclusively confirmed, that the two species of owls are competing for resources. However, given that the presence of barred owls has been identified as a negative effect while using methods designed to detect a different species (spotted owls), it seems safe to presume that the effects are stronger than estimated. Because there has been no research to quantitatively evaluate the strength of different types of competitive interactions, such as resource partitioning and competitive interference, the particular mechanism by which the two owl species may be competing is unknown.

Barred owls were initially thought to be more closely associated with early successional forests than spotted owls, based on studies conducted on the west slope of the Cascades in Washington (Hamer 1988, p. 34; Iverson 1993, p. 39). However, recent studies conducted in the Pacific Northwest show that barred owls frequently use mature and old-growth forests (Pearson and Livezey 2003, p. 270; Schmidt 2006, p. 13). In the fire prone forests of eastern Washington, a telemetry study conducted on barred owls showed that barred owl home ranges were located on lower slopes or valley bottoms, in closed canopy, mature, Douglas-fir forest, while spotted owl sites were located on mid-elevation areas with southern or western exposure, characterized by closed canopy, mature, ponderosa pine or Douglas-fir forest (Singleton et al. 2005, p. 1).

The only study comparing spotted owl and barred owl food habits in the Pacific Northwest indicated that barred owl diets overlap strongly (76 percent) with spotted owl diets (Hamer et al. 2001, p. 226). However, barred owl diets are more diverse than spotted owl diets and include species associated with riparian and other moist habitats, along with more terrestrial and diurnal species (Hamer et al. 2001, pp. 225-226).

The presence of barred owls has been reported to reduce spotted owl detectability, site occupancy, reproduction, and survival. Olson et al. (2005, p. 924) found that the presence of barred owls had a significant negative effect on the detectability of spotted owls, and that the magnitude of this effect did not vary among years. The occupancy of historical territories by spotted owls in Washington and Oregon was significantly lower ($p < 0.001$) after barred owls were detected within 0.8 kilometer (0.5 mile) of the territory center but was "only marginally lower" ($p = 0.06$) if barred owls were located more than 0.8 kilometer (0.5 mile) from the spotted owl territory center (Kelly et al. 2003, p. 51). Pearson and Livezey (2003, p. 271) found that there were significantly more barred owl site-centers in unoccupied spotted owl circles than occupied spotted owl circles (centered on historical spotted owl site-centers) with radii of 0.8 kilometer (0.5 mile) ($p = 0.001$), 1.6 kilometer (1 mile) ($p = 0.049$), and 2.9 kilometer (1.8 miles) ($p = 0.005$) in Gifford Pinchot National Forest. In Olympic National Park, Gremel (2005, p. 11) found a significant decline ($p = 0.01$) in spotted owl pair occupancy at sites where barred owls had been detected, while pair occupancy remained stable at spotted owl sites without barred owls. Olson et al. (2005, p. 928) found that the annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by 5 percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area.

Olson et al. (2004, p. 1048) found that the presence of barred owls had a significant negative effect on the reproduction of spotted owls in the central Coast Range of Oregon (in the Roseburg study area). The conclusion that barred owls had no significant effect on the reproduction of spotted owls in one study (Iverson 2004, p. 89) was unfounded because of small sample sizes

(Livezey 2005, p. 102). It is likely that all of the above analyses underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (USFWS 2008, p. 65). Anthony et al. (2006, p. 32) found significant evidence for negative effects of barred owls on apparent survival of spotted owls in two of 14 study areas (Olympic and Wenatchee). They attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate.

In a recent analysis of more than 9,000 banded spotted owls throughout their range, only 47 hybrids were detected (Kelly and Forsman 2004, p. 807). Consequently, hybridization with the barred owl is considered to be "an interesting biological phenomenon that is probably inconsequential, compared with the real threat - direct competition between the two species for food and space" (Kelly and Forsman 2004, p. 808).

The preponderance of evidence suggests that barred owls are exacerbating the spotted owl population decline, particularly in Washington, portions of Oregon, and the northern coast of California (Gutierrez et al. 2004, pp. 7-39 to 7-40; Olson et al. 2005, pp. 930-931). There is no evidence that the increasing trend in barred owls has stabilized in any portion of the spotted owl's range in the western United States, and "there are no grounds for optimistic views suggesting that barred owl impacts on spotted owls have been already fully realized" (Gutierrez et al. 2004, p. 7-38).

Wildfire

Studies indicate that the effects of wildfire on spotted owls and their habitat are variable, depending on fire intensity, severity and size. Within the fire-adapted forests of the spotted owl's range, spotted owls likely have adapted to withstand fires of variable sizes and severities. Bond et al. (Bond et al. 2002, p. 1025) examined the demography of the three spotted owl subspecies after wildfires, in which wildfire burned through spotted owl nest and roost sites in varying degrees of severity. Post-fire demography parameters for the three subspecies were similar or better than long-term demographic parameters for each of the three subspecies in those same areas (Bond et al. 2002, p. 1026). In a preliminary study conducted by Anthony and Andrews (2004, p. 8) in the Oregon Klamath Province, their sample of spotted owls appeared to be using a variety of habitats within the area of the Timbered Rock fire, including areas where burning had been moderate.

In 1994, the Hatchery Complex fire burned 17,603 hectares in the Wenatchee National Forest in Washington's eastern Cascades, affecting six spotted owl activity centers (Gaines et al. 1997, p. 125). Spotted owl habitat within a 2.9-kilometer (1.8-mile) radius of the activity centers was reduced by 8 to 45 percent (mean = 31 percent) as a result of the direct effects of the fire and by 10 to 85 percent (mean = 55 percent) as a result of delayed mortality of fire-damaged trees and insects. Direct mortality of spotted owls was assumed to have occurred at one site, and spotted owls were present at only one of the six sites 1 year after the fire (Gaines et al. 1997, p. 126). In 1994, two wildfires burned in the Yakama Indian Reservation in Washington's eastern Cascades, affecting the home ranges of two radio-tagged spotted owls (King et al. 1998, pp. 2-3). Although the amount of home ranges burned was not quantified, spotted owls were observed using areas that burned at low and medium intensities. No direct mortality of spotted owls was observed, even though thick smoke covered several spotted owl site-centers for a week. It appears that, at least in the short term, spotted owls may be resilient to the effects of wildfire—a process with which they have evolved. More research is needed to further understand the relationship between fire and spotted owl habitat use.

At the time of listing there was recognition that large-scale wildfire posed a threat to the spotted owl and its habitat (55 FR 26114: 26183 [June 26, 1990]). New information suggests fire may be more of a threat than previously thought. In particular, the rate of habitat loss due to fire has been greater than expected with over 102,000 acres of late-successional forest lost on Federal lands from 1993-2004 (Moeur et al. 2005, p. 110). Currently, the overall total amount of habitat loss from wildfires has been relatively small, and is estimated at 1.2 percent on Federal lands (Lint 2005, p. v). It may be possible to influence through silvicultural management how fire prone forests will burn and the extent of the fire when it occurs. Silvicultural management of forest fuels are currently being implemented throughout the spotted owl's range, in an attempt to reduce the levels of fuels that have accumulated during nearly 100 years of effective fire suppression. However, our ability to protect spotted owl habitat and viable populations of spotted owls from large fires through risk-reduction endeavors is uncertain (Courtney et al. 2004, p. 12-11). The Northwest Forest Plan (NWFP) recognized wildfire as an inherent part of managing spotted owl habitat in certain portions of the range. The distribution and size of reserve blocks as part of the NWFP design may help mitigate the risks associated with large-scale fire (Lint 2005, p. 77).

West Nile Virus

West Nile Virus (WNV) has killed millions of wild birds in North America since it arrived in 1999 (Caffrey 2003, p. 12; Marra et al. 2004, p. 393). Mosquitoes are the primary carriers (vectors) of the virus that causes encephalitis in humans, horses, and birds. Mammalian prey may also play a role in spreading WNV among predators, like spotted owls. Owls and other predators of mice can contract the disease by eating infected prey (Garmendia et al. 2000, p. 3111). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died (Gancz et al. 2004, p. 2137), but there are no documented cases of the virus in wild spotted owls.

Health officials expect that WNV will eventually spread throughout the range of the spotted owl (Courtney et al. 2004, p. 8-31) but it is unknown how WNV will ultimately affect owl populations. Susceptibility to infection and mortality rates of infected individuals vary among bird species, even within groups (Courtney et al. 2004, p. 8-33). Owls appear to be quite susceptible. For example, eastern screech owls (*Megascops asio*) in Ohio experienced 100 percent mortality (Courtney et al. 2004, p. 8-33). Barred owls, in contrast, showed lower susceptibility (Courtney et al. 2004, p. 8-34).

Courtney et al. (2004, p. 8-35) offer two possible scenarios for the likely outcome of spotted owl populations being infected by WNV. One scenario is that a range-wide reduction in spotted owl population viability is unlikely because the risk of contracting WNV varies between regions. An alternative scenario is that WNV will cause unsustainable mortality, due to the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the spotted owl's current range. WNV remains a potential threat of uncertain magnitude and effect (Courtney et al. 2004, p. 8-34).

Sudden Oak Death

Sudden oak death was recently identified as a potential threat to the spotted owl (Courtney et al. 2004, p. 11-8). This disease is caused by the fungus-like pathogen, *Phytopthora ramorum*, that was recently introduced from Europe and is rapidly spreading. At the present time, sudden oak death is found in natural stands from Monterey to Humboldt Counties, California, and has reached epidemic proportions in oak (*Quercus* spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 186 miles (300 km) of the central and northern California coast (Rizzo et al. 2002, p. 733). It has also been found near Brookings, Oregon, killing tanoak and causing dieback of closely associated wild rhododendron (*Rhododendron* spp.) and evergreen huckleberry (*Vaccinium ovatum*) (Goheen et al. 2002, p. 441). It has been found in several different forest types and at elevations from sea level to over 2625 ft (800 m). Sudden oak death poses a threat of uncertain proportion because of its potential impact on forest dynamics and alteration of key prey and spotted owl habitat components (e.g., hardwood trees - canopy closure and nest tree mortality); especially in the southern portion of the spotted owl's range (Courtney et al. 2004, p. 11-8).

Inbreeding Depression, Genetic Isolation, and Reduced Genetic Diversity

Inbreeding and other genetic problems due to small population sizes were not considered an imminent threat to the spotted owl at the time of listing. Recent studies show no indication of reduced genetic variation and past bottlenecks in Washington, Oregon, or California (Barrowclough et al. 1999, p. 922; Haig et al. 2004, p. 36). However, in Canada, the breeding population is estimated to be less than 33 pairs and annual population decline may be as high as 35 percent (Harestad et al. 2004, p. 13). Canadian populations may be more adversely affected by issues related to small population size including inbreeding depression, genetic isolation, and reduced genetic diversity (Courtney et al. 2004, p. 11-9). Low and persistently declining populations throughout the northern portion of the species range (see "Population Trends" below) may be at increased risk of losing genetic diversity.

Climate change

Climate change, combined with effects from past management practices is influencing current forest ecosystem processes and dynamics by increasing the frequency and magnitude of wildfires, insect outbreaks, drought, and disease (USFWS 2011, pp. III-5 - III-11). In the Pacific Northwest, mean annual temperatures rose 0.8° C (1.5° F) in the 20th century and are expected to continue to warm from 0.1° to 0.6° C (0.2° to 1° F) per decade (Mote and Salathe 2010, p. 29). Climate change models generally predict warmer, wetter winters and hotter, drier summers and increased frequency of extreme weather events in the Pacific Northwest (Salathé et al. 2010, pp. 72-73).

Predicted climate changes in the Pacific Northwest have implications for forest disturbances that affect the quality and distribution of spotted owl habitat. Both the frequency and intensity of wildfires and insect outbreaks are expected to increase over the next century in the Pacific Northwest (Littell et al. 2010, p. 130). One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration and severity. Since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period from 1970-1986 (Westerling et al. 2006, pp. 940-941). The total area burned is more than 6.5 times the previous level and the average length of the fire season during 1987-2003 was 78 days longer compared to 1978-1986 (Westerling et al. 2006, p. 941). The area burned annually by wildfires in the Pacific Northwest is expected to double or triple by the 2080s (Littell et al. 2010, p. 140). Wildfires are now the primary cause of spotted owl habitat loss on Federal lands, with over 236,000 acres of habitat loss attributed to wildfires from 1994 to 2007 (Davis et al. 2011, p. 123).

Potential changes in temperature and precipitation have important implications for spotted owl reproduction and survival. Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Dugger et al. 2005, p. 863; Olson et al. 2004, p. 1039), survival (Franklin et al. 2000, pp. 576-577; Glenn et al. 2011, p. 1279; Olson et al. 2004, p. 1039), and recruitment (Glenn et al. 2010, pp. 2446-2447). Cold, wet weather may reduce reproduction and/or survival during the breeding season due to declines or decreased activity in small mammal populations so that less food is available during reproduction when metabolic demands are high (Glenn et al. 2011, pp. 1288-1289). Cold, wet nesting seasons may increase the mortality of nestlings due to chilling and reduce the number of young fledged per pair per year (Franklin et al. 2000, p. 557; Glenn et al. 2011, p. 1286).

Drought or hot temperatures during the summer have also been linked to reduced spotted owl recruitment (Glenn et al. 2010, p. 2549). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals that spotted owls prey upon (Glenn et al. 2010, p. 2549).

In summary, climate change is likely to further exacerbate some existing threats to the spotted owl such as the projected potential for increased habitat loss from drought-related fire, tree mortality, insects and disease, as well as affecting reproduction and survival during years of extreme weather.

Disturbance-Related Effects

The effects of noise on spotted owls are largely unknown, and whether noise is a concern has been a controversial issue. The effect of noise on birds is extremely difficult to determine due to the inability of most studies to quantify one or more of the following variables: 1) timing of the disturbance in relation to nesting chronology; 2) type, frequency, and proximity of human disturbance; 3) clutch size; 4) health of individual birds; 5) food supply; and 6) outcome of previous interactions between birds and humans (Knight and Skagen 1988, pp. 355-358). Additional factors that confound the issue of disturbance include the individual bird's tolerance level, ambient sound levels, physical parameters of sound and how it reacts with topographic characteristics and vegetation, and differences in how species perceive noise.

Although information specific to behavioral responses of spotted owls to disturbance is limited, research indicates that recreational activity can cause Mexican spotted owls to vacate otherwise suitable habitat (Swarthout and Steidl 2001, p. 314) and helicopter overflights in close proximity to nest sites can cause a flush response (Delaney et al. 1999, p. 68). Additional effects from disturbance, including altered foraging behavior and decreases in nest attendance and reproductive success, have been reported for other raptors (Andersen et al. 1989, p. 296; McGarigal et al. 1991, p. 5; White and Thurow 1985, p. 14).

Spotted owls may also respond physiologically to a disturbance without exhibiting a significant behavioral response. In response to environmental stressors, vertebrates secrete stress hormones called corticosteroids (Campbell 1990, p. 925). Although these hormones are essential for survival, extended periods with elevated stress hormone levels may have negative effects on reproductive function, disease resistance, or physical condition (Carsia and Harvey 2000, pp. 517-518; Sapolsky et al. 2000, p. 1). In avian species, the secretion of corticosterone is the primary non-specific stress response (Carsia and Harvey 2000, p. 517). The quantity of this hormone in feces can be used as a measure of physiological stress (Wasser et al. 1997, p. 1019). Recent studies of fecal corticosterone levels of spotted owls indicate that low intensity noise of short duration and minimal repetition does not elicit a physiological stress response (Tempel and Gutiérrez 2003, p.698; Tempel and Gutiérrez 2004, p. 538). However, prolonged activities, such as those associated with timber harvest, may increase fecal corticosterone levels depending on their proximity to spotted owl core areas (Tempel and Gutiérrez 2004, p. 544; Wasser et al. 1997, p. 1021).

Conservation Needs of the Spotted Owl

Based on the above assessment of threats, the spotted owl has the following habitat-specific and habitat-independent conservation (i.e., survival and recovery):

Habitat-specific Needs

1. Large blocks of suitable habitat to support clusters or local population centers of spotted owls (e.g., 15 to 20 breeding pairs) throughout the spotted owl's range;

2. Suitable habitat conditions and spacing between local spotted owl populations throughout its range to facilitate survival and movement;

3. Suitable habitat distributed across a variety of ecological conditions within the spotted owl's range to reduce risk of local or widespread extirpation;

4. A coordinated, adaptive management effort to reduce the loss of habitat due to catastrophic wildfire throughout the spotted owl's range, and a monitoring program to clarify whether these risk reduction methods are effective and to determine how spotted owls use habitat treated to reduce fuels; and

5. In areas of significant population decline, sustain the full range of survival and recovery options for this species in light of significant uncertainty.

Habitat-independent Needs

1. A coordinated, research and adaptive management effort to better understand and manage competitive interactions between spotted and barred owls; and

2. Monitoring to better understand the risk that West Nile Virus and sudden oak death pose to spotted owls and, for West Nile Virus, research into methods that may reduce the likelihood or severity of outbreaks in spotted owl populations.

Conservation Strategy

Since 1990, various efforts have addressed the conservation needs of the spotted owl and attempted to formulate conservation strategies based upon these needs. The various efforts began with the Interagency Scientific Committee's Conservation Strategy (Thomas et al. 1990). The efforts continued with the designation of critical habitat (57 FR 1796-1838, the Draft Recovery Plan (USFWS 1992); the Scientific Analysis Team report (Thomas et al. 1993); and the report of the Forest Ecosystem Management Assessment Team (FEMAT 1993). The efforts culminated with the NWFP (USDA and USDI 1994). Each conservation strategy was based upon the reserve design principles first articulated in the Interagency Scientific Committee's report, which are summarized as follows:

- Species that are well distributed across their range are less prone to extinction than species confined to small portions of their range.

- Large blocks of habitat, containing multiple pairs of the species, are superior to small blocks of habitat with only one to a few pairs.

- Blocks of habitat that are close together are better than blocks far apart. Habitat that occurs in contiguous blocks is better than habitat that is more fragmented.

- Habitat between blocks is more effective as dispersal habitat if it resembles suitable habitat.

Conservation on Federal Lands

Since it was signed on April 13, 1994, the NWFP has guided the management of Federal forest lands within the range of the spotted owl (1994; USFS and USBLM 1994). The NWFP was designed to protect large blocks of old growth forest and provide habitat for species that depend on those forests including the spotted owl, as well as to produce a predictable and sustainable level of timber sales. The NWFP included land use allocations which would provide for population clusters of spotted owls (i.e., demographic support) and maintain connectivity between population clusters. Certain land use allocations in the plan contribute to supporting population clusters: Late-successional Reserves (LSRs), Managed Late-successional Areas, and

Congressionally Reserved areas. Riparian Reserves, Adaptive Management Areas and Administratively Withdrawn areas can provide both demographic support and connectivity/dispersal between the larger blocks, but were not necessarily designed for that purpose. Matrix areas were to support timber production while also retaining biological legacy components important to old-growth obligate species (in 100-acre owl cores, 15 percent late-successional provision, etc. (1994; USFS and USBLM 1994) which would persist into future managed timber stands.

The NWFP with its rangewide system of LSRs was based on work completed by three previous studies (Thomas et al. 2006, pp. 279-280): the 1990 Interagency Scientific Committee (ISC) Report (Thomas et al. 1990), the 1991 report for the Conservation of Late-successional Forests and Aquatic Ecosystems (Johnson et al. 1991), and the 1993 report of the Scientific Assessment Team (Thomas et al. 1993). In addition, the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992) was based on the ISC report.

The Forest Ecosystem Management Assessment Team predicted, based on expert opinion, the spotted owl population would decline in the Matrix land use allocation over time, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (Thomas et al. 1993, p. II-31; USFS and USBLM 1994, p. 3&4-229). Based on the results of the first decade of monitoring, Lint (2005, p. 18) could not determine whether implementation of the NWFP would reverse the spotted owl's declining population trend because not enough time had passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the NWFP (Lint 2005, p. 18; Noon and Blakesley 2006, p. 288). (Courtney et al. 2004, p. 6-34) suggested that more fuels treatments are needed in east-side forests to preclude large-scale losses of habitat to stand-replacing wildfires. Other stressors that occur in suitable habitat, such as the range expansion of the barred owl (already in action) and infection with WNV (which may or may not occur) may complicate the conservation of the spotted owl. Recent reports about the status of the spotted owl offer few management recommendations to deal with these emerging threats. The arrangement, distribution, and resilience of the NWFP land use allocation system may prove to be the most appropriate strategy in responding to these unexpected challenges (Courtney et al. 2004, p. 6-34).

Under the NWFP, the agencies anticipated a decline of spotted owl populations during the first decade of implementation. Recent reports (Anthony et al. 2006, pp. 33-34) identified greater than expected spotted owl declines in Washington and northern portions of Oregon, and more stationary populations in southern Oregon and northern California. The reports did not find a direct correlation between habitat conditions and changes in vital rates of spotted owls at the meta-population scale. However, at the territory scale, there is evidence of negative effects to spotted owl fitness due to reduced habitat quantity and quality. Also, there is no evidence to suggest that dispersal habitat is currently limiting (Courtney et al. 2004, p. 9-12; Lint 2005, p. 87). Even with the population decline, Courtney et al (2004, p. 9-15) noted that there is little reason to doubt the effectiveness of the core principles underpinning the NWFP conservation strategy.

The current scientific information, including information showing spotted owl population declines, indicates that the spotted owl continues to meet the definition of a threatened species (USFWS 2004, p. 54). That is, populations are still relatively numerous over most of its historic range, which suggests that the threat of extinction is not imminent, and that the subspecies is not endangered; even though, in the northern part of its range population trend estimates are showing a decline.

Revised Northern Spotted Owl Recovery Plan

In June 2011, the Service published the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). The recovery plan identifies that competition with barred owls, ongoing loss of suitable habitat as a result of timber harvest and catastrophic fire, and loss of amount and distribution of suitable habitat as a result of past activities and disturbances are the most important range-wide threats to the spotted owl (USFWS 2011, p. II-2). To address these threats, the revised recovery strategy has identified 33 Recovery Actions which address four basic steps:

1. Development of a range-wide habitat modeling tool;
2. Habitat conservation and active forest restoration
3. Barred owl management;
4. Research and monitoring.

In addition to describing specific actions to address the barred owl threat, the Revised Recovery Plan continues to recognize the importance of maintaining and restoring high value habitat for the recovery and long-term survival of the spotted owl.

To address habitat conservation, the Revised Recovery Plan recommends land managers continue to implement the standards and guidelines of the NWFP throughout the range of the species, as well as fully consider other habitat conservation recommendations listed in the Revised Recovery Plan (USFWS 2011, p. II-3).

Conservation Efforts on non-Federal Lands

In the report from the Interagency Scientific Committee (Thomas et al. 1990, p. 3), the draft recovery plan (USFWS 1992, p. 272), and the report from the Forest Ecosystem Management Assessment Team (Thomas et al. 1993, p. IV-189), it was noted that limited Federal ownership in some areas constrained the ability to form a network of old-forest reserves to meet the conservation needs of the spotted owl. In these areas in particular, non-Federal lands would be important to the range-wide goal of achieving conservation and recovery of the spotted owl. The Service's primary expectations for private lands are for their contributions to demographic support (pair or cluster protection) to Federal lands, or their connectivity with Federal lands. In addition, timber harvest within each state is governed by rules that provide protection of spotted owls or their habitat to varying degrees.

There are 17 current or completed Habitat Conservation Plans (HCPs) that have incidental take permits issued for spotted owls—eight in Washington, three in Oregon, and four in California (USFWS 2008, p. 55). The HCPs range in size from 40 acres to more than 1.6 million acres, although not all acres are included in the mitigation for spotted owls. In total, the HCPs cover approximately 2.9 million acres (9.1 percent) of the 32 million acres of non-Federal forest lands in the range of the spotted owl. The period of time that the HCPs will be in place ranges from 5 to 100 years; however, most of the HCPs are of fairly long duration. While each HCP is unique, there are several general approaches to mitigation of incidental take:

- Reserves of various sizes, some associated with adjacent Federal reserves.
- Forest harvest that maintains or develops suitable habitat.
- Forest management that maintains or develops dispersal habitat.
- Deferral of harvest near specific sites.

Washington. In 1996, the State Forest Practices Board adopted rules (WFPB 1996) that would contribute to conserving the spotted owl and its habitat on non-Federal lands. Adoption of the rules was based in part on recommendations from a Science Advisory Group that identified important non-Federal lands and recommended roles for those lands in spotted owl conservation (Buchanan et al. 1994, p. ii; Hanson et al. 1993, pp. 11-15). The 1996 rule package was developed by a stakeholder policy group and then reviewed and approved by the Forest Practices Board (Buchanan and Sweeden 2005, p. 9). Spotted owl-related HCPs in Washington generally were intended to provide demographic or connectivity support (USFWS 1992, p. 272).

Oregon. The Oregon Forest Practices Act provides for protection of 70-acre core areas around sites occupied by an adult pair of spotted owls capable of breeding (as determined by recent protocol surveys), but it does not provide for protection of spotted owl habitat beyond these areas (ODF 2007, p. 64) . In general, no large-scale spotted owl habitat protection strategy or mechanism currently exists for non-Federal lands in Oregon. The three spotted owl-related HCPs currently in effect cover more than 300,000 acres of non-Federal lands. These HCPs are intended to provide some nesting habitat and connectivity over the next few decades (USFWS 2008, p. 56).

California. The California State Forest Practice Rules, which govern timber harvest on private lands, require surveys for spotted owls in suitable habitat and to provide protection around activity centers (CDF 2007, pp. 85-87). Under the Forest Practice Rules, no timber harvest plan can be approved if it is likely to result in incidental take of federally listed species, unless the take is authorized by a Federal incidental take permit (CDF 2007, pp. 85-87) (California Department of Forestry and Fire Protection 2007, pp. 85-87). The California Department of Fish and Game initially reviewed all timber harvest plans to ensure that take was not likely to occur; the Service took over that review function in 2000. Several large industrial owners operate under spotted owl management plans that have been reviewed by the Service and that specify basic measures for spotted owl protection. Four HCPs authorizing take of spotted owls have been approved; these HCPs cover more than 669,000 acres of non-Federal lands. Implementation of these plans is intended to provide for spotted owl demographic and connectivity support to NWFP lands (USFWS 2008, p. 56).

Current Condition of the Spotted Owl

The current condition of a species incorporates the effects of all past human and natural activities or events that have led to the present-day status of the species and its habitat (USFWS and NMFS 1998, pp. 4-19).

<u>Range-wide Habitat Trends</u>

Habitat Baseline – 1994/1996 to 2006/2007

Habitat mapping developed in support of the NWFP indicated a baseline estimate of approximately 7.4 million acres of spotted owl habitat on Federal lands in 1994 (USFS and USBLM 1994, p. G-34). The initial habitat map developed for the NWFP did not include non-Federal lands and was never assessed for accuracy (Davis et al. 2011, p. 21). Subsequent mapping efforts for the NWFP effectiveness monitoring program produced range-wide habitat maps for the 10-year monitoring report (Lint 2005)and the 15-year monitoring report (Davis et al. 2011). The most recent mapping effort indicates approximately 8.85 million acres of spotted owl nesting/roosting habitat existed on Federal lands and 4.19 million acres existed on non-Federal lands at the beginning of the NWFP in 1994/1996 (Table 1).

The NWFP 15-year monitoring report evaluated changes in spotted owl nesting/roosting habitat across all ownerships from timber harvest and natural disturbances (wildfire, insects, and disease), it did not track all foraging habitat. Data from California covered 14 years from 1994 to 2007, data from Oregon and Washington covered 10 years from 1996 to 2006 (Davis et al. 2011, pp. 28-30). Range-wide, 0.6 percent (53,800 acres) of the spotted owl nesting/roosting habitat on Federal lands were lost to timber harvest and 2.8 percent (244,800 acres) to natural disturbances, primarily wildfire, resulting in a total range-wide loss of 3.4 percent (298,600 acres) of owl habitat on Federal lands (Table 1). Most of the habitat loss (79 percent) has occurred within reserved land allocations as a result of wildfires (Davis et al. 2011, p. 43).

The greatest percentage of Federal land habitat loss was in Oregon, specifically in the Oregon Klamath Province (10.2 percent of the habitat) due primarily to wildfire (Table 1). Two provinces, the Oregon and California Klamath accounted for 60 percent of the total habitat loss on Federal lands. In contrast, less than 1 percent of the nesting and roosting habitat in the Olympic Peninsula, Western Washington Cascades, and Oregon Coast Ranges was lost during the time period (Table 1). Habitat losses on non-Federal lands have resulted primarily from timber harvest, with over 625,000 acres of habitat loss (15.5 percent of the habitat) across the three states during the same time period.

Under the NWFP, rangewide spotted owl habitat losses from timber harvest was expected to occur at a rate of approximately 2.5 percent per decade (USDA and USDI 1994, p. 46). Using the revised NWFP baseline of 8.85 million acres, this would equate to a loss of approximately

221,000 acres of habitat per decade. Monitoring for the NWFP indicates habitat losses from timber harvest have occurred at a much lower rate (about 0.6 percent per decade). However, habitat losses from wildfires have exceeded 5 percent in some Provinces, and much of the habitat loss from wildfire has occurred in the reserved land allocations. The large reserve network under the NWFP was designed to function despite losses to wildfires. Habitat loss outside of reserved allocations has been lower than expected, and the NWFP monitoring indicates that most of the reserve network is currently well connected for spotted owl dispersal connectivity, with the exception of a few areas such as the Olympic Peninsula, Oregon Coast Range, and California Klamath (Davis et al. 2011, p. 54).

Table 1. Range-wide estimates of spotted owl nesting/roosting habitat (acres) and losses from 1994/1996 to 2006/2007. Source: Davis et al. 2011, Appendix D, pp. 123-124.

Physiographic Province – Federal Lands	Nesting/Roosting Habitat Baseline (1994/1996)	Habitat Loss from Timber Harvest	Habitat Loss from Natural Disturbance	Total Habitat Loss	Nesting/Roosting Habitat Baseline (2006/2007)	Percent Change
WA Olympic Peninsula	763,100	500	200	700	762,400	-0.1%
WA Eastern Cascades	673,600	8,100	22,000	30,100	643,500	-4.5%
WA Western Cascades	1,283,000	3,700	1,100	4,800	1,278,200	-0.4%
WA Western Lowlands	24,700	400	0	400	643,500	-1.6%
WA Federal Lands Total	**2,744,400**	**12,700**	**23,300**	**36,000**	**2,708,400**	**-1.3**
OR Coast Range	611,200	3,300	0	3,300	607,900	-0.5%
OR Klamath Mountains	985,000	6,800	93,900	100,700	884,300	-10.2%
OR Cascades East	402,900	5,800	20,100	25,900	377,000	-6.4%
OR Cascades West	2,258,700	13,900	30,000	43,900	2,214,800	-1.9%
ORWillamette Valley	3,400	100	0	100	3,300	-2.9%
OR Federal Lands Total	**4,261,200**	**29,900**	**144,000**	**173,900**	**4,087,300**	**-4.1%**
CA Coast Range	145,400	300	2,200	2,500	142,900	-1.7%
CA Cascades	213,200	6,500	2,100	8,600	204,600	-4.0%
CA Klamath	1,489,800	4,400	73,200	77,600	1,412,200	-5.2%
CA Federal Lands Total	**1,848,400**	**11,200**	**77,500**	**88,700**	**1,759,700**	**-4.8%**
Rangewide Federal Lands Total	**8,854,000**	**53,800**	**244,800**	**298,600**	**8,555,400**	**-3.4%**
WA non-Federal lands	1,258,900	234,200	8,400	242,600	1,016,300	-19.3
OR non-Federal lands	1,382,400	301,200	7,800	309,000	1,073,400	-22.4
CA non-Federal lands	1,556,700	90,200	7,500	97,700	1,459,000	-6.3
Rangewide non-Federal lands Total	**4,198,000**	**625,600**	**23,700**	**649,300**	**3,548,700**	**-15.5**
All Lands Range Total	**13,052,000**	**679,400**	**268,500**	**-947,900**	**12,104,100**	**-7.3**

Note: Acres are rounded to the nearest 100 acres.

In addition to the information provided by the NWFP effectiveness monitoring program, the Service also maintains a database of habitat impacts documented through the Endangered Species Act section 7 consultations and technical assistance. This database has been the Service's primary tool for documenting and tracking habitat impacts across the range of the spotted owl. The estimated losses of spotted owl habitat documented through section 7 consultations vary substantially from the estimates derived from NWFP effectiveness monitoring program presented in Table 1. In general, the actual losses of habitat from timber harvest on Federal lands have been less than what we have previously estimated through section 7 consultations, and habitat losses from wildfires have been greater than what has been documented through technical assistance.

From 1994 to 2006, the Service documented an anticipated loss of 158,000 acres of nesting, roosting and foraging (NRF) habitat due to timber harvest, and 168,000 acres of NRF habitat due to wildfire for a total loss of 326,000 acres on Federal lands (USFWS 2006, p. 25). This compares to 53,800 acres lost to timber harvest, and 244,800 acres lost to natural disturbances from 1994-2006/2007 documented by the NWFP 15-year monitoring report (Table 1). Although there are a number of reasons why there are disparities between the two datasets, we attribute the impact of large wildfires as the primary reason. Many areas with planned Federal timber harvest actions have been burned during large wildfire events, such as the Biscuit Fire that burned over a 500,000 acre area in southwest Oregon and northern California in 2002. Other reasons for differences in these datasets include Federal actions that were planned and not implemented, differences in habitat estimation methodology, and the limitations of remote-sensing in determining whether habitat loss is attributable to wildfire, timber harvest, or other disturbance such as windthrow.

The Service considers the spotted owl habitat information developed for the NWFP monitoring program to be the best available information concerning rangewide habitat conditions and trends for the period from 1994 to 2006/2007. However, we recognize the spatial resolution of the NWFP habitat map may limit the utility of the map for site-specific analyses.

Rangewide Analysis 2006/2007 – Present.

Because the data developed for the NWFP monitoring program is only current through 2006/2007, the Service continues to rely on information compiled in the spotted owl consultation database to summarize current owl habitat trends at provincial and rangewide scales. We updated the consultation database to reflect the 2006/2007 habitat baseline developed for the NWFP 15-year monitoring report and summarize the habitat impacts on Federal lands that have occurred since 2006 (Table 2).

Since 2006, the Service has consulted on the removal or downgrading of 52,802 acres associated with Federal timber harvest, and documented 58,889 acres of habitat loss associated with natural disturbances, for a cumulative loss of 111,691 acres (Table 2). These values, combined with the habitat losses documented by the NWFP monitoring program (Table 1), indicate a total cumulative loss of 410,291 acres (4.6 percent) on Federal lands since 1994. The majority of this habitat loss is attributed to wildfires. Habitat losses from past timber harvest (53,800 acres) (Table 1), combined with consulted on effects since 2006 (52,802 acres) (Table 2) indicate a loss of 1.2 percent since 1994, well below the anticipated rate of 2.5 percent per decade under the NWFP (USDA and USDI 1994, p. 46).

It is important to note that the Service continues to update the information in the consultation database as it becomes available. However, we recognize that not all habitat changes that have occurred since 2006 are summarized in Table 2. Habitat impacts associated with wildfires and other natural disturbances are generally under-represented in the Services consultation database. Several large wildfires have occurred in various locations across the species range since 2006, and this information is only partially reflected in the Service's consultation database. For example, the southern portion of the owls range experienced over 615,000 acres of wildfires between 2008 and 2009 (Davis et al. 2011, p. 55), and the full impact that these fires had on spotted owl habitat has not yet been fully assessed or reported to the Service. The Service has documented a loss of over 58,000 acres of owl habitat from natural disturbances since 2006 (Table 2). However, this number likely underestimates the total habitat loss associated with wildfires and other natural disturbances.

Table 2. Summary of spotted owl suitable habitat (NRF[1]) acres removed or downgraded as documented through Section 7 consultations on all Federal Lands within the Northwest Forest Plan area. Environmental baseline and summary of effects by State, Physiographic Province, and land use function from 2006 to present (April 14, 2015).

State	Physiographic Province[2]	Evaluation Baseline (2006/2007)[3]			Habitat Removed/Downgraded[4]						Total NRF removed/ downgraded	% Provincial Baseline Affected	% Range-wide Effects
					Timber Harvest/ Land Management			Habitat Loss from Natural Disturbance					
		Nesting/ Roosting Acres in Reserves	Nesting/ Roosting Acres in Non-Reserves	Total Nesting/ Roosting Acres	Reserves[5]	Non-Reserves	Total	Reserves	Non-Reserves	Total			
WA	Eastern Cascades	462,400	181,100	643,500	2,700	2,238	4,938	1,559	132	1,691	6,629	1.03	5.94
WA	Olympic Peninsula	729,000	33,400	762,400	6	0	6	0	1	1	7	0	0.01
WA	Western Cascades	1,031,600	246,600	1,278,200	529	831	1,360	3	0	3	1,363	0.11	1.22
WA	Western Lowlands	24,300	0	24,300	0	0	0	0	0	0	0	0	0
OR	Cascades East	248,500	128,400	376,900	2,994	7,499	10,493	7,639	1,981	9,620	20,113	5.34	18.01
OR	Cascades West	1,275,200	939,600	2,214,800	1,183	23,087	24,270	761	1,531	2,292	26,562	1.20	23.78
OR	Coast Range	494,400	113,400	607,800	750	1,623	2,373	0	0	0	2,373	0.39	2.12
OR	Klamath Mountains	549,400	334,900	884,300	2,985	5,367	8,352	1,538	3,696	5,234	13,586	1.54	12.16
OR	Willamette Valley	700	2,600	3,300	0	0	0	0	0	0	0	0	0
CA	Cascades	101,700	102,900	204,600	10	1	11	325	0	325	336	0.16	0.30
CA	Coast Range	132,900	10,100	143,000	274	1	275	0	175	175	450	0.31	0.41
CA	Klamath	910,900	501,200	1,412,100	75	649	724	19,139	20,409	39,548	40,272	2.85	36.06
	Total	**5,961,000**	**2,594,200**	**8,555,200**	**11,506**	**41,296**	**52,802**	**30,964**	**27,925**	**58,889**	**111,691**	**1.31**	**100**

Source: USFWS Northern Spotted Owl Consultation Database, Table B.

1 Nesting, roosting, foraging (NRF) habitat. In WA/OR, the values for nesting/roosting habitat generally represent the distribution of suitable owl habitat, including foraging habitat. In CA, foraging habitat occurs in a much broader range of forest types than what is represented by nesting/roosting habitat. Baseline information for foraging habitat as a separate category in CA is currently not available at a provincial scale.

2 Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as Recovery Units as depicted on page A-3.

3 Spotted owl nesting and roosting habitat on all Federal lands (includes USFS, BLM, NPS, DoD, USFWS, etc.) as reported by Davis et al. 2011 for the the Northwest Forest Plan 15-Year Monitoring Report (PNW-GTR-80, Appendix D). NR habitat acres are approximate values based on 2006 (OR/WA) and 2007 (CA) satellite imagery.

4 Estimated NRF habitat removed or downgraded from land management (timber sales) or natural events (wildfires) as documented through section 7 consultation or technical assistance. Effects reported here include all acres removed or downgraded from 2006 to present. Effects in California reported here only include effects to nesting/roosting habitat. Foraging habitat removed or downgraded in California is not summarized in this table.

5 Reserve land use allocations under the NWFP intended to provide demographic support for spotted owls include LSR, MLSA, and CRA. Non-reserve allocations under the NWFP intended to provide dispersal connectivity between reserves include AWA, AMA, and MX.

The Service does not track habitat changes on non-Federal lands except through consultations for long-term Habitat Conservation Plans, Safe Harbor Agreements, or Tribal Forest Management Plans. Service consultations conducted since 1992 have documented the eventual loss of over 475,000 acres of habitat on non-Federal lands. Most of these losses have yet to be realized because they are part of large-scale, long-term HCPs. However, the NWFP 15 year monitoring report documented habitat losses on non-Federal lands associated with timber harvest continues to occur at a rate of 1 to 2 percent per year in Oregon and Washington, and at a lesser rate in Califorinia (Table 1).

Spotted Owl Numbers, Distribution, and Reproduction Trends

There are no estimates of the historical population size and distribution of spotted owls, although they are believed to have inhabited most old-growth forests throughout the Pacific Northwest prior to modern settlement (mid-1800s), including northwestern California (USFWS 1989, pp. 2-17).

The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (55 FR 26114 [June 26, 1990]). The range of the spotted owl is partitioned into 12 physiographic provinces (Figure 1) based on recognized landscape subdivisions exhibiting different physical and environmental features (USFWS 1992, p. 31). The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal range of Oregon.

As of July 1, 1994, there were 5,431 known locations of, or site centers of spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 (53 percent) in Oregon, and 1,687 (31 percent) in California (60 FR 9484:9495 [Feb. 17, 1995]). The actual number of currently occupied spotted owl locations across the range is unknown because many areas remain unsurveyed (USFWS 2011, p. A-2). In addition, many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires, and it is possible that some new sites have been established due to reduced timber harvest on Federal lands since 1994. The totals listed above represent the cumulative historical number of locations recorded in the three states, not population estimates.

Because existing survey coverage and effort are insufficient to produce reliable range-wide estimates of population size, researchers use other indices, such as demographic data, to evaluate trends in spotted owl populations. Analysis of demographic data can provide an estimate of the rate and direction of population growth [i.e., lambda (λ)]. A λ of 1.0 indicates a stationary population (i.e., neither increasing nor decreasing), a λ less than 1.0 indicates a declining population, and a λ greater than 1.0 indicates a growing population. Demographic data, derived from studies initiated as early as 1985, have been analyzed periodically (Anderson and Burnham 1992; Anthony et al. 2006; Burnham et al. 1994; Forsman et al. 2011; Forsman et al. 1996) to estimate trends in the populations of the spotted owl.

In January 2009, two meta-analyses modeled rates of population change for up to 24 years using the re-parameterized Jolly-Seber method (λRJS). One meta-analysis modeled the 11 long-term study areas (Table 3), while the other modeled the eight study areas that are part of the effectiveness monitoring program of the NWFP (Forsman et al. 2011, pp. 65-67).

Table 3. Summary of spotted owl population trends from in demographic study areas (Forsman et al. 2011, p. 65).

Study Area	Fecundity	Apparent Survival[1]	λ_{RJS}	Population change[2]
Cle Elum	Declining	Declining	0.937	Declining
Rainier	Increasing	Declining	0.929	Declining
Olympic	Stable	Declining	0.957	Declining
Coast Ranges	Increasing	Declining since 1998	0.966	Declining
HJ Andrews	Increasing	Declining since 1997	0.977	Declining
Tyee	Stable	Declining since 2000	0.996	Stationary
Klamath	Declining	Stable	0.990	Stationary
Southern Cascades	Declining	Declining since 2000	0.982	Stationary
NW California	Declining	Declining	0.983	Declining
Hoopa	Stable	Declining since 2004	0.989	Stationary
Green Diamond	Declining	Declining	0.972	Declining

[1]Apparent survival calculations are based on model average.
[2]Population trends are based on estimates of realized population change.

Point estimates of λRJS were all below 1.0 and ranged from 0.929 to 0.996 for the 11 long-term study areas. There was strong evidence that populations declined on 7 of the 11 areas (Forsman et al. 2011, p. 65), these areas included Rainier, Olympic, Cle Elum, Coast Range, HJ Andrews, Northwest California and Green Diamond. On other four areas (Tyee, Klamath, Southern Cascades, and Hoopa), populations were either stable, or the precision of the estimates was not sufficient to detect declines.

The weighted mean λRJS for all of the 11 study areas was 0.971 (standard error [SE] = 0.007, 95 percent confidence interval [CI] = 0.960 to 0.983), which indicated an average population decline of 2.9 percent per year from 1985 to 2006. This is a lower rate of decline than the 3.7 percent reported by Anthony et al. (2006, p. 23), but the rates are not directly comparable because Anthony et al. (2006) examined a different series of years and because two of the study areas in their analysis were discontinued and not included in Forsman et al. (2011, p. 65). Forsman et al. (2011, p. 65) explains that the indication populations were declining was based on the fact that the 95 percent confidence intervals around the estimate of mean lambda did not overlap 1.0 (stable) or barely included 1.0.

The mean λRJS for the eight demographic monitoring areas (Cle Elum, Olympic, Coast Range, HJ Andrews, Tyee, Klamath, Southern Cascades and Northwest California) that are part of the effectiveness monitoring program of the NWFP was 0.972 (SE = 0.006, 95 percent CI = 0.958 to

0.985), which indicated an estimated decline of 2.8 percent per year on Federal lands with the range of the spotted owl (Forsman et al. 2011, p. 67). The weighted mean estimate λRJS for the other three study areas (Rainier, Hoopa and Green Diamond) was 0.969 (SE = 0.016, 95 percent CI = 0.938 to 1.000), yielding an estimated average decline of 3.1 percent per year. These data suggest that demographic rates for spotted owl populations on Federal lands were somewhat better than elsewhere; however, this comparison is confounded by the interspersion of non-Federal land in study areas and the likelihood that spotted owls use habitat on multiple ownerships in some demography study areas.

The number of populations that declined and the rate at which they have declined are noteworthy, particularly the precipitous declines in the Olympic, Cle Elum, and Rainier study areas in Washington and the Coast Range study area in Oregon. Estimates of population declines in these areas ranged from 40 to 60 percent during the study period through 2006 (Forsman et al. 2011, p. 66). Spotted owl populations on the HJ Andrews, Northwest California, and Green Diamond study areas declined by 20-30 percent whereas the Tyee, Klamath, Southern Cascades, and Hoopa study areas showed declines of 5 to 15 percent (Forsman et al. 2011, p. 66).

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends. Forsman et al. (2011, pp. 65-66) found apparent survival rates were declining on 10 of the study area with the Klamath study area in Oregon being the exception. Estimated declines in adult survival were most precipitous in Washington where apparent survival rates were less than 80 percent in recent years, a rate that may not allow for sustainable populations (Forsman et al. 2011, p. 66). In addition, declines in adult survival for study areas in Oregon have occurred predominately within the last five years and were not observed in the previous analysis by Anthony et al. (2006). Forsman et al. (2011, p. 64) express concern for the decline in adult survival rates across the subspecies range because spotted owl populations are most sensitive to changes in adult survival.

There are few spotted owls remaining in British Columbia. Chutter et al. (2004, p. v) suggested immediate action was required to improve the likelihood of recovering the spotted owl population in British Columbia. In 2007, personnel in British Columbia captured and brought into captivity the remaining 16 known wild spotted owls (USFWS 2011, p. A-6). Prior to initiating the captive-breeding program, the population of spotted owls in Canada was declining by as much as 10.4 percent per year (Chutter et al. 2004, p. v). The amount of previous interaction between spotted owls in Canada and the United States is unknown.

LITERATURE CITED

Andersen, D.E., O. Rongstad, and W.R. Mytton. 1989. Response of nesting red-tailed hawks to helicopter overflights. The Condor 9(2):296-299.

Anderson, D.R., and K.P. Burnham. 1992. Demographic analysis of northern spotted owl populations. Pages 319-328 *In* Draft final recovery plan for the northern spotted owl, U.S. Fish and Wildlife Service, Portland, OR.

Anthony, R.G., and L.S. Andrews. 2004. Summary Report: Winter habitat use by spotted owls on USDI Bureau of Land Management Medford District lands within the boundaries of the Timbered Rock Fire. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, OR. 29 pp.

Anthony, R.G., E.D. Forsman, A.B. Franklin, D.R. Anderson, K.P. Burnham, G.C. White, C.J. Schwarz, J. Nichols, J.E. Hines, G.S. Olson, S.H. Ackers, S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, K.M. Dugger, K.E. Fehring, T.L. Fleming, R.P. Gerhardt, S.A. Gremel, R.J. Gutiérrez, P.J. Happe, D.R. Herter, J.M. Higley, R.B. Horn, L.L. Irwin, P.J. Loschl, J.A. Reid, and S.G. Sovern. 2006. Status and trends in demography of northern spotted owls, 1985-2003. Wildlife Monographs 163:2-68.

Barrowclough, G.F., J.G. Groth, L.A. Mertz, and R.J. Gutiérrez. 2005. Genetic structure, introgression, and a narrow hybrid zone between northern and California spotted owls (*Strix occidentalis*). Molecular Ecology 14(4):1109-1120.

Barrowclough, G.F., and R.J. Gutiérrez. 1990. Genetic variation and differentiation in the spotted owl. Auk 107:737-744.

Barrowclough, G.F., R.J. Gutiérrez, and J.G. Groth. 1999. Phylogeography of spotted owl (*Strix occidentalis*) populations based on mitochondrial DNA sequences; gene flow, genetic structure, and a novel biogeographic pattern. Evolution 53(3):919-931.

Barrows, C.W., and K. Barrows. 1978. Roost characteristics and behavioral thermoregulation in the spotted owl. Western Birds 9(1):1-8.

Bart, J. 1995. Amount of suitable habitat and viability of northern spotted owls. Conservation Biology 9(4):943-946.

Bart, J., and E.D. Forsman. 1992. Dependence of northern spotted owls *Strix occidentalis* caurina on old-growth forests in the western USA. Biological Conservation 62:95-100.

Bingham, B.B., and B.R. Noon. 1997. Mitigation of habitat "take": Application to habitat conservation planning. Conservation Biology 11(1):127-138.

Bond, M.L., R.J. Gutiérrez, A.B. Franklin, W.S. LaHaye, C.A. May, and M.E. Seamans. 2002. Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success. Wildlife Society Bulletin 30(4):1022-1028.

Buchanan, J.B. 2004. In my opinion: Managing habitat for dispersing northern spotted owls-are the current management strategies adequate? Wildlife Society Bulletin 32(4):1333-1345.

Buchanan, J.B., E. Hanson, D. Hays, and L. Young. 1994. An evaluation of the Washington Forest Practices Board Wildlife Committee preferred alternative for a spotted owl protection rule. Washington Forest Practices Board Spotted Owl Scientific Advisory Group, Olympia, WA, July 1994.

Buchanan, J.B., L.L. Irwin, and E.L. McCutchen. 1995. Within-stand nest site selection by spotted owls in the eastern Washington Cascades. Journal of Wildlife Management 59(2):301-310.

Buchanan, J.B., and P. Sweeden. 2005. Final briefing report to the Washington State Forest Practices Board regarding spotted owl status and forest practices rules. Washington Department of Fish and Wildlife, Olympia, WA, August 2005. 85 pp.

Burnham, K.P., D.R. Anderson, and G.C. White. 1994. Estimation of vital rates of the northern spotted owl, Fort Collins, Colorado, January 12, 1994. 26 pp.

Caffrey, C. 2003. Determining impacts of West Nile Virus on crows and other birds. American Birds (103rd Count) 57:12-13.

Campbell, N.A. 1990. Adrenal glands. Pages 923-926 *In* Biology, Benjamin/Cummings Publishing Company, Inc., Redwood City, CA.

Carey, A.B., S.P. Horton, and B.L. Biswell. 1992. Northern Spotted Owls - Influence of Prey Base and Landscape Character. Ecological Monographs 62(2):223-250.

Carey, A.B., and K.C. Peeler. 1995. Spotted owls: Resource and space use in mosaic landscapes. Journal of Raptor Research 29(4):223-239.

Carey, A.B., J.A. Reid, and S.P. Horton. 1990. Spotted owl home range and habitat use in southern oregon coast ranges. Journal of Wildlife Management 54(1):11-17.

Carsia, R.V., and S. Harvey. 2000. Adrenals. Pages 489-500 & 517; 518 *In* G.C. Whittow, ed. Sturkie's Avian Physiology, 5th. Academy Press, San Diego, CA.

CDF (California Department of Forestry). 2007. California forest practices rules 2007. title 14, California code of regulations chapters 4, 4.5, and 10, Sacramento, CA, January 2007.

Chi, T., A. Henke, C. Brinegar, and J. Smith. 2004. Mitochondrial DNA analysis of northern spotted owl and California spotted owl populations, San Jose, CA, May 13, 2004. 4 pp.

Chutter, M.J., I. Blackburn, D. Bonin, J.B. Buchanan, B. Costanzo, D. Cunnington, A. Harestad, T. Hayes, D. Heppner, L. Kiss, J. Surgenor, W. Wall, L. Waterhouse, and L. Williams. 2004. Recovery strategy for the northern spotted owl (*Strix occidentalis caurina*) in British Columbia. BC Ministry of Environment, Victoria, BC. 74 pp.

Courtney, S.P., J.A. Blakesley, R.E. Bilby, M.L. Cody, J.P. Dumbacher, R.C. Fleischer, A.B. Franklin, J.F. Franklin, R.J. Gutierrez, J.M. Marzluff, and L. Sztukowski. 2004. Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute, Portland, Oregon, September 2004. 508 pp.

Davis, R.J., K.M. Dugger, S. Mohoric, L. Evers, and W.C. Aney. 2011. Northwest forest plan-the first 15 years (1994-2008): status and trends of northern spotted owl populations and habitats. USDA, USFS, Pacific Northwest Research Station, General Technical Report PNW-GTR-850, Portland, Oregon, October 2011. 147 pp.

Delaney, D.K., T.G. Grubb, P. Beier, L.L. Pater, and M.H. Reiser. 1999. Effects of helicopter noise on Mexican spotted owls. Journal of Wildlife Management 63(1):60-76.

Diller, L.V., and D.M. Thome. 1999. Population density of northern spotted owls in managed young-growth forests in coastal northern California. Journal of Raptor Research 33(4):275-286.

Dugger, K.M., F. Wagner, R.G. Anthony, and G.S. Olson. 2005. The relationship between habitat characteristics and demographic performance of northern spotted owls in Southern Oregon. Condor 107(4):863-878.

Dunbar, D.L., B.P. Booth, E.D. Forsman, A.E. Hetherington, and D.J. Wilson. 1991. Status of the spotted owl, *Strix occidentalis*, and barred owl, *Strix varia*, in southwestern British Columbia. Canadian Field-Naturalist 105:464-468.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: An ecological, economic, and social assessment. Section V: Aquatic ecosystem assessment. Forest Ecosystem Management Assessment Team, Washington, D.C., July 1993. 273 pp.

Folliard, L. 1993. Nest site characteristics of northern spotted owls in managed forest of northwest California. Master's thesis. University of Idaho, Moscow, Idaho.

Forsman, E.D., R.G. Anthony, K.M. Dugger, E.M. Glenn, A.B. Franklin, G.C. White, C.J. Schwarz, K.P. Burnman, D.R. Anderson, J.D. Nichols, J.E. Hines, J.B. Lint, R.J. Davis, S.H. Ackers, L.S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, S.A. Gremel, D.R. Herter, J.M. Higley, R.B. Horn, J.A. Reid, J. Rockweit, J.P. Schaberl, T.J. Snetsinger, and S.G. Sovern. 2011. Population demography of northern spotted owls. Studies in avian biology No. 40. A publication of the Cooper Ornithological Society. University of California Press, Berkeley, California. 106 pp.

Forsman, E.D. 1975. A preliminary investigation of the spotted owl in Oregon. Master's thesis. Oregon State University, Corvallis, OR.

Forsman, E.D., R.G. Anthony, E.C. Meslow, and C.J. Zabel. 2004. Diets and foraging behavior of northern spotted owls in Oregon. Journal of Raptor Research 38(3):214-230.

Forsman, E.D., R.G. Anthony, J.A. Reid, P.J. Loschl, S.G. Sovern, M. Taylor, B.L. Biswell, A. Ellingson, E.C. Meslow, G.S. Miller, K.A. Swindle, J.A. Thrailkill, F.F. Wagner, and D.E. Seaman. 2002. Natal and breeding dispersal of northern spotted owls. Wildlife Monographs 149(1):35.

Forsman, E.D., S. DeStefano, and M.G. Raphael. 1996. Demography of the northern spotted owl, Studies in Avian Biology No. 17 ed. Cooper Ornithological Society, Lawrence, Kansas. 122 pp.

Forsman, E.D., T.J. Kaminski, J.C. Lewis, K.J. Maurice, and S.G. Sovern. 2005. Home range and habitat use of spotted owls on the Olympic Peninsula, Washington. Journal of Raptor Research 39(49):365-377.

Forsman, E.D., E.C. Meslow, and H.M. Wight. 1984. Distribution and biology of the spotted owl in Oregon. USDA, 87, Corvallis, Oregon, 1984. 64 pp.

Forsman, E.D., I.A. Otto, S.G. Sovern, M. Taylor, D.W. Hays, H. Allen, S.L. Roberts, and D.E. Seaman. 2001. Spatial and temporal variation in diets of spotted owls in Washington. Journal of Raptor Research 35(2):141-150.

Franklin, A.B. 1992. Population regulation in northern spotted owls: theoretical implications for management. Pages 815-827 *In* D.R. McCullough, and R.H. Barrett, eds. Wildlife 2001: Populations, Elsevier Applied Sciences, London, England.

Franklin, A.B., D.R. Anderson, R.J. Gutierrez, and K.P. Burnham. 2000. Climate, habitat quality, and fitness in northern spotted owl populations in northwestern California. Ecological Monographs 70(4):539-590.

Franklin, A.B., K.P. Burnham, G.C. White, and R.J. Anthony. 1999. Range-wide status and trends in northern spotted owl populations. Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, CO and Oregon Cooperative Fish and Wildlife Research Unit, Corvallis, Oregon, April 12, 1999. 71 pp.

Gaines, W., R.A. Strand, and S.D. Piper. 1997. Effects of the Hatchery Complex Fires on northern spotted owls in the Eastern Washington Cascades. Pages 123-129 *In* Proceedings of the First Conference on Fire Effects on Rare and Endangered Species and Habitats, November 13-16, 1995, International Association of Wildland Fire, Coeur d'Alene, Idaho.

Gancz, A.Y., I.K. Barker, R. Lindsay, A. Dibernardo, K. McKeever, and B. Hunter. 2004. West Nile Virus outbreak in North American Owls, Ontario, 2002. Emerging Infectious Diseases 10(12):2135-2142.

Garmendia, A.E., H.J. Van Kruiningen, R.A. French, J.F. Anderson, T.G. Andreadis, A. Kumar, and A.B. West. 2000. Recovery and identification of West Nile virus from a hawk in winter. Journal of Clinical Microbiology 38(8):3110-3111.

Glenn, E.M., R.G. Anthony, and E.D. Forsman. 2010. Population trends in northern spotted owls: Associations with climate in the Pacific Northwest. Biological Conservation 143(11):2543-2552.

Glenn, E.M., M.C. Hansen, and R.G. Anthony. 2004. Spotted owl home-range and habitat use in young forests of western Oregon. Journal of Wildlife Management 68(1):33-50.

Glenn, E.M., R.G. Anthony, E.D. Forsman, and G.S. Olson. 2011. Reproduction of northern spotted owls: The role of local weather and regional climate. The Journal of Wildlife Management 75(6):1279-1294.

Goheen, E.M., E.M. Hansen, A. Kanaskie, M.G. Williams, N. Oserbauer, and W. Sutton. 2002. Sudden oak death caused by *Phytophthora ramorum* in Oregon. Plant Disease 86(4):440-444.

Gremel, S.A. 2005. Factors controlling distribution and demography of northern spotted owls in a reserved landscape. Master's Thesis. University of Washington, Seattle, WA.

Gutierrez, R.J. 1989. Hematozoa from the spotted owl. Journal of Wildlife Disease 25(4):614-618.

Gutierrez, R.J. 1996. Biology and distribution of the northern spotted owl. Pages 2-5 *In* E.D. Forsman, S. DeStefano, M.G. Raphael, and R.J. Gutiérrez, eds. Demography of the northern spotted owl: Studies in Avian Biology, 17th. Cooper Ornithological Society.

Gutierrez, R.J., M.B. Cody, S. Courtney, and D. Kennedy. 2004. Assessment of the potential threat of the northern barred owl. Pages 7-1-7-52 *In* Scientific evaluation of the status of the northern spotted owl, Sustainable Ecosystems Institute, Portland, OR.

Gutierrez, R.J., A.B. Franklin, and W.S. LaHaye. 1995. Spotted owl (*Strix occidentalis*). Pages 1-28 *In* A. Poole, and F. Gill, eds. The birds of North America no. 179, The Academy of Natural Sciences and The American Ornithologists' Union, Washington, D.C.

Haig, S.M., T.D. Mullins, E.D. Forsman, P. Trail, and L. Wennerberg. 2004. Genetic identification of spotted owls, barred owls, and their hybrids: legal implications of hybrid identity. Conservation Biology 18:1347-1357.

Haig, S.M., R.S. Wagner, E.D. Forsman, and T.D. Mullins. 2001. Geographic variation and genetic structure in spotted owls. Conservation Genetics 2(1):25-40.

Hamer, T.E. 1988. Home range size of the northern barred owl and northern spotted owl in western Washington. Master's Thesis. Western Washington University, Bellingham, WA.

Hamer, T.E., E.D. Forsman, A.D. Fuchs, and M.L. Walters. 1994. Hybridization between barred and spotted owls. Auk 111(2):487-492.

Hamer, T.E., D.L. Hays, C.M. Senger, and E.D. Forsman. 2001. Diets of northern barred owls and northern spotted owls in an area of sympatry. Journal of Raptor Research 35(3):221-227.

Hamer, T.E., S.G. Seim, and K.R. Dixon. 1989. Northern spotted owl and northern barred owl habitat use and home range size in Washington: Preliminary report. Washington Department of Wildlife, Olympia, WA, November 1989. 65 pp.

Hanson, E., D. Hays, L.L. Hicks, L. Young, and J.B. Buchanan. 1993. Spotted owl habitat in Washington: a report to the Washington Forest Practices Board. Washington Forest Practices Board Spotted Owl Scientific Advisory Group, Olympia, WA, December 20, 1993. 116 pp.

Harestad, A., J. Hobbs, and I. Blackburn. 2004. Precis of the northern spotted owl in British Columbia. Pages 12-14 *In* Zimmerman, K., K. Welstead, E. Williams and J. Turner eds. Northern spotted owl workshop proceedings, Forrex Series 14, January 21-22, 2004, 94 pp.

Henke, A.L., T.Y. Chi, J. Smith, and C. Brinegar. 2005. Microsatellite analysis of northern and California spotted owls in California. Conservation Genetics Laboratory, Department of Biological Sciences, San Jose State University, San Jose, CA. 19 pp.

Hershey, K.T., E.C. Meslow, and F.L. Ramsey. 1998. Characteristics of forests at spotted owl nest sites in the Pacific Northwest. Journal of Wildlife Management 62(4):1398-1410.

Herter, D.R., and L.L. Hicks. 2000. Barred owl and spotted owl populations and habitat in the central Cascade Range of Washington. Journal of Raptor Research 34(4):279-286.

Herter, D.R., L.L. Hicks, H.C. Stabins, J.J. Millspaugh, A.J. Stabins, and L.D. Melampy. 2002. Roost site characteristics of northern spotted owls in the nonbreeding season in central Washington. Forest Science 48(2):437-446.

Hoberg, E.P., G.S. Miller, E. Wallner-Pendleton, and O.R. Hedstrom. 1989. Helminth parasites of northern spotted owls (*Strix occidentalis caurina*) from Oregon. Journal of Wildlife Disease 25(2):246-251.

Irwin, L.L., D.F. Rock, and G.P. Miller. 2000. Stand structures used by northern spotted owls in managed forests. Journal of Raptor Research 34(3):175-186.

Iverson, W.F. 1993. Is the barred owl displacing the spotted owl in western Washington? Master's Thesis. Western Washington University, Bellingham, WA. 54 pp.

Iverson, W.F. 2004. Reproductive success of spotted owls sympatric with barred owls in western Washington. Journal of Raptor Research 38(1):88-91.

Johnson, D.H. 1992. Spotted owls, great horned owls, and forest fragmentation in the central Oregon Cascades. Master's Thesis. Oregon State University, Corvallis, OR. 125 pp.

Johnson, K.N., J.F. Franklin, J.W. Thomas, and J. Gordon. 1991. Alternatives for management of late-successional forests of the Pacific Northwest: a report to the agriculture committee and the merchant marine and fisheries committee of the U.S. House of Representatives, October 8, 1991.

Kelly, E.G., and E.D. Forsman. 2004. Recent records of hybridization between barred owls (*Strix varia*) and northern spotted owls (*S. occidentalis caurina*). Auk 121(3):806-810.

Kelly, E.G., E.D. Forsman, and R.G. Anthony. 2003. Are barred owls displacing spotted owls? The Condor 105:45-53.

King, G.M., K.R. Bevis, M.A. Rowe, and E.E. Hanson. 1998. Spotted owl use of habitat impacted by 1994 fires on the Yakama Indian Reservation: three years post fire. *In* The Second Fire Effects on Rare and Endangered Species Conference, March 29- April 1, 1998, Yakama Indian Nation, Toppenish, Washington. 8 pp.

Knight, R.L., and S.K. Skagen. 1988. Effects of recreational disturbance on birds of prey: A review. Pages 355-359 *In* Glinski, R.L., B.G. Pendleton and M.B. Moss eds. Proceedings of the Southwest Raptor Management Symposium Workshop, May 21-24, 1986, National Wildlife Federation, Washington, DC. 2 pp.

LaHaye, W.S., R.J. Gutiérrez, and J.R. Dunk. 2001. Natal dispersion of the spotted owl in southern California: dispersal profile of an insular population. The Condor 103:691-700.

Laidig, K.J., and D.S. Dobkin. 1995. Spatial overlap and habitat associations of barred owls and great horned owls in southern New Jersey. Journal of Raptor Research 29(3):151-157.

Leskiw, T., and R.J. Gutiérrez. 1998. Possible predation of a spotted owl by a barred owl. Western Birds 29:225-226.

Lint, J. 2005. Northwest Forest Plan - The first 10 years (1994-2003): Status and trends of northern spotted owl populations and habitat. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-648, Portland, Oregon, September 2005. 20 pp.

Littell, J.S., E.E. Oneil, D. McKenzie, J.A. Hicke, J.A. Lutz, R.A. Norheim, and M.M. Elsner. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change 102(1):129-158.

Livezey, K.B. 2005. Iverson (2004) on spotted owls and barred owls: comments on methods and conclusions. Journal of Raptor Research 39(1):102-103.

Marra, P.P., S. Griffing, C. Caffrey, A.M. Kilpatrick, R. McLean, C. Brand, E. Saito, A.P. Dupuis, L. Kramer, and R. Novak. 2004. West Nile virus and wildlife. Bioscience 54(5):393-402.

McGarigal, K., R.G. Anthony, and F.B. Isaacs. 1991. Interactions of humans and bald eagles on the Columbia River estuary. Wildlife Monographs 115:1-47.

Meyer, J.S., L.L. Irwin, and M.S. Boyce. 1998. Influence of habitat abundance and fragmentation on Northern Spotted Owls in Western Oregon. Wildlife Monographs 139:1-51.

Miller, G.S., S.K. Nelson, and W.C. Wright. 1985. Two-year-old female spotted owl breeds successfully. Western Birds 16:93-94.

Miller, G.S. 1989. Dispersal of juvenile spotted owls in Western Oregon. Master's Thesis. Oregon State University, Corvallis, OR.

Miller, G.S., R.J. Small, and E.C. Meslow. 1997. Habitat selection by spotted owls during natal dispersal in Western Oregon. Journal of Wildlife Management 61(1):140-150.

Moen, C.A., A.B. Franklin, and R.J. Gutiérrez. 1991. Age determination of subadult northern spotted owls in Northwest California. Wildlife Society Bulletin 19:489-493.

Moeur, M., T.A. Spies, M.A. Hemstrom, J.R. Martin, J. Alegria, J. Browning, J.H. Cissel, W.B. Cohen, T.E. Demeo, S. Healey, and R. Warbington. 2005. Northwest forest plan - the first 10 years (1994-2003): status and trend of late-successional and old-growth forest. USDA, Forest Services, Pacific Northwest Research Station, General Technical Report PNW-GTR-646, Portland, OR, November 2005. 142 pp.

Mote, P.W., and E.P. Salathe. 2010. Future climate in the Pacific Northwest. Climatic Change 102(1):29-50.

Noon, B.R., and J.A. Blakesley. 2006. Conservation of the northern spotted owl under the Northwest Forest Plan. Conservation Biology 20(2):288-296.

North, M.P., J.F. Franklin, A.B. Carey, E.D. Forsman, and T. Hamer. 1999. Forest stand structure of the northern spotted owl's foraging habitat. Forest Science 45(4):520-527.

North, M.P., G. Steger, R. Denton, G. Eberlein, T. Munton, and K. Johnson. 2000. Association of weather and nest-site structure with reproductive success in California spotted owls. Journal of Wildlife Management 64(3):797-807.

ODF (Oregon Department of Forestry). 2007. Forest practice administrative rules and forest practices act. Oregon Department of Forestry, Chapter 629 forest practices administration, Oregon, January 2007. 86 pp.

Olson, G.S., R.G. Anthony, E.D. Forsman, S.H. Ackers, P.J. Loschl, J.A. Reid, K.M. Dugger, E.M. Glenn, and W.J. Ripple. 2005. Modeling of site occupancy dynamics for northern spotted owls, with emphasis on the effects of barred owls. Journal of Wildlife Management 69(3):918-932.

Olson, G.S., E.M. Glenn, R.G. Anthony, E.D. Forsman, J.A. Reid, P.J. Loschl, and W.J. Ripple. 2004. Modeling demographic performance of northern spotted owls relative to forest habitat in Oregon. Journal of Wildlife Management 68(4):1039-1053.

Pearson, R.R., and K.B. Livezey. 2003. Distribution, numbers, and site characteristics of spotted owls and barred owls in the Cascade Mountains of Washington. Journal of Raptor Research 37(4):265-276.

Rizzo, D.M., M. Garbeloto, J.M. Davidson, G.W. Slaughter, and S.T. Koike. 2002. *Phytophthora ramorum* as the cause of extensive mortality of Quercus spp. and *Lithocarpus densiflorus* in California. Plant Disease 86:205-214.

Rosenberg, D.K., and R.G. Anthony. 1992. Characteristics of northern flying squirrel populations in young second- and old-growth forests in western Oregon. Canadian Journal of Zoology-Revue Canadienne de Zoologie 70(1):161-166.

Rosenberg, D.K., K.A. Swindle, and R.G. Anthony. 2003. Influence of prey abundance on northern spotted owl reproductive success in Western Oregon. Canadian Journal of Zoology 81:1715-1725.

Salathé, E.P., L.R. Leung, Y. Qian, and Y. Zhang. 2010. Regional climate model projections for the state of Washington. Climatic Change 102(1):51-75.

Sapolsky, R.M., L.M. Romero, and A.U. Munck. 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocrine Review 21(1):55-89.

Schmidt, K. 2006. Northern spotted owl monitoring and inventory Redwood National and State parks: 2005 annual report, Orick, California, July 17, 2006. 21 pp.

Singleton, P., S. Graham, W. Gaines, and J. Lehmkuhl. 2005. The ecology of barred owls in fire-prone forests: Progress report. U.S. Department of Agriculture, Wenatchee, Washington, December 2, 2005. 32 pp.

Sisco, C.L. 1990. Seasonal home range and habitat ecology of spotted owls in northwestern California. Master's Thesis. Humboldt State University, Arcata, CA.

Solis, D.M., and R.J. Gutiérrez. 1990. Summer habitat ecology of Northern Spotted Owls in Northwestern California. The Condor 92:739-748.

Sovern, S.G., E.D. Forsman, B.L. Biswell, D.N. Rolph, and M. Taylor. 1994. Diurnal behavior of the spotted owl in Washington. The Condor 96(1):200-202.

Swarthout, E.C.H., and R.J. Steidl. 2001. Flush responses of Mexican spotted owls to recreationists. The Journal of Wildlife Management 65(2):312-317.

Tempel, D.J., and R.J. Gutiérrez. 2003. Fecal corticosterone levels in California spotted owls exposed to low-intensity chainsaw sound. Wildlife Society Bulletin 31(3):1-5.

Tempel, D.J., and R.J. Gutiérrez. 2004. Factors related to fecal corticosterone levels in California spotted owls: implications for assessing chronic stress. Conservation Biology 18(2):538-547.

Thomas, J.W., M.G. Raphael, R.G. Anthony, E.D. Forsman, A.G. Gunderson, R.S. Holthausen, B.G. Marcot, G.H. Reeves, J.R. Sedell, and D.M. Solis. 1993. Viability assessments and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest. USDA Forest Service, Portland, Oregon, March 1993. 552 pp.

Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Meslow, B.R. Noon, and J. Verner. 1990. A conservation strategy for the northern spotted owl: report of the Interagency Scientific Committee to address the conservation of the northern spotted owl. U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service, and National Park Service, Portland, Oregon, May 1990. 427 pp.

Thomas, J.W., J.F. Franklin, J. Gordon, and K.N. Johnson. 2006. The Northwest Forest Plan: origins, components, implementation experience, and suggestions for change. Conservation Biology 20(2):277-287.

Thome, D.M., C.J. Zabel, and L.V. Diller. 1999. Forest stand characteristics and reproduction of northern spotted owls in managed north-coastal California forests. Journal of Wildlife Management 63(1):44-59.

USDA, and USDI. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl; standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl (Northwest Forest Plan). U. S. Department of Agriculture and U. S. Department of the Interior, Portland, Oregon. 232 pp.

USFS, and USBLM. 1994. Final Supplemental Environmental Impact Statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. U. S. Department of Agriculture and U. S. Department of the Interior, Portland, Oregon. 557 pp.

USFWS. 1989. The northern spotted owl: a status review supplement. U. S. Fish and Wildlife Service, Portland, Oregon, April 21, 1989.

USFWS. 1992. Final recovery plan for the northern spotted owl - draft. U. S. Fish and Wildlife Service, Portland, Oregon. 662 pp.

USFWS. 2004. Northern spotted owl - five year review: summary and evaluation. U. S. Fish and Wildlife Service, Portland, Oregon, November 15, 2004. 73 pp.

USFWS. 2006. Northern spotted owl status of the species. Prepared by the USFWS Northern Spotted Owl Consultation Coordination Team for use in Biological Opinions. Unpublished Agency Report. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Lacey, Washington, August 29, 2006. 39 pp.

USFWS. 2008. Final recovery plan for the northern spotted owl, *Strix occidentalis caurina*. U. S. Fish and Wildlife Service, Portland, Oregon, May 13, 2008. 142 pp.

USFWS. 2011. Revised Recovery Plan for the Northern Spotted Owl *(Strix occidentalis caurina).* U.S. Fish and Wildlife Service, Portland, Oregon. xvi + 258 pp.

USFWS, and NMFS. 1998. Final endangered species consultation handbook: Procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. U. S. Fish and Wildlife Service and National Marine Fisheries Service, U.S. GPO: 2004-690-278, Washington, D.C., March 1998. 189 pp.

Wagner, F.F., E.C. Meslow, G.M. Bennett, C.J. Larson, S.M. Small, and S. DeStefano. 1996. Demography of northern spotted owls in the Southern Cascades and Siskiyou Mountains, Oregon. Pages 67-76 *In* E.D. Forsman, S. DeStefano, M.G. Raphael, and R.J. Gutiérrez, eds. Demography of the northern spotted owl. Proceedings of a workshop Fort Collins, CO: Studies in Avian Biology No.17, 17th. Cooper Ornithology Society.

Ward, J.P., R.J. Gutiérrez, and B.R. Noon. 1998. Habitat selection by northern spotted owls: the consequences of prey selection and distribution. The Condor 100:79-92.

Ward, J.W.J. 1990. Spotted owl reproduction, diet and prey abundance in Northwest California. Master's Thesis. Humboldt State University, Arcata, CA. 70 pp.

Wasser, S.K., K.R. Bevis, G. King, and E. Hanson. 1997. Noninvasive physiological measures of disturbance in the northern spotted owl. Conservation Biology 11(4):1019-1022.

Weathers, W.W., P.J. Hodum, and J.A. Blakesley. 2001. Thermal ecology and ecological energetics of the California spotted owl. The Condor 103(4):678-690.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940-943.

WFPB (Washington Forest Practices Board). 1996. Final Environmental Impact Statement on Forest Practices Rule Proposals for northern spotted owl, marbled murrelet, western gray squirrel. Washington Forest Practices Board, Olympia, WA.

White, C.M., and T.L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. The Condor 87:14-22.

Zabel, C.J., J.R. Dunk, H.B. Stauffer, L.M. Roberts, B.S. Mulder, and A. Wright. 2003. Northern spotted owl habitat models for research and management application in California (USA). Ecological Applications 13(4):1027-1040.

Zabel, C.J., K.M. McKelvey, and J.P. Ward Jr. 1995. Influence of primary prey on home-range size and habitat-use patterns of northern spotted owls (*Strix occidentalis caurina*). Canadian Journal of Zoology 73:433-439.

Zabel, C.J., S.E. Salmons, and M. Brown. 1996. Demography of northern spotted owls in southwestern Oregon. Pages 77-82 *In* E.D. Forsman, S. DeStefano, M.G. Raphael, and R.J. Gutiérrez, eds. Demography of the northern spotted owl. Studies in Avian Biology No. 17, Cooper Ornithology Society.

APPENDIX B
STATUS OF THE SPECIES: MARBLED MURRELET

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Legal Status

The marbled murrelet (murrelet) was listed as a threatened species[1] on September 28, 1992, in Washington, Oregon, and northern California (57 FR 45328 [October 1, 1992]). Since the species' listing, the FWS has completed two 5-yr status reviews of the species: September 1, 2004 (USFWS 2004) and June 12, 2009 (USFWS 2009). The legal status of the murrelet remains unchanged from the original designation.

Threats to Murrelet Survival and Recovery

Murrelets are long-lived seabirds that spend most of their life in the marine environment, with breeding adult birds annually nesting in the forest canopy of mature and old-growth forests from April 1 through September 15. Murrelets have a naturally low reproductive rate. Breeding adults lay just one egg and renesting, in the event of nest failure, is thought to be an extremely rare event.

Several threats to murrelets, present in both the marine and terrestrial environments, have been identified. These threats collectively comprise a suite of environmental stressors that, individually or through interaction, have significantly disrupted or impaired behaviors which are essential to the reproduction or survival of individuals. When combined with the species naturally low reproductive rate, these stressors have led to declines in murrelet abundance, distribution, and reproduction at the population scale within the listed-range.

When the murrelet was listed under the Endangered Species Act (57 FR 45333-45336 [October 1, 1992]) and summarized in the Recovery Plan (USFWS 1997a, pp. 43-76), several anthropogenic threats were identified as having caused the dramatic decline in the species.

- habitat destruction and modification in the terrestrial environment from timber harvest and human development caused a severe reduction in the amount of nesting habitat
- unnaturally high levels of predation resulting from forest "edge effects" ;
- the existing regulatory mechanisms, such as land management plans (in 1992), were considered inadequate to ensure protection of the remaining nesting habitat and reestablishment of future nesting habitat; and
- manmade factors such as mortality from oil spills and entanglement in fishing nets used in gill-net fisheries.

[1] The Act defines a threatened species as a species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

There have been changes in the levels of these threats since the 1992 listing (USFWS 2004, pp. 11-12; USFWS 2009, pp. 27-67). The regulatory mechanisms implemented since 1992 that affect land management in Washington, Oregon, and California (for example, the Northwest Forest Plan (NWFP)) and new gill-netting regulations in northern California and Washington have reduced the threats to murrelets (USFWS 2004, pp. 11-12). The threat levels for the other threats identified in 1992 listing (57 FR 45333-45336 [October 1, 1992]) including the loss of nesting habitat, predation rates, and mortality risks from oil spills and gill net fisheries (despite the regulatory changes) remained unchanged following the FWS's 2004, 5-year, range-wide status review for the murrelet (USFWS 2004, pp. 11-12).

However, new threats were identified in the FWS's 2009, 5-year review for the murrelet (USFWS 2009, pp. 27-67). These new stressors are due to several environmental factors affecting murrelets in the marine environment. These new stressors include:

- Habitat destruction, modification, or curtailment of the marine environmental conditions necessary to support murrelets due to:
    - elevated levels of polychlorinated biphenyls in murrelet prey species;
    - changes in prey abundance and availability;
    - changes in prey quality;
    - harmful algal blooms that produce biotoxins leading to domoic acid and paralytic shellfish poisoning that have caused murrelet mortality; and
    - climate change in the Pacific Northwest.
- Manmade factors that affect the continued existence of the species include:
    - derelict fishing gear leading to mortality from entanglement;
    - energy development projects (wave, tidal, and on-shore wind energy projects) leading to mortality; and
    - disturbance in the marine environment (from exposures to lethal and sub-lethal levels of high underwater sound pressures caused by pile-driving, underwater detonations, and potential disturbance from high vessel traffic).

Detailed discussions of the above-mentioned threats, life-history, biology, and status of the murrelet are presented in the Federal Register, listing the murrelet as a threatened species (57 FR 45328 [October 1, 1992]); the Recovery Plan, Ecology and Conservation of the Marbled Murrelet (Ralph et al. 1995); the final rule designating murrelet critical habitat (61 FR 26256 [May 24, 1996]); the Evaluation Report in the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004); and the 2004 and 2009, 5-year Reviews for the Marbled Murrelet (USFWS 2004; USFWS 2009).

Nesting Habitat Abundance

The destruction, modification, or curtailment of nesting habitat from logging, urbanization, and land use conversion has generally been regarded as the most influential environmental stressor that led to the 1992 Federal listing of the species under the Act. The FWS estimates that over 80 percent of the historic nesting habitat has been rendered unsuitable for nesting (57 FR 45328 [October 1, 1992]). Because of the important role nesting habitat plays in the survival and recovery of the species, significant attention has been given to describing the quality, quantity, and location of the remaining nesting habitat and planning for the restoration of nesting habitat in California, Oregon, and Washington.

Loss of Nesting Habitat Since 1992

The FWS has determined that the rate of habitat loss has declined since listing, particularly on Federal lands due to implementation of the NWFP (USFWS 2004, pp. 11 and 13). Between 1992 and 2003, the estimated loss of suitable murrelet habitat totaled 22,398 acres in Washington, Oregon, and California combined, of which 5,364 acres resulted from timber harvest and 17,034 acres resulted from natural events (McShane et al. 2004, pp. 4-64). Those data primarily represented losses on Federal lands, and did not include data for most private or State lands within the murrelets' range.

More recently, (Raphael et al. 2006 in Huff et al. 2006) used habitat models to estimate losses of potential murrelet habitat for the period from 1994-1996 to 2002-2003 on both Federal and non-Federal lands within the five Conservation Zones in the NWFP area. Results indicate that losses of potential nesting habitat may be greater than previously estimated, with losses ranging from 61,000 to 279,000 acres (depending on the model, see discussion below) in the 5-Conservation Zone area, with 10 to 28 percent of habitat loss occurring on Federal lands and 72 to 90 percent on non-Federal lands.

Current Amount of Nesting Habitat

McShane et al. (2004, p. 4-2), reviewed and summarized habitat estimates from 16 sources and estimated the amount of murrelet nesting habitat at 2,223,048 acres distributed throughout Washington, Oregon, and California (McShane et al. 2004, p. 4-5). Washington State contains almost half of all remaining nesting habitat with an estimated 1,022,695 acres or 48 percent of the total. Approximately 93 percent (2,000,000 acres) are reported to occur on Federal lands (McShane et al. 2004, p. 4-10).

In another effort, (Raphael et al 2006 in Huff et al. 2006) produced two spatial models for the NWFP Effectiveness Monitoring (EM) program to predict the amount, location, and distribution of murrelet nesting habitat. Combining vegetation-based maps derived from satellite imagery and prior estimates of habitat on State and private lands from 1994 to 2003, (Raphael et al. 2006, p. 109 in Huff et al. 2006) used a panel of experts to reclassify 22 old-growth forest classes into four classes of murrelet habitat based upon nesting suitability. Referred to as the Expert Judgment Model, the model classifies existing forest structure, based upon percent conifer cover, canopy structure, quadratic mean diameter, and forest patch size, into four classes of suitability for nesting murrelets. (Raphael et al. 2006, p. 116-123 in Huff et al. 2006) found that across the murrelet range, most habitat-capable land (52 percent) is unsuitable nesting habitat (Class 1) and 18 percent is classified as Class 4 habitat (highest suitability), with an estimated 41 percent of the Class 4 habitat (1,620,800 acres) occurring on non-Federal lands.

The second habitat model developed by (Raphael et al. 2006 in Huff et al. 2006) used the Biomapper Ecological Niche-Factor Analysis methodology developed by Hirzel et al. (2002). The resulting murrelet habitat suitability maps are based on both the physical and vegetative attributes adjacent to known murrelet occupied polygons or nest locations for each NWFP province. The maps provide a range of habitat suitability values, each with acreage estimates. In Washington, 2.1 million acres of habitat were rated with a habitat suitability (HS) greater than 60 and captured 82 percent of the stands documented as occupied, while 440,700 acres of habitat were rated as HS >80 habitat and captured 36 percent of the known occupied stands.

The FWS believes the Expert Judgment and Ecological Niche Factor Analysis models, which relate known (occupied) murrelet nest stands to habitat abundance, distribution, and quality, represent the best available information on the subject. While not necessarily the best means to describe suitable habitat at the site scale, the FWS expects these models have higher reliability for provincial-scale analysis compared to previous efforts.

Population Status

The initial at-sea surveys for murrelets that began during the 1990s in the marine waters of Washington, Oregon, and California were generally independent and sporadic efforts to assess murrelet population status (abundance, trends, distribution, and fecundity). Through a more coordinated effort, researchers developed the EM Program for the NWFP (Bentivoglio et al. 2002) in 2000 that unified the various at-sea monitoring efforts within terrestrial portions of the five Conservation Zones contained within the planning area of the NWFP. At-sea surveys in Conservation Zone 6, are independent of the EM Program, but are conducted using similar survey methods. The at-sea survey data collected prior to the EM Program are generally not suitable for statistical comparisons or trend analyses due to differences in survey methods, (McShane et al. 2004).

<u>Abundance and Distribution</u>

Murrelet abundance during the early 1990s in Washington, Oregon, and California was estimated at 18,550 to 32,000 birds (Ralph et al. 1995). Through the efforts of the EM program, the 2010 murrelet abundance in the listed range of the species (Table 1) is estimated at 16,691 birds (13,075 – 20,307, 95 percent confidence interval (CI); (Falxa 2011). Conservation Zones 3 and 4 support approximately 65 percent (10,981/6,691) of the murrelet population within the U.S., have the highest reported densities and generally the lowest within-zone statistical variation in population size (Falxa 2011). Murrelets occur in the lowest abundance in Conservation Zones 5 and 6.

At the time of listing, the distribution of active nests in nesting habitat was described as non-continuous (USFWS 1997a, p. 14). The at-sea extent of the species currently encompasses an area similar in size to the species historic distribution, but with the extremely low density of murrelets in Conservation Zones 5 and 6, the southern end of the murrelet distribution is sparsely populated compared to Conservation Zones 1-4.

Table 1. Estimates of murrelet density and population size (95 percent confidence interval (CI)) in Conservation Zones 1 through 5 during the 2010 breeding season (Falxa 2011) and in Conservation Zone 6 during the 2009 breeding season (Peery and Henry 2010).

Conservation Zone	**Density** (birds/km^2)	**Coefficient of Variation** (% Density)	**Population Size Estimates with 95% CI**			**Survey Area** (km^2)
			Number of Birds	Lower	Upper	
1	1.26	20.4	4393	2,689	6,367	3,497
2	0.18	25.7	1,286	650	1946	1,650
3	4.53	16.9	7,223	4,605	9,520	1,595
4	3.16	27.3	3,668	2,196	6,140	1,159
5	Not Surveyed	-	-	-	-	-
6	-	-	631	449	885	-
Zones 1-6	-	-	17,322	13,524	21,192	-

The at-sea distribution also exhibits discontinuity within Conservation Zones 1, 2, 5, and 6, where five areas of discontinuity are noted: a segment of the border region between British Columbia, Canada and Washington, southern Puget Sound, WA, Destruction Island, WA to Tillamook Head, OR, Humboldt County, CA to Half Moon Bay, CA, and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

Trend

There are two general approaches that researchers use to assess murrelet population trend: at-sea surveys and population modeling based on demographic data. In general, the FWS assigns greater weight to population trend and status information derived from at-sea surveys than estimates derived from population models because survey information generally provides more reliable estimates of trend and abundance.

Marine Surveys

Researchers from the EM Program detected a statistically significant decline ($p \leq 0.05$) in the abundance of the surveyed populations in Conservation Zones 1 through 5 for the 2000-2010 sample period (Falxa 2011). The annual rate of decline was 3.7 percent during the 2001-2010 survey period.

While the 2008 population estimate for Conservation Zone 6 indicated a decline of about 55 percent from the 2007 estimate and a 75 percent decline from the 2003 estimate (Peery et al. 2008), the 2009 estimate was similar to estimates from 1999-2003. Peery and Henry (2010) speculated that their 2009 results may have indicated murrelets in central California moved out of the survey area in 2007 and 2008, then returned in 2009, or the increase may have been due to immigration from larger populations to the north.

At the scale of individual conservation zones, the murrelet population is declining at an estimated rate of 7.4 percent per year in Conservation Zone 1. No statistically significant, zone-specific trends were detected for any of the other four conservation zones (Falxa 2011). With a *p value* estimate of 0.06, it appears the change in murrelet abundance during the 2000-2010 sample period is approaching significance in Conservation Zone 2 (Falxa 2011). For Washington State (Conservation Zones 1 and 2 combined) there was a 7.31 percent (standard error = 1.31 percent) annual rate of decline in murrelet density for the 2001-2010 period (Pearson et al. 2011, p. 10), which equates to a loss of approximately 47 percent of the murrelet population since 2001.

Population Models

Prior to the use of survey data to estimate trend, demographic models were more heavily relied upon to generate predictions of trends and extinction probabilities for the murrelet population (Beissinger 1995; Cam et al. 2003; McShane et al. 2004; USFWS 1997b). However, murrelet population models remain useful because they provide insights into the demographic parameters and environmental factors that govern population stability and future extinction risk, including stochastic factors that may alter survival, reproductive, and immigration/emigration rates.

In a report developed for the 5-year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004, p. 3-27 to 3-60), computer models were used to forecast 40-year murrelet population trends. A series of female-only, multi-aged, discrete-time stochastic Leslie Matrix population models were developed for each conservation zone to forecast decadal population trends over a 40-year period with extinction probabilities beyond 40 years (to 2100). The authors incorporated available demographic parameters (Table 2) for each conservation zone to describe population trends and evaluate extinction probabilities (McShane et al. 2004, p. 3-49).

McShane et al. (2004) used mark-recapture studies conducted in British Columbia by Cam et al. (2003) and Bradley et al. (2004) to estimate annual adult survival and telemetry studies or at-sea survey data to estimate fecundity. Model outputs predicted -3.1 to -4.6 percent mean annual rates of population change (decline) per decade the first 20 years of model simulations in murrelet Conservation Zones 1 through 5 (McShane et al. 2004, p. 3-52). Simulations for all zone populations predicted declines during the 20 to 40-year forecast, with mean annual rates of -2.1 to -6.2 percent per decade (McShane et al. 2004, p. 3-52). These reported rates of decline are similar to the estimates of -4 to -7 percent per year reported in the Recovery Plan (USFWS 1997b, p. 5).

Table 2. Rangewide murrelet demographic parameter values based on four studies all using Leslie Matrix models.

Demographic Parameter	Beissinger 1995	Beissinger and Nur 1997*	Beissinger and Peery (2007)	McShane et al. 2004
Juvenile Ratio (Ŕ)	0.10367	0.124 or 0.131	0.089	0.02 - 0.09
Annual Fecundity	0.11848	0.124 or 0.131	0.06-0.12	-
Nest Success	-	-	0.16-0.43	0.38 - 0.54
Maturation	3	3	3	2 - 5
Estimated Adult Survivorship	85 % – 90%	85 % – 88 %	82 % - 90 %	83 % – 92 %

*In U.S. Fish and Wildlife FWS (1997b).

McShane et al. (2004, pp. 3-54 to 3-60) modeled population extinction probabilities beyond 40 years under different scenarios for immigration and mortality risk from oil spills and gill nets. Modeled results forecast different times and probabilities for local extirpations, with an extinction risk[2] of 16 percent and mean population size of 45 individuals in 100 years in the listed range of the species (McShane et al. 2004, pp. 3-58).

Reproduction

Generally, estimates of murrelet fecundity are directed at measures of breeding success, either from direct assessments of nest success in the terrestrial environment, marine counts of hatch-year birds, or computer models. Telemetry estimates are typically preferred over marine counts for estimating breeding success due to fewer biases (McShane et al. 2004, p. 3-2). However, because of the challenges of conducting telemetry studies, estimating murrelet reproductive rates with an index of reproduction, referred to as the juvenile ratio (Ŕ),[3] continues to be important, despite the debate over use of this index (see discussion in Beissinger and Peery 2007, p. 296).

Although difficult to obtain, nest success rates[4] are available from telemetry studies conducted in California (Hebert and Golightly 2006; Peery et al. 2004) and Washington (Bloxton and Raphael 2006). In northwest Washington, Bloxton and Raphael (2005, p. 5) documented a nest success rate of 0.20 (2 chicks fledging from 10 nest starts). In central California, murrelet nest success is 0.16 (Peery et al. 2004, p. 1098) and in northern California it is 0.31 to 0.56 (Hebert and Golightly 2006, p. 95). No studies or published reports from Oregon are available.

[2] Extinction was defined by McShane et al. (2004, p. 3-58) as any murrelet conservation zone containing less than 30 birds.
[3] The juvenile ratio (Ŕ) for murrelets is derived from the relative abundance of hatch-year (HY; 0-1 yr-old) to after-hatch-year (AHY; 1+ yr-old) birds (Beissinger and Peery 2007, p. 297) and is calculated from marine survey data.
[4] Nest success here is defined by the annual number of known hatchlings departing from the nest (fledging) divided by the number of nest starts.

Unadjusted and adjusted values for estimates of murrelet juvenile ratios suggest extremely low breeding success in northern California (0.003 to 0.008 - Long et al. 2008, pp. 18-19), central California (0.035 and 0.032 - Beissinger and Peery 2007, pp. 299, 302), and in Oregon (0.0254 - 0.0598 - Crescent Coastal Research 2008, p. 13). Estimates for Ŕ (adjusted) in the San Juan Islands in Washington have been below 0.15 every year since surveys began in 1995, with three of those years below 0.05 (Raphael et al. 2007, p. 16).

These current estimates of **Ŕ** are assumed to be below the level necessary to maintain or increase the murrelet population. Demographic modeling suggests murrelet population stability requires a minimum reproductive rate of 0.18 to 0.28 (95 % CI) chicks per pair per year (Beissinger and Peery 2007, p. 302; USFWS 1997b). Even the lower level of the 95 percent confidence interval from USFWS (1997b) Beissinger and Peery (2007, p. 302) is greater than the current range of estimates for Ŕ (0.02 to 0.13 chicks per pair) for any of the Conservation Zones (Table 2).

The current estimates for **Ŕ** also appear to be well below what may have occurred prior to the murrelet population decline. Beissinger and Peery (2007, p. 298) performed a comparative analysis using historic data from 29 bird species to predict the historic **Ŕ** for murrelets in central California, resulting in an estimate of 0.27 (95% CI: 0.15 - 0.65). Therefore, the best available scientific information of murrelet fecundity from model predictions and trend analyses of survey-derived population data appear to align well. Both indicate that the murrelet reproductive rate is generally insufficient to maintain stable population numbers throughout all or portions of the species' listed range.

Summary: Murrelet Abundance, Distribution, Trend, and Reproduction

The 2010 estimated abundance for murrelets within Conservation Zones 1-5 was the lowest recorded since inception of the EM program (Falxa 2011)(Falxa et al. 2009, p. 9), with the current population size within the listed range of the species estimated at 17,322 birds (95 percent CI: 13,524 – 21,192) (Table 1). Although murrelets are distributed throughout their historical range, the area of occupancy within their historic range appears to be reduced from historic levels. The distribution of the species also exhibits five areas of discontinuity: a segment of the border region between British Columbia, Canada and Washington; southern Puget Sound, WA; Destruction Island, WA to Tillamook Head, OR; Humboldt County, CA to Half Moon Bay, CA; and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

A statistically significant decline was detected in Conservation Zone 1 for the 2001-2010 period and the decline in Conservation Zone 2 is approaching significance ($p = 0.0106$) for the 2001-2010 period (Falxa 2011). The overall population trend from the combined 2001-2010 population estimates (Conservation Zones 1 - 5) indicate a statistically significant, rangewide annual rate of decline of 3.7 percent (Falxa 2011).

The current range of estimates for **Ŕ**, the juvenile to adult ratio, is assumed to be below the level necessary to maintain or increase the murrelet population. Whether derived from marine surveys or from population modeling (**Ŕ** = 0.02 to 0.13, Table 2), the available information is in general agreement that the current ratio of hatch year birds to after-hatch year birds is insufficient to maintain stable numbers of murrelets throughout the listed range. The current estimates for **Ŕ** also appear to be well below what may have occurred prior to the murrelet population decline (Beissinger and Peery 2007, p. 298) and model predictions forecast an extinction risk of 16 percent, with a 3-state mean population size of 45 individuals in 100 years in the listed portion of the species' range (McShane et al. 2004, p. 3-58).

Thus, considering the best available data on abundance, distribution, population trend, and the low reproductive success of the species, the FWS concludes the murrelet population within the portion of its listed range currently has little or no capability to self-regulate, as indicated by the significant, annual decline in abundance the species is currently undergoing throughout the listed range. The FWS expects the species to continue to exhibit further reductions in the distribution and abundance into the foreseeable future, due largely to the expectation that the variety of environmental stressors present in the marine and terrestrial environments (discussed in the *Threats to Murrelet Survival and Recovery* section) will continue into the foreseeable future.

Recovery Plan

The Marbled Murrelet Recovery Plan outlines the conservation strategy with both short- and long-term objectives. The Plan places special emphasis on the terrestrial environment for habitat-based recovery actions due to nesting occurring in inland forests.

In the short-term, specific actions identified as necessary to stabilize the population include protecting occupied habitat and minimizing the loss of unoccupied but suitable habitat (USFWS 1997b, p. 119). Specific actions include maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance. The designation of critical habitat also contributes towards the initial objective of stabilizing the population size through the maintenance and protection of occupied habitat and minimizing the loss of unoccupied but suitable habitat.

Long-term conservation needs identified in the Plan include:

- increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size;
- increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat;
- protecting and improving the quality of the marine environment; and
- reducing or eliminating threats to survivorship by reducing predation in the terrestrial environment and anthropogenic sources of mortality at sea.

Recovery Zones

The Plan identified six Conservation Zones (Figure 1) throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4), Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6). Recovery zones are the functional equivalent of recovery units as defined by FWS policy (USFWS 1997b, p. 115).

Recovery Zones in Washington

Conservation Zones 1 and 2 extend inland 50 miles from marine waters. Conservation Zone 1 includes all the waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border and the Puget Sound, including the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Conservation Zone 2 includes marine waters within 1.2 miles (2 km) off the Pacific Ocean shoreline, with the northern terminus immediately south of the U.S.-Canadian border near Cape Flattery along the midpoint of the Olympic Peninsula and extending to the southern border of Washington (the Columbia River) (USFWS 1997b, pg. 126).

Lands considered essential for the recovery of the murrelet within Conservation Zones 1 and 2 are 1) any suitable habitat in a Late Successional Reserve (LSR), 2) all suitable habitat located in the Olympic Adaptive Management Area, 3) large areas of suitable nesting habitat outside of LSRs on Federal lands, such as habitat located in the Olympic National Park, 4) suitable habitat on State lands within 40 miles off the coast, and 5) habitat within occupied murrelet sites on private lands (USFWS 1997b).

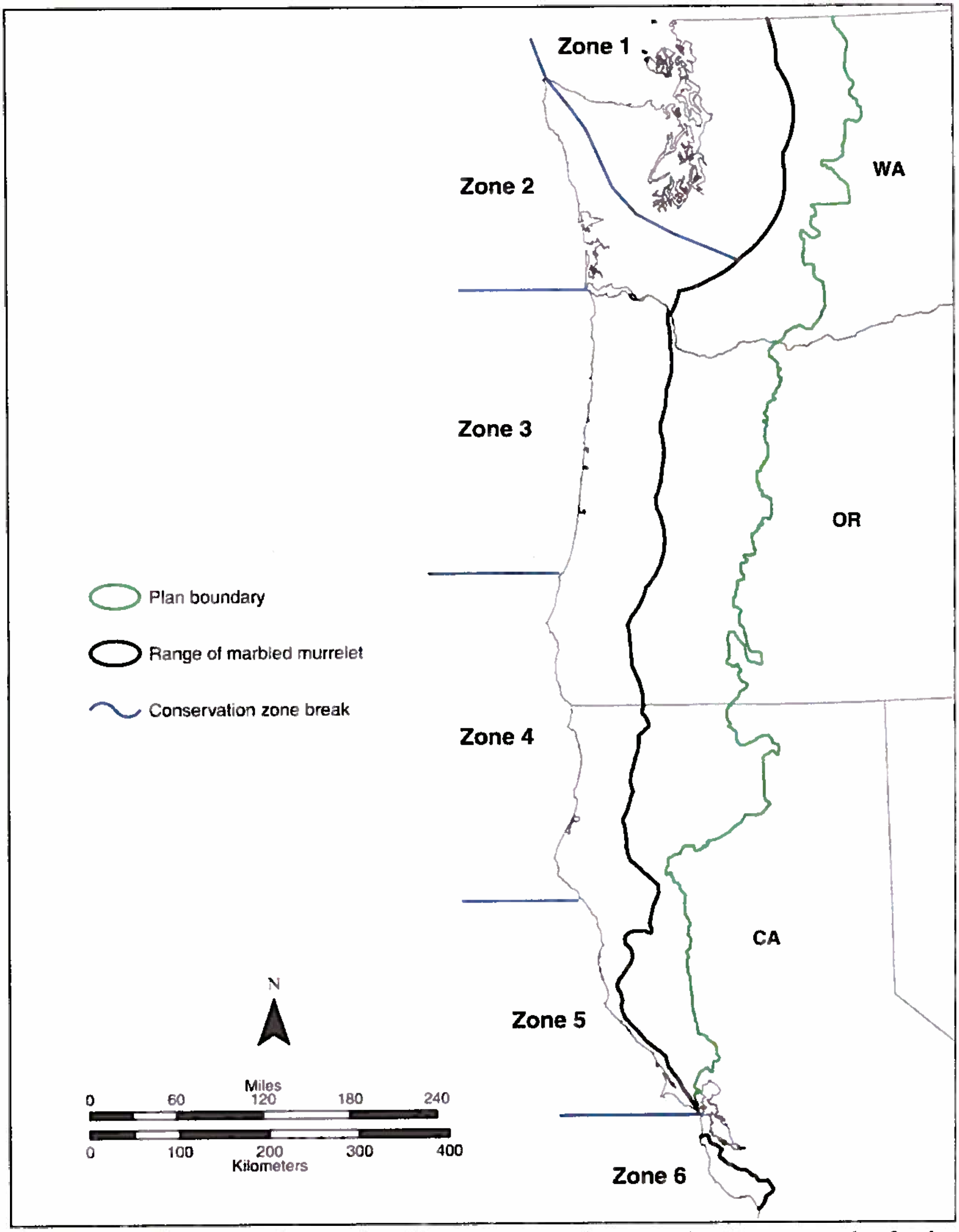

Figure 1. The six geographic areas identified as Conservation Zones in the recovery plan for the marbled murrelet (USFWS 1997b). Note: "Plan boundary" refers to the Northwest Forest Plan. Figure adapted from Huff et al. (2006, p. 6).

Conservation Needs of the Species

Reestablishing an abundant supply of high quality murrelet nesting habitat is a vital conservation need given the extensive removal during the 20th century. However, there are other conservation imperatives. Foremost among the conservation needs are those in the marine and terrestrial environments to increase murrelet fecundity by increasing the number of breeding adults, improving murrelet nest success (due to low nestling survival and low fledging rates), and reducing anthropogenic stressors that reduce individual fitness[5] or lead to mortality.

The overall reproductive success (fecundity) of murrelets is directly influenced by nest predation rates (reducing nestling survival rates) in the terrestrial environment and an abundant supply of high quality prey in the marine environment during the breeding season (improving potential nestling survival and fledging rates). Anthropogenic stressors affecting murrelet fitness and survival in the marine environment are associated with commercial and tribal gillnets, derelict fishing gear, oil spills, and high underwater sound pressure (energy) levels generated by pile-driving and underwater detonations (that can be lethal or reduce individual fitness).

General criteria for murrelet recovery (delisting) were established at the inception of the Plan and they have not been met. More specific delisting criteria are expected in the future to address population, demographic, and habitat based recovery criteria (USFWS 1997b, p. 114-115). The general criteria include:

- documenting stable or increasing population trends in population size, density, and productivity in four of the six Conservation Zones for a 10-year period and
- implementing management and monitoring strategies in the marine and terrestrial environments to ensure protection of murrelets for at least 50 years.

Thus, increasing murrelet reproductive success and reducing the frequency, magnitude, or duration of any anthropogenic stressor that directly or indirectly affects murrelet fitness or survival in the marine and terrestrial environments are the priority conservation needs of the species. The FWS estimates recovery of the murrelet will require at least 50 years (USFWS 1997b).

Summary

The level of risk posed by some threats to the murrelet population may have been reduced as a result of the species' listing under the Act, such as the passage of the Oil Pollution Act and implementation of the NWFP. However, the FWS is not aware that any threats have been removed since listing and in some portions of the listed range, new threats (identified above) have been identified which affect the species at the local population or listed-entity scales. Currently, the FWS expects these threats to continue into the foreseeable future and those that cause direct mortality or reduce individual fitness are likely to contribute to murrelet population declines.

[5] Fitness is measure of the relative capability of individuals within a species to reproduce and pass its' genotype to the next generation.

Considering the life history characteristics of the murrelet, the species' capability to recover from the mortality or reduced-fitness stressors is extremely low. The low observed reproductive rate causes the murrelet population to be highly sensitive to mortality and fitness-reducing stressors, particularly when they occur at a frequency which exceeds the species' loss-replacement rate. Despite the relatively long life span of murrelets and a reasonably high adult survival rate, the annual replacement rates needed for long-term population maintenance and stability is currently well below the annual rate of individuals being removed from each Conservation Zone.

Therefore, given the interactive effect of an extremely low fecundity and the current threats facing the species, it is reasonable to predict that the murrelet populations (in each Conservation Zone) throughout the listed range are likely to continue to decline. The decline is expected to continue until murrelet fecundity is significantly improved and the anthropogenic stressors affecting fitness, survivorship, and nest success are eliminated or sufficiently reduced.

LITERATURE CITED

Beissinger, S.R. 1995. Population trends of the marbled murrelet projected from demographic analyses. Pages 385-393 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report: PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Beissinger, S.R., and M.Z. Peery. 2007. Reconstructing the historic demography of an endangered seabird. Ecology 88(2):296-305.

Bentivoglio, N., J. Baldwin, P.G.R. Jodice, D. Evans Mack, T. Max, S. Miller, S.K. Nelson, K. Ostrom, C.J. Ralph, M.G. Raphael, C.S. Strong, C.W. Thompson, and R. Wilk. 2002. Northwest Forest Plan marbled murrelet effectiveness monitoring 2000 annual report. U.S. Fish and Wildlife Service, Portland, Oregon, April 2002. 73 pp.

Bloxton, T.D., and M.G. Raphael. 2005. Breeding ecology of the marbled murrelet in Washington State: 2004 Season Summary, A report to the U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington; Pacific Northwest Research Station, U.S. Forest Service, Olympia, Washington. 14 pp.

Bloxton, T.D., and M.G. Raphael. 2006. A t-sea movements of radio-tagged marbled murrelets in Washington. Northwestern Naturalist 87(2):162-162.

Bradley, R.W., F. Cooke, L.W. Lougheed, and W.S. Boyd. 2004. Inferring breeding success through radiotelemetry in the marbled murrelet. Journal of Wildlife Management 68(2):318-331.

Cam, E., L.W. Lougheed, R.W. Bradley, and F. Cooke. 2003. Demographic assessment of a marbled murrelet population from capture-recapture data. Conservation Biology 17(4):1118-1126.

Crescent Coastal Research. 2008. Population and productivity monitoring of marbled murrelets in Oregon during 2008, Final Report to USFWS Oregon State Office, Portland, Oregon, December 2008. 13 pp.

Falxa, G.A. 2011. Marbled murrelet population monitoring results, 2000-2010. Arcata Fish and Wildlife Office, Arcata, California, March 30, 2011. 6 pp.

Falxa, G.A., D. Baldwin, S.K. Lynch, S.L. Nelson, and S.F. Miller. 2009. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2008 summary report, August 2009. 19 pp.

Hebert, P.N., and R.T. Golightly. 2006. Movements, nesting, and response to anthropogenic disturbance of marbled murrelets (*Brachyramphus marmoratus*) in Redwood National and State Parks, California. California Department of Fish and Game, 2006-02, Sacramento, California, May, 2006. 321 pp.

Hirzel, A.H., J. Hauser, D. Chessel, and N. Perrin. 2002. Ecological-niche factor analysis: how to compute habitat-suitability maps without absence data? Ecology 83(7):2027-2036.

Huff, M.H., M.G. Raphael, S.L. Miller, S.K. Nelson, and J. Baldwin. 2006. Northwest Forest Plan - The first 10 years (1994-2003): Status and trends of populations and nesting habitat for the marbled murrelet. U.S. Department of Agriculture, Forest Service, General Technical Report: PNW-GTR-650, Portland, Oregon, June, 2006. 149 pp.

Long, L.L., S.L. Miller, C.J. Ralph, and E.A. Elias. 2008. Marbled murrelet abundance, distribution, and productivity along the coasts of Northern California and Southern Oregon, 2005-2007, Report to USFWS and Bureau of Land Management, Arcata, California, 2008. 49 pp.

McShane, C., T.E. Hamer, H.R. Carter, R.C. Swartzman, V.L. Friesen, D.G. Ainley, K. Nelson, A.E. Burger, L.B. Spear, T. Mohagen, R. Martin, L.A. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation reports for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. EDAW, Inc, Seattle, Washington. 370 pp.

Pearson, S.F., M.G. Raphael, M.M. Lance, and T.D. Bloxton. 2011. Washington 2010 at-sea marbled murrelet population monitoring: research progress report. Washington Department of Fish and Wildlife, Wildlife Science Division, and USDA Forest Service, Pacific Northwest Research Station, Olympia, WA, February 2011. 23 pp.

Peery, M.Z., and R.W. Henry. 2010. Abundance and productivity of marbled murrelets off central California during the 2009 breeding season. Final Report. California State Parks, Half Moon Bay, California, February 2010. 16 pp.

Peery, M.Z., S.R. Beissinger, S.H. Newman, E.B. Burkett, and T.D. Williams. 2004. Applying the declining population paradigm: diagnosing causes of poor reproduction in the marbled murrelet. Conservation Biology 18(4):1088-1098.

Peery, M.Z., L.A. Hall, J.T. Harvey, and L.A. Henkel. 2008. Abundance and productivity of marbled murrelets off central California during the 2008 breeding season. Final Report Submitted to California State Parks, Half Moon Bay, CA, September, 2008. 10 pp.

Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt. 1995. Ecology and conservation of the marbled murrelet in North America: An overview. Pages 3-22 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, United States Department of Agriculture, Forest Service, Albany, California.

Raphael, M.G., J.M. Olson, and T. Bloxton. 2007. Summary report of field observation of marbled murrelets in the San Juan Islands, Washington. USDA Forest Service, Pacific NW Research Station, Olympia, Washington. 25 pp.

USFWS. 1997a. Intra-FWS concurrence memorandum and biological opinion on the proposed issuance of an incidental take permit (PRT- 812521) for northern spotted owls, marbled murrelets, gray wolves, grizzly bears, bald eagles, peregrine falcons, Aleutian Canada geese, Columbian white-tailed deer, and Oregon silverspot butterflies, and the approval of the implementation agreement for the Washington State Department of Natural Resources Habitat Conservation Plan (FWS Reference: 1-3-96-FW-594).

USFWS. 1997b. Recovery Plan for the threatened marbled murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. U.S. Department of the Interior, Portland, Oregon, 1997. 203 pp.

USFWS. 2004. Marbled murrelet 5-year review process: overview, Portland, Oregon. 28 pp.

USFWS. 2009. Marbled Murrelet (*Brachyramphus marmoratus*) 5-Year Review. U.S. Fish and Wildlife Service, Lacey, Washington, June 12, 2009.

APPENDIX C
REVISED DISTURBANCE ANALYSIS FOR MARBLED MURRELET

APPENDIX C

Revised In-Air Disturbance Analysis for Marbled Murrelets

Emily Teachout, U. S. Fish and Wildlife Service - Washington Fish and Wildlife Office, Lacey, WA. Draft - 06/18/2012

Introduction

Upon renewal of several U.S. Forest Service programmatic biological opinions in 2012, we revisited our analysis of the effects of disturbance to nesting marbled murrelets contained in Appendix 1 of USFWS (2003): Estimated of distances at which incidental take of murrelets and spotted owls due to harassment are anticipated from sound-generating, forest-management activities in Olympic National Forest. Appendix 1 documented our rationale for analyzing the in-air noise and visual disturbance effects of a variety of actions. Due to advances in our understanding of noise analysis and availability of more recent research on disturbance, we undertook an effort to update the approach presented in Appendix 1.

We recognize three primary challenges with applying the approach in Appendix 1. The first is that it presents thresholds specific to type of stimuli such as "sound-only", "visual", and "combined". This assumes an ability to separate an animal's response to either auditory or visual stimuli. This is very difficult as one must characterize the degree to which a noise source is visible to an animal (Pater et al. 2009, p. 793). Secondly, the approach relies on predicting an animal's response as a function of distance from a noise source, which difficult because received sound levels are highly variable due, in part, to sound-propagation conditions in the field (Pater et al. 2009, p. 793). Lastly, much of the literature used in the earlier analysis is not applicable to development of a sound-only threshold, as the authors did not describe their sound metrics in enough detail to allow comparison (see Teachout pers. comm. 2012 for more detail). There is a growing awareness of the importance of using appropriate metrics and methodologies in sound measurement and analysis (Pater et al. 2009, p. 788; Grubb et al. 2010, p. 1283). In revisiting the literature cited in Appendix 1, we found that, although some of the papers have information that is applicable to the overall discussion of disturbance, they were not directly applicable to developing sound-only thresholds for these purposes. Only one paper, Delaney (1999), included defined and reliable sound metrics While Delaney (1999) does identify some responses of Mexican spotted owls to sound-only stimuli, it is unclear whether those results may have been confounded by the subject animals' ability to associate those sounds with humans that were earlier seen placing equipment. Delaney et al. (1999, p. 72) stated: "Although chainsaws were operated out of sight ... field crews had to set up recording equipment beneath the spotted owls. Subsequent chain saw operations may have been associated more with this ground-based human activity." As such, there is not currently enough information to develop a sound-only threshold and assume for the purposes of this analysis that information on the response of murrelets to disturbance includes components of both auditory and visual stimuli.

Herein, we present a revised approach that groups stressor types and assumes that there may be a visual component to each of these exposures. The stressor types are grouped as follows:

a) Aircraft noise (helicopters and planes)

b) Ground-based continuous noise and human activity (e.g., chainsaws, heavy equipment)

c) Impulsive noise (impact pile driving and blasting)

Any acoustic analysis needs to consider relevant aspects of the sound source, the receiver, and the path along which the sound is transmitted (Pater el al. 2009, p. 788). Use of appropriate sound metrics is necessary to relate responses to an animal and to maximize the utility of the results. For example, if a sound is comprised of frequencies outside of the range of what the animal of interest can detect, a response is less likely (Grubb et al. 2010, p. 1283). If the range of frequencies of a particular sound is not reported, it is difficult to assess where it might overlap with the hearing range of the animal of interest. Appropriate sound metrics are designed to best represent a particular sound type (i.e., continuous vs. impulsive) and should account for the frequencies within the hearing range of the species of interest (Pater et al. 2009, p. 789). We group stimuli by the type of sound produced so that appropriate metrics can be applied for both pre-project assessment and eventual monitoring and reporting.

Behaviors Constituting Harassment

A disturbance is event is considered significant when project activity causes a murrelet to delay or avoid nest establishment, flush away from an active nest site or aborts a feeding attempt during incubation or brooding of nestlings. A flush from a nest site includes movement out of an actual nest, off of the nest branch, and away from a branch of a tree within suitable habitat during the nesting season. Such events are considered significant because they have the potential to result in reduced hatching success, fitness, or survival of juveniles and adults.

Noise and visual disturbance that causes an adult murrelet to abort a prey delivery to the nestling creates a likelihood of injury for the adult through an increased energy cost, and by exposing the adult to an increased risk of predation. Hull et al. (2001, p. 1036) report that murrelets spend 0.3 to 3.5 hours per day (mean 1.2 ± 0.7 hours per day) commuting to nests during the breeding season. The distance traveled between the nest site and foraging areas ranged from 12 to 102 km, and is a substantial energy demand for the adults. Each flight to the nest is energetically costly, increases the risk of predation from avian predators, and detracts from time spent in other activities such as foraging (Hull et al. 2001, p. 1036). Increases in prey capture and delivery efforts by the adults results in reduced adult body condition by the end of the breeding season, and increases the predation risks to adults and chicks as more trips inland are required (Kuletz 2005, pp. 43-45).

If an adult would conduct a single feeding, and that feeding is aborted, and it later returns with another prey item the same day, its time spent commuting would increase by 100%, and on days when the adult would make two feeding roundtrips, commute time would increase by 50%. Ralph et al. (1995, pg. 16) state, "Predation on adult murrelets by raptors occurs in transit to nest sites...Given the small number of nest sites that have been monitored, observations of the taking of adult murrelets by predators raises the possibility that this is not a rare event." They proceed to list several observations of raptors killing adult murrelets and of murrelet wings and bones being found in peregrine falcon (*Falco peregrinus*) nests. An aborted feeding significantly increases an adult murrelet's time airborne, creating a likelihood of injury from predation.

Sound Metrics

A sound metric is a measureable parameter used to characterize and quantify a sound event (Pater et al. 2006, p. 789). A metric designed to measure continuous sound may not adequately characterize an impulsive sound such as an explosive or impact pile driving and vice versa. Care is warranted, in describing sounds and their effect on wildlife, to most accurately predict animal responses. Anthropogenic sound must be meaningfully quantified or the predicted responses will be of little utility and the results of an analysis will not be applicable to any other situation. An appropriate metric is one that measures the characteristics of a stimulus in a way that can be related to the response of an animal (Pater et al. 2009, p. 789).

Based on our review of the literature and on input we received from acousticians (Laughlin pers. comm. 2012), we conclude that LEQ is an appropriate metric for chainsaws and other construction-generated sounds. For continuous sounds, an average sound level is the most appropriate way to characterize the sound (Pater et al. 2009, p. 789). One applicable metric is the LEQ measured over a specified time period (e.g., 1 second, 24 hours, etc.) (Pater et al. 2009, p. 789).

The duration of the measurement period varies depending on the characteristics of the event being measured, and should always be reported as part of the measurement. For example, for vibratory pile driving a 10-minute LEQ or 10-minute rms is typically reported (Laughlin, 2010). For highly variable or transient sounds, simple measurement of LEQ is not appropriate. For sound events of a few to several seconds (e.g., pass-by vehicle traffic or aircraft), the choice of measurement period duration is important. In these situations, it is best to divide the event duration into short (typically 1-second) increments. The LEQ is measured during each increment, and then the maximum value occurring in any time increment is reported. Total duration of the event should also be reported (Pater et al. 2009, p. 789).

Short duration transient or impulsive sounds (<1 second) are complex, so a simple measure of average sound level is also not adequate (Pater et al., 2009, p. 789). Sound exposure level (SEL) is a metric that is often used to characterize very brief events such as blasts, gunshots, and impact pile driving (Pater et al. 2009, p. 790). However, there is little information available on the behavioral response of animals to impulsive sound described relative to SEL. As such, until more information is available, we currently rely on observed response distance for estimating potential behavioral responses from impulsive sound.

Exposure

Anthropogenic activities occurring within, or near, suitable murrelet nesting habitat expose murrelets to a variety of stressors. This analysis is limited to those stressors associated with "disturbance" that result from a combination of noise and visual stimuli. Anthropogenic activities considered in this analysis are those typically occurring with activities such as transportation system maintenance, maintenance of infrastructure that supports recreational activities, and forest management. Specific activities may include timber harvest and hazard tree removal, road and trail maintenance, and bridge repair. Equipment that may be used to conduct these activities includes chainsaws, aircraft, heavy equipment, and impact pile drivers.

To estimate the expected response of murrelets to these exposures we grouped them as follows: aircraft (helicopter and small planes), ground-based human activity (e.g., chainsaws, heavy equipment), and impulsive sound (impact pile driving and blasting).

Exposure to Aircraft (Helicopter and Small Plane) Activities

The sounds of aircraft are rich in low-frequency energy, and travel long distances efficiently (Pater et al. 2006, p. 792; Grubb et al. 2010, p. 1280). The highest levels of sound energy produced by helicopters are below 100 Hz (Grubb et al. 2010, p. 1280), which is well below the best hearing sensitivities of most birds (Dooling and Popper 2007, p. 21). Further, much of the sound energy from aircraft is at frequencies below those that most birds can detect (Grubb et al. 2010, p. 1281; Dooling and Popper 2007, p. 21). Grubb et al. (2010) present sound level for four helicopter models (Table 1 in Grubb et al. 2010, p. 1277). The ranges in A-weighted SEL were:

Table 1. SELs for four helicopter models (rounded to nearest dB)

Helicopter Model	**dBA SEL Overhead**	**dBA SEL at 100 m**
AH-64 Apache	95–99	88-97
Eurocopter AS350 B3	86-89	85-85
Eurocopter EC130-B4	83-84	82-82
Bell 206 L4	87-91	85-89

Potential Response to Aircraft Activities

A few studies have examined raptor responses to aircraft, and these note that flush rates were higher if raptors were naive (Platt 1977 in Grubb et al. 2010, p. 1282), and a majority flushed at ≤50 meters (Grubb et al. 2010, p. 1282). During incubation, diurnal raptors such as osprey (*Pandeon haliaetus*) (Carrier and Melquist 1976, p. 79), red-tailed hawks (*Buteo jamaicensis*) (Craig and Craig 1984, p. 24), bald eagles (*Halieetus leucocephalus*) (Fraser et al. 1985, p. 585) and Mexican spotted owls (*Strix occidentalis lucida*) (Delaney et al. 1999, p. 60) appear reluctant to flush.

Grubb et al. (2010) conducted an extensive study of the response of golden eagles to four models of helicopters and concluded that no special management restrictions were required for heli-ski operations (p. 1283). There were no significant responses or detrimental effect to nesting success even with what are considered large helicopters (Apache AH-64) (p. 1282). The study recorded 303 helicopter passes at 22 nesting territories. Nest success, productivity, and rates of re-nesting in the following year, were not reduced. No flushes were observed during incubation and three flushes were observed, though the authors note that these might have been imminent departures that were precipitated rather than a startle or avoidance response (p. 1275).

Delaney (1999) studied response of Mexican spotted owls to helicopters and found that they did not flush when SELs were ≤92 dBA. They concluded that helicopter sounds below this level should not detrimentally affect spotted owls (p. 74). The farthest distance that helicopter elicited a flush response was 89 m.

During a study of radio-tagged murrelets in British Columbia, helicopters were used to locate the incubating adults by circling and hovering over nest sites. The hovering and circling came within 100-300 meters of the nest and lasted approximately three minutes. None of the radio-tagged adults incubating any of the nests (n = 125) flushed (R. Bradley, Univ. BC, 2002, pers. comm. in USFWS 2003, p. 278).

Long and Ralph (1998, p. 18) noted that murrelets did have an observable response to either airplanes or helicopters flying overhead, except when they passed at low altitude. One chick did not respond to an airplane passing twice within 0.25 mile at 1,000 feet, but another chick lay flat on the branch "when an aircraft passed at low altitudes" ("low altitudes" was not defined) (Long and Ralph 1998, p. 18).

Expected Response to Aircraft Activities

The likelihood of an animal responding to a particular sound is related, in part, to whether or not the frequencies contained in the sound are within their hearing range. This was observed by Grubb et al. (2010) when they found that golden eagles were not disrupted by helicopter noise, potentially because most of the sound energy is below their auditory threshold (p. 1275, p. 1283). We assume that marbled murrelets have hearing sensitivities similar to most other birds and, as a result, the majority of the sound energy from aircraft is likely to be below their best sensitivities and, possibly below the frequency range that they can detect. We therefore expect sounds from aircraft will either need to be of very high amplitude (more than 90 dBA SEL) or have a highly visible approach for murrelets to respond.

During incubation, we do not expect marbled murrelets to flush in response to aircraft based on studies of other species as described by Grubb et al. 2010; Craig and Craig 1984; Fraser et al. 1985; and Delaney 1999, and based on observations of marbled murrelets (R. Bradley, Univ. BC, 2002, pers. comm. in USFWS 2003; and Long and Ralph 1998).

We expect that marbled murrelets may abort or delay feedings in response to exposure to aircraft at sound levels exceeding 92 dBA SEL based on observed response of Mexican spotted owls to helicopters (Delaney 1999, entire). Adult murrelets conducting an incubation exchange or delivering a prey item may alter their behavior in response to aircraft. We expect that nestlings will respond to approach by aircraft by lying flat on the nest branch.

Exposure to Ground-based Activities

Ground-based activities addressed here include activities such as transportation system maintenance, maintenance of infrastructure that supports recreational activities, and forest management. Specific activities may include timber harvest and hazard tree removal, and road and trail maintenance. This section does not address operation of roads (i.e., consistent traffic noise), or extremely loud or impulsive noises. We group these activities in this analysis in the category of ground-based human activities because we expect that responses of murrelets to these types of activities involve components of both auditory and visual stimuli.

Potential Response to Ground-based Activities

In response to ground-based human activity, adult murrelets have delayed and aborted feedings (Hamer and Nelson 1998, p. 11, p. 17; Long and Ralph 1998, p. 16, p. 21), diverted their flight paths (Hamer and Nelson 1998, p. 17), delayed entry to nesting habitat (Hamer and Nelson 1998, p. 12), and vacated suitable habitat (E. Burkett, pers comm.). Chicks have responded to human presence by assuming defensive postures (Binford et al. 1975; p. 307; Long and Ralph 1998, p. 16; Simons 1980, p. 4).

There are a number of studies on how disturbance affects a variety of birds (see USFWS 2006). Multiple studies on bald eagles (e.g., Knight and Knight 1984, McGarigal et al. 1991, Stalmaster and Kaiser 1997), for example, recommend limiting activities beyond 250 meters to reduce threats from visual disturbances. Bednarz and Hayden (1994 in USFWS 2006) state that approaches by humans flushed 100 percent of great horned owls at a mean distance of 111.3 m, with a range of 5-700 m, and that owls did not return to initial site as long as humans were visible.

Delaney et al. (1999) evaluated the effects of chainsaw operation and helicopters on Mexican spotted owls and found that chainsaws elicited a greater flush response rate than helicopters at comparable distances and noise levels. They found that owls did not flush when noise stimuli were more than 105 m. When helicopter sound levels were ≤92 dBA SEL, and when chainsaw noise was ≤46 dB LEQ, the authors did not observe any flushes of Mexican spotted owls. Building off this work, Delaney and Grubb (2001, entire) used those thresholds (more than 105 meters or more than 46 dBA LEQ) to predict potential flush responses to motorcycles.

Delaney (1999, p. 66, p. 71) and Delaney and Grubb (2001, p. 11) note that ground-based disturbance may have a greater effect than aerial disturbance on nesting success. Long and Ralph (1998, p. 20) concluded that pedestrians had the greatest impacts to nesting birds, especially when there were no visual barriers between people and nests.

Due to the difficulties locating, and then monitoring, marbled murrelet nests, there are no peer-reviewed, published articles providing empirical evidence on disturbance of marbled murrelets. We rely, instead, on observations by murrelet researchers in the field. One of the earliest and most detailed descriptions of murrelet response to disturbance came with the inadvertent discovery of a ground nest of marbled murrelets in Alaska (Simons 1980). The exposed location and ease of access allowed for observation in closer proximity than tree nests typically provide. The observer discovered the nest during incubation and monitored it closely until near fledging. The observer noticed that the incubating adults appeared to be extremely alert and exhibited "keen hearing and sight and responded to the slightest disturbance" (p. 3). Further, he noted that, "Even a very faint unfamiliar noise would cause them to become agitated. On several occasions, my shuffling or the click of a camera shutter caused them to sit up erectly as if about to fly, looking cautiously from side to side for the source of the noise" (p. 3).

Additionally, Simons (1980) noted that the newly hatched chick was very alert and seemed to have well-developed vision and hearing. It responded immediately to unusual sounds and would detect the observer's approach at over 10 meters (p.4). Overall, he characterized the murrelets as having "...extremely keen senses, alertness, and rapid flushing and flight behavior." (p. 6).

Visual stimuli appear to be important as murrelets have successfully delivered prey items while researchers were in a nest tree, but were hidden from view (Hamer pers. comm. in Long and Ralph 1998, p. 16). Researchers approaching within a few meters of a nest caused delayed or aborted feedings (Hamer and Nelson 1998, p. 19), and triggered defensive postures and behavior in nestlings (Long and Ralph 1998, p. 16; Simons 1980, p. 4). Hamer and Nelson (1998, p. 11) report that a ground observer who moved from being out of sight to 35 meters away from the base of a nest tree caused a murrelet that was attempting to feed its chick to drop its fish and fly away. The same adult returned 1 hour 21 minutes later and fed the chick, although it took a different flight path to the nest.

A radio-tagged male murrelet entered a stand of suitable habitat in Big Basin State Park three mornings in a row. On the third morning, he landed on a branch, when people arrived in a car, slammed the car doors, and talked loudly within 30 meters of the tree. The murrelet vocalized and then flew with another murrelet from limb to limb before they both flew from the stand. The male was preyed upon by a peregrine falcon (*Falco peregrinus*) later that day (E. Burkett, Cal. Dept. Fish and Game, pers. comm. In USFWS 2003, p. 270), so it is unknown whether he would have nested there.

Adult murrelets in nest trees located 10 meters and 25 meters from heavily used hiking trails and three nests overhanging a trail used by 25,000 visitors per year "rarely showed behavior suggesting agitation from human presence or noise" or showed "no visible reaction to loud talking [or] yelling...near the nest tree" (Singer 1991 in Long and Ralph 1998, p. 17). However, two perched murrelets were observed to flush from a branch 10 meters away from pedestrians (E. Burkett, Cal Dept. of Fish and Game, pers. comm., in USFWS 2003, p. 270).

In their review of disturbance observations at active nest sites in Oregon and Washington, Hamer and Nelson (1998, p. 9) reported that human activity caused adult murrelets to abort nest visits or flush from the nest a large proportion of the time. Human presence around nest trees caused birds to abort feedings or flush from the nest limb. A person walking under a nest tree when an adult was on the nest limb resulted in flushing the adult off the nest limb before feeding could take place. Reactions by adults were not observed when human were out of sight (p. 17). At the Little Rackheap nest (Oregon) (located 9.9 meters off the ground), the presence of observers standing on the road within 15 m of the nest tree appeared to have an impact on whether adults would land at the nest during the pre-egg-laying period. Once observers moved off the far edge of the road and into the brush (5-10 meters farther away), the birds would land at the nest on their next flight up the road (p. 12). Twenty-seven percent of the time ($n = 30$) that people walked within 40 meters of a nest near a busy state highway, the adults aborted nest visits or flushed (p. 9). A researcher in an active nest tree on the Siuslaw River caused an adult to flush while attempting to deliver a fish. The adult flushed from the tree and flew off with the fish. The researcher hid behind the trunk of the tree and the adult returned minutes later, landed on the branch and successfully fed the young (p. 19). Adult murrelets also aborted feedings due the presence of automobiles traffic on the road (p. 17). One or more vehicles passing a nest caused adults to abort a nest visit (p. 9). A pickup driving down the road as two murrelets were flying above canopy height caused the murrelets to veer away and then they were no longer seen (p. 12). Heavy equipment operation on a road adjacent to suitable habitat appeared to cause murrelet detections to cease when they had previously been frequently observed (p. 12).

Hamer and Nelson (1998, p. 21) noted that nest disturbances that shorten or interfere with feeding interchanges could be detrimental to young birds. They recommended a 125-meter buffer to allow for machinery (vehicles and chainsaw) noise to reach ambient noise levels, and a 150 m buffer for any type of blasting (p. 19). The researchers recommend that the first concern in protecting nesting habitat from disturbances should be to visually screen any disturbances near areas where birds are nesting (p. 20).

As described above, Hamer and Nelson (1998) observed various responses of adult murrelets to noise and human activity. However, Hébert and Golightly (2006) documented few overt responses of nesting murrelets to chainsaw noise and the presence of people hiking on trails in Redwood National and State Parks in northern California. They conducted chainsaw disturbance tests for 15-minute intervals at a distance of 25 meters from the base of occupied nest trees (n = 12). Adult and chick responses to chainsaw noise, vehicle traffic, and people walking on forest trails resulted in no flushing and no significant increase in corvid presence (pp. 35-39). However, adults exposed to chainsaw noise spent more time with their head raised, and their bill up in a posture of alert, vigilant behavior. When undisturbed, adult murrelets spent 95 percent of the time resting or motionless. Many adult murrelets exposed to an operating chainsaw ultimately experienced complete nest failure, but the authors caution that the relationship, if any, between the disturbance trials during the incubation period and fledgling success was unclear. They concluded that reproductive success was similar for control (13 percent) and experimental nests (30 percent) (p. 37).

Hébert and Golightly (2006) suggest that the behaviors they observed are similar to those of an adult murrelet reacting to the presence of a nest predator (p. 35), and that prolonged noise disturbance at nest sites could produce short term behaviors that have unknown consequences (p. 37). It is reasonable to assume that a murrelet responding to a noise by moving or shifting position would increase the chance that it will be detected by a predator. Additionally, the energetic cost of increased vigilance to protracted disturbance could have negative consequences on nesting success (p. 37). Adult murrelets feed their chicks throughout the day. Operating chainsaws while an adult approaches a nest to feed a chick may cause sufficient disturbance to result in abortion or delay of the feeding. Hébert and Golightly estimated that a single missed feed could deprive the chick of 25-50 percent of its daily energy and water intake, which could have a significant negative impact on fledging success (p. 38). As murrelet chicks grow rapidly compared to most alcids, gaining 5-15 g/day during the first nine days (Nelson and Hamer 1995a, pg. 60), missed feedings may pose a comparatively greater risk.

In general, murrelets make multiple trips to a nest to deliver prey items, and they sometimes spend a considerable amount of time at the nest site during these prey deliveries. The combination of adults making multiple trips and amount of time spent at the nest site increases the likelihood that normal feeding activity could be disrupted. Based on a compilation of radio-telemetry data (Golightly, R., in litt. 2010), we estimate that up to 10 feedings could occur during the mid-day (limited operating period) portion the nestling phase (Livezey, K., *in litt.*

2012). Murrelets sometimes take up to an hour at the nest when delivering a prey item. Given the number of feedings and the amount of time an adult murrelet spends at the nest, the minimum percent time per midday period an adult would be in a forest stand attempting to feed its nestling would be 1 percent (using 12 hours in midday, 1 feeding per midday, 7 minutes per feeding) and the maximum percent would be more than 100 percent (using 8.5 hours in midday, 10 feedings per midday, 1 hour per feeding). A reasonable worse-case scenario would be 58 percent (using 9 hours in midday, 7 feedings per midday, 45 minutes per feeding). A reasonable worse-case scenario indicates that, in an occupied murrelet stand, we would expect that one adult per nest could be present any time during the day. Therefore, there is a reasonable likelihood that the types of activities addressed here would intersect with a prey delivery attempt at some point during each day in the nestling phase.

Nestlings appear more tolerant to potential disturbance than do adult murrelets. Nestlings did not have a noticeable response when researchers were within 6-35 m and they appeared to habituate to researchers changing camera batteries within 1 m (Long and Ralph 1998, p. 16). A nestling videotaped during chainsaw operation within 40 m of the nest tree dozed, preened, and stretched, and had no observable reaction to the activity (P. Hébert, Cal. Dept. Fish and Game, pers. comm. in USFWS 2003, p. 269). Hébert and Golightly (2006) did not find a statistically significant difference in the responses of murrelet chicks exposed to chainsaw noise compared to pre- and post-disturbance trials (p. 36). All three chicks exposed to chainsaw disturbance fledged (p. 29). Hébert and Golightly (p. 36) conclude that chainsaw noise disturbance lasting 10 to 15 minutes at a distance greater than 25 m from the nest does not appear to induce long-term behavioral changes.

Expected Response to Ground-based Activities

Based on the above information, we expect that adult murrelets may respond to ground-based activities such as chainsaw operation, sudden noises, traffic, heavy equipment operation, and human presence within nesting habitat, and that these responses will be strongly influenced by visual clues. Of these, we expect that activity involving human approach in nesting habitat will have the most severe response. The range of potential responses could include delay or avoidance in nest establishment, flushing from a nest, and aborting or delaying a feeding attempt.

We expect that adult murrelets are most likely to exhibit a flush response during nest establishment and while attempting to deliver food to the nestling. We assume that disturbance activities that occur in close proximity to occupied stands are expected to result in these reactions.

Adult murrelets that are incubating an egg are not expected to flush from disturbance. Short-term ground-based disturbance events (such as operating a chainsaw for 15 minutes or less) do not appear to cause a measureable effect to murrelet adults or chicks.

Murrelet chicks appear to be mostly unaffected by noise and human activity. The greatest risk to murrelet chicks from disturbance is the potential for missed feedings during the mid-day period (assuming a limited operating period restricting dawn/dusk activity). We do not expect nestlings to flush in response to ground-based activity based on observations by Long and Ralph (1998) and P. Hébert (California Fish and Game, pers comm. cited in USFWS 2003).

We screened the available information on disturbance by those that provided adequate description of sound metrics to allow for careful interpretation and comparison of the results. We found there is insufficient information to distinguish between a murrelet's response to visual vs. auditory stimuli presented with ground-based disturbance. We assume that murrelet response to ground-based disturbance results from components of both stimuli. Predicting an animal's response solely as a function of distance from a noise source is difficult, and may be inaccurate, because a received sound level will vary substantially due to propagation conditions in the field (Pater et al. 2009, p. 793). Coupled with a lack of empirical evidence on cause-and-effect relationships between ground-based disturbance and murrelet response, we believe it's appropriate to use a standardized buffer width beyond which we do not expect murrelets to flush from a nest or abort or delay a feeding.

Documented response ranges to these activities by forest-nesting birds extend to greater than 100 meters and researchers who have studied murrelet response to disturbance in the field recommend disturbance buffers of greater than 100 meters (Hamer and Nelson 1998). Documented responses of marbled murrelets to ground-based activities have not extended to 100 m, but rigorous studies have not been done and only a small number of occupied nests have been monitored.

In summary, we do not expect ground-based activities to result in significant behavioral responses in chicks, but we do expect significant responses by adults. Adults are expected to respond negatively to human disturbance when they are establishing nest sites and during prey deliveries. Due to the number of trips adult murrelets may make to nest sites, and given the amount of time they spend at the nest during a prey delivery, it is reasonable to expect that these activities will intersect with murrelet occurrence in suitable habitat during the nesting season. There is considerable overlap in the various phases of nest chronology, making it difficult to identify specific periods when responses may differ. Though there appears to be a lower risk of adults flushing during incubation, there is enough variation and overlap in nest establishment, incubation, and hatching periods that management requirements specific to those periods are not feasible without detailed, site-specific, information. Therefore, we assume there is equal risk and similar responses to these exposures throughout the nesting season. We conclude that these responses are reasonably likely to occur within 100 meters of ground-based activity.

Exposure to Impulsive Sound-Generating Activities

Impulsive sound-generating activities addressed in this analysis include impact pile driving and blasting. Impact pile driving may be used for activities such as bridge repair and bank stabilization. Blasting may be used for activities related to road construction.

Impulsive sound may be more disruptive than continuous sounds due to the associated noise levels and/or the concussive nature of the sounds (Schueck et al. 2001, p. 613). At levels less than 140 dBApeak, impact noise such as pile driving behaves similarly to impulse noise from blasting (Hamernik and Hsueh 1991, p. 189). Like aircraft, sounds of explosions and large guns are rich in low-frequency energy and consequently travel long distances efficiently (Pater et al. 2009, p. 792). Impact pile driving creates a short, repetitive broad-band sound with relatively high amplitudes. Sound from impact pile driving will vary depending on the type of equipment, type of pile (e.g., steel vs. wood), substrate type and a variety of other factors. For this analysis, we consider the potential noise levels from impact installation of steel piles to pose the greatest risk for disturbance.

Potential Response to Impulsive Sound-Generating Activities

Impulsive sounds are generated by activities such as impact pile driving and blasting. There is very little information on the response of birds to impulsive noise (Dooling and Popper 2007, p. 27). A review compiled by Dooling and Popper (2007, p. 25) indicates that birds exposed to an impulse (e.g. a blast) of noise of at least 140 dBA SPL, or exposures to multiple impulses of noise at 125 dBA SPL are likely to suffer hearing damage. These data are largely from laboratory experiments with budgerigars (*Melopsittacus undulates*) exposed to short bursts (<10 ms) of pure-tone sounds (Hashino et al. 1988, p. 2540). Other than noting that these exposures were A-weighted SPLs, a metric was not given. Until more information is available, we assume that these levels are the highest observed rms levels.

Individual Impulsive Sound Events (e.g., Blasting)

There is only limited information regarding sound levels associated with various types of blasting (USFWS 2003, pp. 276-277). The sounds produced by blasting are highly variable and dependent on the size and type of charge, the material being blasted, and whether noise minimization techniques are employed (MM&A 2008, p. ii). Holhuijzen et al. (1990, p. 272) reported sound levels for small, experimental blasts using 0.37 lb charges of Kinestek and 1.1 lb. charges of dynamite. Surface (uncovered) charges were detonated at a distance of 100 m from the sound measuring equipment in an open area. Peak noise levels averaged 140 dBA rms (range = 138 – 141 dBA) for Kinestek and 145 dBA (range = 144-146 dBA) for dynamite at 100 m. A review by Dooling and Popper (2007, pp. 23-24) reports that birds exposed to noise levels 140 dBA or greater are likely to suffer hearing damage (injury). The blasts described above would be potentially injurious to birds at distances of at least 100 m (330 feet).

Effects of blasting on nesting prairie falcons (*Falco mexicanus*) were studied at an active construction site as well as experimentally (Holthuijzen et al. 1990). Construction blasts were located 560 to 1000 m (0.34 – 0.62 mile) from falcon nest sites, and experimental blasts were conducted between 120 and 140 m (394 – 459 feet) from nest sites (Holthuijzen et al. 1990, pp. 271-272). Peak sound levels measured at the nest site were 139-140 dB. The authors did not clearly identify the sound level metric they were using though they noted that it was a "peak" level. Given that it is impulsive noise it is reasonable to assume their measurements were reported in A-weighted dBpeak levels.

The overall flushing rate in the experimental study (58 percent) was 4-6 times higher than those observed in the construction area (7 percent) (Holthuijzen et al. 1990, pp. 272-274). Falcons perched in the experimental study area flushed 79 percent of the time (p. 273). Incubating and brooding falcons flushed in 39 and 13 percent of the events, respectively (p. 274). There was no indication that the falcons habituated to repeated exposures as birds exposed to blast noise were just as likely to flush during subsequent exposures (Holthuijzen et al. 1990, p. 274). The nesting falcons exposed to experimental blasting were ultimately successful in fledging young

(Holthuijzen et al. 1990, p. 280). With maintain productivity and nest re-occupancy in subsequent years, the authors conclude that a buffer of 125 meters provided that peak noise levels do not exceed 140 dB at the nest site and that no more than 3 blasts occur on a given day or 90 blasts during the nesting season will be protective (p. 280). This level, however, was not recommended with the intent of predicting individual flush responses.

Concussive Impulsive Sound Events (e.g., Impact Pile Driving and Artillery)

Impact pile driving and artillery fire are similar in that they are repetitive, impulsive sounds with high amplitudes. Sound from impact pile driving will vary depending on the type of equipment, type of pile, substrate type and a variety of other factors. Typical pile types include steel, wood and concrete. Of these, steel piles generate the highest sound levels. Reported sound levels for impact pile driving projects are usually in the range of 101 – 110 dBA Lmax, at 50 feet from the source (FHWA 2006, section 9; WSDOT 2011, p. 7.11). Given the suggested injury thresholds of 140 dBA SPL, and 125 dBA SPL suggested by Dooling and Popper (2007) we don't expect that murrelets would be exposed to injurious sound levels from pile driving unless there was potential exposure within 50 feet (where sound pressure levels would likely be greater than 110 dBA).

Schueck et al. (2001) studied the effect of military training activity on raptors and found that they were more responsive to the impulsive sounds of ammunition fire than the more continuous sounds of tank operation, perhaps due to the concussive nature of ammunition fire (p. 613). They also found that military training activities that involved artillery fire reduced prey capture attempts, and temporally and spatially altered foraging locations (p. 613).

Recently, Delaney et al. (2011) studied the effect of military training activity on red-cockaded woodpeckers (*Picoides borealis*). This work evaluated the effect of impulsive sound from artillery simulators and firing of 0.50-caliber blanks. It is important to consider, though, that the woodpeckers nest in cavities which not only affect the transmission of the sound (i.e., increase the received levels), but also limit the birds visibility of the stressor. However, there are a few points worth noting: the woodpeckers flushed during both the incubation and nestling phase; flush response distances extended to over 150 m; the authors characterized behavioral responses of the woodpeckers as "minimal" when stimuli were greater than 122 m; and they did not observe flush responses when stimuli were farther than 152 m.

Expected Response to Impulsive Sound-Generating Activities

Murrelets exposed to impulsive sound that exceeds 140 dBA SPL are likely to suffer injury in the form of hearing loss because the intensity of the noise is sufficient to damage the delicate inner ear sensory hair cells (Dooling and Popper 2007, p. 24). A partial loss of hearing sensitivity has important implications for the survival and fitness of individual murrelets. Vocal communication between murrelets is an important aspect of murrelet foraging behavior in the marine environment, and vocalizations also appear to serve an important social function at inland nesting sites (Nelson 1997, pp. 9-11). Hearing ability also has important implications for predator avoidance in both marine and terrestrial habitats.

It is widely thought that SEL is the best metric for describing impulsive sounds. However, there is little information available on the behavioral response of animals to impulsive sound described relative to SEL. As such, until more information is available, we currently rely on observed response distance for estimating potential behavioral responses from impulsive sound.

We expect that within 110 m of impact pile driving there is a reasonable likelihood of significant behavioral responses (e.g., flushing). We expect that exposure of murrelets to sound from impact pile driving could cause injury at very close distances and/or could result in flushing from exposure to concussive, impulsive, sound.

For blasting events, we consider the potential disruption zone (flush response) for murrelets to be a 0.25-mile radius around the project site. This is based on the findings of Holthuijzen et al. (1990, p. 273) which is an increase over the distance recommended to avoid productivity impacts in order to include potential flush responses.

Remaining Issues

This analysis does not specifically address risks to nesting murrelets posed by masking of biologically important sounds or disruption of attention.

Conclusion

The body of knowledge on bird response to disturbance indicates that human activity can impact nesting success and can be energetically costly to individual birds. Disturbance can have profound effects throughout the nesting season, including the nest establishment, incubation, and chick rearing phases. Marbled murrelet response to disturbance is variable and appears related to the developmental stage of the individual bird exposed to stimuli, degree of habituation existing prior to exposure, and whether there is a visual component to the stimuli. Murrelets have responded behaviorally to disturbance in ways that create a reasonable likelihood of injury to the adult, the chick, or both.

This analysis groups potential exposures of nesting murrelets to noise and human activity into three categories in a manner that allows for improved comparison of available noise data and acknowledges limitations in existing information. We conclude that under certain scenarios these activities could result in significant disruptions of normal behaviors that result in a likelihood of injury to marbled murrelets. Behavioral responses that we anticipate could occur and that are considered significant are:

- An adult murrelet avoiding or delaying nest establishment
- An adult murrelet flushing from a nest or perch within the vicinity of a nest site
- An adult murrelet delaying or aborting one or more feedings

We expect that these behaviors are likely to occur when:

- Aircraft noise exceeds 92 dBA SEL at a nest site
- Ground-based activity occurs during the nesting season within 100 m of a nest site
- Impulsive noise from blasting within 0.25 mi of a nest site

- Impulsive noise from pile driving within 110 m of a nest site

We expect injury to murrelets (e.g., hearing damage) to occur when in-air sound pressure levels exceed:

- 140 dBA SPL (single impulse)
- 125 dBA SPL for multiple impulses

LITERATURE CITED

Bednarz, J.C. and T.J. Hayden. 1994. The effects of human activities on the productivity of birds of prey in the Los Medanos area, New Mexico. Journal of Raptor Research 28(1):52-53.

Binford, L.C., B.G. Elliott, and S.W. Singer. 1975. Discovery of a nest and the downy young of the Marbled Murrelet. Wilson Bull. 87(3): 303-440.

Carrier, W.D. and W.E. Melquist. 1976. The use of a rotor-winged aircraft in conducting nesting surveys of ospreys in northern Idaho. Raptor Research 10(3) 77-83.

Craig, T. H., and E. H. Craig. 1984. Results of a helicopter survey of cliff nesting raptors in a deep canyon in southern Idaho. Journal of Raptor Research 18:20–25.

Crocker, M.J., editor. 1998. Handbook of acoustics. John Wiley and Sons, New York, New York, USA.

Delaney, D.K., T.G. Grubb, P. Beier, L.L. Pater, and M.H. Reiser. 1999. Effects of helicopter noise on Mexican Spotted Owls. Journal of Wildlife Management 63:60-76.

Delaney, D.K., and T.G. Grubb. 2001. Effects of off-highway vehicles on northern spotted owls: sound data results. A report to the Mendocino National Forest Contract Number 43-91Z9-0-0055. USDA Forest Service Rocky Mountain Research Station. May 2001. 53 pp.

Delaney, D.K., and T.G. Grubb. 2003. Effects of off-highway vehicles on northern spotted owls: 2002 results. A report to the State of California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division under Contract No. 439129-0-0055. USDA Forest Service Rocky Mountain Research Station. May 2003. 38 pages.

Dooling, R.J., and A.N. Popper. 2007. Effects of highway noise on birds. Prepared for the California Dept. of Transportation Division of Environmental Analysis. Sacramento, California. Prepared under contract 43A0139 Jones and Stokes Associates. September 2007. 74 pp.

FHWA. 2006. Highway construction noise handbook. Chapter 9. Construction equipment noise levels and ranges. U.S. Department of Transportation Federal Highway Administration Office of Natural and Human Environment. Washington, D.C. August 2006. http://www.fhwa.dot.gov/environment/noise/handbook/.

Fraser, J. D., L. D. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in north-central Minnesota. Journal of Wildlife Management 49:585–592.

Golightly, Rick. 2002. Personal observation, described in correspondence September 20, 2002 in USFWS 2006.

Grubb, T.G., and W.W. Bowerman. 1997. Variations in breeding bald eagle response to jets, light planes, and helicopters. Journal of Raptor Research 31:213-222.

Grubb, T.G., D.K. Delaney, W.W. Bowerman and M.R. Wierda. 2010. Golden eagle indifference to heli-skiing and military helicopters in Northern Utah. Journal of Wildlife Management. 74:1275–1285

Hamer, Thomas and S. Kim Nelson. 1998. Effects of disturbance on Nesting Marbled Murrelets: Summary of Preliminary Results. Prepared for Paul Henson, US Fish and Wildlife Service, Portland, Oregon. January 1998. 24 pp.

Hébert, P. N. and R. T. Golightly. 2006. Movements, nesting, and response to anthropogenic disturbance of Marbled Murrelets (*Brachyramphus marmoratus*) in Redwood National and State Parks, California. Unpublished report, Department of Wildlife, Humboldt State University, Arcata, California and California Department of Fish and Game Report 2006-02, Sacramento, California.

Hamernik, R. P. and Hsueh, K D. 1991. Impulse noise: some definitions, physical acoustics and other considerations. Journal of the Acoustical Society of America 90:189-196.

Knight, R.L. and S.K. Knight. 1984. Responses of wintering bald eagles to boating activity. Journal of Wildlife Management 48:999-1004.

Laughlin, Jim D. 2012. Personal communication from Jim Laughlin, WSDOT acoustician to Emily Teachout, USFWS, Western Washington Office. Electronic mail dates February 14, 2012.

Laughlin, Jim D. 2010. Memo to Sharon Rainsberry: Airborne Noise Measurements (A-weighted and un-weighted) during Vibratory Pile Installation – Technical Memorandum. WSDOT. June 21, 2010.

Livezey, K. 2012. Division of Consultation and Technical Assistance. Email to: John Grettenberger, Vince Harke, Carolyn Scafidi, and Emily Teachout, Washington Fish and Wildlife Office. Exposure of Adult MAMU to Disturbance. May 7, 2012. Washington Fish and Wildlife Office, Lacey, WA.

Long, L.L. and C.J. Ralph. 1998. Regulation and observations of human disturbance near nesting Marbled Murrelets. Arcata, CA: Pacific Southwest Research Station, Redwood Sciences Laboratory, Forest Service, U.S. Department of Agriculture.

MM&A. 2008. Blasting and helicopter noise analysis and mitigation plan. Unpublished report prepared for the Pacific Connector Gas Pipeline, L.P., by Michael Minor & Associates, Portland, Oregon. 27 pp.

McGarigal et al. 1991, NAVFAC. 2012. Naval Base Kitsap at Bangor EHW-1 Pile Replacement Project, Bangor, Washington. Final Acoustic Monitoring Report. Prepared by Illingworth & Rodkin. April 2012.

Pater, L.L., T.G. Grubb, and D.K. Delaney. 2009. Recommendations for Improved Assessment of Noise Impacts on Wildlife. The Journal of Wildlife Management. Vol. 73, No. 5, pp. 788-795.

Platt, J. B. 1977. The breeding behavior of wild and captive gyrfalcons in relation to their environment and human disturbance. Dissertation, Cornell University, Ithaca, New York, USA.

Ralph, C.J, G.L. Hunt Jr., M.G. Raphael and J.F. Piatt. 1995. Ecology and conservation of the Marbled Murrelet in North America: An overview. Pages 3-22 in, Ralph, C.R., G.L. Hunt Jr., M.G. Raphael and J.F. Piatt eds., Ecology and conservation of the Marbled Murrelet. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Simons, T.R., 1980. Discovery of a ground-nesting marbled murrelet. Condor 82:1-9.

Stalmaster, M.V. and J.L. Kaiser. 1997. Flushing responses of wintering Bald Eagles to military activity. Journal of Wildlife Management 61:1307-1313.

Teachout, Emily. 2012. Memo to Carolyn Scafidi, Forest Resources Branch Manager, Washington Fish and Wildlife Office, USFWS, Lacey, WA. February 15, 2012.

USFWS. 2003. Biological Opinion and letter of concurrence for effects to bald eagles, marbled murrelets, northern spotted owls, bull trout, and designated critical habitat for marbled murrelets and norther spoted owls from Olympic National Forest program of activities for August 5, 2003 to December 18, 2008. Service Reference 1-3-03-F-0833. U.S. Fish and Wildlife Service, Lacey, Washington.

USFWS. 2006. Transmittal of Guidance: Estimating the Effects of Auditory and Visual Disturbance to Northern Spotted Owls and Marbled Murrelets in Northwestern California. Arcata Fish and Wildlife Office, July 31, 2006.

WSDOT. 2011. Biological assessment preparation for transportation projects – advanced training manual. Washington State Department of Transportation. Olympia, Washington. Available online at: http://www.wsdot.wa.gov/Environment/Biology/BA/BAguidance.htm

APPENDIX D
MARBLED MURRELET NESTING SEASON

APPENDIX D

Marbled Murrelet Nesting Season and Analytical Framework for Section 7 Consultation in Washington

U. S. Fish and Wildlife Service - Washington Fish and Wildlife Office (WFWO) Lacey, WA.
June 20, 2012

The following narrative presents a summary of the best available science to describe (1) the timing of the marbled murrelet nesting season, (2) the distribution of feedings throughout the day, and (3) our analytical framework for section 7 analyses. It is intended to provide guidance for conducting section 7 consultations in Washington, but should not substitute for consultation with the U.S. Fish and Wildlife Service on actions that may affect marbled murrelets.

This document was prepared by Kent Livezey and Kim Flotlin of the WFWO. Technical support and review were provided by John Grettenberger, Emily Teachout, Deanna Lynch, Carolyn Scafidi, Carrie Cook-Tabor, Tim Romanski, Kevin Shelley, and Marc Whisler, all of the WFWO; Bridgette Tuerler of the Oregon Fish and Wildlife Office; and Lynn Roberts of the Arcata Fish and Wildlife Office.

I. Timing of the nesting season

Background. Starting in the early 1990s, we considered the marbled murrelet nesting period to have two seasons—the early (incubation) season and the late (nestling) season. We considered the early season to take place from April 1 to August 5, and the late season to take place from August 6 to September 15. The August 5 date was based on survey information used in the Inland Survey Protocol of the Pacific Seabird Group which indicated the likelihood of detecting murrelets using audio/visual methods dramatically dropped after August 5.

Here we analyze best-available information to help us (1) select the best data to use to estimate the timing of the murrelet nesting season; (2) decide whether it is biologically informative to break the nesting season into two parts; and (3) choose the dates to use for the beginning and end of the nesting season(s).

Selection of data. We gathered all data available to us from researchers conducting studies of nesting murrelets (unpublished data on file in WFWO, Lacey). Two data sets were applicable to Washington: radio-telemetry and nest site data from Washington only ($n = 27$) and similar data from Desolation Sound, British Columbia (BC) to Newport, Oregon ($n = 137$). The larger area brackets the state of Washington to the north and south, including nests in latitudes with similar habitat types and day length to those in Washington. Mean hatching date for the Washington-only data was June 29 and the mean for the BC-to-Oregon data was only 2 days later (July 1).

Decision: We had the option of using Washington-only data or the combined dataset. Due to the similarity in these datasets and our desire to make our estimates more robust and more broadly applicable, we chose to use the combined dataset.

One- or two-season nesting period. Based on the dataset, the complete murrelet nesting period lasts approximately 5 months (Figure 1). During the first month, only eggs are in the nests; during the middle 3 months, either eggs or nestlings are present; and during the last month, only nestlings are present (Figure 1). Adults are present throughout the nesting season.

Decision: Due to the large overlap between the incubation and nestling periods, we chose to view the complete nesting period as one season.

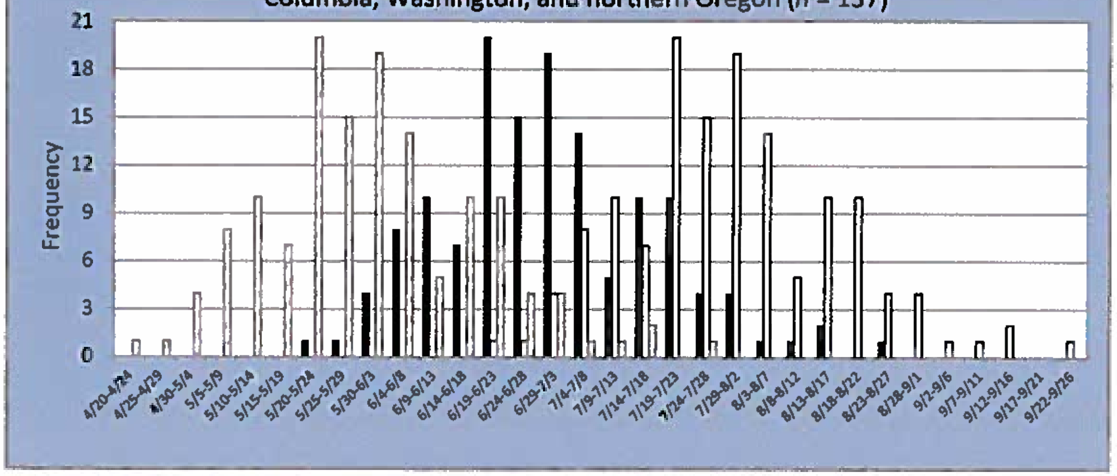

Figure 1. Dates of egg-laying (dashed bars), egg-hatching (black bars), and fledging (white bars) for marbled murrelet nests in southern British Columbia, Washington, and northern Oregon (n = 137)

Beginning of the nesting season. Both incubation and nestling phases last about 30 days (Nelson and Hamer 1995, p. 59; Nelson 1997, p. 17). The earliest egg-hatching day in our data was May 23, which places the earliest egg-laying day at April 24. Hamer et al. (2003, p. 10) stated "Incubation was estimated to begin 26 April and end 30 July." Murrelets in British Columbia have been captured with fully developed brood patches as early as March 20 (Tranquilla et al. 2005, p. 365). We determined the nesting season should start several weeks before commencement of egg-laying to capture the time during which murrelets establish their nest sites.

Decision: Assuming several weeks are needed for murrelets to establish nest sites before they begin laying eggs on April 24, we chose April 1 as the beginning of the nesting period.

End of the nesting season. The last known fledging of a murrelet in our dataset is on September 23. The distribution of our dataset is normal with a median ordinal date of 181, mode of 181, and mean of 181.6 (rounded to 182 or July 1; standard deviation (SD) = 17.7 days). Assuming our dataset is representative of the population, 95.45 percent (2 SDs above the mean) of murrelets in our area fledge by September 4, 99.73 percent (3 SDs above the mean) fledge by September 22, and 99.99 percent (4 SDs above the mean) fledge by October 9.

Decision: We consider the end of the murrelet nesting season to be September 23, which includes the fledging of all murrelets in our dataset and, assuming our dataset is representative of the population, includes 99.73 percent (3 SDs above the mean) of the murrelets in our area.

II. Timing of feedings during the day and Limited Operating Periods

Background. We previously assumed that adult murrelets make only a small number of prey delivery trips during the middle of the day (described as the period from 2 hours after sunrise to 2 hours before sunset). The primary source of information we used for these times was the histogram presented in Nelson and Hamer (1995, p. 62) which, depending on the time of year, indicates that approximately 5 to 6 percent of feedings took place between 9 am and 6 pm.

The 2-hour diurnal periods subsequently were corroborated by radar and audio-visual surveys that found murrelets attending nests and nest stands from 1 hour, 45 minutes before sunrise to 1 hour, 50 minutes after sunrise (with a few detections at 2 hours, 30 minutes after sunrise), and from 30 minutes prior to sunset to 1 hour, 10 minutes after sunset (Burger 1997, pp. 213 and 219; Burger 2001, p. 701; Cooper et al. 1999, pp. 18–25; Cooper et al. 2001, p. 223; Cooper et al. 2003, p. 9; Meekins and Hamer 2000, p. 17; Naslund and O'Donnell 1995, pp. 130–132) (Table 1). However, these studies typically did not gather data beyond the dusk and dawn periods.

Table 1. Daily timing of trips to nesting stands by marbled murrelets

Reference	**Page: Figure**	**Dawn** (study area, year, sample size, timing of detections)	**Dusk** (study area, year, sample size, timing of detections)
Burger (1997)	213: Fig. 3		Carmanah BC, 13 Jun 1995. *n*=48; no data before to 1 hr 10 min after sunset
Burger (1997)	213: Fig. 3		Bedwell-Ursus BC, 20 Jun 1995 *n*=213; 30 m before to 1 hr 10 min after sunset
Burger (1997)	213: Fig. 3		Bedwell-Ursus BC, 21 Jun 1995 *n*=288; 30 m before to 1 hr 5 min after sunset
Burger (1997)	219: Fig. 6[1]	Carmanah BC, 6–15 Jun 1995, *n*=330; 1 hr 15 min before to 1 hr 45 min after sunrise	
Burger (1997)	219: Fig. 6[1]	Bedwell-Ursus BC, 19–24 Jun 1995, *n*=2647; 1 hr 25 min before to 2 hr after sunrise	
Burger (2001) (*n*=150 for all 3 days)	701: Fig. 2	Moyeha BC, 14 Jun 1997; 1 hr 10 min before to 1 hr after sunrise	
Burger (2001) (*n*=150 for all 3 days)	701: Fig. 2	Moyeha BC, 15 Jun 1997; 1 hr 10 min before to 1 hr 30 min after sunrise	
Burger (2001) (*n*=150 for all 3 days)	701: Fig. 2	Moyeha BC, 6 Jul 1998; 1 hr 40 min before to 2 hr 30 min after sunrise	
Cooper et al. (1999)	18: Fig. 2	Olympic Peninsula WA, 1996–1998, *n*=5163; 1 hr 45 min before to 1 hr 25 min after sunrise	

Reference	Page: Figure	Dawn (study area, year, sample size, timing of detections)	Dusk (study area, year, sample size, timing of detections)
Cooper et al. (2001)	223: Fig. 2	Olympic Peninsula WA, 1996–1999, *n*=8653; 1 hr 45 min before to 1 hr 25 min after sunrise	
Cooper et al. (2003)	9: Fig. 2	Olympic Peninsula WA, 1996–2002, *n*=23,510; 1 hr 45 min before to 1 hr 50 min after sunrise	
Meekins and Hamer (2000)	8	Mendocino County CA, 2000, *n*=193; 1 hr 29 min before to 1 hr 11 min after sunrise	
Naslund and O'Donnell (1995)	130: Fig. 1	Big Basin Redwoods SP CA (*n*=9764), Phantom Creek BC (*n*=2142), Naked Island AK (*n*=1649), 1989–1991; 1 hr 45 min before to 1 hr 45 min after sunrise	

[1] We presented the summarized data in Fig. 6 of Burger (1997), rather than those in Fig. 2, for the Carmanah study area because Fig. 6 included earlier and later detections, probably generated from the larger sample size presented in Fig. 6.

To reduce the risk of disturbance to nesting murrelets, we used these estimates to establish limited operating periods (LOPs) that allowed action agencies to work only from 2 hours after sunrise to 2 hours before sunset. Application of these LOPs was required during the early nesting season (April 1 to August 5). In the late nesting season (August 6 to September 15), with these LOPs in place, we typically did not anticipate that disturbance would result from activities such as the use of heavy equipment. Here we analyze the best available information on feeding frequency throughout the day to better document the value of and basis for the LOPs and to decide whether adjustments in their timing are warranted.

New information. We obtained preliminary results from two studies pertinent to this issue. In the first, Rick Golightly (5/19/2010 in litt. to Kim Flotlin) sent us the following summary of his work from northern California:

> "We conducted the analysis to look for mid-day flyins from our data logger recordings (24h) of radioed birds in northern California (see Hébert and Golightly 2006). The 2002 year had the best productivity, and thus the most potential for mid-day flyins. We used breeders (not necessarily confirmed to have chicks) in the period 15 June to 31 July. We stratified the data into time blocks, and assigned the period of 0801 to 1500 as outside the night, morning, or evening periods (this was somewhat arbitrary, but we had logic for the time division). Of the 16 breeders, 9 had flights during the mid day period. The average percent of daily flights per bird that occurred in this period was 3.13 +/- 1.05%. For 2003, with only 4 birds available, the average was 1.9 +/- 1.9%."

Golightly's use of 08:01 to 15:00 as the midday period excluded several hours of the day, depending on the time of sunrise and sunset. Consequently, it is very likely that a higher percentage of murrelets they studied fed their young during what we consider to be "midday." Detailed analysis of these data cannot be done until this work is published.

In the second set of preliminary data, Alan Burger provided information from three survey periods during which he and his crew observed marbled murrelets making feeding trips to their nests in southern British Columbia (5/11/ 2010 in litt. to Kim Flotlin, from Jones 2001, appendix). We estimated sunrise and sunset times for each date and placed the feedings into midday (from 2 hours after sunrise to 2 hours before sunset) vs. morning/evening periods (other times). It is impossible to compare number of feedings per hour in midday vs. morning/evening periods because the information provided to us presented the total number of hours of observation per day, not the starting and ending times for each period of observation. The most feedings observed per day were 7 (during 7.5 hours of observation), 7 (during 17 hours of observation), and 8 (during 8 hours of observation). Hours of observation per day ranged from 1 to 17 (typically 3–5), with an emphasis on the morning and evening hours. For example, on June 29, 1997, they observed a nest for 5.5 hours in the morning (with feedings at 5:42, 6:05, 7:12, 8:17, 10:09) and 1.5 hours in the evening (with a feeding at 21:01). This was done, presumably, to optimize the chance of witnessing feedings. Even with this emphasis, midday feedings comprised 46 percent (22 of 48 feedings; 73.5 hours of observation; Aug 7–20, 1993), 31 percent (5 of 16; 36.5 hours; Jun 9–Jul 3, 1994), and 46 percent (19 of 41; 101.5 hours; Jun 14–Jul 1, 1997) of observed feedings in 1993, 1994, and 1997, respectively.

III. Summary and application of this best available science in the context of a section 7 consultation

1. Using data from 137 nests from southern British Columbia to northern Oregon, the nesting season of marbled murrelets in Washington is best defined as the period from April 1 to September 23.

2. Due to the large overlap in time when murrelets have eggs vs. young on their nests throughout the nesting season, we consider the nesting season to be one season that is not divided into two nesting periods.

3. Due to the high proportion of feedings during the morning and evening hours, LOPs remain an appropriate measure to reduce exposure of nesting murrelets to disturbance from activities during those times; therefore, we will continue to recommend or require LOPs.

4. Given the large variability in the distribution of observed feedings, we are not proposing to refine the timing of LOPs. Therefore, they remain from 2 hours after sunrise to 2 hours before sunset.

5. Due to the large proportion of feeding that occurs during the middle of the day (during the LOPs) in some areas, we cannot assume that implementation of LOPs will avoid adverse effects to murrelets, eggs, or chicks.

6. After September 4, when all incubation has been completed and less than 5 percent of murrelets are still nesting, the potential to encounter a murrelet during the implementation of a single action may be extremely low. It may therefore be feasible, with implementation of an LOP, to justify that the risk of exposure of murrelets is discountable after September 4. Factors that could support a discountable determination

during this time period include low habitat quality (based on consideration of tree size, platform numbers, location, stand size, disturbance history), type of the activity, and duration of the activity. When projects are considered programmatically, the additive risk may not be discountable. These decisions are most appropriately made through the consultation process, during which site- and project-specific information can be evaluated.

LITERATURE CITED

Bloxton, T.D., Jr. and M.G. Raphael. 2009. Breeding ecology of the marbled murrelet in Washington State. Five year project summary (2004–2008). May 2009. USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington.

Burger, A.E. 1997. Behavior and numbers of marbled murrelets measured with radar. Journal of Field Ornithology 68:208–223.

Burger, A.E. 2001. Using radar to estimate populations and assess habitat associations of marbled murrelets. Journal of Wildlife Management 65:696–715.

Cooper, B.A., D.M. Evans, and M.G. Raphael. 1999. Radar studies of marbled murrelets on the Olympic Peninsula, Washington, 1996-1998. ABR, Inc., Forest Grove, Oregon and USFS Pacific Research Station, Olympia, Washington. 62 pp.

Cooper, B.A., M.G. Raphael, and D. Evans Mack. 2001. Radar-based monitoring of marbled murrelets. Condor 103:21–229.

Cooper, B.A., M.G. Raphael, and D. Evans Mack. 2003. Refining a landscape-scale habitat model and inland monitoring program for marbled murrelets in the Olympic Peninsula. ABR, Inc., Forest Grove, Oregon and USFS Pacific Research Station, Olympia, Washington. 44 pp.

Hamer, T.E. and S.K. Nelson. 1995. Nesting chronology of the marbled murrelet. In: C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt (Tech. eds.), Ecology and Conservation of the Marbled Murrelet. Gen. Tech. Rept. PSW-GTR-152. Albany, California: Pacific Southwest Experiment Station, Forest Service, U.S. Dept. of Agriculture. 420 pp.

Hamer, T.E., S.K. Nelson, and T.I. Mohagen, II. 2003. Nesting chronology of the marbled murrelet in North America. Unpublished report. 22 pp.

Hébert, P.N. and R.T. Golightly. 2006. Movements, nesting, and response to anthropogenic disturbance of marbled murrelets (*Brachyramphus marmoratus*) in Redwood National and State Parks, California. Unpublished report, Department of Wildlife, Humboldt State University, Arcata, California and California Department of Fish and Game Report 2006-02, Sacramento, California.

Meekins D.J. and T.E. Hamer. 2000. Use of radar to determine the presence of marbled murrelets within selected watersheds of Mendocino County, California. Hamer Environmental, Mount Vernon, WA.

Jones, P.H. 2001. The marbled murrelets of the Caren Range and Middlepoint Bight. Vancouver, BC: Western Canada Wilderness Committee. 150 pp.

Meekins, D.J. and T.E. Hamer. 2000. Use of radar to determine the presence of marbled murrelets within selected watersheds in Mendocino County, California. Final report prepared for Mendocino Redwood Company. 35 pp.

Naslund, N.L. and B.P. O'Donnell. 1995. Daily patterns of marbled murrelet activity at inland sites. *In*: C.J. Ralph, G.L. Hunt, M.G. Raphael, and J. F. Piatt (Tech. eds.), Ecology and conservation of the marbled murrelet. Gen. Tech. Rept. PSW-GTR-152. Albany, California: Pacific Southwest Research Station, Forest Service, U.S. Dept. of Agriculture. 420 pp.

Nelson, S.K. 1997. Marbled murrelet *(Brachyramphus marmoratus)*. Birds of North America, No. 276. 32 pp.

Nelson, S.K. and T.E. Hamer. 1995. Nesting biology and behavior of the marbled murrelet. In: C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt (Tech. eds.), Ecology and Conservation of the Marbled Murrelet. Gen. Tech. Rept. PSW-GTR-152. Albany, California: Pacific Southwest Experiment Station, Forest Service, U.S. Dept. of Agriculture. 420 pp.

Tranquilla L.M., N.R. Parker, R.W. Bradley, D.B. Lank, E.A. Krebs, L. Lougheed, and C. Lougheed. 2005. Breeding chronology of marbled murrelets varies between coastal and inshore sites in southern British Columbia. Journal of Field Ornithology 76:357–367.